Biotechnology in development: A case study from Burkina Faso

Bt cotton in Burkina Faso's agriculture

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Preface

This thesis is written as part of the graduation of the bachelor International Development Studies at the Wageningen University and Research centre. The content of this thesis will be concerned with technical developments in the agricultural development of Burkina Faso. This topic is chosen due to personal interest in both technological developments and rural developments; within this thesis, both developments are covered. The main point in this thesis is the indication of the intertwinement of both developments. During the thesis several notions will be made about both developments on the basis of literature which is gathered (mainly literature concerning biotechnology in Burkina Faso) and analysed by sociological and technical concepts. Empowerment and power-knowledge interactions are two examples of sociologic notions used in this thesis. In advance a word of gratitude should be made towards prof.dr. Ruivenkamp, due to his voluntarily supervision of this thesis. His remarks in the process of writing improved the content.

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Summary

Since the onset of technological developments, technologies have been used to improve processes. In the cotton production sector, Bt cotton is introduced, which is a genetically modified form of cotton. Within this crop, external proteins are inserted, creating the possibility of cotton to fight its natural enemy, the bollworm. This modification is made assuming that higher cotton yields could be realised in Burkina Faso, which should assist poverty reduction. Due to the large amount of poor smallholder farmers in Burkina Faso's cotton production made this technological development a tempting technology. Although, with the development of technologies, changes can be measured not only on technological fields, but technological developments can also have a social field of impact. This intertwinement of the technical and social is not always taken into account in studies and might form dangers in application measures. In Burkina Faso, the application of Bt cotton resulted in higher yields for producer, but negative effects also arose due to the application of Bt cotton. These negative effects are mainly noticed on the social field of impact. The social influences of biotechnological applications are clearly visible; producers face dependencies towards public institutions due to the monopolistic positions of these public institutions. In this way, the codes of the technologies are only known by the public institutions and not by the producers. Due to this situation, producers are dependent and lack a liberty of production and choice. In response to the advantages and disadvantages, a pro-contra debate arose in which only two dimensions of biotechnology were recognised; biotechnology was regarded as being advantageous or disadvantageous. However, a third dimension should be recognised, which is called the tailor-made biotechnology. TMBT is founded on the idea that re-establishing relations between biotechnological and endogenous developments can support the success of technological innovations[1]. Within the endogenous developments, local aspects are taken into account which can prevent negative social effects. This co-evolution could form an important aspect in the development of technologies. Next to tailoring biotechnologies, other possible improvement of Burkina Faso's cotton production are noted. For instance, a producer-centred organisation in agricultural technology developments can form a useful tool for a producers to counter the dependency relationships towards public institutions. This producer-centred organisation can form networks through which information and means can be distributed to producers without the involvement of monopolistic institutions. In this way, producers can realise higher incomes and poverty reduction is more likely to be accomplished than in the contemporary situation. When tailor-made biotechnologies can be accomplished, a re-appropriation of production means occur, shifting the appropriation of these production means from institutions towards producers and in this way limiting the influence of public institutions. Although, the existence of public institutions also provided tools which can be helpful for a producer-centred organisation; the networks created over time are helpful tools in reaching producers and can ease the distribution of means and knowledge for cotton production. A combination of the advantageous aspects of both the institutional model and the producer-centred model could improve the process of cotton production and reduce poverty in Burkina Faso.

[1]Ruivenkamp, G (2008a). *Biotechnology in development: experiences form the south.* Wageningen, Wageningen Academic Publishers.

1. Introduction

Cotton was introduced in Burkina Faso in the colonial period, when it was occupied by France in the beginning of the 20th century. The crop was mainly important because cotton was used to manufacture clothes for the (French) population[1]. Next to the material functionality, cotton was an important trading good to the north, in the Sahara, where it was traded against salts, and in the south, where it was traded against kola[1]. Due to the French ruler, initiatives to increase cotton production occurred, but failed. When Burkina Faso became an independent country, the Burkinabe continued the production of cotton because it was easy to combine it with the production of maize and livestock farming, both having the same cropping system (due to the same demand in rainfall levels and soil nutrients)[1].

In contemporary African farming, the use of genetically modified crops is implemented assuming that this can create bigger yields and higher incomes for the producers in African countries. In this way, the producers might be able to realise better living conditions in their area. A few examples of the improvements of better living conditions are 1) the realisation of public services, like schools, roads and public health, which might be improved due to the alleviating poverty in cotton producing areas, but also 2) pest controls might be able to improve productions, due to new technologies[1]. These pests are controlled by adapting the genetic code of a crop in such a way that it can fight its natural enemy. In Burkina Faso, the Bt cotton is genetically modified to produce Cry proteins, which is toxic to its natural enemy, the American Bollworm[1]. Next to the benefits described above, 3) GM crops can also cause more sustainability in an area. Forms of sustainability in which Bt cotton can contribute are: 3.1) the reduction of insecticide use, 3.2) sustainability of yields (sustainable production), 3.3) sustainable energy use and 3.4) the preservation of the environment[1]. Burkina Faso is one of view African countries which try to enhance sustainability and poverty reduction by introducing modern, science-driven technologies in the agricultural sector[1]. The implementation of genetically modified (GM) cotton became the first trial for technological change in Burkina Faso. With such a big impact on an important income sector, the implementations should be well-regulated and controlled by capable actors, for instance by public or private institutions. In Burkina Faso, several steps had to be undertaken in order to make sure the implementations would turn out positive. For example, a policy on biotechnology had to be formed and laws and regulations on biosafety were needed, to make sure the results would turn out positive[2]. These implementations are introduced on a national scale, while the results will be observed at a local or even individual level. This thesis focusses on the effects of the national implementations of biotechnological means in the agricultural sector of Burkina Faso and the effects of these implementations on the national, local and individual level. The effects on the national level will be analysed by means of the institutional set up regarding Bt cotton in Burkina Faso and national implementation measures. The effects on the local level will be analysed by means of interactions between public institutions and producers (farmers as well as peasants, which will be further examined later). The effects on the individual level will be analysed by means of empowerment of the producers with respect to the public institutions.

[1]Vitale, J., Ouattara, M., Vognan, G. (2011). Enhancing sustainability of cotton production systems in West Africa: A summary of empirical evidence from Burkina Faso. Sustainability, 3: 1136-1169.
[2]Karembu, M., Nguthi, F., Abdel-Hamid, I., (2009). Biotech crops in Africa: The final Frontier, ISAAA AfriCenter.

The involvement of public institutions in such a case can have positive as well as negative effects on different places in the production chain. A problem that could occur is the increase of dependencies of producers on public institutions. The dependencies are mainly results of the knowledge-dependent technologies and the seed-supplying process. The knowledge-dependent technologies can cause dependencies due to the absence of knowledge needed for the production process by producers. The public institutions are assumed to control the knowledge for Bt cotton production and in this way, create a decency relation, The intertwinement of the social and technical will also been stressed during this thesis. Although, due to analytical considerations, the technical and social will be analysed separately in the chapters, whereas in the conclusion, the intertwinement will be described clearly and extensively. In this intertwinement of the social and technical, the political bias in the artefacts (in this case Bt cotton) plays an important role, mainly through the operations of institutions, this political bias is visible in the cotton producing sector of Burkina Faso. These institutions tend to exert their power and authority through the technical means (Bt cotton) on the producers. How this process develops and could be countered can be read in this thesis.

2. Analytical framework

The analytical framework of this thesis will be two-fold, meaning that both the social and the technical domains of the situation will be explored and combined in order to clarify the intertwinement of both domains. Technical changes can cause rather high social changes within an area, but the social construction of a country can have effects on the development and implementation of technology as well (for instance through to the institutional set-up). In earlier researches, the social and technical domains were seen as separate domains, whether in more recent studies, these domains are noticed as related fields of impact. As is mentioned, technological improvements can influence social structures, but social structures can also influence technical improvements in an area. This phenomenon is called the co-evolution of social and technical creations[1]. In this view, "biotechnology should not be regarded simply as a group of techniques, but rather as a composition of social and technical dimensions" (Ruivenkamp 2008a: 25)[1]. Therefore, this thesis includes not only the technical relation of genetically modified cotton in Burkina Faso, but also the social relations which are inscribed in the technical artifacts of the developments. Here, the social can be perceived as software which is inscribed in the hardware of genetically modified cotton.

2.1 Technology as a social-technical composition

When analysing technology as a separate domain, several aspects need to be covered to create a clear image of the techniques. Next to the theoretical side of what biotechnology contains, the benefits and drawbacks of biotechnology will be discussed. These benefits and drawbacks are part of the pro-contra debate which forms the dominant paradigm in biotechnology applications. The pro-contra debate can create a clear image of contemporary technical potentials and shortcomings, which all play a role in Burkina Faso's agricultural sector, however, this paradigm is rather fixed an leaves little space for manoeuvre. In efforts to look passed the pro-contra debate, the notion of tailor-made biotechnologies is used. This paradigm tends to be more flexible than the pro-contra debate and can therefore form a third option in the consideration of biotechnology.

Biotechnology

In order to frame the broad concept of biotechnology, this thesis will use the definition by Karembu et al. (2004); In this definition, biotechnology is seen as "any technique that uses living organisms or substances from these organisms to make or modify a product for a practical purpose" (Karembu et al. 2009: 3)[2]. Here, the technical side of biotechnology is explained as biotechnology being a technique to modify existing organisms with new characteristics which are extracted from other organisms. However, the social side of biotechnology is neglected. Therefore, this definition should be elaborated with social characteristics. Also, the interaction between the social dimension and the technical dimension should become apparent within a newly formed definition of biotechnology. Using the first definition, biotechnology can be seen as a technique that puts pieces into places of a puzzle at which these pieces originally would not fit. By reshaping or manufacturing new pieces, new parts can be added to the original puzzle; here, the puzzle is a place of conflict between the technical and the social side and therefore, the pieces should be shaped in a way that they fit in the social as

[1]Ruivenkamp, G (2008a). *Biotechnology in development: experiences form the south.* Wageningen, Wageningen Academic Publishers.
[2]Karembu, M., Nguthi, F., Abdel-Hamid, I., (2009). Biotech crops in Africa: The final Frontier, *ISAAA AfriCenter.*

well as in the technical side of the puzzle. In practrice, this process is far more complex, but the idea is rather the same; improving crops with features they did not poses before in order to make these crops more efficient or sustainable. In contemporary agriculture biotechnology is used in different scientific techniques. Most common techniques are tissue cultures, genetic modification and molecular breeding[1]. Tissue cultures stands for the artificially growing of specific cells or groups of cells. These cells are grown outside of organisms, and are mostly grown in laboratories. Genetic modification corresponds with the example of the puzzle given above. Within this technique, genes are artificially adapted in a favourable way. Genes are parts of the DNA of organisms which entail specific codes for the characteristics of an organism, and by introducing a new piece, the organism receives a new characteristic. An example of genetic modification is the rDNA technique[2], in which one form of recombinant DNA (artificially developed DNA) is produced out of different DNA hosts. Molecular breeding includes the reproduction of organisms in an artificial way. Genes of parent organisms (mostly plants) are studied and the most favourable genes of both parent organisms are combined in a new 'super' organism. This technology can be considered as an artificial way of gene crossing[3]. The three techniques mentioned above are becoming more common in contemporary agricultural production, but are mostly exercised in laboratories and delivered to producers in new forms of seeds. These improved seeds are just one of the biotechnological improvements which producers can use. Next to these improved seeds (which should have genetically advantages over conventional seeds), chemical fertilizers, insecticides and herbicides[1] are forms of biotechnological implementations which agricultural producers can use on their fields. Next to the features mentioned above, biotechnology is also perceived as a tool for substitution[2]. Substitution refers to the replacement of original food sources by products of an industrial-biochemical origin[2]. Substitution is used more frequently, due to the benefits it may provide (e.g. lower production costs, better product quality). The development of new enzyme techniques[2] constructs the basis for substitution possibilities. By using this technique, components from different foodstuffs can be extracted and placed into another foodstuff[2]. In this way, food can be improved in e.g. quality, nutritional value or costs. These new applications are assumed to create better opportunities for producers (peasants, smallholder farmers as well as middle-sized and big enterprise farmers), but knowledge is often needed in order to make the new forms of technology work. This knowledge, or set of rules, (also called the 'code' or know-how) is very important in realising a successful implementation of biotechnological methods on the field.

Codes in biotechnology

The codes of technology form an important facet which will be described. In order to make something work, knowledge about what is performed is important. Especially in technologies, knowledge is an important factor for success. It is widely assumed that the success of modern biotechnology can hamper due to inaccurate, unreliable information, lack of knowledge and awareness in the society. In Burkina Faso, Bollgard II cotton is a bio-technological technique used by a large amount of producers[4]. This kind of cotton (which will be elaborated on later in this chapter) possesses various codes in order to generate all the benefits of the product. The codes are hard to find out by the producers themselves, therefore the suppliers of the modified seeds should provide

[1]Karembu, M., Nguthi, F., Abdel-Hamid, I., (2009). Biotech crops in Africa: The final Frontier, *ISAAA AfriCenter*.
[2]Ruivenkamp, G. (1993). Tailor-made biotechnologies: Possibilities for farmer-centred development, *Agriculture and human values.*
[3]Science daily. (S.A.). Chromosomal crossover. *Science daily*.
[4]Vitale, J., Ouattara, M., Vognan, G. (2011). Enhancing sustainability of cotton production systems in West Africa: A summary of empirical evidence from Burkina Faso. *MDPI open publishing*, sustainability 2011, 3: 1136-1169.

the codes to increase the probability of a successful implementation. As Ruivenkamp states: "farming practises with biotechnological development supposes not only an active line up of farming organisations, but also a willingness on the part of technology designers to discuss the differing contents (codes) of biotechnology"(Ruivenkamp 1993: 29)[1]. This interaction between designer and implementer can be considered as one of the main important facets of making biotechnological changes work in agriculture. If this interaction works in a proper way, biotechnological reforms in agriculture are assumed to have very positive effects, some of which will be discussed now.

Three approaches towards biotechnological implementations

Within the development of technologies, different approaches and paradigms can arise, due to the paradigms of different actors. With every new invention people are in favour of the invention or people are against it. This so called pro-anti debate has been going on for some time in the technical innovation world. The actors involved in the technical implementation debate can be divides in three groups; first, splitters; second, weavers; and third, re-designers[2]. The splitters can be seen as actors which consider the social and the technical domain as two different worlds of study, where biotechnology as a factor has influence on society as another factor[1]. The theory of technological politics from Winner applies to this approach: "The theory of technological politics draws attention to the momentum of large-scale sociotechnical systems, to the response of modern societies to certain technological imperatives, and to the all too common signs of the adaptation of human ends to technical means" (Winner 1980: 123)[3]. Here, the one way approach from technology interfering with the social becomes clear. The weavers consider biotechnology as not only a factor that causes social changes but also as a factor that is influenced by social changes[1]. Here, the concept of co-creation is used to stress the interrelation between the technical and the social[1]. The re-designers go deeper into the interaction between the technical and the social; "they try to find room for manoeuvre within which other socio-technical ensembles, other forms of biotechnology, can be developed" (Ruivenkamp 2008a: 25)[2]. Ruivenkamp (2008b) stresses that next to the pro- and anti-side of technological innovation, a third approach can be distinguished. This new approach is called the tailor-made biotechnology (TMBT)[4] and can be related to the re-designers view on technology.

The re-design perspective of tailor-made biotechnologies

An important notion in the attempt of looking past the pro-contra debate is that the effects of technologies are place-bound and that the results of technologies in different places of the world will be different. A rather important part of this vision of technology in development is the tailoring of biotechnology[5]. This concept has already been used in studies of the previous decades, but is still seen as an essential part of ensuring success of technological implementations and will therefore been used in this thesis. TMBT is founded on the idea that re-establishing relations between biotechnological and endogenous developments can support the success of technological innovations[2]. Therefore, the TMBT approach can be considered a technique which can be used in the

[1]Ruivenkamp, G. (1993). Tailor-made biotechnologies: Possibilities for farmer-centred development, *Agriculture and human values.*

[2]Ruivenkamp, G (2008a). *Biotechnology in development: experiences form the south.* Wageningen, Wageningen Academic Publishers.

[3]Winner, L. (1980). Do artifacts have politics? *Modern technology: problem or opportunity* Daedalus, Vol. 109, No 1: 121-136.

[4]Ruivenkamp, G. (2008b). Tailoring biotechnologies: a manifesto. In: Ruivenkamp, G., Hisano, S., Jongerden J. (2008). Reconstructing biotechnologies: critical social analysis. Wageningen, Wageningen Academic Publishers: 29-76.

[5]Ruivenkamp, G. (2003). Tailor-made biotechnologies for endogenous developments and the creation of new networks and knowledge means. *Biotechnology and Development Monitor, 50.*

re-designers approach. The approach of re-designing is derived from the notion that existing approaches should be modified into more endogenous centred approaches, or as Ruivenkamp states: "...trends within technological developments that may offer social-technical networks to re-appropriate, modify and democratise (bio) technological developments". (Ruivenkamp 2008b: 35)[1].

The social dimension will contain the issues that arise because of the technological frame; here already the intertwinement becomes clear. The implementation side, in which public and parastatal institutions play an important role, will be discussed along with the empowerment of producers due to the technological changes in the agricultural sector. Within this context, empowerment does not necessarily mean that producers become empowered due to the implementation of technical means, on the contrary, producers might become dependent on institutions because of the implementation of the new technological products.

2.2 Problem statement and research questions

With the application of biotechnologies, actors can undergo changes, which might have large impacts on these actors. The main problems in Burkina Faso, regarding the application of genetically modified cotton, are the changes in living conditions and changing relations between actors. Here, the interaction (or co-evolution) of institutional settings and Bt cotton (as a technological artifact) is clearly visible. Therefore, the main question of this thesis is: '*what effect does the implementation of Bt cotton in Burkina Faso's agriculture have on actors involved in cotton production?*' In order to answer this question, the next sub questions are formulated:

- What is biotechnology in general?
    - What forms of biotechnology are used?
    - What are the benefits and drawbacks of biotechnology?
- How does the implementation of Bt cotton influence the functioning of public research institutions within Burkina Faso?
    - How becomes co-evolution clear from the application of biotechnology in Burkina Faso?
    - What is the institutional set-up in Burkina Faso?
- How is the empowerment of the producers affected by the institutions involved in Bt Cotton production?
    - How do institutions contribute to empowerment (or the restriction of empowerment) of producers?
    - Can Tailor-made biotechnologies contribute to the empowerment of producers?

The producers can be distinguished in farmers (producing for a global market) and peasants (producing for local markets). In order to make sure all the aspects concerned with this process are described, the sub questions within this thesis will be addressed to the separate aspects, combining them in the concluding chapter. The sub questions will cover a) the technical aspects; what is biotechnology in general, how is biotechnology used in the Burkina Faso agricultural system, which codes are important to make biotechnology a success, etc.; and b) the social aspects; how biotechnology is implemented in Burkina Faso, what role the institutions play in the country, what

[1]Ruivenkamp, G. (2008b). Tailoring biotechnologies: a manifesto. In: Ruivenkamp, G., Hisano, S., Jongerden J. (2008). Reconstructing biotechnologies: critical social analysis. Wageningen, Wageningen Academic Publishers: 29-76.

effects Bt cotton has on the empowerment of producers, etc. Goal in this thesis is to clarify the intertwinement of the technical and social by stressing both domains separately (for analytical reasons, as is stressed earlier) and combining them in the conclusion. In this way a clear analysis of the intertwinement can be realised. Winner strengthens the relation of the social and the technical by stating: "What matters is not technology itself, but the social or economic system in which it is embedded"[1] (Winner, 1980: 122). Ruivenkamp however, gives a broader view of biotechnology: "Each technology – and also biotechnology – relates to and is developed within a certain context. Besides a technical dimension (the techniques), biotechnology contains a social dimension, such as the social relations that reflect themselves in the technology-development, and the aims for which the technology is used" (Ruivenkamp, 1993: 26)[2]. Ruivenkamp here reflects to the co-evolution of the social and the technical. Within Ruivenkamp's statement, the intertwinement of the social and the technical framework is described clearly and is therefore also used as core principle in this thesis.

In a research which is embedded in several domains, an outcome is hard to predict. First question to be asked is whether the domains described above, the technical and social, are separate domains. Since technical artefacts started to take over important facets of human life, the technical and social have become intertwined in daily life. Winner, a scientist who proposed that technologies and social relations interact , states: "... technical things have political qualities" (Winner 1980: 121)[1]. He herein recognises the impact of social structures on technical developments, which can have impacts on the structures within human societies. The next quote, used from his article *Do artifacts have politics?,* reflects the range in which technology and technological implementations should be considered within policies: "At issue is the claim that the machines, structures and systems of modern material culture can be accurately judged not only for their contributions of efficiency and productivity, not merely for their positive and negative environment side effects, but also for the ways in which they can embody specific forms of power and authority" (Winner 1980: 121)[1]. This last notion is of main importance in this thesis, because the impact of technical developments on the social relations (and also institutional operations) and vice versa is the central theme of this thesis. The intertwinement of the social and technical is considered as the co-evolution of development. This co-evolution (which will be elaborated in the sections of tailoring biotechnologies) is stressed frequently, because this concept is of main importance in order to look beyond the pro-contra debate. The implementation of Bt cotton can have several positive effects as well as negative effects on both the environment (and nature) and social relations. The institutions in Burkina Faso play a major role in the supply of Bt cotton seeds and other related resources. Therefore, the institutions in Burkina Faso play a key role in the intertwinement of technical and social aspects; the supply of seeds on the one hand and generating forms of power and authority on the other hand, and therefore, the institutions have to be discussed within this topic. The producers consist mainly of smallholder producers which have been cotton producers for a prolonged time. These producers were lured by the genetically modified cotton industry because of the good results in test periods. The involvement of smallholders, however, can have negative consequences for the degree of freedom in the production cycle. Mainly the strict regulations of institutions can cause for dependency relations of smallholder producers towards the supplying institution. The implementation of Bt cotton in Burkina Faso is assumed to

[1]Winner, L. (1980). Do artifacts have politics? *Modern technology: problem or opportunity.* Daedalus, Vol. 109, No 1: 121-136.

[2]Ruivenkamp, G. (2003, March). Tailor-made biotechnologies for endogenous developments and the creation of new networks and knowledge means. *Biotechnology and development Monitor, 50.*

have several effects on the role of institutions (distributional and influentially) and producers will, in this respect, remain less empowered due to constructed dependency relations by public institutions.

2.3 Empirical setting

The question mentioned above will be discussed in the empirical setting of biotechnological developments in Burkina Faso. Mainly the technological developments in the cotton production of Burkina Faso will be discussed in relation with the institutional set up in the country. Thereby, commercialisation and dependency relations of cotton production will be discussed, both being important factors in the application of Bt cotton. The former being a cause of the application of Bt cotton and the latter being a result of the application of Bt cotton.

Institutions

Within this thesis, institutions are described as important actors in the cotton sector of Burkina Faso. The institutions (or organisational bodies) described are considered public institutions, meaning that the institutions are regulated mainly by the government. In Burkina Faso, public institutions play an important role, due to their monopolistic positions in the cotton producing process. The historical context of the country (the occupations by the French) formed the basis of the monopolistic position; the French founded the first public cotton institution with a monopoly on the production process. After the colonial era, the Burkinabe government continued the French model by maintaining the monopolistic institutions. Institutions form important actors in Bt cotton production. These actors will be discussed in the second chapter. In this chapter, the institutional set-up in cotton production is discussed along with the co-evolution between the institutions and technical applications.

Commercialisation

Commercialisation is an important feature of the implementation of biotechnology and will be recognised as an important element for the institutional side and therefore been taken into account as well in this thesis. Burkina Faso can serve as a clear example of how commercialisation of a crop in a country alters the lives of a social class, in this case the cotton producer class. Commercialisation of a crop can cause shifts in the agricultural sector of Burkina Faso and can therefore attract institutions to get involved in the production of this crop.

Dependencies

Producers depend on the knowledge, which in this case is obtained by public institutions. Dependency relations are regarded as negative; the occurrence of dependency relations between the institutions and producers can limit the degree of liberty in production and can also cause a decrease of varieties of cotton produced in the country, because of the supply of a single seed-form (the Bt cotton); the decrease of varieties is the result of the profit-interested institutions. This dependency would depend on the level of involvement of a state-led institution within the production process of cotton, which can depend on what kind of producer a person is (farmer of peasant). In some cases, it could occur that the institution which provides seeds to producers can take advantage of these producers by making them depend on the supply of seeds. Also, the provision of knowledge about the new products can cause a dependency relationship. So, this dependency relation is two-fold: First, the provision of genetically modified seeds, and second, the provision of knowledge about how to produce cotton with these seeds in a proper way. This dependency on knowledge can be linked to the power-knowledge concept of Foucault, in the way that knowledge (in this case the knowledge of technological means) can have major consequences for the social power of an actor. This notion about Foucault will be elaborated during the thesis. The

dependency of smallholder producers is usually a direct effect of technical developments in a poor area, because institutions want to take advantage of the situation in such an area. In the following chapter, the empirical setting of the thesis is discussed. This setting contains Burkina Faso's cotton producing sector, including producers and institutions.

3. Biotechnology in Burkina Faso's agricultural development

3.1 Introduction

This chapter contains the empirical data of Burkina Faso's cotton producing sector. First, the intertwinement of agricultural and biotechnological developments in Burkina Faso will be described. Here, the agricultural conditions of the country will be discussed along with the technical applications in the country. The technical application mentioned in this chapter is the genetically modified Bt cotton. The benefits and drawbacks of Bt cotton are discussed as well in this chapter; these benefits and drawbacks are extracted from literature.

3.2 Intertwinement of social and technical dimensions

Since humans started to form civilizations, the provision of sufficient food formed one of the main important occupations every day. While time progresses, changes to the ways in which food provisioning was established occurred and modernizing techniques were discovered in assuming that these techniques can develop more efficient or sustainable ways of food provisioning. In history, several developments can be recognised in which men were able to change their ways of food production by making it more efficient or sustainable. Whether these techniques were based on social changes or technology, they created a huge impact on human life. A first example is the construction of civilizations in settled places. This phenomenon, also called the first agricultural revolution or Neolithic revolution, was first implemented in the middle-east around 3000-2500 B.C.E. (before the common era/before Christ)[1]. Due to this revolution, people were able to settle in one place and create artefacts to improve farming life. A second important historical phenomenon was, quite obviously, the second agricultural revolution (also called the British agricultural revolution). This phenomenon took place in the 18th and 19th century by inventions of steam driven machines. These machines were able to replace animals as working forces on the land, were more efficient and could realise higher yields[2]. During the 20th century, fertilizers and insecticides where developed to improve agricultural production. In this respect, several other important changes are left untreated, however, the point made in this introducing sector is that the contemporary changes in agricultural production do not come out of the blue; improving the production of food, the main concern of human existence, is in this context historically defined. Therefore, the emergence of Bt cotton is not surprising. Next to the fact that humans are able to develop improvements suited to their needs, history also provides evidence that these improvements can alter the social structure of civilization. This thesis will contain information about the newest improvements in agriculture and its impacts on the social domain.

The phenomenon introduced above is the rise of biotechnology. This technology is also called the fourth agricultural revolution, or the biochemicalisation of agriculture[3]. This form of technology is used in contemporary agricultural enterprises assuming this technology will create higher yields.

[1] Gilbert, E. & Reynolds, J.T. (2012). *Africa in world history: from prehistory to present*. New Jersey: Pearson Education.
[2] Bieleman, J. (2008). *Boeren in Nederland: geschiedenis van de landbouw 1500-200*. Amsterdam, Boom.
[3] Ruivenkamp, G. (2003). Genomics and food production – the social choices, *edepot.wur.nl*, Wageningen. Wageningen University and Research centre.

However, the implementation of this technology causes several changes in the structures of the production chain.

3.3 Intertwinement of agricultural and biotechnological development in Burkina Faso

In this section the agricultural characteristics of Burkina Faso are discussed along with the biotechnological applications. These two domains are closely intertwined due to the effects both domains have on one another.

3.3.1 Agriculture in Burkina Faso

Burkina Faso is considered one of the poorer countries in the world[2]. The country is situated in an area just below the Sahara desert which is called the Sahel. The Sahel is an area with limited rainfall; in the southern parts of the country, around 100 centimetres of rainfall per year is measured, in the northern part, only 25 centimetres of rainfall comes down per year[1]. The agricultural sector is a very important one in Burkina Faso; 40% of the country's Gross Domestic Product (GDP) is generated from agriculture and this sector provides 80-85%% of the inhabitants a job[1]. Although, due to droughts, pests, poor soils, insufficient infrastructure and financial problems, agricultural and economic development are stagnating[1]. Cotton is seen as the principal cash crop of the country due to its large share in the country's export earnings (60%)[2]. Considering these numbers, new possibilities could arise when the cotton production is more efficient. By combining crops with technological and scientific knowledge, one 'super crop' could emerge. These 'super crops' are believed to increase nutrition, yields, risk-reduction and profits for the large amount of smallholders in the area, who face prolonged poverty and relative low agricultural productivity[3], however, the notion of the super crop is questioned by several studies due to its place-dependency. In Burkina Faso, this technological and scientific knowledge, needed to improve their cotton production, was found at the Monsanto company in the United States. This biotechnological corporate business was able to enhance the capabilities of the cash crop cotton. The new-formed cotton was called Bollgard II cotton and higher yields in Burkina Faso were measured[1]. Whether this increase was only due to the implementation of Bollgard II cotton is hard to prove, because researchers found that the increase in production was not based on significant productivity increases, but were influenced by the accumulation of factors like land, labour and other inputs[4]. Whether this increase in yield is beneficial for the country can be questioned as well, due to the institutional inputs in its production. Because of the influence of institutions in the cotton producing sector, cotton can be seen as a politicizing product[5]. More about the institutional input will be discussed in the chapter about institutionalisation. A rather important character of Burkina Faso in relation with genetically modified cotton is the huge amount of smallholder producers involved in the technical change[1]. Thereby, Burkina Faso is the only African country which adopts Bt cotton, where smallholders dominate the agricultural sector[2]. This cotton sector, however, faces several challenges. Examples of these challenges are environmental challenges like the threat of soil impoverishment and the emerging conflicts of accesses to land[2].

[1]Karembu, M., Nguthi, F., Abdel-Hamid, I., (2009). Biotech crops in Africa: The final Frontier, *ISAAA AfriCenter*.
[2]ISAAA (2006, May). Pocket K No. 19: Molecular breeding and marker-assisted selection. *ISAAA.*
[3]Dowd-Uribe, B. (2013). Engineering yields and inequality? How institutions and agro-ecology shape Bt cotton outcomes in Burkina Faso. *Geoforum*, 53: 161-171.
[4]Kaminski, J. (2011). Cotton dependence in Burkina Faso: constraints and opportunities for balanced growth. In *Chuhan-pole P. & Angwafo* M. (2011). Yes Africa can: success stories from a dynamic continent). Washington D.C: World Bank: 107-121.
[5]Ruivenkamp, G (2008). *Biotechnology in development: experiences form the south.* Wageningen, Wageningen Academic Publishers.

3.3.2 Biotechnology in Burkina Faso

As is mentioned in the introduction, the cotton industry of Burkina Faso is one of the main production sectors of the country, because cotton is the cash crop of the country. Therefore, it is not surprising that actors strive to improve the productivity of the crop and its production cycle. This aim for productivity caused for radical social chances in the cotton producing sector during the colonial ages. These social changes will be discussed in the next chapter; within this section, the technical changes will be discussed. In Burkina Faso, Bt cotton was introduced assuming it would lead to bigger yields and higher profits for the producers. This Bt cotton was genetically modified by adapting the genetic structure of the cotton. The genetic code of the cotton was modified with the Cry protein (short for crystal protein), derived from the *Bacillus Thuringiensis (Bt)*, a bacterium[1]. These proteins are pore-forming toxins, which have an insecticide character; by forming pores in the gut of an insect, the Cry proteins kill pests and cause a decrease in pest influences on the production[1]. These Cry proteins are very effective on Lepidopteron (butterflies and moths) pests which are fond of cotton plants[2]. A major advantage of the Cry proteins is the specificity of its working; the cry proteins are very effective against lepidopteron pests, but mean no harm against other insects. In this way, ecological sustainability could be enhanced, due to the preservation of the biodiversity. In case a resistance against the cry protein would occur in time, two Cry proteins are used instead of one; the Cry1Ac and Cry2Ab proteins[1]. The probability of resistance against one protein can occur in pests, but resistance against both Cry proteins is very small and therefore, the pests should be easier to control[3]. In Burkina Faso, the relative easy and secure availability of credit is an important reason for the widespread adoption of Bt cotton[2]. The institutional setting becomes apparent in this process. These credits are offered to members (mostly men) of local cotton grower cooperatives and ease the process of obtaining resources like fertilizers, seeds and pesticides[1]. Here, the institutionalisation of biotechnology in Burkina Faso becomes clear, because the resources obtained by smallholders are obtained from public institutions involved in the Bt cotton production. These institutions can position themselves in a strong position towards the smallholders; by supplying resources and other forms of help, the institutions can demand payments in return. These payments might be in money or crops, and can construct a dependency relation between the producer and institution. In the chapter about institutions, this concept will be elaborated. Burkina Faso, being one of the first African countries to institutionalize Bt cotton, could form an example for other African countries in the use of biotechnology in the agriculture, because the country might realise development through this introduction. Mainly for the surrounding countries, Burkina Faso can set an example in the introduction of biotech crops, because these countries share “similar agro ecological zones, farming systems and cotton industry structures” (Vitale et al. 2010: 320)[4]. However, it can be questioned whether Burkina Faso can set an example; it is one of the poorest countries of Africa and might lack means (e.g. money) to realise a smooth introduction of genetically modified crops.

3.3 Benefits and drawbacks of biotechnology in Burkina Faso

In the discussion whether the involvement of bio-technological means in agriculture are beneficial, several advantages and disadvantages are taken into account. Overall, it is very hard to decide

[1]Vitale, J., Ouattara, M., Vognan, G. (2011). Enhancing sustainability of cotton production systems in West Africa: A summary of empirical evidence from Burkina Faso. *Sustainability*, 3: 1136-1169.
[2]Wikipedia (2014, May). Bacillus thuringiensis. Wikipedia..
[3]Tabashnik, B.E., Unnithan, G.C., Masson, L., Crowder, D.W., Li, X., Carrière, Y. (2009). Asymmetrical cross-resistance between Bacillus Thuringiensis toxins Cry1Ac and Cry2Ab in pink bollworm. PNAS, 106 (29): 11889-11894.
[4] Vitale, J. D., Vognan, G., Outtarra, M., Traore, O. (2010). The commercial application of GMO crops in Africa: Burkina Faso’s decade of experience with Bt cotton. *AgBioForum*, 13(4): 320-332.

whether the features of bio-technical means are overall advantageous or not. Based on studies extracted from literature, several advantageous sides of technology are given. For example Karmebu et al. (2009) describe advantages of the new technology: "there is evidence that countries which have embraced modern agriculture technologies have improved economic performance, reduced poverty, and ensured greater food security for their people"(Karembu et al. 2009: 8)[1]. This statement is very positive about the technologies, so in order to create a balance and a more realistic image of the technological implementations in the agricultural sector, some critical notes will be given about the advantages provided in the literature. The advantages of biotechnology in agriculture, given in the literature, are many-fold and can be subdivided in economic benefits, health benefits, environmental/natural benefits and may all be covered by sustainability[1,2].

3.3.1 Economic benefits

First of all the economic benefits of the implementation of Bollgard II will be discussed. Numbers are provided by the ISAAA (2011), which indicate a growth in the production yield of Bollgard II cotton, compared to conventional cotton, in Burkina Faso. On average, an increase of 21.30% cotton yield in the years 2003-2009 were realised by implementing Bollgard II cotton[2]. This increase is calculated by measuring conventional cotton yields and Bollgard II cotton yields over the years. In 2007, the Bollgard II yield was even 35% higher than the conventional cotton yields[2]. This kind of genetically modified cotton increases the yield growth on the short-term, which is tempting for producers[3]. On first sight, this looks like a positive situation for Burkinabe producers, but questions can be made about the utility of the increase in yield profits. These questions will be elaborated on in the chapter of institutions and empowerment. Figure 1, shown below, provides results of studies which were performed on cotton farms in Burkina Faso.

[1]Karembu, M., Nguthi, F., Abdel-Hamid, I., (2009). Biotech crops in Africa: The final Frontier, *ISAAA AfriCenter*
[2]Vitale, J., Ouattara, M., Vognan, G. (2011). Enhancing sustainability of cotton production systems in West Africa: A summary of empirical evidence from Burkina Faso. *Sustainability*, 3: 1136-1169.

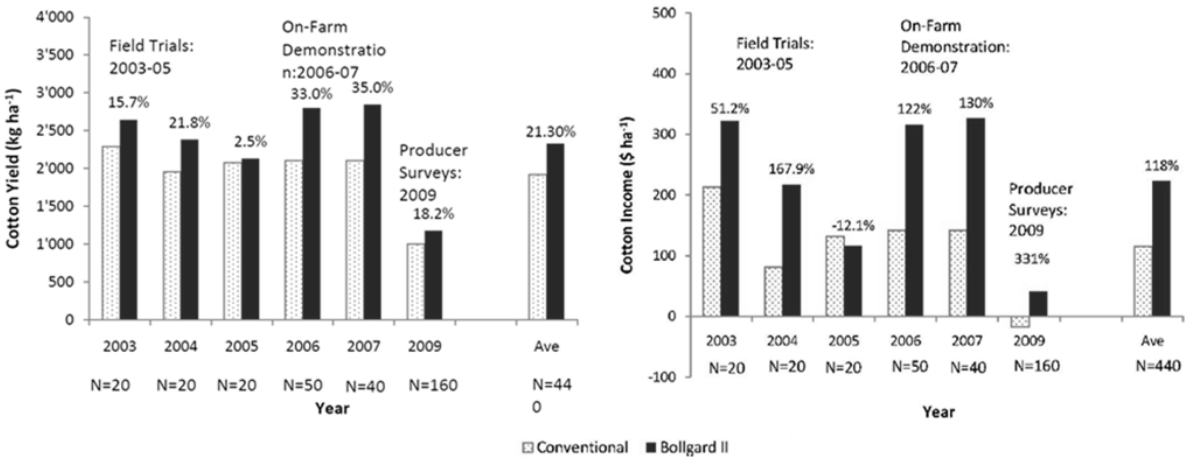

Figure 1. A comparison of conventional & Bollgard II cotton. Yields (left) and income (right) of producers in the two cotton sectors. Source: Vitale et al. (2011).

3.3.2 Health benefits

Above, the significance of the codes of production is described. The codes for producing Bollgard II cotton can have beneficial effects on the health of producers. A main benefit is the reduction of insecticide use by producers. With the conventional cotton plants, the spraying of insecticides should be done six times in order to make it work[1]. These insecticides contain gasses which are harmful to the health of people. With the Bollgard II cotton, spraying times are reduced because of the genetic advantage of the seed. With the conventional cotton, two spraying times were identified; early sprays and late sprays[2]. While producing the conventional crop, spraying should be done four times in the early stage of production and two times in the late stage of production. When producing the Bt cotton (Bollgard II), spraying should only be done two times in the late stage of production. This reduction in spraying can lead to a decreased exposure to harmful gasses and therefore be less harmful to human health.

3.3.3 Environmental/natural benefits

Biotechnological cotton production is also advantageous because it has a positive impact on sustainability by reducing energy use[1]. In Vitale's research (2011), a decrease of 6.6% in overall energy use was found on cotton producing farms[1]. This accounts for 1010 Btu kg^{-1} (British thermal unit per kg produced cotton, 1 Btu is equal to 1055 joule)[1]. A decrease in energy use may cause lower costs for producers to produce, which makes it more beneficial for poorer producers or smallholders to use the modified crop instead of the conventional variant. A second environmental benefit is the reduced emission of carbon dioxide (CO_2), due to the reduced amount of insecticide and herbicide sprays[1]. In 2007, a reduction of 1.1 billion kg CO_2 was measured, next to another 13.1 billion kg CO_2 savings by conservation tillage, due to increased soil carbon sequestration[1].

3.3.4 Pest control

Due to the fact that pest control has already been covered in the section of biotechnology in Burkina Faso, here only a brief explanation of pest control as advantage due to genetically modified crops will be given. The main notion about the inbuilt defence system of the crops is that the defence system can be effective against the target pest and tolerant towards other organisms which will not harm

[1]Vitale, J., Ouattara, M., Vognan, G. (2011). Enhancing sustainability of cotton production systems in West Africa: A summary of empirical evidence from Burkina Faso. *Sustainability*, 3: 1136-1169.
[2]Karembu, M., Nguthi, F., Abdel-Hamid, I., (2009). Biotech crops in Africa: The final Frontier, *ISAAA AfriCenter.*

the crop[1]. In this way, the balance in nature can be sustained while still reducing the amount of pests and in this way increase the production.

3.3.5 Critical notes on advantages

Some critical notes need to be placed next to the advantages given above. One critical note on the increase of the yields can be made, because it is likely that the differences in yields can be explained by the differences in pest population pressures. These pressures can differ across locations[1]; thereby, the figure showing the increase in yields and incomes of producers during the years 2003-2009 (figure 1) is probably not as positive as it seems, because these numbers are accumulated by different studies and under different levels of pest pressure and agronomic conditions[1]. These factors are very likely to have an influence of the cotton growing sector (e.g. higher pest pressures are assumed to cause more crop damage and therefore lower yields. Thereby, nutrient poor soils are assumed to result in lower yields than nutrient rich soils) and therefore the numbers provided in this study might be misleading. A second critical note has to be made about the knowledge of the codes by producers. The importance of knowing the codes is clearly shown by the effect of spraying on crops. Vitale et al. (2011) describe the case of 2009 in which a survey was done under producers of Bollgard II cotton. Within this survey, 78% of the producers did not follow the codes of spraying. The producers who did follow the code generated 14% higher yields than the producers who did not follow the codes of spraying[1]. An important note here is that the accessibility to the codes might be restricted for producers, and therefore the economic and health benefits will not be fully enjoyed. Third, the reduction in energy use can be a benefit for the environment of the natural surroundings, like the soil, but the implementation of Bt cotton on a farm can cause a shift in the production cycle; this cycle might shorten, making the production of cotton more intensified and causing land/soil degradation. The reduction in energy use can most likely not compensate this degradation. As for the CO_2 reduction, other harmful gases (e.g. biocides, metals or other dioxins) might occur in new spraying techniques and the soil and human health might be affected due to these other gasses. Last critical note is about the pest control. While proof might be given about the effectiveness of inbuilt pest control features of genetically modified crops, in most occasions a part of the non-target population will be struck by the defence mechanisms of the crop.

3.3.6 Drawbacks of Biotechnology in Burkina Faso

While having several advantages, the implementation of biotechnology in agriculture also has disadvantages which are visible in a direct way. First, the Bt cotton was tested to be quite effective in certain places, but while implemented in the field, the functionality decreases due to the exposure to UV-light[2]. This UV-light degrades the Cry proteins in the crops, making them less resistant towards pests[2]. A second disadvantage is the cognition of the codes. When a producer is not familiar with the codes to make sure the modified crop is grown in the right way, limited functionality of the modified crop can occur[2]. One example is the knowledge of the spraying norms; if spraying coverage of the crop is not performed in an optimal way, pests might be able to escape the control of the crops[1]. Third, the region specific aspect of implementations creates an everlasting uncertainty for implementations of new products; although studies demonstrate that smallholder producers from the global south in many cases benefit from the implementation of Bt cotton, other reviews demonstrate at the same time that these benefits depend on a mix of agro-ecological, institutional

[1]Vitale, J., Ouattara, M., Vognan, G. (2011). Enhancing sustainability of cotton production systems in West Africa: A summary of empirical evidence from Burkina Faso. *Sustainability*, 3: 1136-1169.
[2]Karembu, M., Nguthi, F., Abdel-Hamid, I., (2009). Biotech crops in Africa: The final Frontier, *ISAAA AfriCenter.*

and socio-economic factors[1]. Another disadvantage explained by Glover (2010b) is the character of transgenic cotton to not as much reduce risk as spread it across seasons, due to the difference in pest pressures between growing seasons[3]. In fact, it only protects against one type of pest, the target pest infestation, but does not control the other risks by which producers or smallholders are confronted, e.g. agro-climatic variability[3]. Another drawback, mentioned by Ruivenkamp (1993) is the effect of new technological products on the production chain. The seed-producing companies might use their position in the production chain to impose a specific way of farming[2]. In this situation, producers can lose their autonomy of production. In order to create an overview on the effects of biotechnology on the technical level, table 1 shows the advantages and drawbacks in a schematic way.

Table 1. Advantages and disadvantages of implementing biotechnology in Burkina Faso's cotton production.

	Advantages of Biotechnology		Drawbacks of biotechnology
1)	**Yields can grow better / faster due to biotechnology and therefore the smallholder producer can generate a higher income on the farm.**	1)	**Environmental characteristics can alter the effectiveness of genetically modified crops (for example the impact of UV-light on the working of Cry proteins).**
2)	**By the technological knowledge, added to the crop, the amount of spraying with insecticides or herbicides is reduced and therefore less harmful to human health.**	2)	**Knowledge of the codes is essential for making biotechnology work. The codes are mostly provided by the institutions, but communication is not always optimal.**
3)	**By reduced energy use (so more energy savings) and a reduced emission of Carbon dioxide (CO_2), environmental benefits can occur.**	3)	**The influence of regional characteristics is not yet well defined. The outcome of genetically modified crops can be different in different ecological zones.**
4)	**By biotechnological improvements (like the Cry proteins in cotton) pests are assumed to be controlled and therefore less pest damage can occur.**	4)	**The risk reducing factor of genetically modified crops is usually for one risk (pests) but do not reduce other risks which may occur.**

Combining the advantages and drawbacks listed above, there is no clear evidence to put a label on genetic modification as being either positive or negative in agricultural use. The main conclusion that can be drawn is the importance of place-dependency and knowledge within the implementation of genetically modified crops. These factors might be the main components of making the implementation work, and are therefore of main importance in this thesis.

3.5 The search for another trajectory

Due to the focus on the pro-contra debate, the developments of technologies could stagnate or blocked by the actors concerning biotechnologies as negative. Therefore, another trajectory could provide an outcome which is more profitable for several actors. The intertwinement between the social and technical have been recognised and therefore the outcomes should not be analysed as separate outcomes, but related to both domains. The intertwinement of the social and technical is clearly shown before (by explaining the dependency relationship) and is elaborated in the next

[3]Dowd-Uribe, B. (2013). Engineering yields and inequality? How institutions and agro-ecology shape Bt cotton outcomes in Burkina Faso. *Geoforum*, 53: 161-171.
[2]Ruivenkamp, G. (1993). Tailor-made biotechnologies: Possibilities for farmer-centred development, *Agriculture and human values.*

chapter; the application of Bt cotton in the production chain causes for several changes in relations between actors. Thereby, the institutional set up of the country can influence the application of technologies by including or excluding actors from the applications. Being in favour of the application of technologies or being against the application of technologies is in this respect not stimulating for a positive of the application of technologies. In this sense, a new trajectory can provide better outcomes of the application. Tailoring biotechnologies (as is described in the analytical framework and will be elaborated in chapter 5) can provide means of escaping the current intertwinement of actors. Within the current intertwinements, institutions (whether these are public institutions or private institutions) have been dominating the application of technologies in Burkina Faso, which forms an important notion of contra-biotechnology thinkers, With the implementation of tailoring biotechnologies, the positions of institutions might be weakened in order to reduce the power of institutions on the production chain. In the next chapter, the intertwinement of the social and technical will be elaborated.

4. The intertwinement of institutional and technical dimensions

With every development, whether this is economic, technical or social, responses to this development occur. These responses can be embedded and observed within the social structures of a society. With the development of the technical innovation described in the previous chapters, the social dimension is affected by the technical development, but also vice versa; the technical developments are affected by the social relation is the country. The origin of these alternations in social relations can be explained by the foucauldian notions of power and knowledge, as is also mentioned in the introduction. By gathering knowledge about the new technologies, actors (most likely institutions) can position themselves in a favourable position towards producers. With their knowledge, or better said, with the absence of knowledge of the producers themselves, these actors can influence social relations on the basis of their knowledge. Here, knowledge can lead to a powerful position of institutions and create dependency relations between producers and institutions. This chapter will describe the policy regulations by public institutions on the implementation of Bt cotton in Burkina Faso's agricultural sector. First, a general overview of institutions will be given. Second, the policy regulations of Bt cotton in the country will be explained to create a view of how the first regulations were settled. Here, already the starting movements of social alterations can be found. Third, the impact of commercialisation of Bt cotton on the social relations in the agriculture will be described. Burkina Faso is one of the first African countries to commercialise Bt cotton on a large scale and therefore, it is interesting to consider the influences this commercialisation made on social relations. The increasing influences of institutions will be mainly explored within this section. Finally, the influence of these rising institutions on the empowerment of cotton producers will be described. Because of the knowledge gap between institutions and producers, the institutions have beneficial positions towards producers and may try to take advantage of their position. Whether this statement is true will become clear in the final section of this chapter.

4.1 Institutional regulations of technical changes

With the invention of a new product, the implementation of this product should be regulated in order to make this product available on a large scale. The problem, however, is to decide which actor(s) can be in charge of the regulation process. The ministry of a country can be elected to take charge over the regulation process, but also non-governmental organisations (NGO's) can be assigned to regulate the implementation. As Vitale et al. (2010) states, the monitoring is needed, because "continued monitoring will be required to determine the technical and economic viability of Bt cotton over the short and long term" (Vitale et al. 2010: 331)[1]. First, the historical trends in technological implementations will be described. Afterwards, newly intended implementation measures are giving which can be helpful for the country to make sure producers can adapt to these technological implementations. Last, the biosafety regulations will be taken into account, because technological changes can have severe effects on a natural and environmental level.

[1]Vitale, J. D., Vognan, G., Outtarra, M., Traore, O. (2010). The commercial application of GMO crops in Africa: Burkina Faso's decade of experience with Bt cotton. *AgBioForum*, 13(4): 320-332.

4.1.1 Institutions and cotton in Burkina Faso

In this section, the influences of institutional agencies on the production process of cotton are discussed related to the commercialisation (which will be discussed later on) of the crop in Burkina Faso. With institutions, the state-led or parastatal organisations which are operational in cotton production (mainly to supply seeds and other means for cotton production) are intended. The main problem with these institutions is the relations towards the producers (farmers and peasants). Within these relations, the power of both actors is unequally distributed, which can cause for exploitations of the weaker actor (in this case the producer) by the more powerful actor (in this case the institutions). The most important institutions which will be mentioned in this chapter are SOFITEX, Faso Coton and SOCOMA; all three are institutions active in the cotton producing sector in Burkina Faso. The country is divided in three production zones; the SOFITEX zone, which is the traditional cotton-production zone and where cotton has been produced since the colonial era[1]; the other two sectors are divided in a SOCOMA region and a Faso Coton region[1]. The last two sectors have been introduced recently to reduce the monopolistic position of SOFITEX (which will be mentioned in the section of implementations of cotton). Both SOCOMA and Faso Coton can benefit from the existence of SOFITEX, because the channels through which the institutions are linked with the producers were already established by SOFITEX during the colonial era[1.] As Vitale et al. describe, these channels are an important tool for institutions: "In the case of Burkina Faso, the technology provider was able to introduce Bt seed through existing input channels in each of the three cotton companies that directly connected to the vast network of smallholder producers" (Vitale et al. 2010: 330)[1]. The institutions mentioned above are all parastatal or state-led, which means that the government has a high influence on the production of cotton. The implementation of Bollgard II cotton in Burkina Faso is therefore also regulated by the government; the government requires an annual assessment of the outcomes (technical as well as socioeconomic) of Bollgard II implementation[1]. Depending on these outcomes, the government can decide whether to continue with the new crop or not and therefore, the government (as well as the institutions) are the decisive actors in Bt cotton in Burkina Faso[1]. Although, Vitale et al argue that the monitoring of the government should not be restricted to the socioeconomic and technical outcomes, but also on "the farmer compliance with biosafety protocols and environmental impacts" (Vitale et al. 2010: 331)[1].

Whether the regulations by institutions are advantageous or not is hard to decide, several positive aspects can be mentioned, but negative consequences can also be found. To begin with the assessment of the institutions, first the positive aspects will be described. As is mentioned by Vitale et al., Burkina Faso can serve as a working example of how a cash crop can be successfully implemented in a production sector which is strongly influenced by the public sector, in which credit is provided for the purchase of seed[1]. Here, the producers can benefit from the state regulated sector, because without the credit loans, these producers would not be able to purchase the seeds and in this way, would not be able to produce the cash crop. Second, as is mentioned above, the networks (for instance transport networks) ease the distribution of Bt cotton seeds, making it possible for a large range of producers to gather seeds. Third, the experience of the institutions in the cotton production process can increase the income of producers as is shown in the research of Vitale et al., where significant higher household incomes were found with households producing cotton in the SOFITEX zone[1]. Fourth, as Kaminski states, this organisational form of cotton

[1]Vitale, J. D., Vognan, G., Outtarra, M., Traore, O. (2010). The commercial application of GMO crops in Africa: Burkina Faso's decade of experience with Bt cotton. *AgBioForum*, 13(4): 320-332.

production, in which the government is involved in the consensus building of production, producer organizations can be created which can empower the producers; “Consensus building was forged by top-down establishment of the cotton union, state authoritarianism, trust-building with foreign partners, and accumulation of social capital at the village level. Consensus building followed by institutional innovations built partnerships along the supply chain with the professionalizing of farmers’ groups and reinforced their bargaining power” (Kaminski 2011: 114)[1]. The last positive point which will be elaborated here is the influence of the institutional framework on the production chain of cotton. As Kaminski describes: “Reinforcing the institutional framework has ensured better market coordination along the value chain and higher levels of contract self-enforcement, the main bottleneck to better performance of cotton industries in the region” (Kaminski 2011: 110)[1]. Here, the reform model of the Burkinabe cotton production sector is described in which the institutional set-up is substantially different than the conventional institutional set-up[1]. In this way, the producers are assumed to enforce themselves towards the institutions, making the producers less dependent from these institutions. Kaminski adds that: “Burkina Faso’s success in creating an efficient cotton value chain stems from the institutional capacity for improved contractual coordination and collective action – something that was achieved through the creation of professional cooperatives of cotton growers, which substantially improved cotton marketing and input credit repayment, yielding significant operational cost savings” (Kaminski 2011: 108)[1]. Here, the producers are represented by grower groups, which can cause a more favourable position for producers towards the institutions. As Kaminski states, this can cause an increase in efficiency of producers. Again, a critical note has to been added, because questions can be asked whether efficiency is the only desirable outcome of reforms; sustainability could also be a desirable outcome of reforms. Thereby, the advantages mentioned above are advantageous for farmers (producers for the global scale). The peasants (producers for the local scale) are not mentioned in the discussion about the institutional influences, which might indicate that the peasants are gradually replaced by farmers in the country. Questions can be made whether institutions can be advantageous for the remaining peasants, due to the characteristic of institutions to mainly strive for profits, which most likely is not the main concern of most peasants (because peasants strive for cotton varieties for local markets which makes it likely that they will not support the formation of monocultures). In this way, peasants might only be able to benefit from the presence of institutions by accessing the networks which are possessed by institutions. Here, the peasants could obtain means for production which will not threaten the conventional crops they produce.

Above, the positive outcomes of the institutional influences in cotton production are described. The main positive outcomes are the economic benefits of producers and the existing networks through which the producers are able to produce cotton. Although, the institutional influences can have negative effects as well, which will be mentioned here. First of all, Ruivenkamp mentions the influence of institutions in the global food-producing industry, in which the main characteristics have shifted, from appropriation and substitution (which are mentioned earlier in this thesis) towards the following three trends :”Shifted to the trends for an increased control at a distance from the seed-supplying industries and an increased interchangeability of agrarian food sources as inputs to food components aggregating companies, supported by a third trend, that of an increasing privatisation of

[1]Kaminski, J. (2011). Cotton dependence in Burkina Faso: constraints and opportunities for balanced growth. In *Chuhan-pole P. & Angwafo* M. (2011). Yes Africa can: success stories from a dynamic continent (pp 107-121). Washington D.C: World Bank: 107-121.

the politicizing products of the reorganised food production system" (Ruivenkamp 2008b: 45)[1]. Here, three outcomes can be distinguished: first, the control at a distance, from which institutions can decide which crops will be produced. The room for choices of producers is limited in this way; second, the interchangeability of agrarian food sources makes the crops less traditional and more globally defined. In this way, the identity of producers can be affected due to the institutional influences; third, the privatisation of the politicizing products, which can position the institutions in even stronger organisations in which the producers will not have any influence. In this way, the producers can face more dependency and less liberty of production. A second disadvantage is the role of institutions within the production chain; the institutions which supply the credit loans and other inputs to producers, force the producers to buy these means at this institution[2]. In addition, the producers are forced to sell their cotton yields to the same institution, which in this situation has a monopolistic position towards the producer[2]. These power relations (also mentioned as the Foucauldian notion) will be discussed further in the section about empowerment of producers (which' definition is also mentioned in section 3.3).

4.1.2 Historical implementation measures on agricultural innovations

Since the French occupied Burkina Faso, the occupier changed the organisation of agriculture in the country. During the 1950's efforts were made to set up a vertically integrated export-oriented cotton sector[3]. Here a top-down approach was used and the producers encountered a high degree of control by the state. During the 1990's, a World Bank-led effort was made to reduce the degree of state power and state control on the agricultural sector[3]. Although these efforts was made, little result was noticed and the Compagnie Française pour le développement des fibres et textilles (CFDT) was settled by the French government[1]. This state-led organisation might be one of the reasons for producers to dislike the governmental decisions, being that the CFDT was responsible for the destruction and eradication of the local grown cotton varieties, and construction a monopoly over cotton production[3]. The CFDT created, again, a vertically integrated supply chain called the filière which modified form is still active in Burkina Faso's agricultural sector in contemporary farming life[3]. The impact of the monopoly is made clear by Dowd-Uribe in the next way: "The filière model integrates all aspects of production including credit supply, seed production and disseminations, extensions services, transportation, ginning and marketing under the control of one parastatal cotton company" (Dowd-Uribe 2013: 163)[3]. In this way, the producers depend on one company for their entire farming enterprise. Here, already the dependency of the producers becomes clear. This way of institutional operation is called a one-step cotton farming system[4]. Within this farming system, the institution (in this case SOFITEX in combination with CFDT) provides all the necessary means for production, but at the same time maintains exclusive purchasing rights of the produced cotton[2]. Although next to these negative influences of the company, one positive point can be found, which is the decision of the company to fix the cotton prices before the planting season, giving the producers a certain form of security on an income[2]. This last point is of main importance in Burkina Faso, because this decision by CFDT is assumed to be the main driving force of modernization in the

[1]Ruivenkamp, G. (2008b). Tailoring biotechnologies: a manifesto. In: Ruivenkamp, G., Hisano, S., Jongerden J. (2008). Reconstructing biotechnologies: critical social analysis. Wageningen, Wageningen Academic Publishers: 29-76.
[2]Vitale, J. D., Vognan, G., Outtarra, M., Traore, O. (2010). The commercial application of GMO crops in Africa: Burkina Faso's decade of experience with Bt cotton. *AgBioForum*, 13(4): 320-332.
[3]Dowd-Uribe, B. (2013). Engineering yields and inequality? How institutions and agro-ecology shape Bt cotton outcomes in Burkina Faso. *Geoforum*, 53: 161-171.
[4]Vitale, J., Ouattara, M., Vognan, G. (2011). Enhancing sustainability of cotton production systems in West Africa: A summary of empirical evidence from Burkina Faso. *Sustainability*, 3: 1136-1169.

agricultural sectors of several francophone African countries, causing a boost for cotton production (which faced a six-fold increase) between 1974 and 1999[1]. The World Bank however, saw the need to liberalize the cotton sectors of the francophone African countries[1]. The World Bank realised this liberalization in three ways; first, in 1996, a restructuring of village-level cooperatives was realised. These cooperatives were in charge of administering credit to cotton producers; second, in 1999, the cotton producers union was included as a shareholder in the (again) state-led company la Société Burkinabè des Fibres Textilles (SOFITEX); and third, in 2004, two private (not state-led) companies were established to operate as regional monopolies parallel to SOFITEX[1]. The liberalization measures of the World Bank did not find their sought effects; a vertically integrated regulation structure is still in operation with the cotton companies still accounting for 80% of the national cotton production and state still being the major shareholder of the companies[1]. Considering these facts, it can be said that the state has a large impact on the production of cotton in Burkina Faso and the concerns by producers can be considered can be justified, being that state-led monopolies are often sensitive for corruption or nepotisms.

4.1.3 Public regulation models of Bt cotton

In order to make sure the implementation measures will be performed in a better way, some changes on an individual and national level should be made to make sure the implementation can have the wanted effects. One of the first problems which have to be overcome, in order to implement a radical change in people's lives, is the by Ruivenkamp explained 'acceptability problem'[2]. Here, knowledge on the individual level plays an important role. The ignorance of biotechnological developments can cause fear about the effects of the new technology. Rightly so, in most occasions, the impact of biotechnological developments on the long run is not always predictable and therefore, the first measure in the implementation process should be the provision of knowledge about the biotechnological development. This can be done by convincing the producer that he/she should not be afraid or irrational, but that he/she should embrace the possibilities which new biotechnologies can offer[1]. This convincing process can be realised by providing information to the producers, in which several aspects are covered; information about the crop itself is important, but also information about the production cycle of the crop is of main importance. The codes, already mentioned in the previous chapter, are equally important to provide to producers. Also, the results of other projects in which Bt cotton is used should be mentioned to produces in order to convince them what the possibilities of genetic modification are. Of course, in order to create a general view on the situation, the drawbacks of the new cotton variety should be mentioned, making sure the producer can make a rationalised choice whether to implement the Bt cotton or not. When the individual problems are overcome, the implementation of genetically modified crops can be continued. Subsequently, the national level should be altered; the influence of monopolies should decrease and producer-centred or NGO-led organisations should increase their influence on the production cycle of Bt cotton by e.g. constructing f lows of knowledge between producers, creating local markets for cotton producers and increase cooperation possibilities for smallholder producers. Although several negative aspects about the contemporary organisation of cotton production have been discusses, not all the aspects of this organisations are bad. For instance, the credit loans for producers, discussed earlier in this thesis, can form a stimulus for producers to enhance in cotton

[1]Dowd-Uribe, B. (2013). Engineering yields and inequality? How institutions and agro-ecology shape Bt cotton outcomes in Burkina Faso. *Geoforum*, 53: 161-171.
[2]Ruivenkamp, G. (1993). Tailor-made biotechnologies: Possibilities for farmer-centred development, *Agriculture and human values.*

production. In this way, poverty might be reduced in the country, but chances for poverty-reduction could be higher when the contemporary form of organizing (state-led) is altered towards a more bottom-up approach. An example here, how this might be done is given by Kaminski: "Burkina Faso's success in creating an efficient cotton value chain stems for the institutional capacity for improved contractual coordination and collective action – something that was achieved through the creation of professional (under free membership principles) cooperatives of cotton growers, which substantially improved cotton marketing and input credit repayment, yielding significant operational cost savings" (Kaminski 2011: 110)[1]. Here, the element of collective action and cooperatives of cotton growers are fine examples of how the institutional powers might be countered. To strengthen the point of reorganisation in the cotton industry of Burkina Faso, next conclusion of the World Bank is used: "The process of cotton sector reform in Burkina Faso was driven by complex political economy interests and tensions, but with positive outcomes. Although the sector had showed positive impacts on poverty reduction prior to reform, and while recognizing that cotton prices and cotton production in Burkina Faso are considerably dependent on the international cotton market, the reform's impact on the performance of the sector to date nevertheless seems favourable. Cotton showed an annual increase in output of 33.4 percent, from 480.000 tons in 2003 to 641,000 tons in 2004, which in turn contributed to a strong increase in exports" (World bank, 2008: 47)[2]. Here, a note has to be added, because the positive effects are related to the international cotton market. With the distinction made between farmers and peasants as producers of cotton, this would mean that the farmers would benefit from the reforms, but this would not guarantee beneficial outcomes for the peasants, which focus on the local market rather than the international market. In order to provide beneficial outcomes for all producers, so farmers as well as peasants, studies should be performed and the results should be taken into account. Continuing on the reforms of the cotton sector, two models are shown below (figure 3 and 4) which reflect the organisational model of cotton production in Burkina Faso before and after reforms have been made during the 1990's and 2000's. Figure 3 shows the organisational model of the cotton sector in Burkina Faso before the reforms were performed.

[1]Kaminski, J. (2011). Cotton dependence in Burkina Faso: constraints and opportunities for balanced growth. In *Chuhan-pole P. & Angwafo* M. (2011). Yes Africa can: success stories from a dynamic continent (pp 107-121). Washington D.C: World Bank: 107-121.

[2]World Bank (2008). Agricultural sector reform: Cotton sector reform in Burkina Faso. In: The Political Economy of Policy Reform: Issues and Implications for Policy Dialogue and Development Operations. World Bank: 47-50.

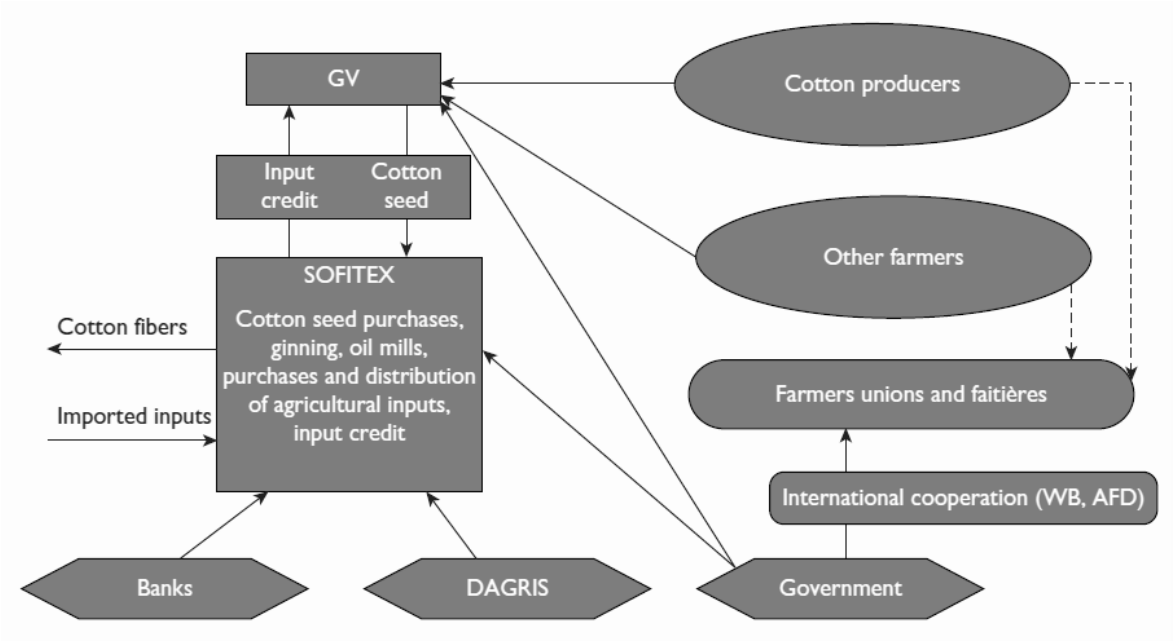

Figure 1. Organisational model of the cotton sector in Burkina Faso before the reforms were conducted. Source: Kaminski (2011).

In the figure shown above (figure 3), GV are village groups; the AFD is Agence Française de Développement; DAGRIS stands for Développement des agro-industries du Sud, which is a semi-governmental organisation[1]. In this figure, the influence of SOFITEX is clearly shown but the functions the organisation provides, but also by the relations it has in the model; the producers depend on SOFITEX in order to generate means for the production of the modified cotton. This direct involvement could create dependencies of producers on one organisation or cooperation as SOFITEX. Therefore, reforms were implemented in the organisational form of cotton production and the next model was designed (figure 4). In figure 4 (shown on the next page), SOCOMA and FASOCOTTON are two companies parallel to SOFITEX with monopolies in other regions in the country. SOFITEX and SOCOMA are regulated by DAGRIS (a development agency) and FASOCOTON is regulated by Reinhardt (a worldwide cotton merchant, which promotes sustainability).The UNPCB is the Union Nationale des Producteurs de Coton du Burkina Faso (the national cotton producers union), the GPC is the Groupement de Producteurs de Coton (Group of cotton producers). The percentages given in the model are the shares producers in the capital of cotton companies; according to Kaminski, the shares of producers in SOFITEX' capital decreased from 30% to 10%[1]. Figure 4 is a more complex model which is observed in the contemporary (2007) cotton production sector in Burkina Faso. Here, the main importance is the interference in the direct control of SOFITEX on the cotton sector. Its power is restricted by two other monopolistic companies (SOCOMA and FASOCOTON), but also by other, non-monopolistic actors (like cotton unions and the credit committees). Another important observation which can be made is the establishment of the GPC, because here, the elements of collective action and cooperation become apparent, which might be the basis of a new organisational model for cotton production. This model should smoothen the unequal power relations in the production sector and give producers more possibilities and fewer dependencies.

[1]Kaminski, J. (2011). Cotton dependence in Burkina Faso: constraints and opportunities for balanced growth. In *Chuhan-pole P. & Angwafo* M. (2011). Yes Africa can: success stories from a dynamic continent (pp 107-121). Washington D.C: World Bank: 107-121.

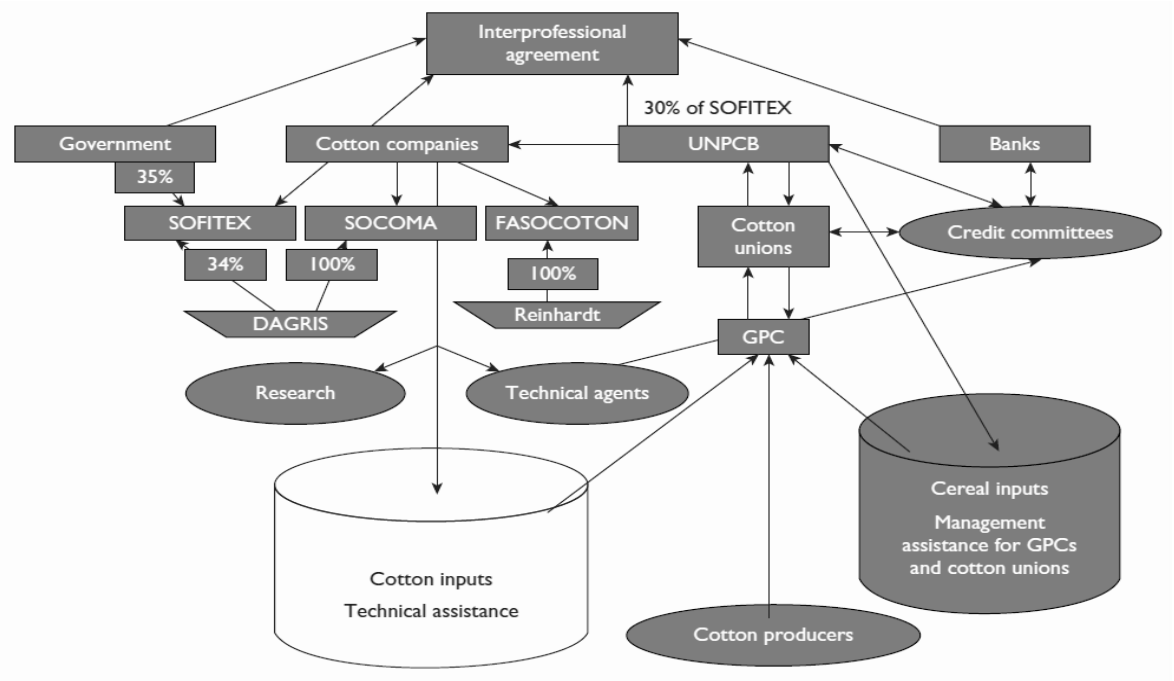

Figure 4. Organisational model of the cotton sector in Burkina Faso after the reforms were conducted (2007). Source: Kaminski (2011).

Within the new organisational model, policies will play important roles. Mainly, the communication between actors might form obstacles in order to manage agreements on sustainability and Bt cotton production. The importance of policy making becomes clear in the next quote: "Managing the sustainability of Bt cotton will require policy direction and leadership by government agencies to maintain and enforce biosafety compliance, on-going research by the agricultural scientists to monitor and assess the performance of Bt cotton, a strong extension network to deliver training and information to producers in a timely manner, maintain communication, and a business environment that encourages competitive pricing" (Vitale et al. 2011: 1157)[1]. Although, a side note has to been added, because not only governmental agencies should be considered within this policy making process, but also producer alliances, like the GPC in figure 4, should be involved. Thereby, in reality, government agencies and policy makers are assumed to have self-interest in these decisions and therefore are not useful in developing policies which are equally as beneficial for the producers. When these problems are overcome, better communication can take place and the production cycle should improve. Within this cycle, institutions like SOFITEX will have restricted, yet important roles (due to the provision of e.g. technical means), just like governmental agencies (which can provide knowledge and permits, but should not conduct the on-farm production process). The producers themselves (farmers and peasants), centred in endogenous development, will form the third group in the policy making process. Them being the actors which will perform the policy and experience its consequences. A mediator which, in theory, could contribute in these negotiations is the Centre for Agriculture and Biotechnology (although this organisation no longer exists). As Ruivenkamp explains, this centre "sought to involve farmers' organisations actively in the redesigning process of biotechnological developments" (Ruivenkamp 1993: 27)[2]. Within these negotiations, regarding the

[1]Vitale, J., Ouattara, M., Vognan, G. (2011). Enhancing sustainability of cotton production systems in West Africa: A summary of empirical evidence from Burkina Faso. *Sustainability*, 3: 1136-1169.

[2]Ruivenkamp, G. (1993). Tailor-made biotechnologies: Possibilities for farmer-centred development, *Agriculture and human values.*

social-economic contents of the technological developments, the acceptability problem (mentioned above) can be solved[1]. When this individual obstruction is overcome, the implementation of the technical developments is assumed to become smoother.

4.1.3.1 Biosafety regulations

With the implementation of new technologies, the impacts of these technologies should be measured and regulated, in order to confirm the advantages, or disadvantages, of the technology. Biosafety regulations are important in the Bt cotton production due to its implementation in the soil and the possible consequences it can have on the environment. An example of a negative consequence of the implementation of genetically modified crops is the occurrence of gene-outflow, which is "the inadvertent transfer of genetic material from one species to another" (Vitale et al. 2011: 1159)[1]. Gene-outflow is considered negative, because traditional (or wild-type) crops can get contaminated by the genetically modified crop[1]. In this way, biodiversity can be affected, as well as the control on the modified crops[1]. Therefore, measures of isolation have been taken to make sure the gene-outflow wouldn't occur[1]. The only problem within the isolation measures are the calculations of the thresholds to counter gene-outflow; these thresholds are therefore overestimated in order to be sure gene-outflow will not take place[1]. A negative consequence here for farmers can be that the yields will not be optimal, due to less planting space. A rather important question regarding biosafety is the way in which, or maybe more important by whom, the biosafety is regulated. Most African countries have "signed and ratified important legally binding international instruments like the Conventions on Biological Diversity (CBD) as well as the Cartagena Protocol on Biosafety" (Karembu et al. 2009: 24)[2]. These instruments entail the agreement to take necessary legal, administrative or other measures to set up obligations to make sure that the development, transportation, handling, usage, transfer and release of alive modified organisms are undertaken in such a way that it reduces or even prevents the risks to biological diversity or human health[2]. These measures are implemented in National Biosafety Frameworks (NBFs), which are used in several African countries, and control the development or utilization of genetically modified products/crops[2]. The NBFs can be slightly different from country to country, but always consist components of the following points; first, a general policy on biotechnology; second, regulations and laws on biosafety, which entails a regulatory regime for biotechnology; third, an administrative system which handle with the applications and distributing of permits; and fourth, a mechanism for public participation which is embedded in the biosafety decision making process[1]. In the African countries, involved in NBFs, the stages in which the legislations are formed differ from one country to the other; some countries already have functional frameworks, others only have temporal legislations[2]. The importance of regional cooperation in biotechnology and biosafety regulations is recognized by the Africa Panel on Biotechnology (APB)[2] and therefore, it can be questioned whether the regulations based on international agreements will work out in a favourable way.

The interaction between technical implementations and social responses are clearly shown here. At first, the emergence of a technical innovation caused a reaction in the social domain; most prominently in the structuring of social relations between institutions and producers, but next, the social domain (in this case biosafety regulations) influences which technical devices are appropriate to implement and which technical devices are deemed unfit. This interrelation between the social

[1]Vitale, J., Ouattara, M., Vognan, G. (2011). Enhancing sustainability of cotton production systems in West Africa: A summary of empirical evidence from Burkina Faso. *Sustainability,* 3: 1136-1169.
[2]Karembu, M., Nguthi, F., Abdel-Hamid, I., (2009). Biotech crops in Africa: The final Frontier, *ISAAA AfriCenter.*

and technical can appear more frequently in contemporary farming enterprises, whether these enterprises are farmer enterprises or peasant enterprises, and can occupy a prominent position in agricultural or even national policies. In this respect, it would be unwise to retain the vision of splitters in which the technical and social domains are perceived as two different and separate aspects of politics. The notions of the weaver or re-designers would make more sense in making policies for the implementation of Bt cotton in Burkina Faso.

4.1.4 The role of corporations in public regulations of Bt cotton

As is said before, the cotton industry in Burkina Faso grew due to the French occupation. During this time, the French sought to increase the production of cotton, but this failed due to the failures in modernizing traditional production systems, the harsh treatment of smallholder producers and the poor commercial infrastructure[1]. The cotton sector remained an important one in the country, mainly because smallholder producers could benefit from the market which the French developed. From 1995 to 2003, a significant rise of expenditures from smallholder cotton producers occurred in the country, attesting a pro-poor growth effect of cotton farmers in Burkina Faso[2]. Therefore, it is not surprising that the cotton sector was focussed regarding pro-poor development in the country. This development could be realised by scale-enlargement, which, looking at the amount of cotton producers in Burkina Faso, is one of the solutions, or by technical improvements. This second option is also implemented in Burkina Faso, as can be read in earlier parts of this thesis. The take-off of technical improvements was done by the ministry of Environment (the MOE), which was assigned the primary legal authority in the process of cotton commercialisation[2]. This ministry was also charged to develop a regulatory infrastructure, in convention with the established biosafety laws, in order to test and develop the environmental release of the newly designed cotton[1]. When this beginning was established, the national agricultural research centre of Burkina Faso (INERA) conducted field trials form 2003 to 2005 to test the practical results of the cotton; these field trials were monitored by the technical company Monsanto[1]. The trials were performed under confined conditions and focussed to test the environmental effects, like pollen-mediated gene flow (which has been described in the previous section), and possible effects on non-target species (in this case bees)[3]. In 2009, the new cotton production process was commercially released, which was only possible because of the positive results of the trails concerning technical, legal and business requirements for stakeholders[1]. Since the outset of the changes in the production process of Bt cotton, several assumptions were made regarding the effects it would have on social relations in this production process. Ruivenkamp already predicted several outcomes concerning the technical implementations in social practices. His first prediction is that, “this expansion of industrial appropriation of controllable biological activities has taken place especially as a result of the uncoupling of agriculture from its natural environment. Scientific plant improvement reinforced by biotechnological developments has provided an important contribution to that uncoupling process” (Ruivenkamp 2003: 25)[4]. Here the social and technical domains are de-coupled from each other, while both domains, as is argued in this thesis, have strong ties and can have effects on one another.

[1]Vitale, J., Ouattara, M., Vognan, G. (2011). Enhancing sustainability of cotton production systems in West Africa: A summary of empirical evidence from Burkina Faso. *MDPI open publishing*, sustainability 2011, 3: 1136-1169.
[2]Kaminski, J. (2011). Cotton dependence in Burkina Faso: constraints and opportunities for balanced growth. In *Chuhan-pole P. & Angwafo* M. (2011). Yes Africa can: success stories from a dynamic continent (pp 107-121). Washington D.C: World Bank: 107-121.
[3]Karembu, M., Nguthi, F., Abdel-Hamid, I., (2009). Biotech crops in Africa: The final Frontier, *ISAAA AfriCenter.*
[4]Ruivenkamp, G. (2003). Genomics and food production – the social choices, *edepot.wur.nl*, Wageningen, Wageningen University and Research centre.

Ruivenkamp's second prediction is more concerned with the impact on both the social and technical by the implementation of technical developments; he states: "The consequence of this specific social organisation of scientific research is that scientists – because of the complex organisation and specific social imbedding of their work – are alienated from the social significance of their work" (Ruivenkamp 2003: 35)[1]. Here, the social is assumed to be forgotten by the scientists, which stand for the designing and improvements of the technical development. Looking at both predictions made by Ruivenkamp in 2003, it can be concluded that the core of the ideas became reality; as mentioned in the splitters approach, people regard the technical as a different and separated domain from the social. The splitters approach still being the most common approach in contemporary scientific fields provides evidence of the notions made by Ruivenkamp. Commercialisation of the implementation of Bt cotton in Burkina Faso can thus be noted as an alienating process between the social and technical, which should be redesigned into a combining process in which both domains are influenced by one another and are considered equally important for achieving successful development. The actors concerned with these requirements for successful development should be operating on both the social and technical domain, involved in local as well as global enterprises and have transparent communicative agencies. In this way, multi-dimensional agreements can be made which are transparent for all the actors involved in the cotton production process, including producers themselves. As is described here, the commercialisation of a crop can have effects on the production cycle of the crop. The actors involved in the cycle can also alter due to interests of e.g. profits. Here should be noted, that the commercialisation of crops mostly occur in the farming enterprises, due to their occupation of producers for a global market. The peasant way of farming, in this respect, could be less altered by institutions because peasants produce mainly for the local markets.

4.1.5 Impact of cotton production on social relations

As is mentioned before, the empowerment of cotton producers can change due to the developments in the cotton industry. Before, general notions about the effect on empowerment were made. In this thesis empowerment is seen as "the process of increasing the capacity of individuals or groups to make choices and to transform those choices into desired actions and outcomes. Central to this process are actions which both build individual and collective assets, and improve the efficiency and fairness of the organisational and institutional context which govern the use of these assets"[2]. In this section a more comprehensive description about the effects on empowerment will be given. Due to institutions, producers can face increased or decreased empowerment, in first instance because increased productions may occur but also dependency relationships may appear. Winner predicted in 1980 already the impacts of technologies on the power relations in the production chain:" At issue is the claim that the machines, structures, and systems of modern material culture can be accurately judged not only for their contributions of efficiency and productivity, not merely for their positive and negative environmental side effects, but also for the ways in which they can embody specific forms of power and authority" (Winner, 1980: 121)[3]. Here, the social and technical are already considered entwined. In this notion, the development of technology will not only influence the efficiency and productivity but also the social relations between actors, which may be seen in the

[1]Ruivenkamp, G. (2003). Genomics and food production – the social choices, *edepot.wur.nl*, Wageningen, Wageningen University and Research centre.
[2]World Bank (2011). Empowerment. The World Bank: a world free of poverty.
[3]Winner, L. (1980). Do artifacts have politics? *Modern technology: problem or opportunity. In* Daedalus, Vol. 109, No 1: 121-136.

implementation process of Bt cotton in Burkina Faso. The notion of Winner can be linked to the earlier mentioned notion of Foucault about power and knowledge; due to the technical developments (in which knowledge is an increasingly important requisite) the power relations between actors can alter. Also in the case of Bt cotton, the knowledge about the codes (as are mentioned in the previous chapter) is an important part of the production process, and therefore, knowledge can form an essential part of the power relation. Ruivenkamp contributes to the notion of knowledge as a crucial factor of technical development by stating that institutions that have the know-how and production capacity to commercialise important means (like enzymes) can become important actors in the production process[1]. Vitale et al. also imply that the implementation of Bt cotton can have socio-economic impacts, and therefore, suggest that the technical implementation will alter social relations[2]. Although these notions mentioned above might suggest that the institutional operations in Burkina are only decreasing the empowerment of cotton producers, some positive aspects can be found considering the empowerment of producers. First, Kaminski states that "The increase in cotton production reduced poverty largely among households that were able to increase their per capita agricultural incomes through more productive assets and factors (Kaminski 2011: 108)[3]. Here, the rise of productive assets and factors (Bt cotton can be considered a productive asset) can reduce the poverty of cotton producers and in that way might increase their empowerment. Thereby, cotton prices are negotiated with the actors concerned with cotton production before the planting of the seeds; in this way, the producers are insured with a basic income and therefore can become less dependent on credit loans obtained from e.g. institutions[3]. Kaminski also describes a way in which farmers can generate a more favourable position in the production process: "Stakeholders are working to provide a more adequate set of micro financial and micro-insurance instruments to farmers to stimulate small-scale farm investments and protect against production risks, including those related to weather. With the sustainable management of smoothing schemes and risk-mitigation strategies, most of the income vulnerability of cotton could be removed" (Kaminski 2011: 111)[3]. In this way, producers should be able to be more independent in their way of producing, although, this depends on which actor is the stakeholder. If a concerned institution is the stakeholder in this situation, not much progress on the empowerment of producers will be realised, because the producers will stay dependent on one single entity. However, if the stakeholder is for example a NGO or a cooperation of producers, this way of managing resources can be a favourable process for producers.

Above, the individual level of empowerment has been discussed, while also a broader few of regulatory levels can be used in the analysis of empowerment of producers. An example is the regional level; due to the existence of institutions operating on a regional level, as is described earlier. This broader view of empowerment contains more actors and could in this way become more complex but also more comprehensive. Ruivenkamp describes the overarching concept of political autonomy in order to define the degree in which empowerment can be measured on regional levels. He states: "Rather the degree of political autonomy of a region will be determined by the possibilities of creating space for another material interpretation of the knowledge-intensive inputs"

[1]Ruivenkamp, G. (2003). Genomics and food production – the social choices, *edepot.wur.nl*, Wageningen, Wageningen University and Research centre.
[2]Vitale, J. D., Vognan, G., Outtarra, M., Traore, O. (2010). The commercial application of GMO crops in Africa: Burkina Faso's decade of experience with Bt cotton. *AgBioForum*, 13(4): 320-332.
[3]Kaminski, J. (2011). Cotton dependence in Burkina Faso: constraints and opportunities for balanced growth. In *Chuhan-pole P. & Angwafo* M. (2011). Yes Africa can: success stories from a dynamic continent (pp 107-121). Washington D.C: World Bank: 107-121.

(Ruivenkamp 2003: 27)[1]. In this view, the degree of possibilities for new technical implementation can be used to determine the degree of empowerment of producers. The last statement can be supported by the thought of institutional influence in the production process; when institutional influence is high, so the institutions decide which seeds and other means are used in the production process, the degree of autonomy of producers is lower and these producers can be considered less empowered towards the regulating institution. Thereby, Ruivenkamp describes the processes taking place in the production chains, which he calls the agro-industrial production chain[1]. Within this chain, institutions can influence social relations between the institution and producers. In this chain, four different phases can be described; first, the production of the input means for agricultural production, like seeds, fertilizers or insecticides; second, the agricultural production of crops in the fields; third, the processing of agricultural products (harvested crops) into food or foodstuffs; fourth, the distribution of the foods and foodstuffs to consumers[1]. Within this production chain, institutions can influence different phases which are mentioned above. The influences in the first phase have been mentioned earlier in this thesis; institutions may form monopolistic organisations which force producers to buy their seeds and other input means. In the second phase, institutions may oblige producers to grow crops which are most interesting for the global market. These two phases form clear examples of how institutions can influence social relations. Although, questions can be asked whether the examples given are applicable on all producers; it is most likely that mainly the farmers are affected by these example, where peasants might face less extreme interferences. This, because institutions are assumed to be mainly interested in profits on the global market.

What should already became clear in the sections written earlier in this thesis, is that institutions can have a great impact on the whole cotton producing happening; on the technical as well as the economic as well as the social level. Not all of these domains will be influenced in a negative way; institutional networks can provide new technologies (whether or not tailored) which can offer new possibilities for producers, regions or countries. In this way, increases of profits might be realised which can form a good facet in the process of poverty-reduction in developing countries. Although some positive notions about the involvement of institutions are mentioned, negative side effects can occur due to this involvement. Below, the negative aspects of institutional involvement in Burkina Faso's cotton production are discussed. One important disadvantage which can occur due to institutional involvement is mentioned by Ruivenkamp: "through the "industrial annexing" of the important production techniques farmers will lose the possibilities of organizing agricultural production according to their own initiatives" (Ruivenkamp 1993: 27)[1]. In this way, the commercialisation and institutional regulations, the farmers can lose their way of farming and become more dependent on the providing institution, because the companies delivering the means for production can increasingly determine how producers will produce their crops[2]. This is an example in which way dependency relations can emerge. Not only are producers in this way dependent on institutions, they are also dependent on the world market for which they produce. Kaminski describes this dependency as a cause for the exacerbated vulnerability of producers to exogenous shocks. As examples he mentions falling world prices of cotton and more expensive input

[1]Ruivenkamp, G. (1993). Tailor-made biotechnologies: Possibilities for farmer-centred development, *Agriculture and human values.*

prices, the decline of farm productivity and local profitability, and poorly performing cotton firms, which lack the characteristics to adjust to the evolving global markets[1].

Within this chapter, the influences of institutional organisations on the production of cotton are discussed. Looking at the provided information, the institutions concerned with the cotton production in Burkina Faso can be regarded as a more negative influence than positive influence. Mainly the monopolistic power characteristics of the institutions provide evidence for negative influences. This power is mainly generated by the knowledge of scientific improvements in agriculture, which, according to Ruivenkamp, is becoming increasingly influential due to "the increasing possibilities for production of components at the regional level plus more intensive competition between te regional extraction and production methods, which carries with it the fact that for apparently independent regional production systems there will be increasing dependence on scientific research in the biochemical industry" (Ruivenkamp 2003: 30)[2]. A question which can be asked here is why producers get involved with these institutions. Several possible answers can be given; for instance, the possibility of obtaining means for production more cheaply or easily. Winner states that the "ways in which the intractable properties of certain kinds of technology are strongly, perhaps unavoidably linked to particular institutionalized patterns of power and authority. Here, the initial choice about whether or not to adopt something is decisive in regard to its consequences" (Winner 1980: 134)[3]. In this respect, producers are seen as rational actors, weighing options and possibilities before deciding whether or not to adopt the services (and thereby the demands) of an institution. Another example can be a form of desperation due to harsh environmental circumstances and the possibilities institutions can provide to bypass these circumstances (e.g. by pest resistant crops or by crops modified to survive in water-poor areas). Whether knowledge is the key factor in this social issue can be proposed, as knowledge can increase or reduce the influence of power-related institutions on the cotton producing process. Mainly on empowerment of producers, knowledge can play an important role. Therefore, the importance of knowledge about the technical dimension should be emphasized and elaborated in future development programs in order to stimulate pro-poor growth in Burkina Faso. In this respect, the assumption is made that pro-poor development will have advantageous effect for the whole of the Burkina Faso cotton industry and therefore (the cotton sector being the biggest industry in the country) advantageous for the whole country.

[1]Kaminski, J. (2011). Cotton dependence in Burkina Faso: constraints and opportunities for balanced growth. In *Chuhan-pole P. & Angwafo* M. (2011). Yes Africa can: success stories from a dynamic continent (pp 107-121). Washington D.C: World Bank: 107-121.

[2]Ruivenkamp, G. (2003). Genomics and food production – the social choices, *edepot.wur.nl*, Wageningen, Wageningen University and Research centre.

[3]Winner, L. (1980). Do artifacts have politics? *Modern technology: problem or opportunity. In* Daedalus, Vol. 109, No 1: 121-136.

5. Tailoring technical innovations to local needs

5.1 Countering the pro-anti debate

With the application of biotechnologies different positions towards the technologies are discussed in the analyitical framework. These different approaches are included in the so called pro-anti debate. This so called pro-anti debate has been going on for some time in the technical innovation world. The actors involved in the technical implementation debate can be divides in three groups; first, splitters; second, weavers; and third, re-designers[1]. The splitters can be seen as actors which consider the social and the technical domain as two different worlds of study, where biotechnology as a factor has influence on society as another factor[1]. The weavers consider biotechnology as not only a factor that causes social changes but also as a factor that is influenced by social changes[1], where the re-designers go deeper into the interaction between the technical and the social; "they try to find room for manoeuvre within which other socio-technical ensembles, other forms of biotechnology, can be developed" (Ruivenkamp 2008a: 25)[2]. Ruivenkamp (2008b) stresses that next to the pro- and anti-debate of technological innovation, a third approach can be distinguished. This new approach is called the tailor-made biotechnology (TMBT)[2] and can be related to the re-designers view on technology. The tailoring biotechnologies are discussed as a possibility to counter the pro-anti debate and as a possibility to create new opportunities and possibilities in technological developments. In this chapter, theoretical literature as well as case-studies are used in order to provide information about tailoring biotechnologies. Although, specific information about tailoring biotechnologies in cotton production are not yet available and therefore, a general reflection is given in this chapter about 1) the possibilities of TMBT in cotton production, 2) the necessity of looking past the pro-contra debate and 3) the importance of re-codification in order to increase the degree of empowerment of producers towards institutions.

5.2 Tailoring biotechnologies

Tailoring biotechnology or tailor-made biotechnology is a concept introduced concerning the implementation of biotechnology in different sections of the world. After biotechnology was used in the agricultural sector soon was found that in different sections, the results were different, while the technological products were similar at all places. In this case, the exogenous (global/large scale) and endogenous (local/small scale) environments would have effects on the working of the genetically modified products/techniques. In this respect, the exogenous and endogenous environments should be combined within the policies of biotechnology implementation. In the tailor-made biotechnology perspective, the combination of both environments is pursued and when properly performed, this might be a more effective way of implementing technological improvements in the agricultural sector. A concept underlying the previous thought of technological implementation in agriculture, is that the introduction of biotechnology in the agricultural landscape is seen as a fast process, which

[1]Ruivenkamp, G (2008a). *Biotechnology in development: experiences form the south.* Wageningen, Wageningen Academic Publishers.
[2]Ruivenkamp, G. (2008b). Tailoring biotechnologies: a manifesto. In: Ruivenkamp, G., Hisano, S., Jongerden J. (2008). Reconstructing biotechnologies: critical social analysis. Wageningen, Wageningen Academic Publishers: 29-76.

can be accepted or refused as a whole[1]. This concept refuses the notion that technologies – so biotechnology as well – can develop in different ways[1]. An important notion for tailoring biotechnologies is the notion that the application of biotechnology in the agricultural sector should be negotiated[1]. In this negotiation, different endogenous (local/small-scale) and exogenous aspects should be taken into account to make sure the implementation will have the wanted result. The main idea of tailoring biotechnologies is the idea that not every region is the same and therefore the technological means provided by the technological companies should also not be exactly the same for all regions. Producers can weigh up the advantages and drawbacks of the tailoring principle for the enterprise, and combine the results with alternative producing methods. Within this decision, not only the optimum agricultural yields should be taken into account, but social functions of agriculture, such as environmental protection and landscaping[1] as well. A problem which might occur becomes clear from Ruivenkamp's article: "It is also clear that a certain form of biotechnology development with a certain social-economic content will be of interest to some parties, but not acceptable to others. Therefore, the 'non-acceptability' of some current biotechnological developments by some agricultural producers cannot be labelled simply as irrational or phobic behaviour. Its rejection must be taken seriously and understood as a criticism of the specific social-economic content (code) of the biotechnological developments" (Ruivenkamp 1993: 27)[1]. Here, the problem of differentiation occurs; some producers might want to apply biotechnological means on their farm, while the existing biotechnological means are not completely suitable for implementations in their region. Producing customized crops especially for the needs of the producers might be expensive, making the customized crops expensive as well. Here, the political question can be asked whether every group of producers should receive customized crops, which would be an expensive operation, or providing these producers with the contemporary crops, knowing these producers will not realise the full capability of these crops. However, when tailoring biotechnologies are implemented in a correct way, producers can benefit in an economic and social way. Thereby, a sustainable agrarian development can be realised, because the development and implementation of biotechnology will no longer only be designed in relation to the single model of industrialized farming, but also in relation to the diversified regional-dependent farming styles[2].

The Bt cotton, described above is used on a large scale, concerning tailoring biotechnology. The bacterium used (*Bacillus Thuringiensis),* requires oxygen, nitrogen and carbon for its growth, and is produced by processes of fermentation[3]. The production of the modified products (in this case cotton) is mostly done by multinationals, mainly because the production demands high capital investment, a high level of automation, high technical skills and continuous power supply[2]. These features make it more likely for wealthier companies to produce the modified seeds than for local companies, which again, may lead to dependency relations between multinationals and producers. Therefore, the tailor-made methodology prefers to approach this cycle in another way. This new methodology strives for a bottom-up approach, aiming to reduce the power of multinationals. By importing the methodology in farming areas the following advantages[2] can occur:

[1]Ruivenkamp, G. (1993). Tailor-made biotechnologies: Possibilities for farmer-centred development, *Agriculture and human values.*
[2]Ruivenkamp, G. (1993). Tailor-made biotechnologies: Possibilities for farmer-centred development, *Agriculture and human values.*
[3]Vimala Devi, P.S., Rao, M.L.N. (2005). Tailoring production technology: Bacillus thuringienses (Bt) for localized production. In Buiatti et al. (2005) Tailoring biotechnologies: networks, practices and paradigms: 107-120.

- The localized production of Bt cotton is enabled due to the establishment of micro-enterprises
- These micro-enterprises can be established using simple equipment, making it less costly to establish the enterprise
- High education is not required in this production methodology, offering unemployed, lower skilled people a chance of employment
- Producers can buy high quality products for an affordable price
- More employment arises for the whole region
- Dependency relations with multinationals might disappear
- Production can become more eco-friendly by lowering the environmental pollution

If the advantages listed above are accomplished, living conditions in cotton producing areas in Burkina Faso can improve. In this respect, possible social threats as e.g. multinational corporations can be avoided and therefore, this methodology may be of value for cotton producing areas in Burkina Faso.

5.3 Re-codification

In section 2.4, the codes of success are mentioned as part of biotechnological development. In this section, an elaboration on the codes of success will be discussed. Within his article, Ruivenkamp argues for a re-codification of technological development, in order to reshape the technologies used in the society from agro-industrial biotechnologies, into tailor-made biotechnologies[1]. The re-codification of technology (agro-industrial biotechnology) is performed by the unravelling of the political element of the concerned technology[1]. The unravelling of the political elements is performed in different steps, of which the analysis of the social organisation (or construction) of the society is the first one[1]. Within this step the existing technology present in the society is destructed on the basis of different approaches[1]. The second step in the re-codification process is the reconstruction of the technological codes[1]. Here, the (new) characteristics of the society can be taken into account in order to improve the technical aspects within the society. The reconstruction of technologies consists of strategic- and tactical actions, in which the strategic actions consists of the focus on challenging the (mostly institutionalised) unequal balance of power, and the tactical actions consists of the focus on changing the material form of technology (by resisting, undermining and redesigning actions)[1]. Ruivenkamp mentions the two important concepts of appropriation and substitution as main techniques of the agro-industrial biotechnology system; “Appropriation here refers to the gradual takeover of biological activities, from farming practices by external institutions, especially industry, while substitution refers to the gradual replacement of the agrarian origin of food sources by products derived through an industrial-biochemical methodology”(Ruivenkamp 2008b: 45)[1]. Appropriation by institutions can cause a problematic situation, because institutions can influence cotton production on the basis of the appropriation of means and knowledge for production. Substitution can cause a higher flexibility of input material and also interchangeability of input material. Therefore, institutions can substitute expensive input means with cheaper ones, in order to create a more attractive product for the global market. Substitution can also be considered problematic due to the increased influence of institutions in the production chain. Re-codification,

[1]Ruivenkamp, G. (2008b). Tailoring biotechnologies: a manifesto. In: Ruivenkamp, G., Hisano, S., Jongerden J. (2008). Reconstructing biotechnologies: critical social analysis. Wageningen, Wageningen Academic Publishers: 29-76.

and tailor-made biotechnology, attempts to counter this influence of institutions. Locality plays an important role in the notion of re-codification; according to Ruivenkamp, re-codification involved in the re-shaping of technology development implies a cooperation of actors situated in different localities, searching for innovations for local and sustainable development, strengthened by the use of location-specific technical means[1]. In general, tailor-made biotechnology can be seen as a revolutionised movement against the agro-industrial system in farming enterprises. Re-appropriation could play an important role within this new movement. The figure shown below gives a simplified reconstruction of the re-codification process from agro-industrial towards tailor-made biotechnologies:

Figure 2. Shift from agro-industrial biotechnology to tailor-made biotechnologies.

5.4 Empowerment of producers

Tailoring biotechnologies could form a tool for producers to become less dependent on public institutions. The specific package from which the technology is composed (the codes of production) should make producers able to manoeuvre through the institutional regulations and become in this sense more empowered. Especially the re-appropriation of means for production, from public institutions to e.g. producers is an important way in which tailoring biotechnologies can form a tool to counter the monopolistic positions of public institutions in the cotton producing sector of Burkina Faso. However, applying tailor-made biotechnologies alone will probably not be sufficient for producers to counter the monopolies of the institutions. Therefore, a producer-centred organisation should, next to tailoring biotechnologies, be founded in order to give producers the opportunity to form a powerful unit. In this way, producers should be able to form a strong coalition over which the public institutions cannot control power. Several aspects should however been covered in order to make sure a producer-centred organisation will be able to create less dependencies from producers on institutions. As is mentioned, the power-knowledge notion of Foucault is an important notion to involve in this process of empowerment; The producer-centred organisation should be able to gather information (knowledge) of the codes for Bt cotton. Networks with Bt cotton producing organisations is important here, due to the availability of knowledge about the modified cotton in those organisations. By providing the producer-centred organisation with knowledge and codes for the production cycle, the producer-centred organisation should be able to distribute this knowledge to the producers engaged in cotton production. In this way, the producers depend less on public institutions and can become less dependent on these institutions. Due to the characteristic of Burkina Faso that mainly smallholder farmers are engaged in Bt cotton production, this producer-centred organisation can have a great impact on the decrease of decencies between producers and public institutions. Therefore, the implementation of tailoring biotechnologies in the cotton production cycle of Burkina Faso through producer-centred organisations could provide a very helpful tool for countering the monopolies of public institutions.

Discussion

As mentioned earlier in this thesis, different areas have different characteristics and therefore, the TMBT approach can be a helpful way in making biotechnology in agriculture successful. As is described above, tailoring biotechnologies should be combined with another organisational structure in order to make sure the technology can have optimal results. The producer-centred organisational model have been mentioned as a tool for making tailoring biotechnology a helpful technology for cotton producers in Burkina Faso. Whether looking forward can help finding methods for a more profitable production cycle for producers, looking back at previous studies can provide information which can also be helpful for Burkina Faso's development. Burkina Faso started only recently with the commercial introduction of genetically modified cotton, whereas other countries adopted similar techniques in other times or in relation to other crops. When former lessons are applied to future or contemporary developments biotechnology may serve as a foundation for a new era of development cooperation[1].

Lesson learnt from case studies

In her article, Ulmanen uses the Human Development Report (HDR) to stress the role biotechnology can play in developing countries: "new technologies provide opportunities for healthier lives, greater social freedoms, increased knowledge and more productive livelihoods" (Ulmanen 2003: 17)[1]. A critical note must been added here, because in the previous chapter, the social freedom have been discussed; biotechnology can be a means for social freedom, but it can also lead to social repression. Also, the knowledge needs some clarification; knowledge should be provided with the biotechnology, it should not be presumed that biotechnology only creates knowledge, it also needs knowledge. An important notion which should remain in development thinking is that the needs of development and technical means very depending on local circumstances[1], so not just one manual for technical development, or technique-supported development is needed, but local specific (or tailored) solutions for developments should be constructed. Regulatory actors should be discussed and a cooperative process between regulators and producers should be constructed; Ulmanen stresses that the identification of stakeholders is important because these stakeholders can influence which actions will take place in the development program; these actions do not always satisfy the needs of the local population[1]. These previous examples are in general not well adopted in demand-led methods of development, whereas the in the participatory approach, actors are able to operate on the basis of the demands form the local population. Here, it is important that "these partners participate on an equal footing and that existing power relations and differences are not reflected within the program" (Ulmanen 2003: 19)[1]. Thereby, the power of producers to influence decision making is equally as important as the equal footing of stakeholders, although this power is still restricted[1]. Therefore, Ulmanen mentions the East African Regional Programme and Research Network for Biosafety and Biotechnology Policy Development (BIO-EARN) as a more realistic (though less ambitious) approach for technology-related development. This approach prioritises institutional capacity enforcement of well-known institutions in developing countries through a regional and international network of academics and experts, which ensure a foundation and at the same time

[1]Ulmanen, J.M.A. (2003, March). 'Monitoring biotechnology for development: Lessons learnt'. *Biotechnology and development Monitor, 50.*

make sure that the quality of actions in developing countries are maintained by peer review[1]. In this approach, the producers are also taken into account in the decision making process; in this way useful and sustainable technologies can be produced and used[1]. Vitale et al. (2010) stresses the importance of national information services which would need to cooperate with the cotton companies and seed companies in order to provide information to producers regarding the production process of their crops, for instance information about the effects of pest management on their crops[1].

The general lesson learnt from former studies, and also from this thesis, is that the effects of technical developments and technical innovations are not restricted to the places where they are produced, but rather also apparent in the places where these developments are implemented. On the whole, the complete arena of biotechnology-affected sites should harmonize in the technical development occurrence. More on the effects of technical developments in the social domain will be discussed in the conclusion. Next, the recommendations about cotton production in Burkina Faso are given. These recommendations are mainly personal views of how the current situation can be altered and improved in the country.

Analysing the research questions

In order to answer the research questions, this thesis analysed several aspects of cotton production and technology applications in Burkina Faso. First, biotechnology in general is discusses. Biotechnology is described as any technique that uses living organisms or substances from these organisms to make or modify a product for a practical purpose, in which later on the social aspects have been taken into account. Tissue cultures, genetic modification and molecular breeding have been discussed as forms of biotechnology, which can be used in agriculture. Genetic modification forms the basis of Bt cotton and is therefore in thesis the most important form of biotechnology. The benefits of biotechnology are diverse but can all be linked to poverty reduction or sustainability. Economic benefits, as well as natural and health benefits have been discussed. Also the increase in pest control is discussed as a benefit of biotechnology. As drawbacks, 1) influences of environmental characteristics on genetically modified crops, 2) knowledge of the codes by actors, 3) The influence of regional characteristics on crops and 4) The specific risk reducing factors have been mentioned. In chapter 4, the institutional aspects of Bt cotton in Burkina Faso have been mentioned. Mainly through regulation measures and dependency relations can institutions manifest themselves in the cotton producing sector. The dependency relations between producers and institutions and empowerment restrictions of producers are examples of how the co-evolution of the technical and social become apparent in Burkina Faso. The institutional set-up models are given in chapter 4. When comparing the old and new model, the new model shows a decrease in power of concerned institutions and an increase in producer initiatives to increase their positions in the cotton producing sector. Still, the empowerment of producers is not optimal; still do producers depend on institution. For example, in obtaining means for production producers can still depend on institutions. Also loans can cause for a lower degree of empowerment of producers. Tailor-made biotechnologies have been mentioned as a possibility of increasing producers' empowerment. In this respect, tailor-made biotechnologies can play an important role in improving working or living conditions for cotton producers in Burkina Faso.

[1]Vitale, J. D., Vognan, G., Outtarra, M., Traore, O. (2010). The commercial application of GMO crops in Africa: Burkina Faso's decade of experience with Bt cotton. *AgBioForum*, 13(4): 320-332.

Recommendations for future developments

Taking the information, given above, into consideration, general recommendations can be given in order to make biotechnology in Burkina Faso's cotton production work in a positive way. First of all, the technical developments can be profitable for the cotton production sector, so technical developments should not be rejected in first instance. The problems in present producing enterprises, however, should be tackled in order to make sure the technical developments will realize profitable outcomes, not only in the economic sense, but also on e.g. the environment, the health status of producers and the empowerment of these producers. The latter is stressed extensively during this thesis because this aspect of the cotton production chain is perceived as most problematic and promising. As is described in this thesis, most producers face monopolistic institutions through which the producers attempt to generate means for production as e.g. fertilizers and insecticides. These means can be generated through these networks, however the institutions demand certain forms of payment in return. These payments can be made with money, but because of the financial situation of most farmers (these farmers are believed to be relatively poor and not in the possession of large amounts of money), these payments can be done by selling parts of the harvest for a low price to the institutions, which, in their turn, can sell the cotton for profits on the global market. Recommended here, is a decrease in the influence of the institution. This can be done by enforcing the producers, which can be realised by producer networks and collective action. These networks can create a flow of resources (for instance money), and in this way make sure cotton producers will not get trapped in the institutional claims of cheap cotton gathering. As stated earlier, the technical developments can realise profitable situation for procures, although most contemporary technical developments are too global-centred instead of local-centred. This situation should be problematized, due to the fact that the technical developments are introduced on arable lands which contain special characteristics and should therefore also approached on specific ways. Tailor-made biotechnologies can form a good alternative for the contemporary agro-industrial organisational model of technologies in agriculture. Within this alternative re-codification and re-appropriation will be important facets in accomplishing the sought technologies for developing countries. Re-codification has been described extensively during this thesis; re-appropriation is a rather new concept, which is used to indicate that the distribution of activities in the agro-industrial system is mainly appropriated by institutions. As is mentioned in the chapter of re-codification, in the definition of appropriation "Appropriation refers to the gradual takeover of biological activities, from farming practices by external institutions, especially industry. Ruivenkamp 2008b: 45)[1]. Re-appropriation, in this sense, is the reshaping of the takeovers by institutions. In this reshaping process, the farming practices (and thereby the biological activities) are returned to the producers. These producers, however, will still need technical means for their production. Therefore, the presence of institutions should not be reduced dramatically, because a modest integration of institution in the cotton production sector is preferable for producers (also because of the existing networks the institutions created). Collective action, thereby, could be a useful tool for producers to replace the monopolies of institutions with producer-centred organisations which should be able to distribute means in an equal manner. In this way, a better production sector should be realised for the producers. A last recommendation is to remain the notion of the technical and social as related and intertwined domains. The technical can influence the social relations in a place or network, but vice versa the social relations can influence the implementation of technical means, mainly through

[1]Ruivenkamp, G. (2008b). Tailoring biotechnologies: a manifesto. In: Ruivenkamp, G., Hisano, S., Jongerden J. (2008). Reconstructing biotechnologies: critical social analysis. Wageningen, Wageningen Academic Publishers: 29-76.

accessibility and availability of actors placed in the lower places at the production chain, but also in other places of the production chain, like the regulatory level as is mentioned in the chapter about institutions. This notion of intertwinement is central in this thesis and should be recognised as important part of the process of biotechnology in agriculture, and even more in biotechnology in development, because biotechnology can and is personally expected to form a very useful tool for the development of developing countries.

Several questions can be asked which should be studied in future researches in order to complete the concept of biotechnology in development. These questions are intended to create clearer overviews of institutional, agricultural and technical models in different developing countries, which all face different environmental, biological and institutional conditions. These conditions are also considered as the endogenous and exogenous conditions of the countries. A first question is how the specific conditions in countries can be determined; which aspects should be studied and which aspects should be neglected in the analysis of countries? Thereby, which actor(s) should be in charge of the analysis? Could this be a global organisation as e.g. an agency derived from the United Nations or an agency derived from the World Bank, or should the analysis be examined by a national organisation as e.g. the ministry of agriculture, which is familiar with the cultural conditions of a country or region? In what extend is corruption an issue in this situation? And how ethical is the implementation of technical means in agriculture? Most producers have traditional values in their way of producing; technologies can alter the way of production in a dramatic way. Therefore, the implementation of technologies are in a sense an interference in the lives of many producers. Whether this interference can be justified by the possible benefits technologies can offer should be discussed extensively by involved actors within this process. Another important question is whether collective action (which is argued as an important tool for empowerment) is sufficient in the process of producer-centred development.

5. Conclusion

In the chapters, several important aspects of the implementation of Bt cotton have been discussed. 1) In the introduction, the general content of this thesis is provided, next to the importance of the notion that the social and technical domains are intertwined and should not be seen as separate domains. 2) In the second chapter, the case study (Burkina Faso) is covered; agriculture and biotechnology in Burkina Faso have been discussed, along with the benefits and drawbacks of biotechnology (in Burkina Faso). 3) In the third chapter, the institutional set-up and regulatory bodies have been discussed; public institutions have been discussed, as well as the implementation measures needed for technical implementations and finally the influences of public institutions on the empowerment of producers in the cotton sector. Here, the main conclusion drawn is the importance of the impact by institutions on producers; up till now, knowledge, which provided the monopolistic power positions of institutions towards producers, deprived the producers' freedom of choice which crop to produce and how to produce it. Thereby, the institutions attempt to regulate the cotton market in the country, attempting to earn more money on the global market. The commercialisation of cotton in Burkina Faso also played an important role in this institutionalisation of the cotton sector, because of the global interests of institutions. During this chapter, the reduction of monopolistic positions of institutions is stressed along with the collective action of producers; in this way, producers can face more empowerment and therefore could become less dependent on institutions. This is of importance in this thesis because collective action is assumed to form a key tool for empowerment of producers, and can also cause changes in the production chain of Bt cotton. 4) The fourth chapter entailed possibilities to counter the pro-contra debate; tailoring of biotechnology is discussed along with its possibilities. The general point made in this chapter, is the point that biotechnology is not a single concept. Several aspects play a role in the implementation of biotechnology. For instance, it is clever to weigh the benefits and drawbacks of biotechnology prior to the implementation of biotechnology by producers. Although, the benefits and drawbacks alone are not sufficient; the codes of success are important to take into account as well. Additionally, the traditional network of biotechnology in agriculture is stressed to be deconstructed and reconstructed from an agro-industrial biotechnological network towards a tailor-made biotechnological network in which the uneven power relations between institutions and producers are reduced. Re-appropriation is mentioned as a possible solution to decrease the influences of institutions on the production chain; when appropriation of production means can be altered from the contemporary situation, institutions can be countered due to a decreased control over the input means for cotton production. Ruivenkamp states that "genomics research mirrors and reinforces the social contrast between an exogenous and an endogenous innovation process that will be especially manifested via various forms of regional integration in global production systems (Ruivenkamp 2003: 37)[1]. This statement forms a core principle in this thesis, emphasising the multi-fold effects of a single development, also considering the exogenous and endogenous influences on the outcomes of the development. Thereby, the place-dependency of technical implementations (the same technical development can have different outcomes in different places) is important to take into account.

[1]Ruivenkamp, G. (2003). Genomics and food production – the social choices, *edepot.wur.nl*, Wageningen, Wageningen University and Research centre.

In the analytical framework, the main question of this thesis is noted: *What effect does the implementation of Bt cotton in Burkina Faso's agriculture have on actors involved in cotton production?* The first sub questions in order to find answers on the main question is: *what is biotechnology in general?* In the analytical framework, biotechnology is explained as a technique that uses living organisms or substances from these organisms to make or modify a product for a practical purpose, which is done with the Cry proteins in Bt cotton. With this technology, new possibilities can arise but also possible dangers can develop. The benefits and drawbacks have been discussed in the second chapter. The second sub question includes the institutional organisations; *How does the implementation of Bt cotton influence the functioning of public research institutions within Burkina Faso?* As is described in the third chapter, the public institutions can have effects on the uptake of Bt cotton in the country, but Bt cotton can also have effects on the regulatory setup of Burkina Faso. The third sub question is also described in the third chapter; *How is the empowerment of the producers affected by the institutions involved in Bt Cotton production? T*he functioning of public research institutions (like SOFITEX, SOCOMA and Faso Coton) can create monopolistic positions and perform a great impact on the cotton production sector and on the lives of cotton producers in Burkina Faso. As is described in this thesis, public institutions can oblige producers to produce one type of crop (probably cash crops) due to the decency relationships between producers and institutions. In these relations, the producers are (almost) completely dependent on a single entity (in this case the institution), which can provide supplies and means for production. The commercialisation of cotton seems to strengthen this organisation of institutions even more due to the economic advantages the genetically modified crops offer for the global market production. Next to the previous influences, the implementation of Bt cotton had several influences on the farm level; economic, health and environmental advantages are given in this thesis, next to the pest control possibilities the crop offers, but also several disadvantages are given which can occur due to Bt cotton. Concerning empowerment of the producers, the institutions affect the position of producers in the production chain. Empowerment "is the process of increasing the capacity of individuals or groups to make choices and to transform those choices into desired actions and outcomes. Central to this process are actions which both build individual and collective assets, and improve the efficiency and fairness of the organisational and institutional context which govern the use of these assets" (World Bank 2011)[1]. In this respect, the empowerment of producers in Burkina Faso is restricted by institutions because of the monopolistic positions of institutions and dependency relations between the producers and the institutions. Therefore, several solutions are given to counter the contemporary situation in cotton production. Tailoring biotechnologies is a first solution, mainly to ensure better results in cotton production on the farm level. The place-dependency can be countered by including local factors in the implementation of Bt cotton in an area. Re-codification is an important facet in the procedure of tailoring biotechnology; by re-codifying the agro-industrial production process, combined with the analysis of the social organisation of society, the reconstruction of technologies can take place which should be advantageous for the producing population. Thereby, the organisational structure of institutional influence should be altered, as is stressed in chapter 3. In figure 4, a rather complex, but realistic model of the actors involved in cotton production is given. This model can be used as a starting point for the reconstruction of the cotton production process, in which institutions should face restricted power, though still is acknowledged as important actors concerning the supply of means for production. Thereby, producer's organisations (constructed through collective action) can act as a useful tool for e.g.

[1]World Bank (2011). Empowerment. The World Bank: a world free of poverty.

information distribution and network-construction and should therefore be acknowledged as equally important as any other actor in the process of empowerment of producers and the reorganisation of cotton production. Farmers and peasants are distinguished in this thesis. Both are recognised as producers, but the farmers are assumed to be influenced by institutions in a higher degree than the peasants. This distinction is made due to the interests of institutions and farmers to operate on a global scale, whereas peasants are assumed to operate on a local level. Therefore, peasants are assumed to be less concerned with Bt cotton and a form of social differentiation can be noticed in this technical tool; by including farmers and excluding peasants from Bt cotton a social differentiation occurs. Collective action is mentioned as a possibility for the empowerment of producers. The farmers and peasants should in this respect co-operate to form associations in order to counter the monopolistic positions of institutions. So, by stimulating the collective action of producers, these producers are assumed to face decreased dependency from institutions. This thesis is mainly focussed on the farmers, due to their focus on the production for the global market; peasants are assumed to be more interested in the production for local markets, but as is mentioned above, a coalition of both groups of producers should be able to counter the monopolists. The contemporary exclusion of peasants should not exclude the capacities of peasants in cotton production; the existing networks can provide profitable conditions for peasants. To stress the influence of peasants in this process, the differences in characteristics of both producer groups are mentioned; Farmers entail networks in which peasants are less included and might have more knowledge about certain forms of production, whereas peasants are less influenced by institutions and are assumed to have higher varieties of seeds and can in this respect contribute to a decreasing dependency on one type of seed. The combination of both producer groups into collective-action could provide a strong position against institutions.

To conclude this thesis, the Burkinabe cotton production sector is a complex, but rather promising sector. The implementation of technical developments influenced this sector, but can also strengthen the sector when the techniques are implemented in a correct way. Tailoring technologies, here, is seen as a great possibility in order to improve the Burkinabe cotton producing sector. When the contemporary problems are overcome, positive prospects will emerge for Burkina Faso. Future studies should try to find answers on the questions mentioned above in order to make sure biotechnology can form a beneficial tool and be recognised as a tool to reduce worldwide poverty and increase producer-centred production in all areas of the world.

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