AGRICULTURAL GENETIC ENGINEERING TECHNOLOGY AND SUSTAINABLE DEVELOPMENT IN THE AFRICAN FOOD SECURITY CONTEXT

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by
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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled:

GENETIC ENGINEERING TECHNOLOGY AND SUSTAINABLE DEVELOPMENT IN THE AFRICAN FOOD SECURITY CONTEXT

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a candidate for the degree of Doctor of Philosophy,

and hereby certify that in their opinion it is worthy of acceptance.

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While good information and ideas are the foundation of human intellectual growth, every idea and information are marked by one flaw: traceability. With lack of traceability there is lack of appropriate acknowledgement to those who contributed to these very ideas and information. I do highly value ideas and information, and I believe I do my best to trace them back to their original owners, so let me try this:

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ABSTRACT

This dissertation seeks to address specific questions: the extent to which SD informs proponents of GE benefits, how farmers' practices are included in GE proponents' arguments, and the applicability of the claim that the EU pressures the developing world, and Morocco in particular, to reject GE technology. This dissertation seeks to contribute to both academic and policy discussion on GE crops within the context of African food security.

While one is considered globally embraced and the other globally controversial, sustainable development (SD) and agricultural genetic engineering (GE) technology are both examined in this dissertation. The dissertation engages with how proponents of genetic engineering (GE) technology argue for its capacity to benefit sustainable development (SD) in the context of African food security. Three sources of information constitute the basis of analysis and discussion. First, meta-analysis and systematic review of peer-reviewed articles and policy studies which argue for SD benefits gained through GE technology within the context of African food security. Second, taking Morocco as a case study, this dissertation uses both interviews and policy analysis to understand how sustainable development informs policy and academic discussion on GE technology. Third, discussions and observations in national and international conferences have been key to build connections between the examined studies and the networks of their authors. The opportunity to interact with these authors has been tremendously beneficial, both to learn about the policy significance of the examined studies, and to understand the research and policy networks of the authors.

Arguments supporting SD benefits of GE technology are examined in four stages. In the first stage, I apply the reviewed theoretical and methodological approaches to examine the studies which argue for SD benefits of GE crops. This stage helps identify the major trends of the reviewed

studies. In the second stage, I focus on SD benefits of GE crops and African farmers. In this stage, I present an elaborate list of SD benefits of GE crops as argued by the examined studies; I also critique these studies. In the third stage, I critique how GE proponents portray SD social benefits in the examined studies. In the fourth stage, I test the prevalent claim about the EU pressure on African countries to reject GE technology, taking Morocco as a case study.

CHAPTER ONE: INTRODUCTION AND OUTLINE

The introduction of genetically modified (GM) crops to African farmers has led to two main arenas of international cooperation and conflict. First, regarding arenas of international cooperation, Africa has witnessed unprecedented concerted efforts among global scientific communities, philanthropic organizations, and African governments to address the dire state of African food insecurity through the development of GM technology. Second, arenas of international conflict, on the other hand, have led to global mobilization of institutional, non/governmental and political actions to stop or promote the proliferation of agricultural biotechnology in both developed and developing countries.

Both pro- and anti-GM agendas, considering that each agenda encompasses a spectrum of different attitudes on GM technology, have revealed new influential stakeholders in the international development arena. The main emerging conspicuous stakeholders of current international development are non-governmental organizations that seek to reshape national food policies of trade and production. Alternative food systems organizations (e.g. fair-trade organizations, slow food movement, and organic food movements), are examples of how food provision is no longer entrusted solely to governmental and global economic stakeholders. This has also amounted to non-governmental organizations whose chief goal is to work with, rather than against, governmental and global economic institutions who promote shared conceptions of agricultural development.

The following panoramic view of debates surrounding the promotion of biotechnology in Africa is necessary to explicate the background of this paper. To date, there have been four major avenues to investigate how biotechnology is promoted as well as condemned in Africa. The first avenue of research examines inter/national policies and collaborative efforts as promoted by governmental institutions to effectuate the implementation of biotechnology in Africa. The second avenue of research delves into the semantic disputes around key terms: GMOs, genetically engineered crops, biotechnology, etc. Though the terms have often been used interchangeably, each one is discursively differentiated from the others. Third, researchers have sought to unravel types of institutional and financial cooperation among agricultural corporations and philanthropic organizations regarding the promotion of biotechnology in Africa. Fourth, few studies to date examine whether perceptions and practices of smallholder farmers are considered throughout the development of genetically modified crops.

Running throughout each of the abovementioned four avenues of research on GM technology, debates around GM crops within the African context have been framed within the broader context of global sustainable development initiatives. This means that arguments promoting or condemning GM food resort to sustainable development, as a concept and agenda, to adduce their claims. There is therefore a strong need to go beyond semantic representations of sustainable development and delve into the assumptions, disciplinary affiliations, and ideological inclinations informing one's reference of sustainable development to argue for or against GM crops in Africa.

I focus mainly on how GM proponents refer to sustainable development to argue for the need for GM technology adoption in Africa. This paper also examines the arguments of critics of GM technology, who invoke sustainable development to warn against the drawbacks of GM technology and critique its relevance to African farming livelihood systems. This paper seeks to expand the discussion around GM technology beyond the dichotomous positions of "anti" or "pro".

Statement of the problem and rationale

Sociologists unravel the fabrics of grand narratives and concepts, such as sustainable development (SD). It is beneficial to examine how SD is invoked to advance one's conception of agricultural development. In terms of theory, the literature on SD reveals there is a need to develop a more comprehensive typology to examine one's conception of SD in ideological (theoretical and political orientation), practical (envisioned livelihood systems and practices), and policy terms. More importantly, as I will discuss, social sciences are needed to contribute to debates around sustainable development. This need becomes more apparent within arenas where sustainable development definition becomes contested as is the case of GM technology.

Relevance of the Study

One of the questions contained in the literature on sustainable development is the role of academic disciplines, such as social sciences, in opening up new spaces of social inquiry into the debates of sustainable development (Becker, Jahn, and Stiess 1999). These challenges range from conceptual difficulties in defining sustainable development to political ideologies on the implementation of sustainable development agendas (Connelly 2007; Du Pisani 2006). This study will explore how the concept of "sustainable development" is framed by pro-biotechnology[1] studies by examining the extent to which sustainable development is emphasized as a main motive behind the promotion of biotechnology in Africa. Critics of biotechnology advocates' deployment of SD establish potential lines of comparison between critics of biotechnology and supporters; this paper examines how both deploy SD as a framework to back up their stance and critique each

[1] I use the term pro-biotechnology studies to indicate published research that provides relatively positive analysis about the use of and benefits of biotechnology in agriculture.

other's stances. However, the focus remains on studies which promote GM technology as a sustainability tool.

Policy Implications of SD at the Global Level

Central to many national and international development agendas is the deployment of SD to guide development programs. It has been estimated that the concept appears in over eight million webpages and is "enmeshed" in thousands of national and international development programs (Kates, Parris, and Leiserowitz 2005). This can be explained by early international community commitment to address global development concerns by designing international and national laws and action plans which promote SD. Such laws and action plans include the *Stockholm conference on the Human Enviroment*,1972, where the "conflicts between development and environment were first recognized" (Kates et al. 2005), *The World Commission on Environment and Development* conceived by the General assembly of the United Nations 1982, the Brundtland Report "Our Common Future" named after –Prime Minister of Norway Gro Harlem Brundtland in 1987 (Kates et al. 2005), and *Agenda 21*, an offshoot of the *Earth Summit* held in Brazil in 1992 (Lafferty and Eckerberg 2013). Theese plans, and others, stress the importance of considering how SD agendas interact with the developing world's needs and challenges. Within the African context, sustainable development has been invoked on various occasions in relation to GM crops.

Sustainable Development, GMOs and the African Context

The World Summit of Sustainable Development (WSSD), held in Johannesburg in 2002, epitomizes the elusive nature of the concept of SD and its political and policy implications. During the summit clashes erupted between anti-GMO and pro-GMO groups, though the topic of

GMOs topic was not listed on the agenda (Freidberg and Horowitz 2014). The major incident occurred when the participation of Vandana Shiva, an anti GM activist, was publicly denounced by small farmers from Asia and Africa, some of whom decided to award her the "B**S Award" for "advancing policies that perpetuate poverty and hunger" (Freidberg and Horowitz 2014).

Freidberg and Horowitz (2014) stress how blurry the lines between pro- and anti- GM participants were at the summit; participants from both sides belonged to national and transnational networks. This shows that examining the policy implications of GM technology requires paying heed to national and international avenues of influence. It has been argued that GM technology will produce different impacts on various regions and localities (citing Glenn Stone (2002) from Freidberg & Horowitz (2014)). The differential impact of GM technology was likened to the differential impacts of the Green Revolution in 1960s and 70s: some regions benefited while others were negatively affected by it. GM technology therefore has been regarded as a technology which would either "save" or "starve" the world; the contested nature of GM technology is more evident within the developing world (Stone 2002), particularly in the African context. Literature on GM technology and Africa reveals that major proponents of GM technology for Africa critique how anti-GM reference to "sustainable agriculture" does more damage to African farmers by preventing them from obtaining the most innovative technologies to scale-up their production (see Juma, 2011; Paarlberg, 2008, 2010). Some proponents of GM technology hold that there are many conceptions of "sustainable" agriculture that are not sustainable, such as organic farming (Juma 2011c; Paarlberg 2008). Thus, the concept of sustainability is invoked not only to argue for or against GM technology, but also to disparage other "sustainability" projects.

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CONSTRUCT DEFINITIONS

- The concepts of "sustainable development", "sustainable agriculture", "sustainable intensification", and "sustainability" are used interchangeably unless an examined study explicitly invoke a particular usage. Each concept, however, has been discursively distinguished from the others: sustainable development entered the global policy arena thanks to the UN Brundtland Report in 1987 (Bebbington 2001), which states that the difference between sustainable development and sustainability is that "Sustainable development is the pathway[means] to sustainability [the end]" (Stemler, Shackelford, and Richards 2016). Sustainable intensification emerged as a response to the environmental challenge of meeting future food needs: "Sustainable agricultural intensification is defined as producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services" (Pretty, Toulmin, and Williams 2011). Sustainable intensification therefore is a means to attain sustainable agriculture (Tilman et al. 2011).
- In this study, the terms "GMOs", "Genetic modification (GM) technology", "agricultural biotechnology", and "genetic engineering (GE)" are used interchangeably while paying heed to instances where a discussion of the differences among them is relevant and needed. For example, it would be worthwhile to highlight the fact that many studies prefer using agricultural biotechnology or genetic engineering, as will be discussed. Examining the discursive tensions governing debates on the accuracy and credibility of the abovementioned concepts would be itself an independent research avenue to pursue.

- "Africa" is a historically and politically molded label which has been subject to various politics of homogenization, exoticization and romanization. The representations of Africa will be discussed based on the covered literature.

RESEARCH METHODOLOGY

OBJECTIVES OF THE STUDY

Understanding how GM technology proponents argue for SD benefits experienced by GM growers is key in order to: a) address shortcomings of their research approach and theoretical foundations, b) forge avenues of collaboration by incorporating their unique analysis and insights that may not be attained using other methodologies, c) think in inter/transdisciplinary terms on how to integrate in research the experiences of populations most affected by GM technology, for instance small-holding farmers in Africa. The objectives of this paper are twofold:

- First, to examine how GM technology proponents invoke SD both explicitly and implicitly to argue for the benefits of GM crops within the African context.
- Second, to examine through the case study of Moroccan policy attitudes on GM crops how and the extent to which SD informs policies on the adoption/rejection of GM technology.

CONCEPTUAL FRAMEWORK

"A conceptual framework is a visual or written product that "explains, either graphically or in narrative form, the main things to be studied—the key factors, concepts, or variables—and the presumed relationships among them" (Maxwell, 2013, citing Miles and Huberman (1994)). The following conceptual framework outlines how the two objectives will be examined:

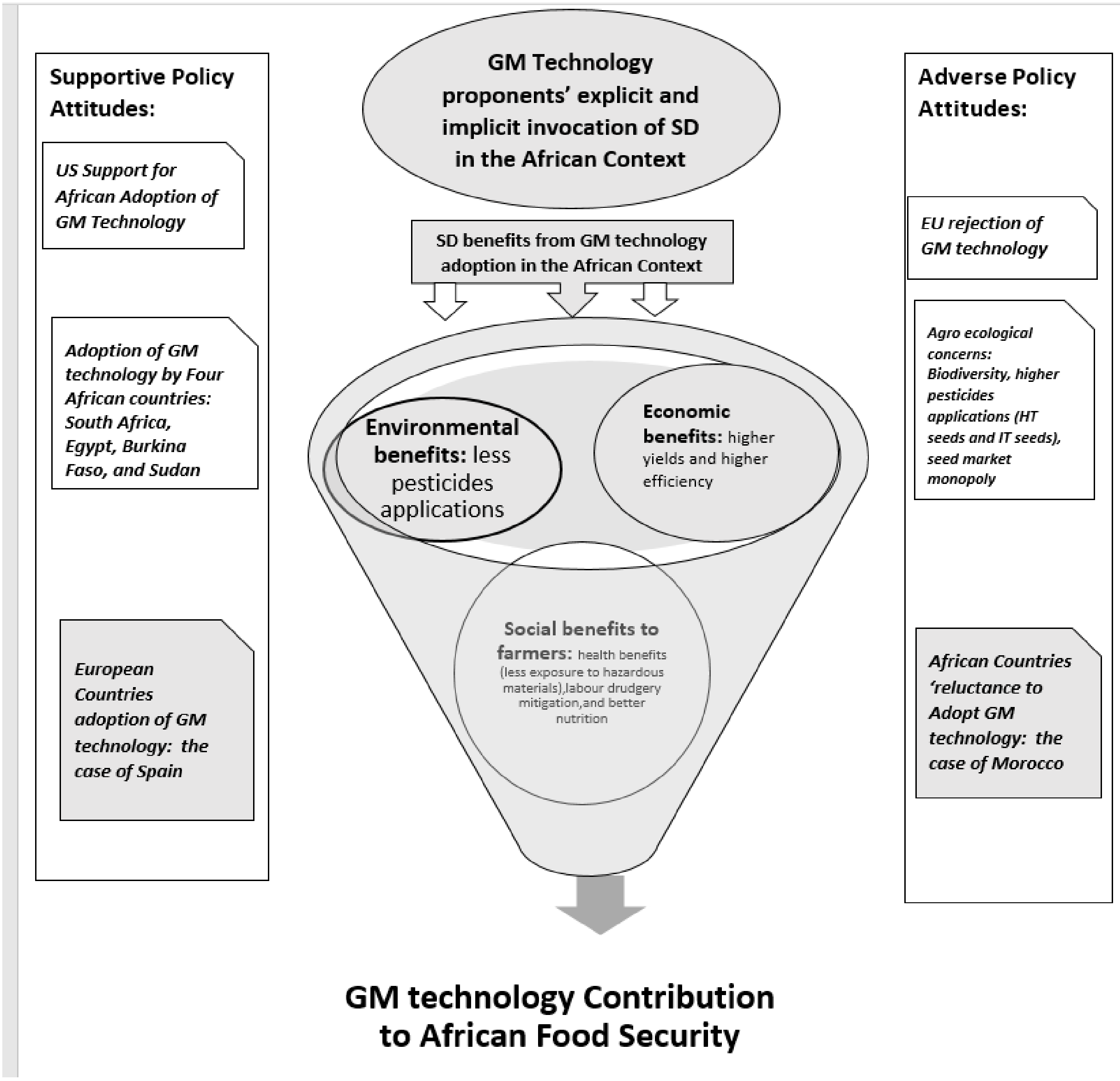


Figure 1 GM Technology Proponents' explicit and implicit invocation of SD in the African Context

This conceptual framework outlines the research itinerary to examine how proponents of biotechnology invoke SD. The literature shows that SD concept has been very elusive, and therefore difficult to define and operationalize. Kates, et al (2005) argue that national and international initiatives make either implicit or explicit reference to SD, and they vary in their approaches to the questions: "what is to be sustained?," "what is to be developed?," and "for how long?." Taking a cue from Kates' et al. (2005) approach to examine inter/national initiatives' definition of SD and its indicators, this study seeks to examine reference to SD by proponents of GM technology.

RESEARCH QUESTIONS

Research questions revolve around the two abovementioned objectives: a) how proponents of GM technology argue for its SD benefits within the African context; b) whether SD informs policies that reject or adopt GM crops within the African context.

To attain the first objective, I examine the reasons why sustainability is invoked by proponents of GM technology by reviewing the SD concept and its major approaches, reviewing GM debates in relation to SD within the developed and developing world context, and examining GM proponents' arguments on GM technology's capacity to address food insecurity sustainably. Examination of GM advocates' arguments is carried out through a) meta-analysis which will map out the general arguments on SD benefits of GM crops, b) citation network analysis to find out major influential/cited authors to back up claims on SD benefits of GM crops, c) systematic review of SD benefits associated with GM crops, and d) analysis and critique of reported social SD benefits of GM technology.

The second objective is attained by applying the policy debates on African rejection of GM crops, taking Morocco as a case study. This case study seeks to understand the extent to which SD shapes policies behind rejection or adoption of GM crops. This case study addresses Stone's (2010) remark that there is lack of country-specific research on national policy stance on GM technology.

The main research questions and their respective chapters are outlined below:

1. Why is the sustainability concept invoked by proponents of GM technology within the African context?

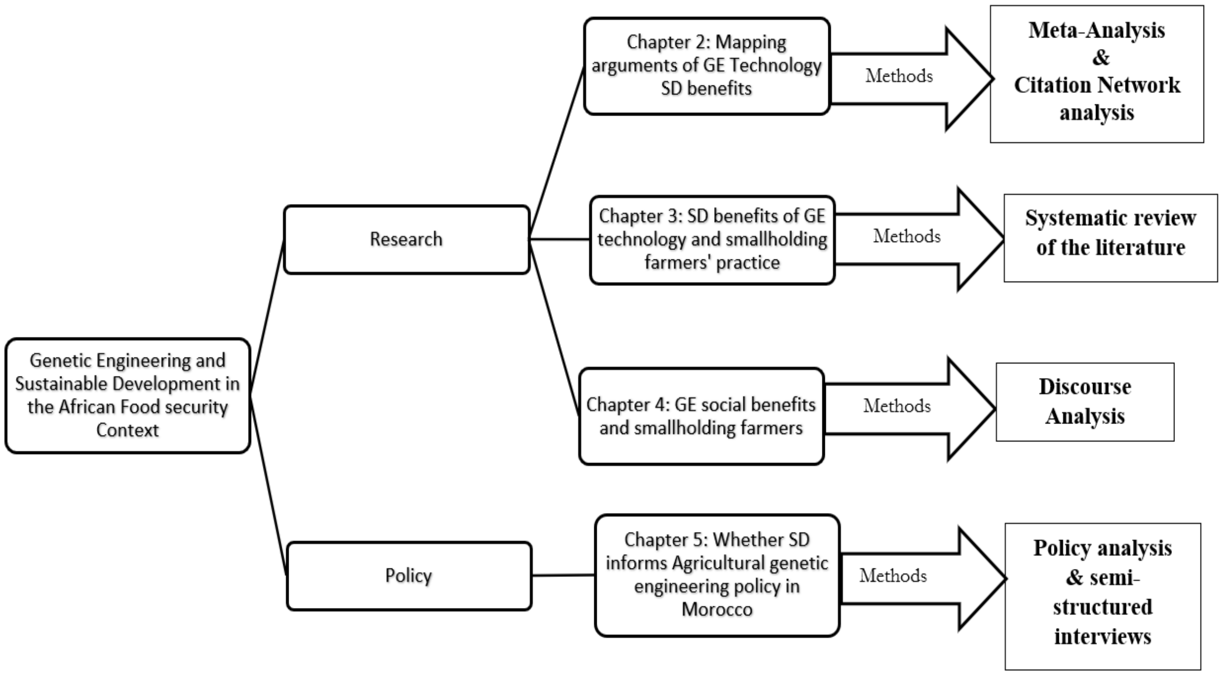
    - Review of SD concept history, approaches, and major related issues and debates (review of the literature in chapter 2)
    - Review of GM debates within developed world, developing world, and the African context (review of literature in chapter 3)
    - Review of GM proponents' arguments on GM technology's capacity to address African food insecurity (Chapters 3 and 4)

2. How is sustainability invoked to argue for the relevance of GM technology to address African food security?

    - Explicit invocation of SD: Meta-analysis and citation network analysis of studies which explicitly and implicitly deploy sustainability to argue for benefits of GM technology (Chapter 2 and 3). Focus is on the analysis of social benefits associated with GM technology adoption (Chapter 4).
    - Case study of Morocco to examine the extent to which SD informs its policies on GM technology (chapter 5).

3. To what extent is GM proponents' conception of sustainability sustainable? (throughout the chapters' concluding remarks)

Research Methods:



The four chapters examine how proponents of GM technology attribute SD benefits to the technology. I start from the general to more specific examination of GM proponents' arguments. The general exploration in the second chapter examines the extent to which SD benefits are emphasized by GM proponents using meta-analysis. While meta-analysis is generally known to be applied using quantitative data analysis (Glass 1978), various discussions have pointed out severe problems with quantitative meta-analysis (Zhao,1991: 385). These problems include loose assumptions which lack foundational examination, reductionist views of data using dichotomous values, and failure to consider the complexity of examined variables (Zhao, 1991:385).

In the second chapter, meta-analysis is used to gain insight into assumptions undergirding GM technology proponents' arguments. Examining "the underlying assumptions of various data-analytic procedures" is a way of conducting meta-analysis that goes beyond a) "the comparison of different forms of data in terms of their quality and utility," and b) "the synthesis of the findings of a range of research studies that are related to the same phenomenon" (Zhao,1991). In the second chapter, I provide details on study selection criteria, meta-analysis typology, and limitations of and future avenues for research. Major conclusions drawn from the second chapter inform the choice of research questions and methods of the third chapter.

The third chapter examines specifically whether farmers' practices inform arguments that GM technology yields SD benefits. This chapter systematically reviews studies that argue for SD benefits experienced by farmers who have adopted the technology. The chapter also maps out types of GM SD benefits, sources of evidence, geographic locations, research methods, assumptions, and policy claims informing studies which argue for SD benefits of GM crops.

The fourth chapter builds upon the third chapter by focusing on SD social benefits of GM crops as argued by pro-GM studies. Using discourse analysis methods, I critique how proponents of GM technology argue for SD social benefits of the technology. The chapter provides a critique to the sociological assumptions undergirding GM proponents' conceptions of GM SD benefits. I focus on the analysis of studies which use data based on farmers.

One central argument prevalent among proponents of GM technology and dominant in the examined studies, is that countries are reluctant to adopt the technology despite demonstrated SD benefits results from EU pressure on Africa not to adopt GM crops. The fifth chapter focuses on the question of whether SD informs policies on GM technology. Taking Morocco as a case study, I conducted policy analysis and semi-structured interviews to examine the extent to which SD informs the Moroccan policy stance on GM technology. This chapter critiques GM proponents' claim.

OVERVIEW AND OUTLINE OF CHAPTERS

The second chapter. After reviewing the different theoretical and methodological scholarly debates that examine arguments based on SD concepts, I apply a developed SD typology on selected peer-reviewed articles which argue for GM technology SD benefits in Africa. The developed typology is customized from the reviewed SD typologies debated by various social scientists. This chapter is based on meta-analysis of peer-reviewed articles which argue for SD benefits of GM crops within the African context. The meta-analysis yields general results and informs the choice of the main research question of the third chapter.

Third chapter. This chapter focuses on the extent to which African farmers' experiences with GM technology inform arguments that GM technology produces benefits associated with SD, namely productivity, environmental, health, and labor. The focus on peer-reviewed articles' reference to African farmers stems from pursuing the first chapter finding that only 4 studies used farmers' experiences to argue for GM benefits associated with SD. The choice of peer-reviewed articles is justified by their high impact in influencing agricultural policies on GM technology.

Fourth chapter. This chapter is based on the general findings of third chapter, it focuses on arguments which promote GM social benefits, particularly those related to health and labor. Using discourse analysis, I examine how pro-GM peer reviewed articles frame GM technology benefits to address labor and health issues of African farmers who have adopted GM crops.

Fifth chapter. Based on policy analysis and interviews with Moroccan key stakeholders, this chapter engages with the dominant narrative that the EU pressures its economic partners to reject GM technology. The chapter starts with a comparison between the US and EU framings of

GM technology and how they are informed by SD concepts. It then examines how the EU stance on GMOs plays out within the Moroccan context.

CHAPTER 2: GMOS AND AFRICAN AGRICULTURAL SUSTAINABILITY: A META-ANALYSIS OF PRO-GMO STUDIES

This chapter is divided into two sections. In the first section, I engage with the different theoretical and policy debates around SD. In the second section, I present the methods used to examine studies which explicitly deploy SD to argue for the benefits of GMOs within the African food security context. This paper's selection criteria, conceptual mapping and analytical methods are presented.

REVIEW OF SUSTAINABLE DEVELOPMENT: AN ELUSIVE CONCEPT AND AGENDA

Historical Overview

Though SD has become the zeitgeist almost in every field of study and profession, consensus on its historical roots is lacking. Du Pisani (2006) asserts that the concept of "sustainability" was added to the Oxford English Dictionary in the second half of the 20th century. However, the comparable French (durabilite, durable), German (Nachhaltigkeit, literally meaning 'lastingness', and nachhaltig) and Dutch (duurzaamheid and duurzaam), have been used for centuries. To track key historical events which led to the emergence of SD, Du Pisani (2006) outlines three main historical periods. The first period refers to pre-modern conceptions of "progress," a concept developed mainly within the Hebrew and Christian theology. "Progress" then pertained not solely to material linear progress but also to spiritual progress. However, transformational historical events in the West upset the philosophical underpinnings of "progress" whose religious premises eventually were replaced by more secular ones. In the second period, concerns such as environmental degradation, and aspirations shaping "sustainability," were debated and cherished for many decades. One example is Russel Wallace's *The Wonderful Century: Its Successes and Its Failures* (1898), which examines the social and environmental drawbacks resulting from 19th socio-economic transformations. The third period refers to contemporary conceptions of SD which are attributed mainly to dominant discourses that have governed the global conception of development at the political (colonization), economic (free market), and institutional (IMF and the World Bank) levels. Discontent with the definition of "development" formulated by major powerful economies, pushed people, like Barbara Ward (1970s), founder of the International Institute for Environment and Development, to coin "sustainable development" as an indispensable model for global growth to attain global equity and environmental sustainability.

The Study of SD by Social Scientists

In 1999, Becker et al (1999) called for the inclusion of social sciences in debates on sustainable development. These authors argue that the incorporation of the social sciences perspective in sustainable development debates would benefit primarily social sciences to hone their research tools to address questions around SD. More importantly, social sciences perspective opens an avenue for critique and reconstruction global development projects premised on SD (Becker et al. 1999).

Methodologically, Becker et al (1999) propose a "*social trajectory approach"* as opposed to the "*retrospective approach*": the authors call for a social science perspective that not only reflects on past socio-economic issues –using the retrospective approach, but also projects future issues/scenarios related to sustainable development –using the social trajectory approach. Thus, the social science perspective's role is twofold. First, its role is reflective because it revisits socio-economic issues to reveal lessons learned. Second, its role is preemptive because it seeks to project future concerns that may arise because of the present interaction among human dimensions, material factors, and environmental processes. This interaction can be examined by pursuing three avenues of social science research on sustainable development: a) examining societal impacts on environmental processes (energy consumption), b) investigating the mediating roles of institutional arrangements, and c) critiquing the "hermeneutic" or "interpretive" disputes over the concept of sustainable development (Becker et al. 1999).

My research project fits within the last two avenues of research on SD: investigation of mediating roles of institutional arrangements, and the hermeneutic and interpretive disputes on SD definition. The conceptualization of both avenues has been problematic and continues to evolve.Various approaches have attempted to grasp the institutional dynamics governing SD as well as the policy translation/interpretation of SD concepts. Eichler (1999) calls for sociological investigation which pays heed to different conceptions and policy translations of SD by considering gender equity, "Inter/Intra generational equity," and equity issues between the developed world and the third world. For Eichler (1999) equity issues pertain to examining, a) the extent to which conceptions of SD are equitably shared, and b) the perpetrators of challenges obstructing the implementation of SD, i.e. environmental degradation and social inequality.

Mapping and Conceptualizing SD Arguments

The need to constantly revisit key perspectives and ideologies governing debates over sustainable development is widely acknowledged (Connelly 2007; Davidson 2014; Hopwood, Mellor, and O'Brien 2005). One approach calls for "the identification of ideological attributes" of the "policy actors" who shape sustainable development debates (Davidson 2014: 10). Davidson (2014:12) proposes "a layered political economy typology" to categorize policy actors' stances on sustainable development based on the ideological attributes undergirding their positions. For instance, positions on "the substitutability of capitals" and "power relationships" are regarded as defining traits of policy actors' positions on the SD debate (Davidson 2014). Other approaches seek to to critique and deconstruct perspectives that use sustainable development as a "rhetorical cloak" to cover up unsustainable policies (Connelly,2007:259). Connelly (2007) holds that contested perspectives defining sustainable development should be taken seriously since, irrespective of the quality of their definition of sustainable development, they have policy ramifications.

Connelly (2007) argues that because SD has been dominated by, first, normative definitions (what should be done), second, sophisticated accounts (more open to debate), and third, analytical approaches (philosophical and deep), literature on sustainable development presents two major issues. First, linear analysis disregards complex linkages among different perspectives on sustainable development. Second, the literature suffers from a high level of "normativity" marking most perspectives. Connelly (2007:262) therefore suggests a fourth approach which regards definitions of sustainable development as "rhetorical claims" whose real meaning can only be grasped when converted into "political actions." The author's mapping technique is useful to compare rhetorical claims with their "substantive political arguments."

One of the least conventional approaches suggests probing into and mapping stories behind any SD conception or agenda. Any formulation of SD is channeled through stories, most of which are often disregarded or unreported by development stakeholders for reasons including appropriateness, language, relevance, and audience appeal. Bell & Morse (2007) argue that defining and mapping those stories would uncover other aspects of SD. They add that the stories of sustainable development are solely and selectively told in a manner that appeals to a "projectified world order" that practices sustainable development in a mechanistic and reductionist manner without considering local socio-economic peculiarities (Bell and Morse

2007). They therefore propose “story telling” as well as an analytical model to gain insights into the stories and other alternative accounts about the characteristics of a sustainable development project. Their approach of probing other narratives of sustainable development stems from their conception of sustainable development as “a mess” (Bell and Morse 2007). Such a “mess” requires investigating various opinions and stories to understand its inception, its effect, and its future consequences. Taking a cue from health research institutions, the authors propose “institutional ethnography” to collect and examine different narratives on development projects. Their analytical model involves examining both quantitatively and qualitatively alternative stories and narratives. The authors argue that these alternative stories and narratives will assist sustainable development practitioners to grasp and account for other factors to consider to improve their future sustainable development projects (Bell and Morse 2007).

Sustaining Community through Sustainable Community Development

One of the least emphasized components of SD in policy arenas is the role of community. Any approach to sustainable development which stresses the role of community would not only emphasize the social aspects of SD, but it would also, importantly, understand the necessity to sustain community building, interactions, and cultural growth. The sustenance of community building has been argued to depend heavily on culture[2]. Cultural growth of community has been argued as catalyst to sustain the very idea of human life. It is not surprising then that Mathew Arnold (1869) sees anarchy as the nemesis of culture, as elaborated by his book Culture and Anarchy. For Arnold, “Culture [...] is a study of perfection.” He wrote:

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[2] Culture definition here pertains more to its less popular definition: how social interactions are shaped by livelihood habits, traditions, and economic practices, which lead to multiple and contradictory “common senses”, such as the contradictory perspectives governing SD. This definition is adapted from Stuart Hall: “By culture, here I mean the actual grounded terrain of practices, representations, languages and customs of any specific society. I also mean the contradictory forms of common sense which have taken root in and helped to shape popular life’” (Barker 2003).

> The whole scope of the essay is to recommend culture as the great help out of our present difficulties; culture being a pursuit of our total perfection by means of getting to know, on all the matters which most concern us, the best which has been thought and said in the world, and, through this knowledge, turning a stream of fresh and free thought upon our stock notions and habits, which we now follow staunchly but mechanically, vainly imagining that there is a virtue in following them staunchly which makes up for the mischief of following them mechanically.

The role of culture to enlighten and build communities was heavily emphasized in the twentieth century which witnessed the surge of cultural studies and critical theory studies that sought to save global community from the ravages of consumerism and materialism, such as: Centre for Contemporary Cultural Studies, or The Birmingham School, and the Frankfurt School. In addition to the works of the Birmingham School and Frankfurt School, the Club of Rome issued a report, titled "No Limits to Learning" where the role of "culture" is emphasized as a way to create global consensus to address persistent challenges (Botkin, Elmandjra, and Mailitza 1979):

> Moreover, because the global problematique affects all four and a half billion people grouped into more than 150 nation states and territories whose boundaries cut across a much higher number of cultures, it demands a type of learning that emphasizes value-creating more than value-conserving. The search for a global consensus on certain key values should not undermine the vital diversity of cultures and their corresponding value systems. At the same time, recognizing the claims of diverse cultures to their own identity also entails the necessity of encouraging joint responsibility for the solution of global problems.

While the report emphasizes the role of community to attain cultural evolution by creating more inclusive values, it does not address the very challenge of defining community and its role in sustainable development.

Bridger & Luloff (1999) outline major differences between sustainable community development and SD. Unlike sustainable development, "sustainable community development" stresses two routes of development. The first route of development seeks to sustain community cohesion; cohesion here does not imply homogeneity, but mainly sustaining "*community fields*" of interaction by bridging different social fields of interaction. These social fields of interaction are not defined by physical boundaries (borders) but rather socio-cultural interests. The second route of development, which has always been reiterated by development studies, in various and contentious forms, emphasizes economic development without compromising the needs of the environment and future generations (intergenerational equity) (Bridger and Luloff 1999). By adopting Wilkinson's (1991) definition of community which stresses the interaction dimension, the authors propose "*sustainable community development*" for two reasons. First, the proposed minimizes the shortcomings of contentions over the question of whose conception of sustainable development is more valid, e.g. the "constrained growth approach" or "the resource maintenance approach." Second, the adoption of "sustainable community development" empowers asking questions on the relevance and success of a development project; these questions are more context-bound as well as more community-based. This means that sustainable community development not only aims at developing material needs but also strengthening and creating more locally-based "community fields of interaction" (Bridger and Luloff 1999). These "community fields of interaction" are not necessarily well-defined, but rather constantly evolving depending on members' decisions to join the "community fields" which meet their needs.

Similarly, Wals & Schwarzin (2012) emphasize the crucial importance of interaction among members of a community to shape the course of a sustainable development (SD) project. They call for a shift to a more meaning-oriented approach which includes interaction among the people affecting/affected by the project, to examine an SD project. To attain a more meaning-oriented analytical model, the authors propose a "paradigmatic whole system redesign" (Wals and Schwarzin 2012). This means revisiting our most deep-seated convictions and interpretations of concepts such as conflicts, development, and interaction. For instance, the concept of conflict has been generally regarded as negative; the authors however conceive of conflict as an opportunity through which potential routes of interaction can emerge (Wals and Schwarzin 2012). In order to facilitate interaction among members of an SD project, "a learning system" based on "reflexive" and flexible learners should be encouraged. Such a type of "learning system" cannot be encouraged unless "uncertainty and controversy" on an SD project are seen as opportunities to maximize dialogue and interaction (Wals and Schwarzin 2012). The type of interaction the authors propose is "dialogic interaction." "Dialogic interaction" can be defined as sustained efforts to fully grasp other thoughts as well as reflect on our meta-cognitive patterns when it comes to thinking and expressing our positions on a certain SD project (Wals and Schwarzin 2012). "Dialogic interaction" does not seek closure; rather it is the "maximization of meaning" and community reflexivity which are regarded as processes of sustained community cohesion. "Dialogic interaction" contributes to building up "sustainability competence" to deal with difficulties including "indeterminacy, value-ladenness, controversy, uncertainty, and complexity" (Wals and Schwarzin 2012).

One major challenge to gauge who is more genuinely interested in sustainable community development is the question of legitimacy. Based on theoretical analysis of legitimacy and field work study of how legitimacy manifests itself in an English city, Connelly (2011) argues for conceptualizing legitimacy as an evolving constructed practice. This means that legitimacy should be examined at both the formal level (institutions, law, and politics) and the informal level. It is the informal level of legitimacy that demonstrates how legitimacy turns into a complex arena of power negotiation through informal spaces and manners of interaction such as personal relations and meetings in cafes. Thus, taking a cue from Beetham (1991), Connelly (2011) proposes investigating avenues of legitimacy as a "constructed property" continually subject to mutations. By studying how the project managers in the English city gain their legitimacy as community development organizers, Connelly (2011) concludes that “activism” should be used as a criterion to gauge the performance of community development staff. This is in contrast with the criterion of whether they are remunerated for their work. Remuneration for community organizing does not necessarily imply lack of commitment and legitimacy; one might be remunerated for community organizing to support his/her actions and tasks as one who is resistant to cooptation or corruption. Therefore, remuneration cannot be associated with lack of integrity and commitment (Connelly, 2011). It is worth-emphasizing that “activism,” for Connelly (2011), differs from the connotations usually associated with activism as publicly stereotyped: demonstrations, strikes, and risk-taking. Activism as a criterion assesses the extent to which the community development staff are engaged and committed to their works, and how their commitment and interaction with community members endorse the legitimacy of their stances and perspectives (Connelly 2011).

Central to legitimacy is identity projection: people resort to material(consumption) and non-material(social status and style) markers to legitimize their social and individual identity. Hurth (2010) examines the interaction between affluent identity and environmentalist identity and how they affect SD. The author starts by remarking that those who hold both affluent identity and environmentalist identity tend to have higher environmental footprints. This is explained by the fact that affluent identity is socially pressured to maintain its socio-economic status, yet it must constantly and anxiously renegotiate its environmental choices; which creates “value-action gap.” Hurth (2010) explains that the “value-action gap” marking affluent groups’ consumption choices brings into focus how socio-cultural factors shape affluent identity as well as environmental identity. After Hurth (2010) elaborated on postmodern perspectives and identity theories in the quest to account for how present consumption patterns are strongly linked to socio-economic transformations, she suggested to shift the focus from sustainable consumption to sustainable identities.

The attainment of sustainable identities requires, first, grasping what it means socioeconomically to be environmentalist or affluent, or what it means to hold both identities. Second, economic agencies, namely marketing ones, shaping consumers' choices should propagate consumption styles which contribute to the creation of sustainable identities. These sustainable identities, if embraced, will erode social pressures associated with affluence, as well as social stigmas linked to environmentalism (Hurth 2010). In a nutshell, there is a need to forge sustainable identities prior to the formation of sustainable consumption, since consumption communicates one's identity, and identity determines one's consumption choices. Similarly, Soron (2010) critiques economistic frameworks for attributing consumption patterns to socioeconomically and politically driven motives, suggesting perspectives that provide multifaceted explanations of how consumption patterns are enmeshed intricately in cultural identity, structural arrangements, and daily communicative acts. Soron (2010) therefore critiques engaging in the discussion of consumption styles from a dichotomous perspective: consumption as an individual self-identify act versus consumption as an economically and institutionally perpetuated act. Deploying "alternative models of sustainable consumption" developed by Seyfang (2006), Soron (2010) calls for more community-oriented initiatives not only to challenge the institutional and economic powers shaping our consumption patterns, but also to provide cultural and symbolic support to "individuated consumers."

Though sustainable development is rooted in the history of economic development/progress carried out within many cultures and civilizations, there has been a lack of consensus on what constitutes SD. This calls for concerted research and applied efforts to incorporate perspectives from different disciplines to build a comprehensive conception of SD. Social scientists therefore are invited to think about SD from their relevant disciplines, namely sociology of development and international development studies. Social scientists have attempted to develop a variety of methods to articulate a conception of SD. Application of these methods would be beneficial for two reasons: a) to examine the extent to which these methods themselves need revision to examine SD, and b) to identify or customize more methods to capture in deeper ways one's conception of SD. My goal is to familiarize myself with these methods and apply them, keeping in mind my main objective to gain insight into how proponents of GM technology argue for SD benefits experienced by adopters of GM crops.

METHODS

In this section I present the steps involved in sample choice, literature search protocol, themes identification, and analytical methods.

Sample Choice

Sample choice of this study is premised on the objective to focus on studies which put forward the benefits of biotechnology within the African context. This choice is justified by the need to fully grasp various conceptual and ideological precursors governing the pro-biotechnology camp before establishing any comparison with other camps which have different positions on biotechnology. To this end, I have revisited the studies covered in my past research experience on biotechnology in Africa to see if they emphasize the concept of sustainable development. My initial conclusion was that many articles, namely the ones drawing their data from African smallholder farmers, do not discuss sustainable development, directly or indirectly, with the exception of a very few studies which will be kept for analysis by in this chapter. This does not mean that they do not argue for SD benefits of GM crops: citation network analysis identifies authors who argue for a specific benefit of GM crops, e.g. environmental benefits, being cited by the selected studies which argue explicitly for SD benefits of GM crops. More importantly some of these cited authors themselves have published articles arguing explicitly for SD benefits: for example (Morse, Mannion, and Evans 2012), Gouse in his thesis (Gouse 2004), (Piesse and Thirtle 2009), and (Sexton et al. 2009). I elaborate below on how these cited authors were selected and describe their disciplinary backgrounds and analytical methods: see section (Influencers).

Following guidelines by Galvan (2006), I conducted a search for literature which relates the benefits of biotechnology to sustainable development or sustainability within the African agriculture context. This is meant to do justice to the question of whether sustainability has been examined as a core concept by pro-biotechnology studies. I emphasize that I excluded studies which do not make a direct mention of the concept of sustainability even if they evoke meanings of sustainable development in relation to biotechnology, such as: sustained productivity due to drought resistant maize, social welfare resulting from higher yields experienced by genetically modified (GM) crops growers, and environmental protection achieved by the reduction of pesticides sprayed as a result of using GM crops. Thus, the sample choice criteria are:

- Support SD benefits of GM technology by broaching definitional, conceptual and practical discussions of SD.
- Focus on the African context

Literature Search Protocol

I chose to use a search engine provided by the University of Missouri libraries to find relevant literature on genetically modified crops and sustainable development in Africa. In the early part of my dissertation research, this search engine tool was provided by ProQuest, while in later stages, the libraries switched to a search engine tool provided by Ebsco Discover Services.[3] While the exact databases that these search engines crawl is proprietary, they include major databases such as Agricola, EconLit and Scopus; thus, I am confident these search engines produced a comprehensive, if not completely exhaustive, list of relevant studies. In addition, the citations located within the relevant studies were reviewed to find more related articles.

The following descriptors were used to find relevant articles; priority was given to peer-reviewed articles, policy briefings, and books:

- *Genetically modified crops and sustainability in Africa*: This search resulted in a large number of studies, many of which are not relevant to the sample choice criteria. Many titles suggest anti- biotechnology attitudes or do not base their research on Africa. Most other studies focus on other types of biotechnology, namely medical biotechnology.

- *Biotechnology and sustainability in Africa*: I found many articles relevant to my research topic in the 20 first results. However, most of the references are related to other parts of the world, namely the United States, Asia and Latin America.

The latter descriptor, “biotechnology and sustainability in Africa,” yields more relevant results not because it is specific but rather because GM technology proponents prefer using the term biotechnology rather than GMOs (Cook 2004). It was clearly stated that the term “GMOs” tends to bring out negative images and misunderstandings; therefore most scientists prefer using “biotechnology” or “genetic engineering” instead (Ronald and Adamchak 2008). However,

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[3] Ciccone and Vickery (2015) showed no significant differences between these two search engines for either known-item or topical searches. Google scholar does slightly outperform either search engine on topical searches.

GMOs are defined as seeds or living organisms that have been genetically modified by either conventional breeding or biotechnology including genetic engineering; this definition is widely adopted by websites of both agribusiness and scientists (James Clive 2017). Food and Agriculture Organization (FAO) makes a clear distinction between GM technology and biotechnology: GM technology is one technique among the many techniques of biotechnology (FAO 2011). However, many US researchers and science organizations use the term biotechnology interchangeably with GM and genetic engineering (GE). In their online game[4], called *Biotech Biters*, ISAAA makes a distinction between traditional biotechnology (including conventional breeding) and modern biotechnology (including genetic engineering) that is more precise and accurate to transfer the desired gene .I discuss in the fifth chapter how using "biotechnology" in the Moroccan context would have yielded completely different results since some forms of biotechnology are widely adopted in Morocco, while the use of GM technology is still hotly debated.

I also used the word "sustain" as a search term within primary sources to find relevant references that are either published by journals whose niche research interest is related to sustainability or their titles refer to concepts of biotechnology and sustainable development.

Final Sample

After examining more than 100 peer-reviewed articles that argue for the benefits of biotechnology in the African context, I chose 35 studies (four later added for citation network analysis) to be coded according to the customized typology from Davidson (Davidson 2014). The selected studies argue explicitly for the benefits of biotechnology to African agriculture

[4] See the game on their website: http://www.isaaa.org/resources/interactivegame/biotechsquizbox/default.asp

from a sustainability perspective. They do so primarily by engaging with theoretical and practical dimensions of SD and how it can benefit from GM technology.

The themes for my conceptual model are:

- The capacity of biotechnology to address environmental stresses caused by the use of pesticides and insecticides through the development of insect and pest resistant crops (Abidoye and Mabaya 2014; Bennett et al. 2003; Bennett, Morse, and Ismael 2006; Elbehri and Macdonald 2004).

- The capacity of biotechnology to contribute to food security in Africa by increasing production sustainably(Azadi and Ho 2010; Clarke and Zhang 2013; Ozor and Urama 2013; Sasson 2012; Trewavas 2008).

- The capacity of biotechnology to save labor (weeding), arguably allowing more time, namely among women, for child-rearing and household activities (Gouse et al. 2009).

- The capacity of biotechnology, along with other food production systems (such as local food systems and organic farming) to address food security challenges (Azadi and Ho 2010; Novy et al. 2011; Ronald and Adamchak 2008).

Analytical methods: Data search and synthesis followed a systematic review strategy as proposed by Galvan (2006). Thus, the adopted meta-analysis approach seeks to grasp the salient theoretical frameworks, investigative tools, and conceptions of SD deployed by the pro-biotechnology camp to demonstrate the potential benefits of GM crops for African agricultural sustainability.

Conceptual Framework

Because the literature on the contribution of biotechnology to agricultural development in Africa is so rich and diverse, I have decided to limit my meta-analysis to the studies that engage in conceptual discussion of SD and emphasize directly the tenets of sustainable development: economic growth, social benefits, and environmental protection. The developed conceptual framework has been shaped by a) past research experience on biotechnology, and b) recent examination of typologies that seek to systematically outline sustainable development debates. Application of these typologies serves two objectives. First, it contributes to debates about how to build a typology capable of grasping salient features of one's SD conception (these debates will be discussed under the section of sustainable development typologies). Second, major findings obtained from the application of the typology will inform future avenues of research into GM proponents' arguments on GM technology's SD benefits.

A) Past Research on Pro-Biotechnology Groups in Africa

My past review of studies on the benefits of biotechnology to African farmers involved the categorization and synthesis of 82 studies (peer-reviewed articles and policy reports). The main objective was to address the question of the extent to which African small farmers' experiences and practices are considered by proponents of biotechnology. Central to research on the arguments of biotechnology in Africa is the examination of their sources of evidence. As will be elaborated in the subsequent chapter, I found that few articles base their findings on data elicited from smallholding farmers' experience with GM technology. The main linkage between the findings of my past research and the current research topic is the fact that some studies have relied on the concept of sustainable development to argue that biotechnology can solve current African agriculture challenges related to climate change, e.g. droughts, floods, and pests.

Many pro-GMOs studies, namely the ones based on farmers' data, do not explicitly refer to sustainability to argue for GMOs benefits. They do, however, report environmental, social, and economic benefits experienced by adopters of GM crops, which could be interpreted as an implicit reference to sustainability. Though these studies do not invoke sustainability benefits explicitly, they are cited by studies that are explicit about sustainability benefits of GMOs. Through citation network analysis, I will document the number of studies that influence discussions around sustainability benefits of GMOs.

In general, the pro-biotechnology studies pursue four itineraries of argumentation to substantiate the benefits of biotechnology: discussion of international politics hindering the expansion of biotechnology, production benefits of biotechnology, biotechnological contribution to environmental protection, and critique of institutional arrangements as obstacles to fully gain the benefits of biotechnology. Each of the four itineraries of argumentation are expounded upon below.

International politics hindering the expansion of biotechnology. This argument is relevant to debates on what constitutes sustainable development, namely sustainable agriculture, in two ways. First, since the rise of environmentalist voices speaking out against the detrimental effects of conventional farming on the environment, the question of what is "sustainable agriculture" has been contested in various academic and policy arenas (Borlaug 2000; Paarlberg 2010). An unprecedented skepticism arose towards the safety and sustainability of newly developed agricultural technologies, namely biotechnology. Debunking this arguably unfounded skepticism toward the potential benefits of biotechnology to agricultural sustainability has constituted the main avenue of research for various researchers (Borlaug 2000; Morse et al.

2012; Trewavas 2008). Second, various scholars have argued for the contributions of biotechnology to attain sustainable agriculture (Juma 2011c; Ronald and Adamchak 2008).

Another avenue of research argues that GM technology and other farming practices, namely organic farming, are complementary to each other. For instance, Ronald and Adamchak (2008) argue that both organic farming and genetic engineering can contribute to meet our food needs in a healthy and sustainable manner. Ronald and Adamchak (2008), in the following quote, represent organic farming metaphorically as the "Swiss Army Knife" and biotechnology as "molecular scissors": "The Swiss Army knife and the molecular scissors are examples along a continuum of new technologies developed through human endeavor and creativity" (Ronald and Adamchak 2008). Presenting both organic farming and biotechnology as "examples along a continuum of new technologies developed through human endeavor" is an emergent theme in studies positing that organic farming and biotechnology are not antithetical since each one has its own niche market. For example, "research shows that at the national level, organic and GM agriculture are not antagonistic technologies" (Novy et al. 2011). Research on controversies surrounding the rejection/adoption of biotechnology in relation to organic farming has constituted a major research route for proponents of biotechnology to unravel the ideological motivations behind rejection of biotechnology in Africa. Various authors have asserted that European political and economic pressure is the main reason behind Africa's slow adoption of agricultural technological innovations, particularly biotechnology (Okeno et al. 2013; Paarlberg 2008, 2010; Takeshima and Gruère 2011; Wambugu 1999).

Production benefits of biotechnology. Most covered studies associate biotechnology with higher yields experienced by small and large scale farmers (Abdallah 2014; Abidoye and Mabaya 2014; Bennett et al. 2003, 2006; Gouse et al. 2009; Gouse, Pray, et al. 2005; Groote, W.

a Overholt, et al. 2011; IFPRI 2013; Y Ismael, Beyers, et al. 2002). In the African context, only four countries have adopted commercialized genetically modified crops: South Africa (1998), Burkina Faso (2008), Egypt[5] (2008), and Sudan (2012). Yet, most data on farmers' experiences with GM crops is drawn from South Africa, the first African country to adopt GM crops (Karembu 2009).

Biotechnology's contribution to environmental protection. Various studies argue for the environmental benefits provided by biotechnology, including reduced input (pesticides) , reduced water use thanks to water efficient GM crops, and improved human health thanks to reduced exposure to hazardous input (Morse and Mannion 2009; Paarlberg 2010; Popp and Lakner 2013; Virgin et al. 2007; Vitale, Ouattarra, and Vognan 2011). Associating environmental protection with biotechnology makes it, for various studies, an integral solution to combatting environmental stresses (Clarke and Zhang 2013; Thirtle et al. 2003).

Critique of institutional arrangements as obstacles to fully gain the benefits of biotechnology. Proponents of biotechnology have argued that the benefits of the technology cannot be fully gained unless the right institutional arrangements, namely appropriate market structures, are put in place (Adenle 2014; Gouse, Kirsten, et al. 2005).

B) Sustainable Development Typologies

The formulation of the conceptual framework for this paper has also been influenced by typologies suggested to organize information on sustainable development debates (Connelly 2007; Davidson 2014; Hopwood et al. 2005). Such typologies assist in contextualizing and situating arguments about what constitutes sustainable development. As stated earlier,

[5] Conflicting accounts have been found about whether Egypt still grows GM crops, namely GM maize.

Davidson's typology is adopted, but customized, to organize information on pro-biotechnology arguments on SD benefits of GM crops in Africa.

Emphasis on sustainable development	Definition of Sustainability						Authors' sources of Data			
1=significant emphasis 2= some emphasis 3= little emphasis	The approach: 1= neoliberal 2= Social Democratic 3= Radical 4= do not apply	Recognizes Limits to Growth: 1: Yes 2= NO 3= to some extent 4= do not apply	Role of technology 1= emphasized 2= not emphasized 3= fairly emphasized	Capitals substitutability: 1=Yes 2=no 3= to some extent 4= do not apply	Considers power relationships: 1=Yes 2=No 3= to some extent	Emphasize environmental protection: 1:YES 2: NO 3: do not apply	media	Review	politicians	Farmers

Figure 2 Customized typology of pro-biotechnology arguments about sustainability

Special attention was also paid to background information of the coded articles (see appendix A, the second table).

RESULTS: SUMMARY GRAPHS AND DISCUSSION

In this section summary graphs will be presented thematically accentuating the main findings.

A) Emphasis on Sustainable Development:

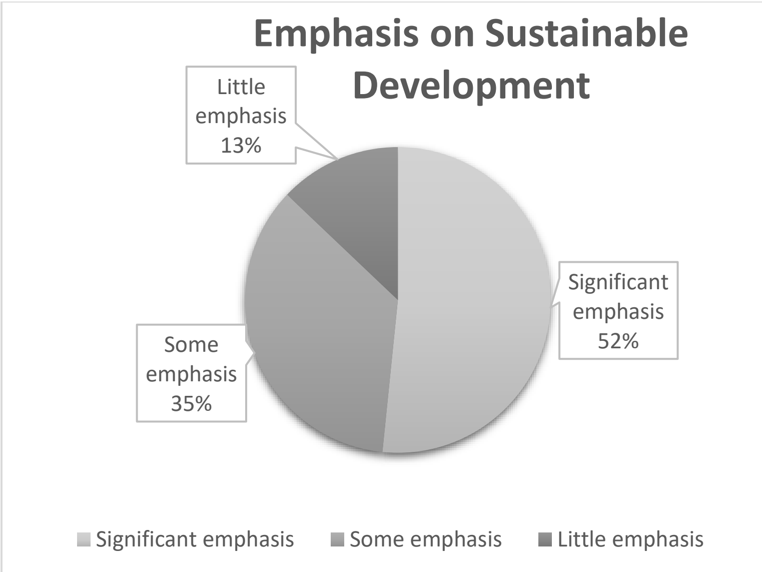


Figure 3 Emphasis on sustainable development

I gauged articles' emphasis on sustainable development based on word count of "sustainable development," journal type (some articles were published by Sustainability Journal), inclusion of sustainable development concept in the title, and direct discussion of sustainable development in relation to biotechnology. As stated in the sample choice section, only articles emphasizing sustainability concept were chosen; yet the extent to which the concept of sustainability is emphasized was examined in depth in each coded study. The general finding is that over 87 percent of studies emphasize sustainability in relation to biotechnology: 52% of studies significantly emphasize sustainable development, and 35% of studies give some emphasis to sustainable development.

B) Approach to Sustainability

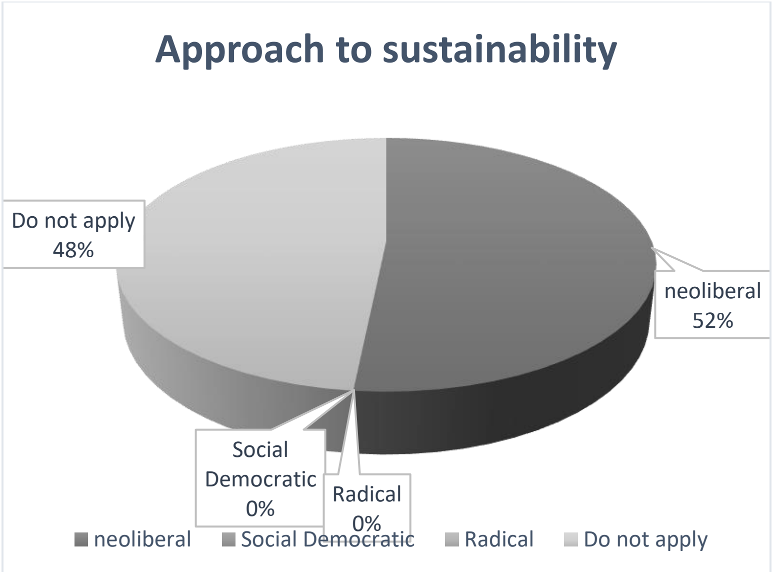


Figure 4 Approach to sustainability

Various taxonomies have been suggested to categorize approaches to sustainable development, such as weak vs strong, reform vs transformation, and others. Davidson's original typology suggests six taxonomies: Neo-liberal, Liberal, Social Democratic (macro), Social Democratic (micro), Radical (Macro), Radical (Micro). I chose three of these taxonomies: social democratic, neoliberal, radical. I decided to add a "does not apply" category for studies that do not show any affiliation to an ideological camp. The unselected taxonomies were excluded because they are nuanced variations of the selected three typologies: e.g. radical (macro) calls for global radical approaches to attain SD by eradicating hierarchical economic relations and ceasing anthropocentric domination of nature, and radical (micro) focuses on local and regional radical approaches to SD.

Fifty-three % of studies adopt a neoliberal approach to implementing biotechnology in Africa; studies were deemed as neoliberal based mainly on their explicit affiliation with major national and international neoliberal organizations, such as the Rockefeller Foundation and seed companies, such as Syngenta and Monsanto (now Bayer). Such studies also emphasize the crucial role of the private sector to facilitate biotechnological diffusion and access to credit.

C) Recognition of Limits to Growth:

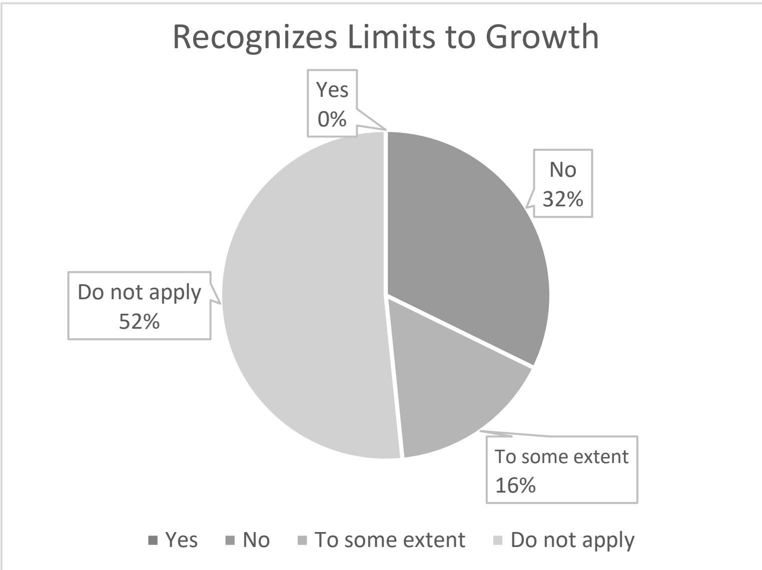


Figure 5 Recognizes limits to growth

Various arguments on the capacity of technological innovation to solve socio-economic and environmental challenges have been brought to the surface by the so-called cornucopian theories, Boserupian theories, and modernization theories. The common feature among these theories is the conception of human challenges as major impetuses of technological innovation; they hold that technological innovation becomes a source of continuous prosperity and welfare. All the examined studies conceive of technological innovation as one of the most important tools to attain sustainable food production in Africa. None of the coded studies recognizes limits to growth: 32% do not recognize limits to growth while 52% were deemed as “do not apply” to the question of whether they recognize limits to growth or not; this is meant to do justice to studies that do not touch directly on the question. Even studies not emphasizing limits to growth do reiterate the argument that population growth requires more technological innovation to feed 9 billion people by 2050. Sixteen % of studies that recognize limits to growth to some extent do so by emphasizing that growth should take place within a holistic approach to sustainability (Virgin et al. 2007).

D) Role of Technology:

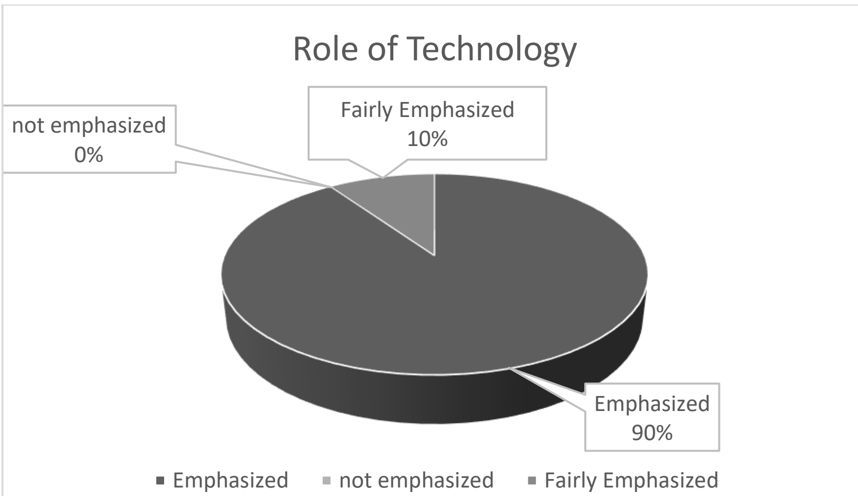


Figure 6 Role of Technology

It is obvious that proponents of biotechnology would present technological innovation as a key solution to attain food security in Africa; it is however interesting that the role of technology is emphasized to build up the tenets of sustainability: economic growth, social equity, and environmental protection. Thus, sustainability, for biotechnology proponents, requires technological innovations, such as genetically modified pest-resistant crops that would reduce input use (pesticides), increase yield, and create more sustainable farming activities (requiring less off-farm activity). There have been, however, arguments put forth on the need to postpone the diffusion of GM technology given the controversies it has created (Bornman el al, 2004). Bornman et al (2004) call for less focus on “glamourous biotechnology”, namely GM technology.

E) Capitals substitutability:

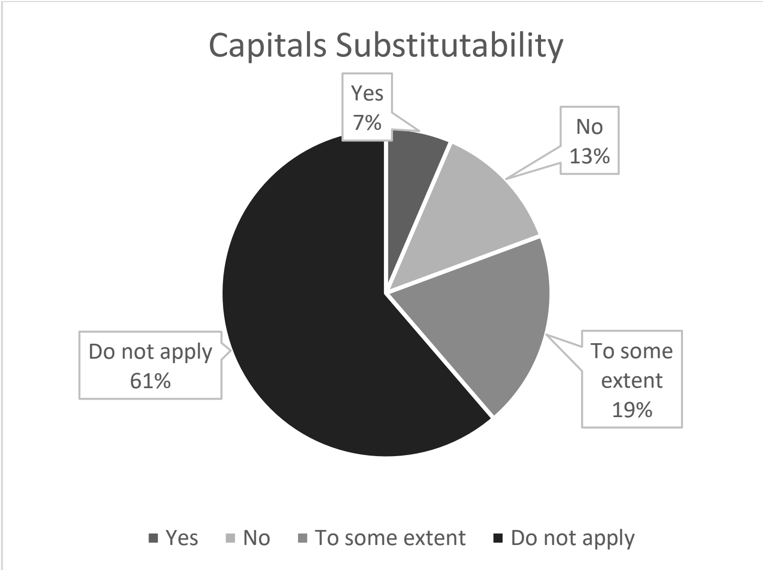


Figure 7 Capitals substitutability

The fact that 61% of the coded studies do not apply to the question of capitals substitutability can be attributed to the fact that studies' unit of analysis is Africa, a continent believed to lack development of various capitals: human, social, economic, and natural.

F) Considering Power Relationships:

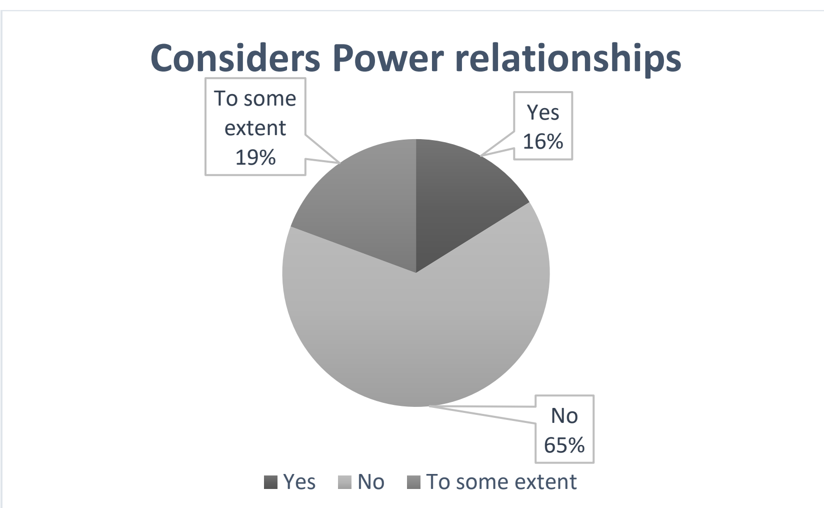


Figure 8 Considers power relationships

Studies that consider power dynamics (22%) have a distinct explanation of how power relations are related to biotechnology in Africa. This explanation attributes Africa's slow adoption of biotechnology to European pressures on African political stakeholders. Various studies have argued that Europe imposes its conception of agricultural sustainability-- GMO free--on Africa, while Africa needs technological innovations at the present and the future more than any time before. Chapter five engages with the literature arguing that Europe pressures Africa not to adopt GM technology.

G) Emphasis on Environmental Protection:

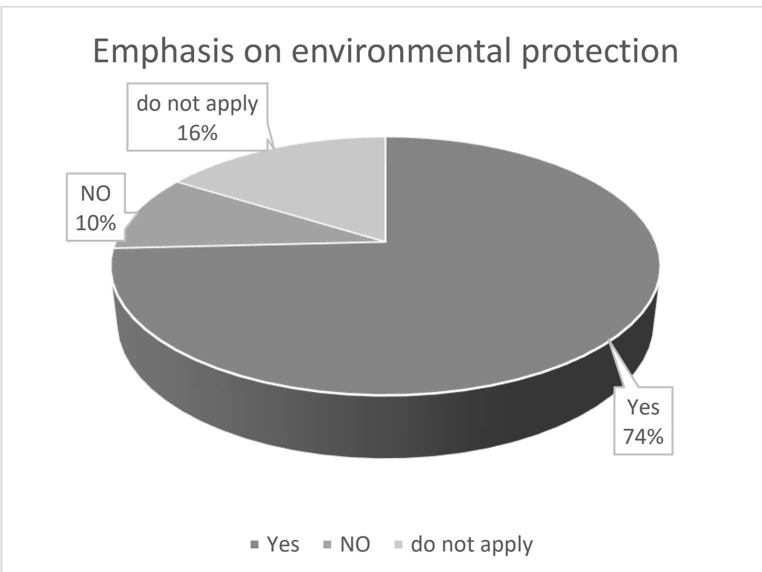


Figure 9 Emphasis on environmental protection

Emphasis on environmental protection in relation to biotechnology is brought into discussion in two ways. First, studies have showed that biotechnology has benign effects on the environment if the right biosafety regulations are put into place. Second, studies argue that biotechnology has proven its potential contribution to environmental protection thanks to its capacity to limit/eliminate harmful inputs if pest resistant crops are adopted, for instance.

INFLUENCERS: RESULTS OF CITATION NETWORKS ANALYSIS

Purpose of Citation Network Analysis: I argue that all GM proponents argue for GM sustainability benefits regardless of whether they make an explicit or implicit reference to SD. In order to respond to the question: why would one classify a study that simply reports one specific GM benefit, e.g. health benefits (less exposure to pesticides), without an explicit reference to SD, as promoter of GM sustainability benefit? The answer is threefold. First, SD is unquestionably embraced almost in every field by business, development agencies, corporations, and non/governmental organizations. For instance, *Philip Morris* (Cigarettes) reports at length on its sustainability agenda and how it seeks to become a "true leader in sustainable business practices" (Philip Morris International Sustainability Report, 2017).

Second, (as mentioned before) some of the cited authors do have studies where they explicitly argue for SD benefits of GM crops : (Gouse 2004; James Clive 2017; Juma 2011c; Morse and Mannion 2009; Paarlberg 2008).

Third, through citation network analysis, using GEPHI (an open-source network analysis and visualization software), I conclude that many studies that do not report explicit GMOs sustainability benefits do inform/influence explicit proponents of GMOs sustainability benefits. The charts below report the results of citation network analysis, which shows the major influencers. They demonstrate that many authors who do not make a direct reference to SD are nonetheless major influencers cited by those who explicitly discuss GM sustainable development benefits. This citation analysis is based on my familiarity with major proponents of GM technology, gained by examination of a sample of 82 scholarly works. These scholarly works will be examined in depth in the third chapter. Eleven authors were selected from the 82 scholarly works based on the hypothesis that they are most highly cited to argue for GM sustainability benefits in Africa; this hypothesis is based on the examination of pro-GM studies in the African context. I do not claim that the list of selected cited authors/influencers is limited to the authors presented below.

The selected authors are Robert Paarlberg, Calestus Juma, Marnus Gouse 2009 who coauthors with Johann Kirsten, Robert Bennett who coauthors with Steven Morse, Clive James, Colin Thirtle, Barfoot and Brookes, Ismael Youssouf, and David Zilberman. I examined the extent to which these authors are cited by the 31 articles that argue explicitly for SD benefits of GM crops.

Understanding the citation network analysis should be linked to the main findings that are substantiated in the third chapter: limited data based on farmers, limited data based on African countries, limited choice of data collection methods (some rely on surveys collected by seed companies), lack of disciplinary diversity among GM proponents (most belong to agricultural economics), and dominance of meta-analysis studies, namely by Clive James and Brook and Barefoot. At this stage, the citation analysis demonstrates that many studies that do not report explicit sustainability benefits do inform others' explicit promotion of GMOs sustainability benefits.

There are three categories of influencers/cited works:

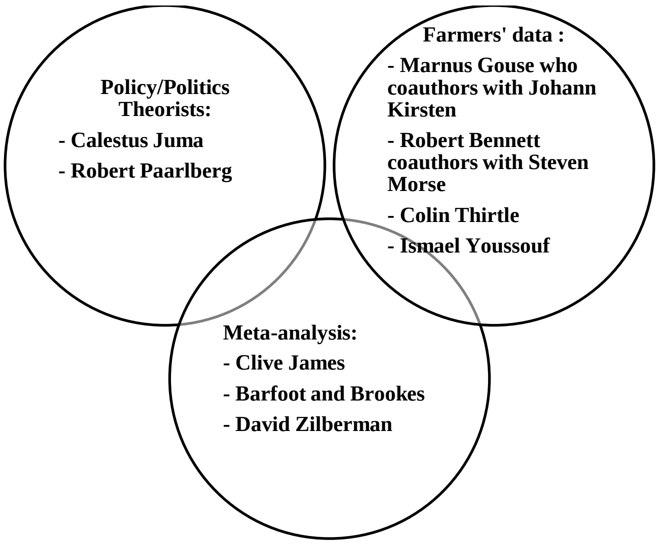


Figure 10 Three categories of influencers/cited works

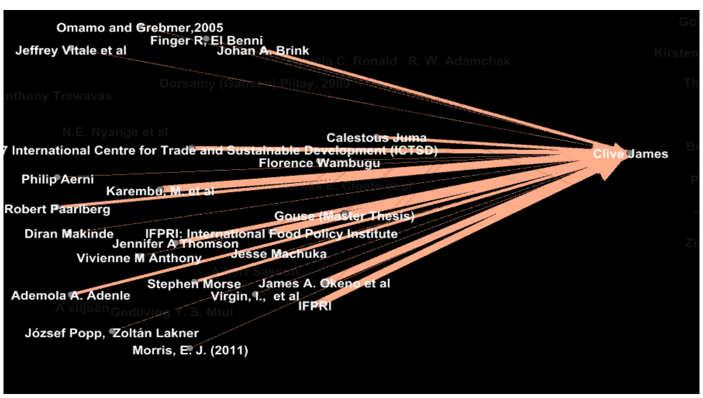
Because four studies in the original sample cited none of the selected influencers/authors, I added four more studies that argue explicitly for SD benefits of GM crops (see figure 11). In addition Gouse's thesis (Gouse 2004), which uses sustainability explicitly, was excluded because it is not a peer-reviewed article.

Figure 11 Articles that do not cite an of the selected influencers

Influencers rely on three sources of evidence: meta-analysis, farmers' survey data, general (policy and review of literature).

Meta-analysis. The first and second main authors: Clive James (James 2010, 2011), and Brook and Barefoot (Brookes and Barfoot 2011, 2013a, 2015a) fall into this category. Clive James holds the Emeritus Chair of the board of directors of ISAAA (The International Service for the Acquisition of Agri-biotech Applications). ISAAA is a key influencer whose work goes beyond research to encompass assisting with agricultural biotechnology capacity building through its research and policy networks worldwide. Brookes and Barfoot are affiliated with big agribusiness through CropLife (https://croplife.org/about/), for which they have published more than 20 articles.[6] The third author is David Zilberman, professor of agricultural and resource economics at University of California Berkeley.

Figure 12 Studies citing Clive James



[6] See the crop life website: http://biotechbenefits.croplife.org/paper_authors/brookes-g/

Figure 13 Studies citing Barfoot and Brook

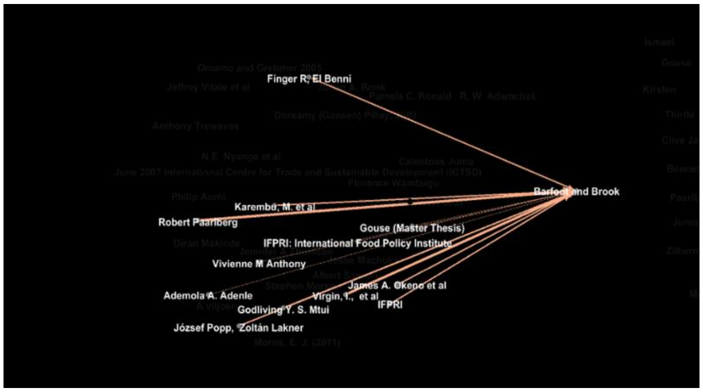
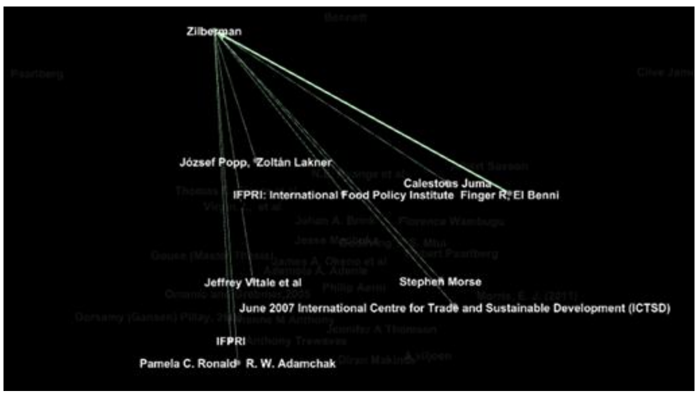


Figure 14 Studies citing Zilberman



Influencers whose data is based on farmers' data. Detailed information on these influencers and others who base their data on farmers' experiences with GM crops, will be provided in the third chapter.

Figure 15 Studies citing Marnus Gouse

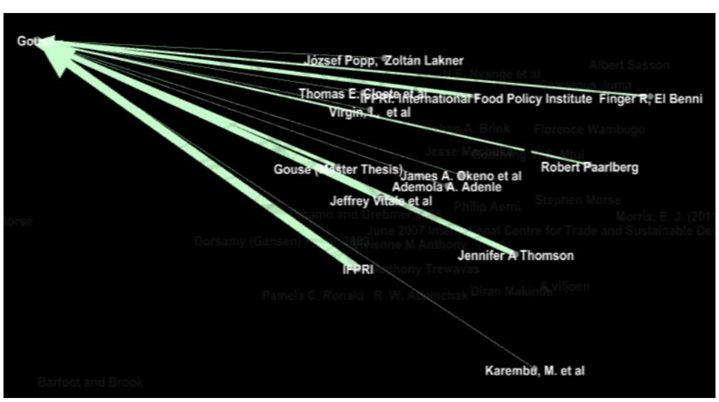


Figure 16 Studies citing Bennet

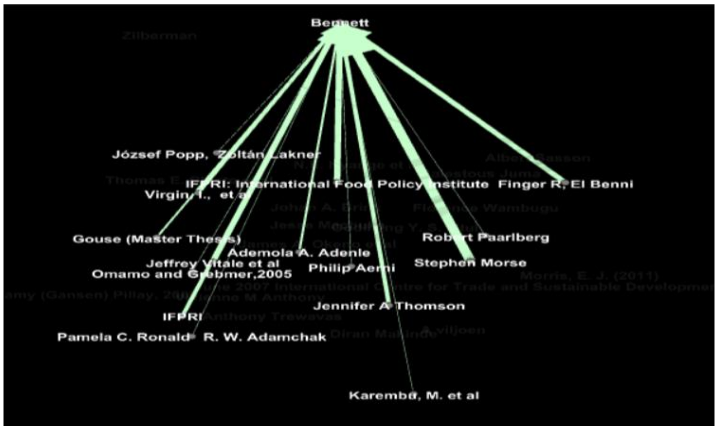


Figure 17 Studies citing Stephen Morse

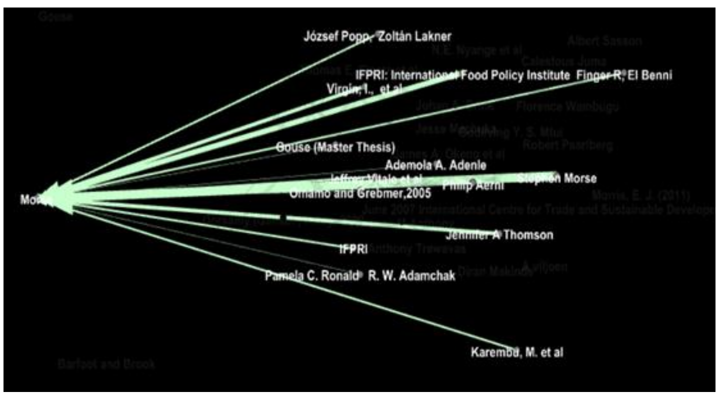


Figure 18 Studies citing Kirsten

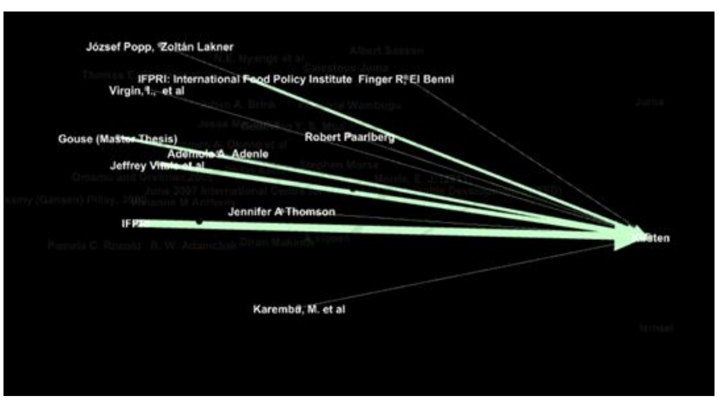


Figure 19 Studies Citing Ismael

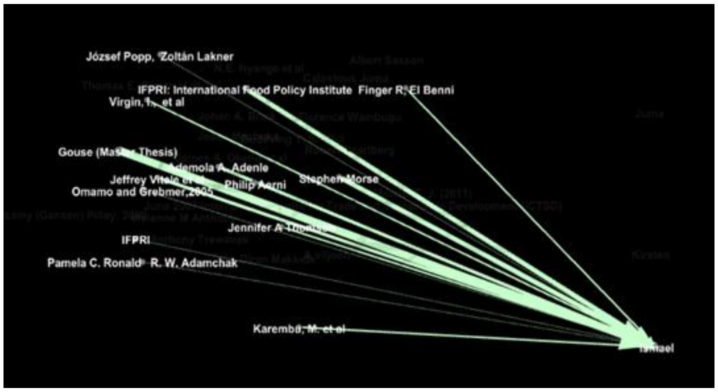
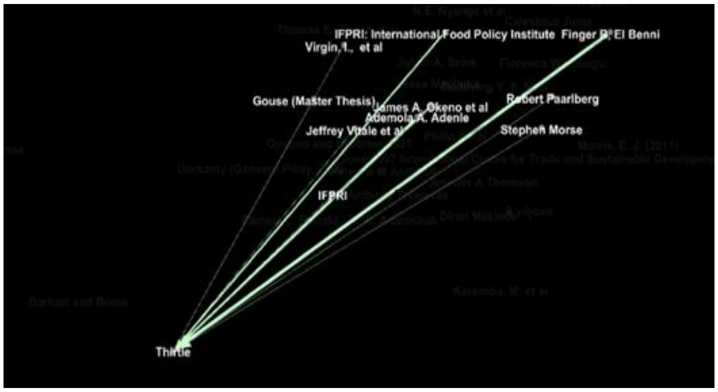


Figure 20 Studies citing Thirtle



General (policy and review of literature). Authors in this category are major influencers in the GMO policy arena at the global level. They challenge negative attitudes towards GM technology. A more elaborate account of their perspectives is presented in the third chapter.

Figure 21 Studies citing Paarlberg

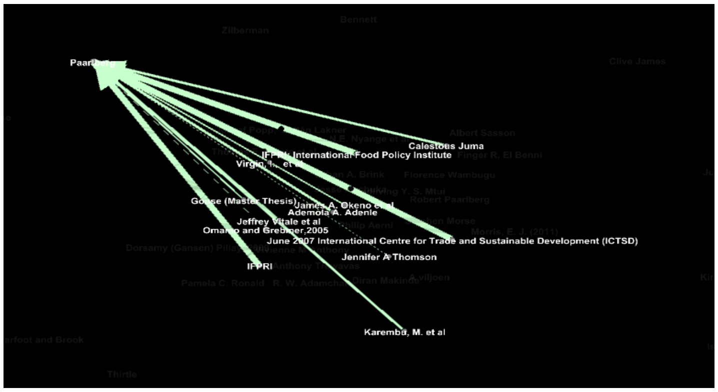
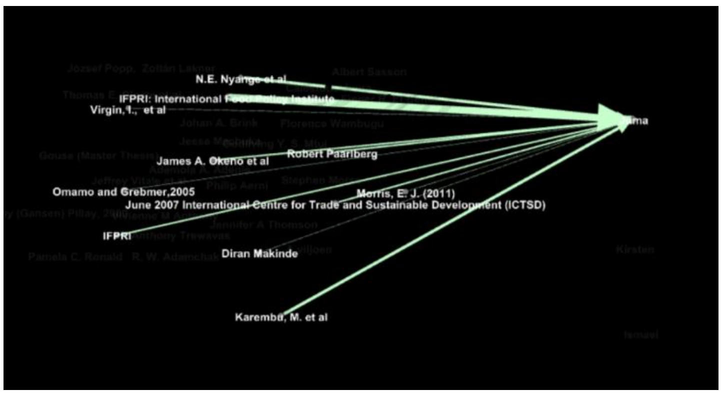


Figure 22 Studies citing Calestus Juma



DISCUSSION

Sustainability as the zeitgeist of pro-biotechnology proponents. Though the selection of relevant studies for this paper was based on the criteria of sustainability emphasis, both the chosen and unselected studies used the term “sustainable” and “sustainability” to denote meanings of sustainability that would not be shared or accepted by other academic/ideological camps who have a different paradigmatic conception of sustainability. What we learn from this is that any reference to the concept of sustainability should be treated as mainly a generic use of the word “sustainability” that is open to various meanings. These meanings can be antithetical though they are represented by the same concept and terminology, which is sustainability. Take for example this statement: *"This project involved collaboration between KARI, a project called Agricultural Biotechnology for Sustainable Productivity, funded by the US Agency for International Development, and Monsanto"* (Wambugu 1999). This statement refers to "sustainable productivity," sustainable production, however, would not be included appropriately within this context if it is not related to biotechnology that is presented in the statement as a key approach to attain sustainable productivity.

The malleability of the concept of "sustainability" calls for a more dialogic interaction among stakeholders in the arena of African agriculture. Dialogic interaction is key to defining the meanings of sustainability. Unfortunately, SD is merely used as a smokescreen by stakeholders who hold antithetical conceptions of what is to be sustained and how to sustain it. It is therefore more sincere to start with the assumption that we mean different things when using SD. Embracing our conceptual differences about SD is a key step in identifying sources of disagreement. These sources of disagreement could result from lack of open dialogue or incommensurability (unsolved incompatibility) of the mental models framing what is sustainable and what is not.

*Sustainability and sources of evidence***.** Only 4 studies base their data on small-holding farmers' experiences with GM crops. The paucity of data on African small farmers' experiences with GM crops raises questions of whether small-holding farmers are familiar with differences between GM crops and non GM ones (Jacobson and Myhr 2013). It also justifies criticisms regarding the relevance of GM crops to small farmers' livelihood systems (Schnurr and Mujabi-Mujuzi 2014). In the next chapter, which examines articles' inclusion of African farmers' experiences with GM crops, I will delve deeper into the question of the extent to which farmers' experiences are considered in the development of GM crops.

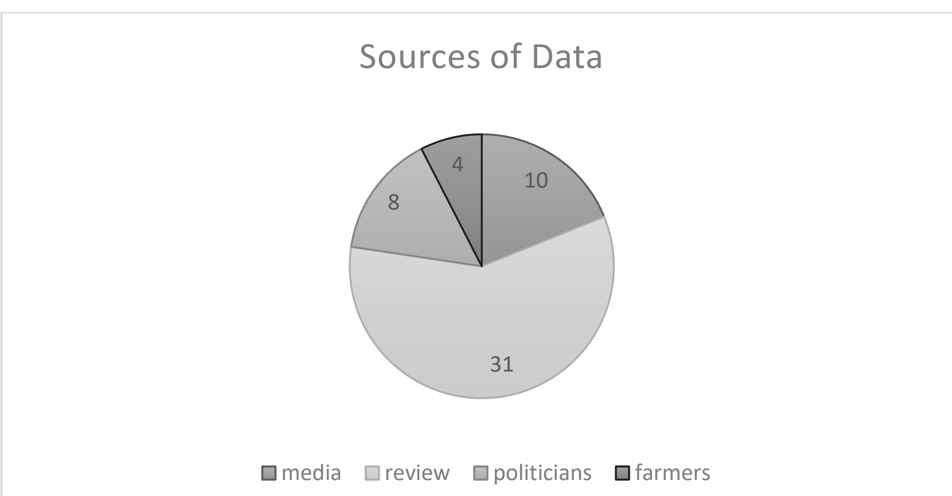
Sustainability and social justice. Though historically lack of social justice is the main socio-economic impediment to attain sustainable development for most African countries, very few pro-biotechnology studies pay attention to how the introduction of GM crops might benefit some stakeholders at the expense of others. There is however emphasis that the success of GM crops depend on appropriate institutional and market arrangements (Gouse, Kirsten, et al. 2005). Though there is a vast literature elaborating on how rural livelihoods suffered under colonial and later governmental oppressive policies, we see reference to such literature lacking among GM proponents (for more accounts on structural oppressive practices affecting farmers, see (Ferguson 2013; Kepe and Ntsebeza 2011). As will be discussed in chapter four, without putting farmers' livelihood struggles in the local and inter/national historical, political, and sociological context, no solution/technology is capable of addressing farmers' struggles.

The purveyors of sustainability and African poverty. Most studies emphasize a definition of sustainability developed by Euro-American stakeholders. Thus, the sustainability definitions used do not stem its principles from African local dynamics of development but rather from visions and agendas developed in Euro-American countries. In his criticism to European influence on African non-adoption of GM crops, Paarlberg (2008) labels European pressure as the "imperialism of rich taste." Taking a cue from Paarlberg (2008), I conclude that both pro- and anti-biotechnology agendas are driven by the imperialism of a Euro-American definition of sustainability and development. Most influencing research and research institutions belong to the European and American context, as indicated by the citation network analysis. The influencers' arguments are provided in detail in the third chapter which focus on articles that refer to African farmers' experiences to argue for benefits of GMOs.

RESEARCH LIMITATIONS AND RESEARCH AGENDA MOVING FORWARD

This study would not be a fully-fledged meta-analysis of biotechnology studies in Africa if it did not systematically examine arguments critical of biotechnology. A deeper look at the literature that is critical towards biotechnology is necessary to formulate a more representative sustainability typology that systematically accounts for both stances governing pro and anti-biotechnology perspectives. More attention should also be given to institutional and academic backgrounds of authors of the coded literature. The customized typology grasped some elements of pro-biotechnology proponents; however, I believe there is a need to develop a framework of analysis that could more deeply examine pro-biotechnology arguments on GM benefits to African farmers. A focus on the question of whether African farmers' livelihood realities are accounted for by pro GM technology would yield more avenues of discussion and research on how GMOs could benefit African farmers, namely smallholder farmers. This question is further pursued in the next chapter (chapter three).

Moving Forward: Where is the Farmer?



While the meta-analysis in general has revealed information on the examined studies, it is striking to see few studies that are based on farmers' practices: only 4 studies of 31 base their data on African farmers. Since the sample number is relatively small and does not encompass all studies that argue for GM sustainability benefits implicitly or explicitly, I decided to delve deeper into studies that argue for benefits of GMOs, with a focus on completing a list that uses farmers as a source of data.

While the meta-analysis provides general results on proponents' arguments that GM technology produces SD benefits, a systematic review of each typology component would be needed to have a deeper understanding on how GM technology is argued to benefit SD. In the third chapter I focus on the question of the extent to which African farmers' practices are considered by GM technology promoters. The focus is justified by the fact that these farmers have unique struggles. They have the highest poverty level where three quarters of people living in extreme poverty are in rural areas and live with 1.25$ a day namely in sub-Saharan Africa (Bailey, Willoughby, and Grzywacz 2014). Agricultural technological solutions are supposed to target first and foremost this vulnerable population. In addition to their roles as farmers, they are food consumers; they are therefore strong representatives of consumers' preferences. Furthermore, "small farmers provide up 80 % of food supply in Asia and sub-Saharan Africa"(FAO n.d.), yet 80 % of farms in Africa are less than two hectares (High Level Expert Forum 2009).

CONCLUSION

This study shows that the concept of sustainability is the mainstay of pro-biotechnology arguments intended to demonstrate the relevance of GM crops to solve African agricultural challenges. It also shows the malleability of the concept of sustainability, which is invoked both by proponents to tout the benefits of biotechnology, and by critics of biotechnology to warn against dangers of GM crops. One of the central conclusions is that the examination of pro-biotechnology arguments on the relevance of biotechnology to African agricultural sustainability has been premised on skimpy sources of evidence from small-holding farmers. Moreover, smallholder farmers' agricultural sustainable development is defined by Euro-American agendas rather than local knowledge. Moreover, African agriculture is treated as a homogeneous system. There is therefore a need for more cooperation among different types of knowledge to account for the peculiarities of sustainability challenges in the different African agricultural contexts. There is no way to account for farmers' context-bound challenges unless we refrain from invoking Africa as a homogenous agricultural reality.

There is also a need to focus more on questions of "the substitutability of capitals" and sustainability "tradeoffs" associated with GM technology adoption (Gliessman and Rosemeyer 2009). This is important given that no sustainability project can be immune from shortcomings and limitations. If GM technology is promoted as a sustainable technology without acknowledging its limitations, skepticism towards it becomes more strongly justified. Criticisms towards SD agendas have been on the rise given that SD has been used in various instances as "rhetorical cloak." It therefore does not suffice to adopt SD as a framework to advance one's claim. Advancing claims on SD requires the inclusion of diverse disciplinary backgrounds that examine SD from various perspectives. Because SD encompasses aspects that are economic, social, environmental, non/human, any SD conception would be a self-defeating enterprise if it does not include diverse non/academic disciplines and stakeholders.

The disciplinary networks of GM proponents tend to be homogenous and very limited: agricultural economists associated with agribusinesses and scientists (holding policy related positions) related to crop sciences, e.g. plant geneticist, biochemists, and molecular biologists (see Appendix B). These homogenous stakeholders seem to face an irreconcilable conflict of interest: growing corporate profits and conducting scholarly/applied research. This makes research on SD benefits of GM crops prone to self-fulfilling prophesy since any research finding that reveals serious limitation of the technology poses market risks to the commercialization of GM crops. Some of the influencers were supported by large agri-businesses and big donors (Bennett et al. 2003; Gouse et al. 2009; Gouse, Pray, et al. 2005; James Clive 2017; Juma 2011c; Morse, Bennett, and Ismael 2005; Shankar and Thirtle 2005; Takeshima 2010; Jeffrey Vitale et al. 2008).

I believe collaboration with the private sector is important given that the involvement of the private sector is inevitable within the current international development setting. However, the main challenge is whether researchers, in general, while supported by the private sector, are empowered enough to change the paradigmatic starting points of agricultural corporations. For instance, can one move from questions on the SD benefits of GM crops to questions on the relevance of GM crops in the first place? This becomes difficult knowing that the marketplace of innovation is strongly founded on hype: the crucial importance of good news to rally stockholders' support.

More importantly, competition to patent and commercialize GM crops is prioritized over examining GM crops' relevance to farmers: Morris (2011) cites examples of domination of large seed companies to obtain regulatory approval of GM crops even faster than national local researchers (Morris 2011).

Finally, for a sustainable collaborative dialogue to take place, several things need to happen:

- The inclusion of farming communities prior to GM crop development, during and after commercialization;
- Diversification of research disciplines by building legitimacy through interaction with different research communities so as not to fall into disciplinary arrogance. This is especially important in order to diversify research methods since GM proponents rely heavily, if not solely, on surveys. Most of these surveys are conducted by seed companies, namely *Vunisa* (Bennett et al. 2004; Gouse, Kirsten, et al. 2005; Morse et al. 2005; Shankar and Thirtle 2005; Smale et al. 2009);
- Maximization of dialogue among stakeholders with opposing agricultural approaches, e.g. between organic and GM crops developers;
- Acceptance of the "uncertainty and controversy" on GM SD benefits as opportunities for further research, dialogue and interaction.

CHAPTER 3: ACTUAL FARMERS' PRACTICE AND GM TECHNOLOGY FOR SUSTAINABLE AGRICULTURE IN AFRICA

Discussions around GMOs in Africa are primarily tied to food insecurity. Many of the arguments for the use of GM crops are based on the idea that food insecurity is caused by low productivity, especially as related to an increasing population that must be fed. However, increasing productivity can also cause environmental damage, as documented with many of the advances of the Green Revolution. One argument for promoting GM hinges on the idea that GM crops will lessen negative environmental externalities by reducing the need for irrigation, pesticides and fertilizers. Rural people themselves tend to be marginalized and food insecure in many places. Some argue that GM crops will allow farmers to make more money and improve their livelihoods (Carpenter 2013; Ozor and Igbokwe 2007).

On the other hand, critics contend that by their very nature, GM crops require large amounts of capital, which smallholders simply do not have. The capital-intense nature of GM crops results from global regulatory regimes that favor the control of intellectual properties by transnational corporations (Pechlaner 2012). Olivier de Schutter, former UN Special Rapporteur on the Right to Food, argued in official documents that agroecological approaches to food insecurity were superior because agroecological production systems rely on locally available inputs and use local and regional markets (O De Schutter 2011). In other words, food is adapted to both locally appropriate production conditions and to local food demands. The United Nations Environmental Program has also published studies showing the superiority of agroecological and organic systems for addressing food insecurity in East Africa (Hine and Pretty 2008; Olivier De Schutter 2010).

As in developed countries, the introduction of GM crops in Africa has created various disputes on the safety of GM technology, the likelihood of its promised benefits, its relevance to African agriculture, and its impact on African smallholder farmers who manage over 80% of

African farmland, namely in Sub-Saharan Africa (FAO, 2012). Still, the major argument of those advancing the adoption of GM crops in Africa centers on the perceived urgent need to attain food security. Paarlberg (2008) and others claim that African agriculture is “starved for science,” because of its slow adoption of more innovative technologies like GM technology, which is touted for its beneficial effects in Asia and North America (Juma 2011b; Paarlberg 2008; Ronald and Adamchak 2008). Institutional, organizational, political, and academic initiatives have ensued to persuade major African stakeholders to embrace GM technology to achieve a “new harvest.” This “new harvest” is characterized by higher levels of productivity, use of agricultural innovation, and more dissemination of nutrition-enriched African staple crops (IFPRI 2013; Juma 2011c).

One major problem with this debate is how uninformed it is by the real experience of farmers and smallholders across the world. Writing a review of the GM technology controversy from an anthropological lens, Stone (2010) called for more research on the social aspects of how smallholders use GM technologies, the different benefits and impacts of the technology for smallholders and others, and the processes by which the smallholders’ use of the technology could improve food security. In this paper, I explore the debate about how well GM crops can address food insecurity by examining the arguments used by GM proponents, analyzed through articles and books promoting GM crops as part of Africa’s food security solution. I explore the degree to which supporters ground their arguments in the needs and experiences of African farmers. The hypothesis is that very few of the supporters of GM as a solution to food insecurity base their arguments on actual farmer practices and needs. I hope to use this analysis to offer suggestions on putting the farmer at the center of these discussions, a practice that will better inform decision-makers, civil society, researchers and others on the best policies and strategies around GM and other technologies.

DEBATING GM TECHNOLOGY AND FOOD SECURITY

The continued existence of food insecurity across the world has made mobilizing adequate resources to solve it a global priority. This has become even more urgent as food insecurity is often associated with global socio-political upheavals, such as social uprisings and political instability in North Africa and the Middle East (Lagi, Bertrand, and Bar-Yam 2011; Pinstrup-Andersen and Shimokawa 2008). Even while it is widely understood that food insecurity is caused by lack of access to food (affordability, adequacy, and availability), the causes of that lack of access remain contentious in the literature from around the world, not just Africa.

Various explanations for the persistence of food insecurity abound in the literature: the absence of appropriate mechanisms of equitable food distribution (Olivier De Schutter 2011a); the effects of climate change on agricultural production (Lobell et al. 2008); inefficient food waste management (Gustavsson et al, 2011), especially at the farm level, in much of the world; the inability of small farmers to access farmland due to land-grabbing by large-scale investments (Olivier De Schutter 2011b); warring interests around food trade (food wars) (Lang and Heasman 2015); unbalanced diet for many of the poor caused by lack of access to nutritious food (Benson 2004), as well as tensions surrounding appropriate agricultural practices, i.e. agribusiness vs alternative food systems (Seck, Diagne, and Bamba 2013). In the last two decades, issues surrounding the development and application of genetic engineering (genetic modification) of food crops has complicated these debates even further.

GM technology has become embroiled in debates within policy/political arenas encompassing world trade agreements, biosafety regulation, market institutional arrangements, consumers' grievances about modern diets, and food safety. Thus, arguments about the potential contribution of GM technology to food security have been packaged in different ways. Often the packaging reflects where the arguments are "enacted" – within the developed world context or the developing world context. The concepts of "developed world" and "developing world" do not refer here to stakeholders/actors from both "worlds." They rather refer to discourses that derive their arguments on GM technology from the agricultural "realities," policies, and issues of the two worlds.

Food Security, GMOs, and the Developed World

Because GM technology was developed and applied first within the "developed world" context, specifically North America, disputes about its relevance to solving food insecurity emerged first in this context (Pray and Naseem 2007; Weasel 2009). There were two main stages of justification for GM technology. In the first stage, GM technology was argued as a way to surpass the limitations of the "green revolution" by harnessing the power of the "gene revolution" (Pray and Naseem 2007). In the second stage, the adoption of GM technology was positioned as a "moral imperative" in order to attain food security (Dibden, Gibbs, & Cocklin, 2013). Dibden el al (2013) examine the two stages of justification of GM technology by comparing attitudes towards GM technology as expressed by agricultural policies of the UK and Australia. The authors conclude that using "food security" as a mantra to promote biotechnology illustrates how proponents of GM crops changed course, from promoting biotechnology as a viable agricultural technology whose threats have not been proved, to promoting the adoption of biotechnology as a "moral imperative" to attain food security, as illustrated by Australia's policy stance. By contrast, in the UK, the rejection of GM crops has been justified by the fear that the biotechnology industry will monopolize food production, thereby increasing food insecurity and leading to the decline of food sovereignty. Taking a cue from Ericksen (2008), the authors characterize these conflicting positions on GM crops as food wars (Dibden et al. 2013). The two parties of the “food war,” Australia and the UK, have been nationally and globally influential in gearing their institutional and policy course of action towards the rejection (in the case of the UK) or promotion of biotechnology (in the case of Australia).

Food Security, GMOs, the "Undeveloped" World, and the African Case

Outside the "developed world," feeding a growing population is portrayed as the major challenge for agriculture since most of the one in seven people who still do not have access to sufficient nutritious food live in developing countries. (Godfray et al. 2010). For instance, GM technology is considered crucial by many as a way to spark an “African Green revolution” (Juma 2011b, 2011c; Karembu 2009; Paarlberg 2008; Wambugu 1999). It is also viewed as way to improve African farmers' livelihood (Morse and Bennett 2008; Morse and Mannion 2009; Paarlberg 2008), and as a way to address African food insecurity in a sustainable manner due to perceived reduction in pesticide use (Brookes and Barfoot 2013b; Karembu 2009; Ronald and Adamchak 2008).

Others in the "undeveloped world" criticize GM technology. The United Nations Environment Programme (UNEP) deplores the pressure put on African countries to adopt GM technology, and views emphasis on GM in research and development as a major hindrance to the spread of sustainable agricultural practices, namely organic farming (Hine and Pretty 2008). In another report, UNEP joined with United Nations Conference on Trade and Development to argue that GMOs pose threats to human health through the creation of potential new types of proteins (and allergens) as well as “potential undesirable metabolic products” (Naqvi, A., & Echeverría 2010). Another line of critique focuses on the idea that GM technology will lead to heavily industrialized commodity crops produced by transnational corporate businesses (Glover 2010). Glover (2010) also argues that big agri-businesses, namely Monsanto (now Bayer), has always sought to frame their GM crops as “a technology for the poor.” Such framings started with the emergence of environmental movements in 1960s that pushed Monsanto to revisit its agricultural innovation priorities: the company moved from chemical-based innovations to seed-improvement innovations (Glover 2010). GM crops therefore have been argued as “corporate crops” to maximize revenues through market control via patenting (intellectual property rights) and limiting farmers’ ability to decide on their farming practices and choices (Pechlaner 2012). GM technology has also been criticized for increasing the use of glyphosate with Round-up Ready crops and thereby causing negative health effects, namely liver and kidney problems (Ewen and Pusztai 1999; Séralini et al. 2011). However, some commentators argue that it is still challenging to set up consensual criteria to assess the environmental and health risks associated with GM crops (Sanvido et al. 2012).

Where are the Farmers?

Farmer involvement in research has been demonstrated to be important in widespread adoption of agricultural technologies but has been conspicuously absent in much of the debate surrounding GM technology. Since “ the majority of the world’s poor and food insecure people” are smallholder farmers, farm laborers and herders (FAO, IFAD, UNICEF 2018), enhancing food security means improving these people’s well-being. Smallholder farmers work under levels of uncertainty, e.g. access to markets, infrastructure, credit, inputs and information; these become exacerbated by climate shocks (FAO, IFAD, UNICEF 2018). These populations use a diverse set of livelihood strategies adapted to local situations. Thus, these situations are quite different than those under which most commercial farmers and research operate (Nelson and Coe 2014) – and very different from the research arena in which most GM crops (particularly those in the first generation) have been developed,. Researchers have long recognized that understanding the constraints and goals of farmers increases the efficiency of agricultural research and development programs (Collinson 2001; Valdivia et al. 2010) by tapping into the innovative capacity of farmers at the local level to produce locally appropriate translations of technological packages (Stone 2010). The importance of farmers' involvement in agricultural research has been recognized by the International Agricultural Research Centers and the World Bank (Ortiz et al. 2011). The question becomes how well smallholder farmers are integrated into the very research on GM crops developed to help them achieve food security.

In summary, debates about GM technologies emerged from their first application in the "developed world" context, followed by the promotion of GM crops as a solution to achieve food security. Debates around GM technology and food insecurity became situated mainly within the "undeveloped world" where most food insecure people live. Africa has become a key focus of those promoting GM crops as it has not enjoyed the same increases in agricultural productivity as Asia or Latin America during the green revolution. Bypassed by the green revolution, Africa is heavily pressured to attain the "gene revolution" through the adoption of GM crops.

Critics contend that promoters of GM crops overlook harms to the environment and health, while hindering the development of organic or agroecological cropping systems in favor of capital intensive, industrialized systems reliant on GM technology. Moreover, the debates seem to exclude smallholder farmers even though they are among the most food insecure and are more likely to adopt agricultural technologies when they are integrated into their research and development. This leads to the research I present here. I examine the degree to which promoters of GM crops in Africa base their arguments on actual farmer practices and needs. I am also interested in the question of the extent to which discussions of GM crops have been informed by the experience of the Green Revolution. I start from the premise that very few of the supporters of GM technology in Africa use farmer practice to inform their promotion of GM crops.

METHODOLOGY

I conducted a review of available articles using a search engine tool provided by the University of Missouri libraries. For most of the research period, this search engine tool was provided by ProQuest, while in later stages, the libraries switched to a search engine tool provided by Ebsco Discover Services. While the exact databases that these search engines crawl is proprietary, they include major databases such as Agricola, EconLit and Scopus. Both are simple search engines that help access anything in the University of Missouri Library collections, including databases that the university subscribes to. For instance, at the time of my research, Summon (by ProQuest) included access to over 6,200 publishers' content which searches over 94,000 journal, newspaper and magazine titles.

I limited the search to scholarly articles, excluding newspaper and magazine articles. However, I included 10 articles, books, and policy reports that do not appear in peer-reviewed formats but are published by highly reputable international think tanks like IFPRI. I also searched relevant references within found articles; this was very helpful to identify networks of research on GM crops in Africa. Articles were selected for inclusion in the analysis if they a) presented an overall positive view of the advantages of GM crops for smallholders b) focused on Africa, and c) discussed GM crop production.

Using these screens narrowed the analysis to 82 articles and reports. I coded these articles/reports based on: 1) the arguments justifying promotion of GM crops, e.g. increased yield, better markets, reduced environmental issues; 2) sources of evidence, e.g. review and farmers; 3) the kinds of empirical data referenced, e.g. actual farming systems, test plots or other experiments, farmer acceptance of GM, consumer demand, consumer acceptance; and 4) the positions and disciplines of the authors. The distribution of selected studies is shown in Table 1 below. More background information on the selected studies is found in appendix C.

Table 1: Studies selected for analysis (N=82 Total Papers Evaluated)

Included Scholarly Outputs	Number of Scholarly Outputs	Percentage of Total Outputs Reviewed
Peer-reviewed articles	70	87%
Books	3	4%
Chapters	2	2%
Policy reports	5	6%
Conference Presentation/ dissertation	2	1%

Figure 23 Studies selected for analysis

FINDINGS

I begin this section by reporting the sources of data used in the scholarly works I examined. Since I was particularly interested in the scholarly outputs that derive their data from African farmers, I subdivided the scholarly outputs into research based on econometric modeling (some of these models were based on other studies that included farmer data), data collected from farmers, and another category that uses neither modeling nor farmer data as the basis of their analysis (see figure 24 below). The 27 studies that included farmer data can be further subdivided into three main categories:

- Data based on farmer adopters’ experiences with commercial GM crops. An overwhelming majority, 19 of 20 studies, collected their data from farmers who grow a commercial GM crop and are in South Africa. One study used farmer adopters from Burkina Faso.
- Data based on farmer adopters' insights, attitudes, and/or anecdotal experiences. Only two studies refer to farmers’ anecdotal experiences with GM crops. They are not based on systematic data collection.
- Studies based on (non-adopter) farmers’ agricultural information. Four studies use data based on farmers’ practices, weather conditions, and input/output information to project the potential impact of adopting GM technology.

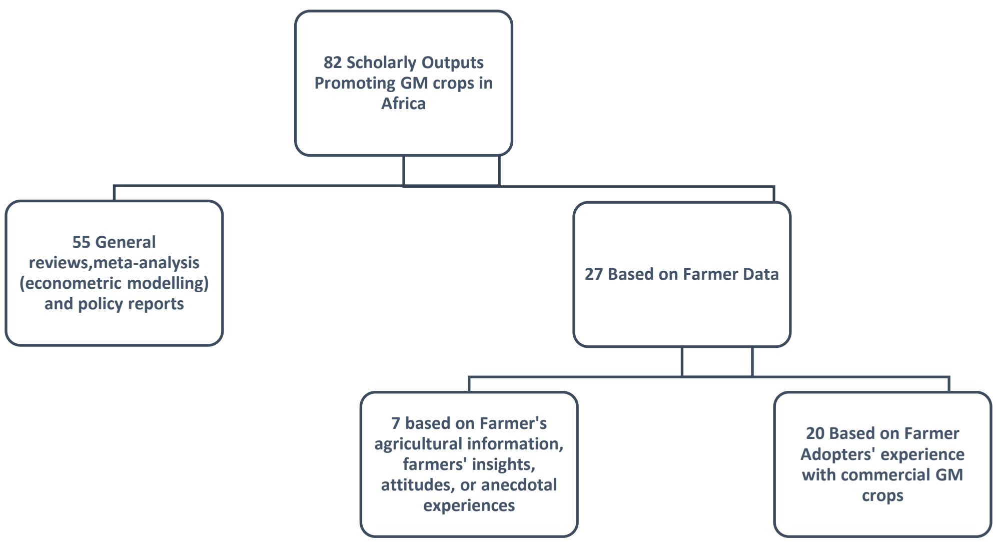


Figure 24 Categories of scholarly outputs reviewed

As noted, 19 of the 27 studies based in farmer practice either came from or used South African farmer data. The other seven studies used a variety of data that came from Ghana, Kenya, Niger, the Great Lakes of Africa, and Burkina Faso. GM crops have been commercialized in South Africa since 1998, which may account for the number of studies performed there. The data collected in these studies includes information on the adopted GM trait, estimates of farmers' crop inputs and yields, and information on how farmers procure the adopted GM seed. As illustrated by Figure 25, most datasets were collected in the first production seasons of the adoption of the technology. The first survey on South Africa's adoption of GM technology, BT cotton, began in late 2000 as a joint project of the University of Pretoria and the University of Reading (Gouse, 2009).

Those studies using data on farmers' experiences with GM technology generally survey the extent to which adopters of the technology have benefitted from it. The results are reported in two ways. First, some researchers use these results to assess the extent to which GM technology has benefited its adopters compared to non-adopters. Second, other researchers use these results to project the potential benefits of GM technology that would accrue if it were disseminated in Africa. The latter point is discussed in the section analyzing studies using econometric modeling to estimate the benefits of GM technology.

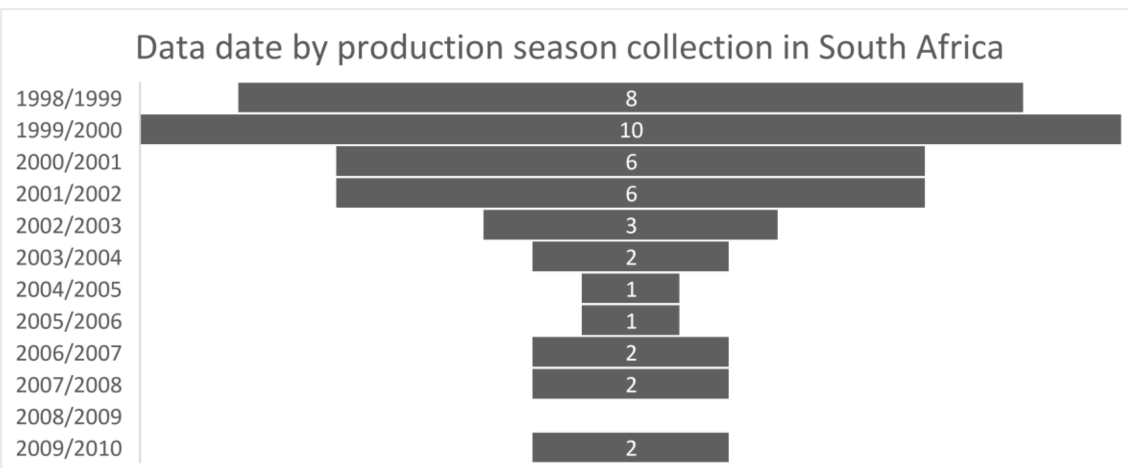


Figure 25 Farmer data primarily comes from 19 studies involving farmer adopters in South Africa collected over the growing seasons from 1998 through 2002

Why GM Technology is Needed in Africa

Four major themes emerged as justifications in the scholarly articles promoting GM crops in Africa. The themes revolve around increasing African agricultural productivity through this technology, benefits to the environment or to the health of farmers, benefits to farmworkers or others from using GM crops, and benefits of reducing the amount of labor required of farmers. I discuss each of these themes below.

Productivity Benefits

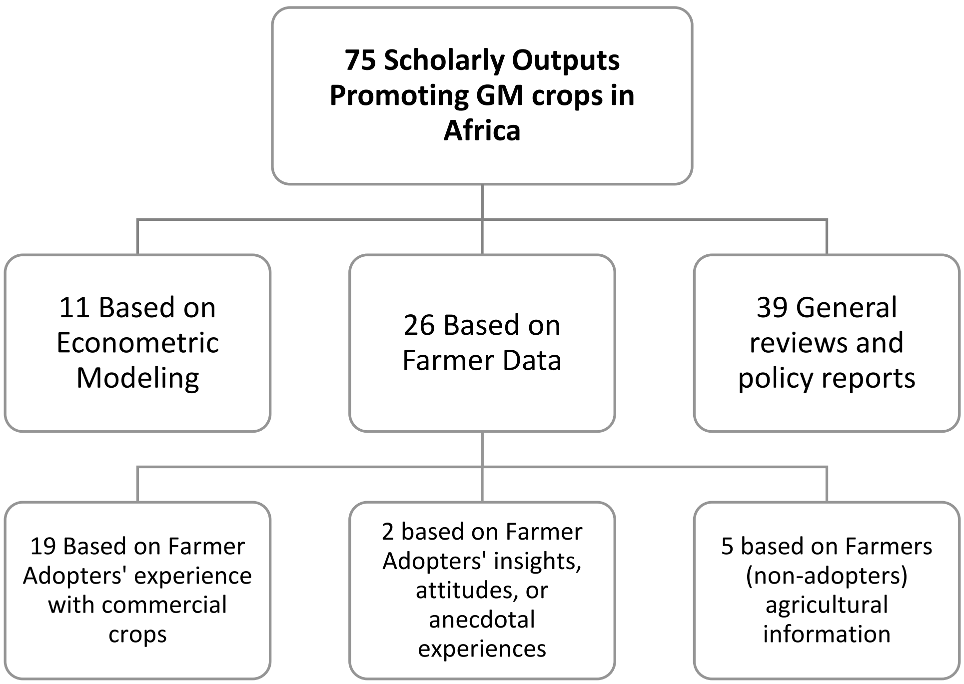


Figure 26 scholarly outputs promoting GM crops productivity benefits

Most examined studies assume that African food insecurity is linked to low agricultural productivity, which genetic modification technology can potentially solve. Thus, the 75 (see figure 26) studies reporting GM yield benefits present GM technology as important to address African farming challenges related to low productivity.

First, I focus on the studies that use data based on farmers. Generally, the results show higher yields experienced by adopters of GM technology compared to non-adopters. Gouse et al (2005) report over 10 percent yield increases on both irrigated and dryland farms among large scale farmers in South Africa who adopted BT yellow maize versus those who did not (Gouse, Pray, Kirsten, & Schimmelpfennig, 2005: 88). Large scale farmers were also reported to have experienced yield benefits by adopting BT cotton (Gouse, Kirsten, & Jenkins, 2003:18). The yield benefits of BT white maize were also reported among small scale farmers even though there was not enough data to assess whether BT maize yield benefits experienced by small scale farmers could lead to a substantial increase in their net income after purchase of the seed, which was supplied free from Monsanto during the course of the study (Gouse, Pray, et al. 2005).

Studies on smallholders' experiences with GM crops show high yield benefits experienced by adopters of the technology compared to non-adopters. Bennett et al (2006) report that South African smallholders who adopted BT cotton

> "achieved consistently higher yields per hectare than non-adopters over the three years, particularly in the poor, wet growing season of 1999/ 2000 (such conditions favor the bollworm), where adopters achieved yields that were 85 per cent higher on average than those growing the conventional crop." (Bennett et al. 2004, 2006:665) .

Similarly, Gouse et al (2005), based on data of the seasons 1998-1999 and 1999-2000, showed that more than 90% of farmers in the Makhatini Flats adopted BT cotton for its "substantial" yield benefit[7]. Gouse et al (2005) found that the benefits of BT cotton for smallholders were due not only to GM technology but also to successful institutional arrangements that allowed smallholders to access BT cotton seeds at lower costs (Gouse, Kirsten, et al. 2005). The central role of institutional arrangements in facilitating the adoption of BT cotton was also identified by Ismael et al (2002) who suggested that early adoption of the cotton relied almost exclusively on credit and technical advice provided by the Vunisa Cotton

[7] M.Gouse et al (2006) Show that white BT maize also benefited smallholding farmers by increasing their income "*except in years with especially low borer infestation levels*" (M.Gouse, Kirsten, Pray, & Schimmelpfennig, 2006, p. 22).

company (Ismael, Bennett, & Morse, 2002, p. 3). The authors also conclude that BT adopters achieved higher average gross margins than non-adopters, particularly in the second season of adoption where the adopters achieved 77% higher average gross margins than non-adopters (Yousouf Ismael et al. 2002)[8].

Yields are not the only measure of increased productivity. Nearly two-thirds of BT small scale cotton growers in the Makhatini Flats in South Africa reported increased yields and savings in terms of reduced pesticide and labor costs (Thirtle et al 2003). While the growers valued the pest control aspect of the technology at a rate of 6 to 1 more than the yield impacts (Thirtle et al. 2003); the authors reported a 40 percent higher yield among adopters than nonadopters (Thirtle et al. 2003:726). The "yield-enhancing effect" of BT cotton, due to its "effective pest control," was elaborated by Shankar and Thirtle (2005) who concluded that BT cotton provides yield benefits for smallholders because it circumvents the input and labor costs associated with pesticide application. Several studies tie the yield benefits of BT cotton to the efficiency benefits it provides, such as savings on pesticides, labor, and inputs. For example, Ismael et al (2002) examined efficiency among smallholders showing that adopters were more than 15 percent more efficient than non-adopters. In the same vein, Bennette et al (2003) concluded that their results "reveal[ed] a direct cost benefit for BT growers of SAR416 ($51 per hectare per season) due to a reduction in the number of insecticide applications." (Bennett et al. 2003:123). In Burkina Faso, the only African country apart from South Africa where researchers used farmers' actual experiences with GM cotton, Vitale, Ouattarra, & Vognan (2011, p. 1136) conclude that "based

[8] (Morse et al. 2005) state that "The economic results obtained on the farm level from the Makhathini flats shows that BT cotton can provide important benefits in terms of gross margin, and this in turn provides more resource for farmers to invest in agriculture or other activities. A benefit of SAR 742 per hectare for BT growers relative to non-adopters is significant, and with a daily rate of SAR 10 for paid labour is equivalent to 3.5 months' work."

on the summary of published data collected from six years of field trials and producer surveys, BT cotton increased cotton yields by an average of 21.3% and raised income by $106.14 per ha."

In spite of reported benefits of GM cotton, Gouse et al (2009) caution against over estimating the contribution of GM crops, namely BT and RR (Round-Up ready) cotton, to smallholders' efficiency (Gouse et al. 2009). Similarly, (Fok et al. 2007) call for putting farmers' experiences with BT cotton in the right context by being cognizant of the impact of institutional arrangements, farmers' scale (large vs small farmers), and climatic conditions (high/low borer infestations and drought).

In addition to these 19 studies that used farmers' experience with GM crops, two studies reported farmer perceptions with using GM crops. The first study (Jacobson and Myhr 2013) reported one-third of respondents obtaining increased yields with BT maize versus landrace maize, but cautioned that farmers were unable to strictly compare the performance of GM maize with their maize landraces since they were also given fertilizer bags to use on all their maize, not just the BT maize they were given (Jacobson & Myhr, 2013). A second study by Karembu (2009) reports anecdotal accounts of Egyptian farmers' positive experiences with GM cotton.

The final category of research based on farmer's data includes five studies that provide information on African farmers' practices and challenges to determine the extent to which GM technology could meet their needs. In Kenya, a study based on analysis of farmers' losses due to maize pests estimated that the adoption of BT maize resistant to *B. fusca* would result in an 30 fold larger economic surplus in 25 years under their stated conditions (Groote, W. a Overholt, et al. 2011). Another study, estimated that adopting BT maize resistant to *B.Fusca* would protect Kenyan farmers against losses "valued at US$ 80 million, more than half of which occur in the moist- transitional zone" (Groote and Mugo 2004:9). In the major African banana-producing countries (Burundi, DRC, Kenya, Rwanda, Tanzania, and Uganda) researchers estimate that the introduction of a GM banana resistant to *Xanthomonas Wilt* would result in benefits between "US$ 20 million–953 million in the target countries" (Ainembabazi, Tripathi, Rusike, Abdoulaye, & Manyong, 2015;pg 15). Other studies within this category examine farmers' willingness to adopt GM technology; they also project future scenarios if farmers adopt the GM crop that meets their needs (see Adenle, Alhassan, & Solomon, 2014; and Horna, Smale, Al-hassan, Falck-zepeda, & Timpo, 2008).

Productivity benefits are also reported by the scholarly works that did not rely on farmer practice or experience. In 11 studies that use econometric modeling, e.g. ex-ante analysis, high yield benefits of GM technology are projected (Anderson & Jackson, 2005; Boue¨t & Grue`re, 2011; and Elbehri & Macdonald, 2004). For example, Elbehri & Macdonald (2004, p. 2062) report "that with 25% transgenic cotton adoption, welfare for WCA [West and Central Africa] increases from 70 to 100 $US million annually," while Vitale et al (2007;p 71) estimate that benefits to both producers and consumers would reach "$89 million in an average year." Most of these studies use global data available from ISAAA (International Service for the Acquisition of Agri-Biotech Applications).

Nearly half of the studies (n=39) I reviewed did not use any farmer-based data, but encompassed themes around consumers' preferences, policy makers' attitudes, political and ideological stance on GMOs, and general review of debates on GM crops. Every one of them argued that GM technology can benefit yields. For instance, Juma (2011) proposes that GM technology can solve the issue of African low productivity; he calls for widespread adoption of BT cotton, which does not raise health concerns, as well as herbicide resistant maize which reduces the need for weeding, a burden faced mainly by women. In a similar fashion, Paarlberg (2010; p 610) argues that "[t]he first generation of GMO crops that came to the market in 1995–1996 provided benefits mostly to farmers growing cotton, maize, and soybean, in the form of lower costs for the control of insects and weeds."

Environmental Benefits

The bulk of the studies reviewed promote the environmental benefits of GM technology e.g. reducing use of pesticides and insecticides, relying on three main sources of evidence. First, 23 of the examined studies use two types of farmers' data: a) farmers who have experience growing GM crops and b) farmers surveyed about their farming practices to deem the relevance of GM technology. Second, 37 studies seek to discredit what they consider ill-founded claims about the negative environmental effects of GMOs by highlighting the crucial role of biosafety policies to monitor the environmental effects of GM technology. Various studies using econometric modeling also project potential benefits of GMOs to the environment due to reduced use of pesticides.

Farmers' experiences with the environmental effects of GM technology. Emphasis on the environmental benefits of GM crops varies from one study to another. For instance, not all studies relate GM adopters' experiences with pesticides reduction to environmental benefits. That is to say, reduction of pesticides application is regarded more as a yield-enhancing effect rather than an environment-enhancing effect, as discussed in the productivity benefits section (see Bennett et al., 2003; M Gouse, Kirsten, Pray, & Schimmelpfennig, 2006; Marnus Gouse, Kirsten, et al., 2005; Horna et al., 2008;and Ainembabazi et al., 2015).

It is also important to tease out that among the studies using data based on farmers' experiences with GM crops, environmental benefits of GM crops are often reported by referring to other studies rather than to their surveyed farmers' experiences. For instance, Karembu (2009, p. 4) references a number of other authors to claim that "modern biotechnology has the potential to ….. reduce the use of pesticides and offer safer and more nutritious food, and consequently contribute to environmental sustainability ([citing] FAO, 2004; Juma and Serageldin, 2007; James, 2008; Brookes and Barfoot, 2008)." Similarly, Gouse, Kirsten, et al., (2005) only suggest environmental benefits could be gained from the adoption GM crops, including protection against damage to the soil and wildlife due to the reduction of pesticides applications. Groote, Overholt, Ouma, & Wanyama (2011) refer to literature asserting that GM crops have the potential to "allow wide-spread use of conservation agriculture" due to their capacity to reduce pesticides/insecticides applications citing (Brookes and Barfoot, 2010).

Thirteen studies report environmental benefits experienced by farmers who grow GM crops. Bennett et al (2006;p. 667) found that South African smallholders who were BT adopters in the Makhatini Flats "were more resilient to bad environmental conditions," namely in wet-growing seasons when pest populations are more widespread. In Burkina Faso, the commercial adoption of BT cotton could help "maintain tropical and sub-tropical ecosystems for environmental services they provide, including carbon sequestration, recreation, water purification, and biodiversity preservation" because of the capacity of GM cotton to reduce pesticide use by two-thirds (Vitale et al. 2011:1148). Reducing pyrethroid insecticides used by GM commercial farmers in South Africa potentially "favoured a greater presence of beneficials (like lady birds)" (Fok et al. 2007:10) .

Because the mishandling of chemical waste and spraying equipment by African smallholders is widely reported to cause environmental hazards to the fields and household (Thirtle et al. 2003), the adoption of BT cotton by South African smallholders has reduced pesticide use, resulting in protection from environmental hazards. According to the authors' data "92% of farmers dumped waste and washed their empty spraying equipment either in the fields or in the household refuse hole"[9] from which they extrapolate that environmental hazards could be decreased through the reduction in pesticide use associated with adoption of GM technology (Thirtle et al. 2003). Different environmental benefits as experienced by large scale farmers and smallholders are also discussed by Gouse, Pray, & Schimmelpfennig (2004) who linked decline in insecticides use by large-scale farmers to "lower diesel costs and fewer tractor hours"; they also report that large-scale farmers "noticed increased populations of beneficial insects (such as ladybirds and lacewings) in BT cotton fields"[10] (Gouse et al., 2004, p. 191). For small-scale farmers, the insecticides-use reduction benefit "is largely in labor savings" (Gouse et al., 2004, p. 190).

Hofs, Fok, & Vaissayre (2006;p. 984) cautions against over optimism with the positive effect of BT cotton on the environment as the surveyed large-scale farmers were reported to apply organophosphates "in substantial amounts." Contrary to large-scale farmers, smallholders who were surveyed reduced pesticides use only in modest terms, which the authors attribute to

[9] On environmental hazards experienced by small-holding farmers in the Makhathini Flats, KwaZulu-Natal ,see also :Y Ismael et al., 2002);and Y Ismael et al., 2002.

[10] Similar finding is reported by Gouse et al., 2003: "Large-scale cotton farmers have indicated other indirect benefits of BT cotton. Spraying less pesticide or none at all has caused predator insects to flourish. More than 46% of farmers have noticed more beneficial insects on their BT cotton fields. Some farmers in the Northern Cape have indicated that Lady Bird beetles and Lacewings have reduced aphid populations to such a level that farmers do not need to spray for aphids on winter wheat anymore." See also Morse et al(2005) who report that, "There are also a number of comments from farmers that biodiversity is increasing in BT plots as less pesticide is used."

inadequate applications of pesticides due to institutional constraints such as lack of access to affordable pesticides (Shankar & Thirtle, 2005).

Sometimes pesticide use was reduced because of misunderstandings on the part of smallholders (Bennett, Ismael, Morse, & Shankar, 2004). In their study, smallholders who were surveyed reduced insecticide applications based on the misunderstanding that BT cotton is resistant to non-bollworm insects (Bennett et al. 2004). The authors emphasized that “[it] is the non-bollworm insecticides that have the largest impact on insecticide use – more quantities of them are used and they have a higher toxicity” which means that smallholders have no reason to reduce their applications when using GM crops once they understand the nature of the technology (Bennett et al. 2004:19). In fact, the authors conclude that “it should not be assumed that the introduction of BT cotton will inevitably reduce toxic load to the environment arising from insecticide.” (Bennett et al. 2004:19).

Review Studies. Generally, all articles whose data is based on review of other studies, e.g. meta-analysis and econometric modeling, argue for environmental benefits experienced by GM adopters:

References	Environmental benefits of GM crops
· (Sengooba et al. 2009) · (Borlaug 2000) · (Chambers et al. 2014) · (Thomson 2008) · (Carpenter 2013) · (Anderson and Jackson 2005) · (Elbehri and Macdonald 2004) · (Vitale et al. 2007) · (Thomson 2015) · (Brookes and Barfoot 2013c) · (Cabanilla, Abdoulaye, and Sanders 2004) · (Gouse 2009) · (Jeffrey Vitale et al. 2008)	• Reduced insecticides use • Less use of Toxic Herbicides thanks to the adoption of GM herbicide resistant crops • Decreased fuel use owing to less pesticides spray application • “reduced-tillage or no-till production methods that help preserve soil quality and reduce soil erosion”

· (Juma, 2011) · (Virgin et al. 2007) · (Paarlberg 2010) · (Adenle 2011) · (Abidoye and Mabaya 2014) · (Mtui 2011)	• Reduce green gas emissions thanks to reductions in pesticides application and fuel use.
· (Qaim and Zilberman 2003) · (Smale et al. 2009) · (Paarlberg 2010) · (Paarlberg 2008)	• Use reduction in “highly hazardous chemicals, such as organophosphates, carbamates, and synthetic pyrethroids, belonging to international toxicity classes I and II” • International organizations, including the ones from the EU have found no environmental hazards caused by GM crops
· (Popp and Lakner 2013)	• Countries with low pesticides management and high pesticides costs, namely developing countries, such as in Africa, benefit most from insect resistant GM crops
· (Kikulwe, Wesseler, and Falck-Zepeda 2011)	• Adopters, namely in Uganda, tend to prefer the environmental benefits of Gm crops more.
· (Novy et al. 2011) · (Zilberman et al. 2014)	• Potential benefits to address environmental stresses e.g. drought, thanks to the development of “the next generation of GM crops”
· (Ozor and Igbokwe 2007) · (Langyintuo and Lowenberg-DeBoer 2006)	• GM crops have the potential to contribute to agricultural sustainability.
· (Adenle 2014)	• Scientists from countries that have not adopted GM crops at the commercial level argue for the environmental benefits of GM crops, namely from Ghana and Nigeria.

Some studies responded to environmental concerns over herbicide resistant GM crops resulting from increasing use of glyphosate sprays. Juma (2011 c) argues that potential adverse environmental effects of herbicide-resistant GM crops are fewer compared to natural crops: natural crops require heavy use of insecticides unlike herbicide-resistant GM crops that “utilize an organic compound called Glyphosate to combat weeds” (Juma 2011c). Glyphosate has “less dangerous toxins,” but weeds could develop resistance to it (Juma 2011c). While Falck-Zepeda, Gruère, & Sithole-Niang (2013) posit that environmental impacts of GM crops are “under-investigated,” Finger et al (2011) assert that positive impact of GM crops on the environment is frequently reported by the literature. In order to benefit from positive environmental effects of GM technology, Mugo, Groote, Bergvinson, & Mulaa (2005) recommend that any adoption of BT technology in Kenya requires the development of “clearly mapped” refugia to avoid resistance to BT genes. Another recommendation proposed by Smale & Groote (2003) is "promoting the cultivation of multiple varieties with diverse resistance mechanisms, or control through refugia."

Health Benefits of GM Crops

Findings based on farmers' data. Of the reviewed studies, 20 argue for health benefits of GM technology based on farmers' data. These 20 studies include 16 that provide data from GM growing farmers, and four that use agricultural data from farmers not growing any GM crop to estimate potential health benefits of GM technology if adopted. The analysis distinguishes between studies whose chief research objective is to estimate direct health benefits associated with GM technology, and studies that provide generic observations and claims on health benefits attributed to the adoption of GM technology.

Among the 20 studies based on farmers' data, 10 articles report broad health benefits associated with the adoption of GM technology:

- BT white maize can potentially reduce health risks resulting from the exposure of rural people to "mycotoxins in maize"(Gouse, Pray, et al., 2005);
- The adoption of BT cotton improved Burkinabe farmers' health by decreasing their exposure to pesticides (Vitale et al. 2011);
- The adoption of BT cotton "would reduce pesticide poisoning, thus benefiting people, wildlife and the environment" (Gouse, Kirsten, et al., 2005; Gouse et al., 2004; Ismael et al., 2002; Ismael et al., 2002; Karembu, 2009; Shankar & Thirtle, 2005);
- And "the advantage of less chemical application for small-scale farmers" who grow BT cotton means "less labor needed, less water transport and less exposure to chemicals"

(Gouse et al. 2003) thus resulting in a “decline in hospital admissions as a result of pesticide use” (Morse et al. 2005).

Four studies report data-driven findings on health benefits of GM crops. Bennett et al (2006) conclude that farmers’ adoption of BT cotton in the Makhatini Flats offsets costs related to “cypermethrin (the insecticide used for bollworm)” which means, in addition to financial gains, BT cotton protects farmers from exposure to the negative health effects of bollworm insecticides, frees them from “walking 27 km per hectare carrying a heavy knapsack, usually spraying in high temperatures and with no protective clothing,” and liberates women and children from the “arduous task” of collecting water. Other authors, conducting research in the same area, report that “health problems resulting from chemical application” decreased as indicated by the hospital records after the adoption of BT cotton; however, the link between BT adoption and reduction in poisoning incidents requires further research (Thirtle et al., 2003). A more direct link found between GM technology and farmers’ health improvement is reported by Pray et al (2013) who report that adopting BT maize on smallholder farms in South Africa could reduce farmers’ exposure to the mycotoxin fumonisin and thus potentially decrease negative impacts of fumonisin in animal and human diets. Bennett et al (2003) report data from local hospitals that show a reduction in the number of insecticides poisoning incidents. However, this reduction is due not simply to BT adoption but also to the adoption of less hazardous insecticides. The authors also emphasize that many insecticide poisoning incidents are not reported to local hospitals (Bennett et al. 2003).

Five studies report on nuanced findings on the interaction between BT cotton adoption, continued application of non-bollworm insecticides, the lack of data on health benefits experienced by smallholders adopting GM, and farmers’ perceptions of pests’ resistance to BT .

Bennett et al (2004) explain that the adoption of BT cotton is not enough to curb the application of insecticides, and that farmers who are educated about the types of bollworm that are unaffected by BT could actually increase insecticide use. Similarly, Hofs et al (2006) report that BT cannot contribute significantly to both ecosystem and human health with the continuation of organophosphate applications. The interaction among BT technology, local farming practices, and difficulties of data collection make measuring the health benefits of GM technology a difficult task (Gouse et al., 2004; Shankar & Thirtle, 2005) .

Four studies use data of farmers who do not grow any GM crops to estimate potential health benefits of adopting GM technology, and study farmers' health concerns about GM technology. The first study by Groote et al (2011) refers to another source, (Zilberman, Ameden, and Qaim 2007), to argue that GM crops may benefit farmers' health. The second study posits that transgenic varieties of banana pose no risks to human health since "The wilt-resistant genes extracted from pepper are not listed as a potential allergen in *AllergenOnline* and should be safe for human consumption" (Ainembabazi et al. 2015:3). Ainembabazi et al (2015) found that 24.1 % of their respondents in the Great Lakes Region of Africa had negative perceptions of GM health impacts. Contrary to Ainembabazi et al (2015), the third study (Adenle et al. 2014:252) found out that the majority of respondents in Ghana and Niger believe that GM technology has "potential benefits" to improve health. Similarly, in their examination of insecticide application in vegetables in Ghana, particularly tomato, garden egg, and cabbage, Horna el al (2008) found out that farmers suffer from health hazards due to the use of insecticides; these health hazards include "burning sensation on the skin" (69%), "headaches after applications (47%)," "itchy or watery eyes (38.7%)," "coughing or breathing difficulties (35.4%)," dizziness (33.4%), "sensations of coldness (23.8%)," and "nausea and vomiting (13.6%)" (Horna et al. 2008b:9).

*Review studie*s. Review studies argue for health benefits of GM technology from varying approaches. The first approach presents the health benefits of GM technology that, including:

- Reduced application of hazardous chemicals (Carpenter 2013; Elbehri and Macdonald 2004; Falck-Zepeda et al. 2013; Finger et al. 2011; Hillocks 2005; Langyintuo and Lowenberg-DeBoer 2006; Novy et al. 2011; Sengooba et al. 2009; Virgin et al. 2007; Vitale et al. 2007)
- Provision of healthier food necessary for African food security (Adenle 2014; Juma 2011b),
- Enhanced Nutritional value of major crops to address nutrition deficiency, such as vitamin A (Anderson and Jackson 2005; Azadi and Ho 2010; Falck-Zepeda et al. 2013; Juma 2011c; Ronald and Adamchak 2008)
- Increased supplies of potable water (Mtui 2011)

In the second approach, many studies seek to debunk concerns over negative health effects of GM technology (Aerni 2005; Borlaug 2000; Chambers et al. 2014; Kikulwe et al. 2011; Paarlberg 2008, 2010; Smale and Groote 2003; Thomson 2015; Virgin et al. 2007; Zilberman et al. 2014). In the third approach, review studies discuss consumers' fear of GM health effects (Abraham 2014; Adenle 2014; Kikulwe et al. 2011; Kimenju and De Groote 2008; Stephen Mugo et al. 2005).

Labor Benefits of GM crops

In general, the 22 studies using data based on African farmers report GM labor benefits. Sixteen studies base their findings on farmers growing a GM crop, while four studies use farmers' farming practices and input/output information to project GM labor effects. Labor benefits of GM technology are explained differently between small-scale and large-scale farmers. For small-scale farmers, constituting the main unit of analysis for the examined studies, GM labor benefits include “less labor for pesticide application,” “more labor for harvesting due to higher yields,” reduction of paid labor costs, drudgery mitigation (knapsack carrying and water collection for spraying), higher efficiency (reduction of time spent for weeding and spraying), availability of time for more off-farm work (Bennett, Morse, & Ismael, 2006; Marnus Gouse, Piesse, Thirtle, & Poulton, 2009; Vitale, Ouattarra, & Vognan, 2011; Fok, Gouse, Hofs, & Kirsten, 2007; Ismael, Bennett, & Morse, 2002; Bennett, Ismael, Morse, & Shankar, 2004; Hofs, Fok, & Vaissayre, 2006; Gouse, Kirsten, & Jenkins, 2003; Morse, Bennett, & Ismael, 2005).

Labor benefits for large scale farmers include “sav[ing] on plant protection operations” in irrigated lands that are more affected by pest problems, “less time spent scouting fields for pest build up,” “higher efficiency levels” for larger farms, and “managerial freedom to go on with other farming activities.” (Gouse et al., 2003, 2004; Marnus Gouse, Pray, et al., 2005; Y Ismael et al., 2002; Vitale et al., 2011).

GM labor benefits are argued to contribute to addressing several labor-related socio-demographic issues in African rural communities growing GM crops. First, African farmers face labor shortages due to rural/urban migration; this issue is mitigated by the adoption of GM crops which are less labor-intensive (Bennett et al., 2003; Gouse et al., 2006; Shankar & Thirtle, 2005; Vitale et al., 2011). Second, unavailability of enough labor during holidays e.g. Christmas and New Year, for spraying is solved thanks to the adoption of GM crops, namely BT cotton (Shankar and Thirtle 2005). Third, “Savings in labor could free up more time for farmers and their families and at the same time reduce farming risks” (Bennett et al. 2003: 124). Fourth, reduction in labor for pesticide application contributes to addressing the lack of able-bodied farmers because of “high HIV/AIDS infection level, and elderly farmers” (Gouse, 2012: 174). Fifth, the adoption of GM crops brings indirect benefits for family, namely women and children who are more responsible for weeding and harvesting (Marnus Gouse, 2012). Sixth, less labor for pesticide applications means freeing farmers from tasks of walking long distances which is arduous and harmful (Bennett et al. 2006). Seventh, less time for farming labor thanks to the adoption of insect resistant GM crops means freeing more time for schooling for children and more time for “child-rearing tasks” for women (Gouse, Piesse, Thirtle, & Poulton, 2009).

The question of whether the labor-saving benefits associated with the adoption of GM technology could produce negative side effects, such as unemployment, was discussed in some of the examined studies. Marnus Gouse, Piesse, Thirtle, & Poulton (2009) examined the impacts of adopting BT cotton and herbicide tolerant (RR) cotton in three districts of Kwazulu Natala, South Africa. They report that GM technology’s impact on labor use depends on the type of adopted GM crop, e.g. BT or RR, and farming practices, e.g. planting without ploughing (PWP), the use of machinery, and labor division among family members (Gouse, Piesse, Thirtle, & Poulton,2009). The authors also recognize difficulties in measuring GM labor impact because of lack of accurate labor use data on the part of farmers, and absence of records on family labor (Gouse, Piesse, Thirtle, & Poulton,2009). Though the authors provided results from the three studied districts on how BT and RR cotton impact labor use, they still grapple with the question “Is labor a constraint or not?” as well as whether the adoption of a GM crop might negatively affect rural employment (Marnus Gouse, Piesse, Thirtle, & Poulton,2009). In a more conclusive manner, Bennett, Morse, & Ismael (2006, p 665) argue that BT adopters in the Makhatini Flats “consistently used more labour for harvesting due to the higher yields achieved, and substantially less labour for spraying pesticides." Gouse (2012, p174) argues that "smallholder maize producers in the Hlabisa district of KZN would "be willing to pay for the weed-control convenience; it appears as if farmers value the yield increase and (especially) the labor-saving benefit of HT maize more than the borer-control insurance of BT maize." Similarly, Ismael, Bennett, & Morse (2002, p 4) argue, after addressing concerns that GM technology might increase rural unemployment, that "there may be additional benefits from BT cotton that this study has not addressed, such as the reduction in labor costs as a result of less spraying." Rural unemployment concerns were also laid out by Shankar & Thirtle (2005, p 114), who conclude that "the concern about BT technology threatening the livelihoods of the poorest section of rural society, i.e. hired labourers, appears to be unfounded, since the expansion of harvest labour compensates for the reduction in spraying labour."

It is argued that more research is needed to grasp the interaction among socio-economic factors, the adopted GM trait, and farming practices. For instance, Gouse (2012, p 174) states that "Future analyses and publications will focus on the labor-saving benefit of HT maize, potential expansion of production due to the decreased need for weeding labor, and gender implications of GM maize adoption and use."

Measuring GM labor effects is argued to face various methodological challenges: the impact of weather conditions, insufficiency of survey data, the fact that labor used for spraying is not taken into account, and difficulties in calculating family labor since "it does not have a price" (Bennett et al., 2003; Gouse, Kirsten, et al., 2005; Y Ismael et al., 2002). Therefore, some studies argue that the impact of the adopted GM trait should be examined in light of the socio-demographic information on labor use: constraints of family labor availability, hired labor, labor division among family members (e.g. tasks allocated for children, men and women), tasks allocated for hired labor (e.g. spraying and tractor use), and price of hired labor (Thirtle et al. 2003). In addition, Ismael, Beyers, Thirtle, & Piesse, (2002) list a few more socio-demographic factors on labor use and constraints: "the labour source of farmers is comprised of children, elderly people and female labourers," "younger men take other jobs away from home," "children under 15 and those still at school often help with certain activities on the farm such as planting, weeding and harvesting," and hired labor is used for spraying, harvesting, and plowing.

In order to assess the relevance of GM technology to farmers' labor practices, some studies surveyed farmers' attitudes on labor benefits of GM technology: "10% believed that the labor-saving properties of BT cotton were critical in the adoption decision," while "4% were troubled by labour shortages" (Y Ismael, Beyers, et al. 2002: 3; Yousouf Ismael et al. 2002) , and 52 % grew BT maize for its labor-saving benefits (Bennett et al. 2003). "When one includes saving on application cost, and labour saving with pesticide saving, more than 63% of small-scale BT adopters agree on the entire bollworm control benefit of BT cotton." (Gouse et al., 2003). Gouse, Kirsten, et al (2005) highlight that one flaw of "commonly used measures of productivity and profitability" is that they do not account for labor-saving benefits of BT cotton, yet "20% of the farmers rated this as the main reason for adoption" (see also (Thirtle et al. 2003).

Review studies: The first group of review studies argue for labor benefits which pertain mainly to effective weed management i.e. reducing the need for weeding (Azadi and Ho 2010; Brookes and Barfoot 2015b; Carpenter 2013; Gouse 2009; Ozor and Igbokwe 2007; Paarlberg 2008; Qaim and Zilberman 2003; Sengooba et al. 2009; J Vitale et al. 2008). By referring to studies reporting data based on African small farmers' experience with GM crops, various studies argue that African small farmers prefer the "weed-control convenience" of GM crops (maize and cotton) more than “insect borer control” (Adenle et al. 2014; Thomson 2015). “Weed-control convenience” is argued, a) to provide farmers with more time for off farm labor (Finger et al. 2011; Popp and Lakner 2013), b) to provide more labor for food crops cultivation by reducing labor needed for cotton (Elbehri and Macdonald 2004; Hillocks 2005), c) to save women the drudgery of long periods of weeding (Juma 2011c), and c) to mitigate labor shortages caused by HIV (Smale et al. 2009). The second group of review studies respond to concerns that the adoption of GM crops would lead to labor reduction and unemployment; they argue that labor reduction of weeding and spraying is compensated by increased labor for harvesting (Cabanilla, Abdoulaye, and Sanders 2005; Chambers et al. 2014; Thomson 2008).

Few studies argue for potential benefits of GM crops to enhance farmers’ productivity. Anderson and Jackson (2011) argue that “Productivity of unskilled labour would rise by 2%” if “second generation GM crops” which are “nutritionally enhanced” are adopted by African farmers (Anderson and Jackson 2005).

Finally, Bouee¨t & P.Gruere (2011) argue that Labor effects of GM crops depend on country farming characteristics.

DISCUSSION

South Africa Accounts for Most of Research Based on Farmers’ Practice.

Most studies that base their sources of evidence on actual smallholding farmers’ experiences with GM crops obtained their data from South Africa. South Africa was the first African country to start producing a GM crop at the commercial level. South Africa established connections with a US company to launch GM crop field trials in 1989 Gouse (2013). This was the main impetus of the development of South African biosafety policies.[11]

The fact that South Africa has grown commercial GM crops since 1998, and 10 years later was joined by Egypt, Sudan, and Burkina Faso, raises questions on the political and socio-economic factors influencing the adoption or rejection of GM commercial crops in Africa. This question I discuss in deeper terms in chapter 5, taking Morocco as a case study.

Less than a third of papers used either small or large-scale farmers as a unit of analysis. The fact that less than a third of articles used either small- or large-scale farmers as a unit of analysis suggests three main conclusions. First, there is insufficient evidence based on actual farmers' practices to assess the relevance of GM crops to farmers' livelihood systems, particularly smallholders. Second, most data based on small- or large-scale farmers is collected from the same country, South Africa, and same location (Kwazulu-Natal). Third, the same network of studies is reiterated by other policy and academic platforms, such as International Food Policy Research Institute (IFPRI) and International Service for the Acquisition of Agri-biotech Applications (ISAAA). As demonstrated in the second chapter, most influencers, which are cited to argue for SD benefits, belong to this network. These influencers themselves highlight, as discussed in every GM finding section, important limitations related to their data collection: surveys were collected by the seed company Vunisa, data collected so far remains insufficient, and GM benefits depend on the interaction among complex factors, e.g. weather conditions, farming practices, and institutional arrangements.

[11] More historical accounts on "South African Biosafety Framework" is provided by Gouse (2013) on IFPRI report (2013): Genetically Modified Crops in Africa Economic and Policy Lessons from Countries South of the Sahara

The shortage of data on actual farmers' experiences with GM crops leaves us with big questions on the socio-economic situation of GM crops in Sudan, Egypt and Burkina Faso. I have also found conflicting accounts on the cultivation of GMOs in Egypt and Sudan. For instance, The Friends of the Earth claims that Egypt has suspended the cultivation of GM crops in their report of February 2015, whereas ISAAA lists Egypt as one of the GM cultivators:

> ISAAA claims that 18 million farmers are currently planting GM crops in 27 countries worldwide, but fails to mention that these farmers still represent only 0.72 per cent of the world farming population. The number of countries has also fallen from 28 in 2012, because Egypt suspended GM crop production (Swanby Haidee 2015).

The only account I found on Egyptian farmers' experiences with GM maize was in the report "Biotech Crops in Africa: The Final Frontier" published by ISAAA, under the section "Farmer experiences with BT maize in Egypt" (Karembu 2009) . This brief section provides an anecdotal account of two farmers' experience with BT maize. Regarding Sudan's experiences with GM crops, I have also noted the lack of attention to farmers' experiences with BT cotton; only one study provides a generic account of Sudanese farmers' experiences with BT cotton (Abdallah 2014). Burkina Faso is the exception, as one article directly examines Burkinabe small farmers' experiences with BT cotton (Vitale et al, 2011).

Is GM Technology Relevant?

The development of genetically modified crops requires financial and human resources to improve the desired traits of a certain crop. Therefore, it is of paramount importance to ensure that investments in GM crops correspond to farmers' needs, namely smallholding farmers in Africa. That is to say, before investments in African biotechnology are made, the relevance of biotechnology to African farmers' socio-political contexts should be assessed in the first place; this should take place for two reasons.

First, the commercialization of GM crops has generated, in many instances, costly political tensions, for example, the Euro-American trade dispute over the commercialization of US GM crops among "European communities." This case, titled by the World Trade Organization as "European Communities — Approval and Marketing of Biotech Products," reveals the arduous and costly stages this conflict went through from May 2003 until November 2006[12]. Because of the high level of urgency marking food insecurity in Africa, African countries cannot afford such disputes, which could foster socio-political destabilization. These disputes or "food wars" (Lang and Heasman 2015) would exacerbate lack of political and economic unity in Africa.

Second, major stakeholders involved in the promotion of GM crops in Africa regard technocratic initiatives as key approaches to improving African agriculture. Insufficient consideration is given to socio-political dimensions of African agriculture. Thus, the ir/relevance of biotechnology to African small-holding farmers should not solely be a science-based debate but should rather encompass issues of international dynamics of agricultural development. Therefore, a comprehensive approach to examining the relevance of GM technology would consider, for instance, questions of international asymmetrical powers, motives of philanthropic organizations to promote GM technology, the politics of development at the local level in African countries, the need to pay heed to the peculiarities of African agriculture across various African countries and regions, and the need to examine the socio-cultural implications of introducing GM technology.

[12] https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds291_e.htm

The history of failures of international development in Africa should not be ignored. First, this history can help understand and empathize with voices which are anti-agricultural modernization in Africa, and second it justifies these voices' skepticism towards the mantra of an African green revolution. I do not posit that past failures of international development justify, in absolute terms, resistance to modern agricultural initiatives in Africa, but rather I hold that anti-GM questions and skepticism should be regarded as refining arguments. Anti-GM refining arguments should be regarded as questions of socio-economic and ethical dimensions. Such questions would contribute to the development of more structured, yet dialogic, efforts among the stakeholders to implement agricultural projects in Africa more effectively, but also ensure a moral responsibility to prioritize African farmers' needs. Determining African needs is not an easy task because of the high level of heterogeneity characterizing them; what is needed most, at this stage, is to purge debates on African agriculture of demagogic disputes propounded by stakeholders from developed countries. There is a nuanced stance to be explained here: I do not hold that partners from developed worlds should not contribute to the identification of African agricultural needs and solutions, but rather hold that political and contentious stances on developed countries' concerns, such as GMOs and agricultural inputs (pesticides) should not plague Africa. I also argue that both stances on GMOs –pro and anti–derive from stakeholders who belong to institutionally, politically, and economically privileged standings.

Third, I have noted that most articles generalize their findings from studies on a specific African context to all Africa knowing the fact that their sources of evidence are very limited and show benefits of a specific GM crop, e.g. cotton, which is not relevant to many other African localities. Moreover, the commercialized GM crops, mainly cotton and maize, do not directly provide food security but could provide cash. Thus, the presumed benefits of any GM crop to an

African locality depends on its nutritional value as well as its market value. The nutritional value of GM maize is very limited since it is a staple food which might meet calorie needs but not necessarily nutritional needs unless provided as part of a nutritious diet. Having access to a nutritious diet requires adequate purchasing power, which cash from selling GM maize and cotton might provide, to buy nutritious food. However, obtaining sufficient cash from GM maize and cotton crops depends on their market value. The problem of market value depends on global/local institutional arrangements that might pose challenges or opportunities to African farmers, namely smallholding farmers. Gouse (2013) clearly discusses the drastic reduction of (BT) cotton production in South Africa because of local and global institutional arrangements:

> Cotton planting in South Africa declined from its peak of 180,000 hectares in 1988 (under tariff protection) to just over 5,000 hectares in 2010 due to a combination of market liberalization, low world cotton prices, and relatively better prices for competing crops like maize, sunflower seed, and sugar cane. South Africa has been a net importer of cotton for the past couple of decades.

This decline, in the first country in Africa to commercially produce GM cotton, reveals that the potency of any agricultural technology in Africa relies heavily on how it is deployed under prevalent socio-economic and institutional conditions.

The Generalizability of GM Crop Benefits

As mentioned before most data comes from South Africa, leaving us with questions on the generalizability of findings. Avoiding sweeping statements of GM-crops benefits in Africa would demonstrate a high level of awareness towards the adoption of other agricultural solutions to “wicked” African agricultural problems. Seeing agricultural issues in Africa as “wicked problems” would encourage various researchers not to overgeneralize findings from few GM-growing countries, namely South Africa, to argue for the need of GM crops in Africa. Moreover, recognizing African agricultural challenges as “wicked problems” would create more concerted efforts that deliberatively combine technocratic and political “decisionistic” models of agricultural development. Technocratic models of agricultural development if properly embedded within political models can stimulate an African public sphere to engage with questions of agricultural development in a more inclusive and collaborative manner, taking a cue from (Habermas,1967). Thus, African food security would be attained only with a strong public sphere which has the capacity to democratically engage in dialogues on African agricultural problems. These dialogues should encompass stakeholders affiliated with the technocratic (scientists), socio-political (activists), and decisionistic (politicians), economic (private sector), cultural (artists) spheres. More importantly, such dialogues should establish strong networks between small-holding farmers in Africa, constituting most farmers in Africa, and the aforementioned spheres. This is easier to say than do. To have such interdisciplinary and inter-spheres collaboration, one needs to practice it constantly: unfortunately, interdisciplinary research is often touted, but rarely practiced, including among proponents of GM crops.

GM Technology and Labor Benefits: A Critique

Genetically modified crops have been generally argued as a key solution to solve food security issues in Africa. Though data on small farmers’ experiences with GM crops are based on very limited cases in South Africa, most articles link GM productivity benefits to labor benefits. I argue that any examination of labor benefits associated with GM crops should consider labor division in African agriculture, and whether the adoption of GM crops increases agricultural employment or exacerbates rural unemployment.

First, farmers or the "*agricultural population*" in Africa represent 54.2 % of the population. Africa is the continent with the largest rural population (63.9 live in rural areas). Most of the rural population is concentrated in Sub-Saharan Africa: "*East Africa had the largest proportion of the rural population (79.1 percent) followed by Central Africa (61.7 percent), Southern Africa (55.8 percent) and West Africa (55.1 percent).*" As shown by the chart below:

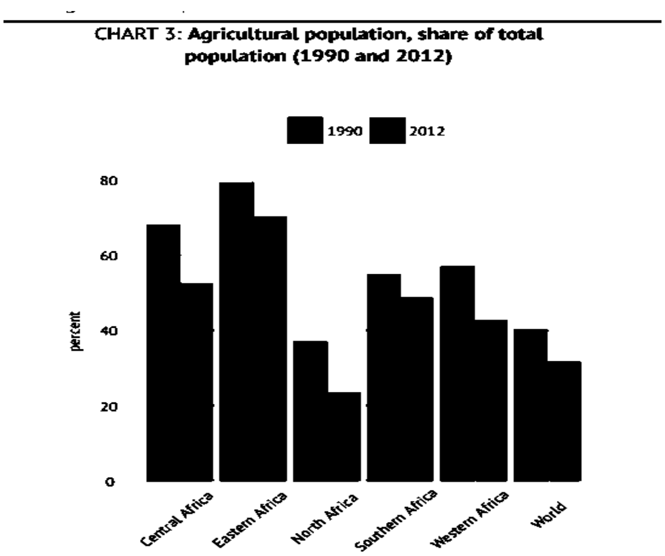


Figure 27 FAO statistical yearbook 2014: Africa food and agriculture

Compared with other continents, the value added of African agriculture share in GDP is higher, representing 14.3 %, as shown by the chart below:

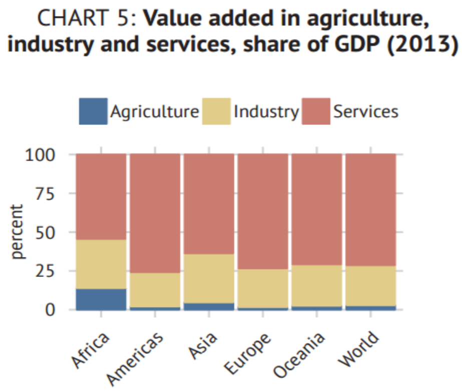


Figure 28 Source: FAO Statistical Pocketbook 2015

African agriculture is highly subsistence-based. Women occupy a central role in daily farming activities: "[in 2010] *women had the highest rate of labor participation (62.8 percent)*" reported by the Food and Agriculture Organization. The crucial role of women labor in African agriculture can be seen vividly in "East Africa [which] had the highest women's participation rate (68.8 percent), followed by Central Africa (68.3 percent), Southern Africa (66.9 percent), and West Africa (53.2 percent)."

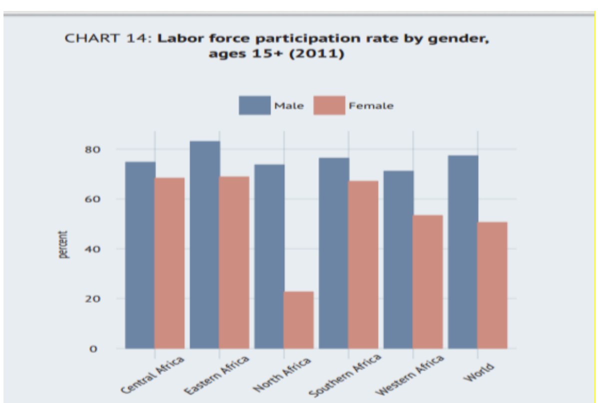


Figure 29 Source: FAO statistical yearbook 2014: Africa food and agriculture

Child labor in African agriculture is also significantly high: *"Sub-Saharan Africa continues to be the region with the highest incidence of child labour with more than one in five children in child labour"* reported by the Food and Agriculture Organization.

GM Crops and Farming Labor Conditions in Africa

According to IFAD (International Fund for Agricultural Development), a UN agency, people who live in rural areas constitute the largest population living in poverty; most are subsistence farmers and herders. The "incidence of extreme poverty" (percentage of rural people living on <US$1.25/day) remains persistently high in Africa, especially in Sub-Saharan Africa. This shows that farming labor is critical to the survival of the African rural population; it is predominantly the only source of rural livelihood. Therefore, context-bound and elaborate examinations of potential impacts on African farming labor should take place prior to the implementation of any agricultural technology or policy. I have noted the clear lack of such examinations in the coded articles. In fact, I have noted conflicting results that are based on speculative assessments rather than structural analysis of labor's socio-economic characteristics in the investigated GM growing region, namely South Africa. For instance, in their examination of the "class of labor [which] was affected" by the adoption "GM maize amongst smallholders in Kwazulu-Natal, South Africa," Gouse et al (2009) assert that the labor reduction among males and females experienced by BT growers has positive outcomes: more time for off-farm labor for men, and more time for women to fulfill the tasks of child rearing and cooking. Such claims seem to presume that off-farm labor is available regularly for men to occupy, and that women do not have time for child rearing and cooking during farming seasons.

Labor benefits associated with GM cannot be assessed solely by the decrease or increase in labor input. Rather, the circumstances of labor prior to the adoption of GM crops must be examined to determine whether farming labor is subsistence-based, temporary or long-term, and regarded positively or negatively by farmers themselves. Moreover, institutional arrangements affecting small farmers' labor, and farmers' self-identified needs to improve their labor conditions and productivity, must be examined. Chapter four engages more with claims on GM labor benefits.

Limitations of Econometric Projections

I have examined various studies which use econometric estimates to argue for the potential benefits of GM crops. These studies include Hillock (2005), Smale and De Groote (2004), Elbehri and Macdonald (2004), Boue and Gruere(2011), and De Groote et al (2003). Econometric modeling has been used to argue for the benefits of adopting GM crops and to project reduced yield that may be incurred if GM crops are not adopted. Though various studies note that institutional arrangements and farming management are of paramount importance to effectively adopt and benefit from GM crops, I have examined very few articles which pay heed to small farmers' needs, namely their needs to have access to right inputs and institutional/market support.

Conclusion

The major issues covered in this chapter do not touch on the technical aspects of the technology (e.g. safety, utility, and productivity); rather, they are concerned with the extent to which farmers' practices are informing the development of GM crops.

Considering GM crops as both a technical issue and socio-economic issue highlights one common feature. Technically speaking, no single discipline is capable of providing a definite assessment of a single GM crop as positive or negative. For instance, there is a need for plant scientists to examine the productivity of a GM crop, toxicologists and allergists to examine its safety, entomologists to examine its effects on other living organisms within the ecosystem, and food scientists to examine its nutritional value. Similarly, socio-economically, there is a need for specialists from various disciplines to examine the impact of GM crops on farmers' livelihood systems: this examination cannot take place simply by using surveys administered by seed companies or even by using surveys as a main source of data. Specialists are needed who invest in understanding the structural constraints facing farmers rather than reducing farmers' struggles to low productivity or pests' problems. Conveying farmers' realities clearly to GMO developers cannot take place without research translators who are equipped with local sociological knowledge as well as sufficient scientific knowledge to facilitate communication.

Unfortunately, GM crops introduced to African farmers were developed within the US context; they are not necessarily relevant to any other global farmers' needs unless they (farmers) are involved prior to the development of GM crops. As discussed before, the mindset of GM proponents is heavily influenced by corporate mindset which is driven by hype and marketing. This prevents any genuine dialogue on GM benefits to take place: if you are critical, you are either luddite or anti-science, and if you are pro-GM technology that means you use the mantra of feeding the world to justify an African Green/gene revolution. Accusatory mindsets from proponents and opponents of GM will not lead to a healthy dialogue, they will only exacerbate the pre-existing academic tribalism around GM technology.

CHAPTER 4: FRAMINGS OF SOCIAL BENEFITS OF GM CROPS EXPERIENCED BY AFRICAN FARMERS

Controversies surrounding the relevance of biotechnology to African small-holding farmers have given rise to debates in academic research, policy arenas, and funding institutions (Stone 2010). Each perspective on genetically modified crops, pro or anti, seeks to back up its position by demonstrating how African smallholder farmers would be impacted by biotechnology. Both proponents and opponents of biotechnology have attempted to back up their arguments using evidence from: biotechnology field trials, estimates of health consequences of the technology, yield data collected from the adopters of the technology, and analysis of the political agendas perpetuating or impeding the spread of biotechnology in Africa (Paarlberg 2010; Schnurr 2013). This study focuses on the social benefits, namely labor benefits, associated with GM crops adoption. Through critical/discourse analysis, the paper examines the arguments supporting social benefits experienced by genetic modification (GM) technology adopters in Africa.

BACKGROUND OF THE PAPER

I have examined peer-reviewed and policy reports and briefings on biotechnology in Africa as part of my dissertation project. Since my goal has been to gauge the extent to which smallholding farmers' practices are considered by biotechnology proponents, I focused mainly on collecting studies which propound the benefits of GM technology with an emphasis on studies that use small farmers as their source of data. Preliminary analysis has revealed that social benefits, namely labor and health-related benefits, constitute the main arguments of biotechnology proponents.

STATEMENT OF THE PROBLEM

General Context of the Study

I focus on Africa. Africa has always been characterized by unchanging representations in the present era, e.g. as a place marked by hunger, civil war, uncontrolled population growth, exoticism, and other plights. Africa has therefore been seen --paradoxically--as a zone of human destructive forces, but also as a zone whose challenges offer opportunities for human ingenuity to prove its capacities to solve African problems. One major African problem is food insecurity which at present seems insurmountable. According to the most recent FAO State of Food Security and Nutrition report , "*The number of undernourished people in sub-Saharan Africa rose from 181 million in 2010 to almost 222 million in 2016, an increase of 22.6 percent in six years, and – based on current projections – may have increased further to more than 236 million in 2017*"(FAO, IFAD, UNICEF 2018). It was also predicted that " *we are still far from reaching millennium development goal (MDG) number 1: to halve extreme poverty and hunger by 2015*" (Sasson 2012). It is therefore unsurprising that there is continued publicity about biotechnology's capacity to contribute to the solution of food insecurity, Africa's number one challenge (Juma 2011a; Leisinger 1999; Okeno et al. 2013; Van de Walle 2008).

Most of the publicity on the potential benefits of GM crops to African food security comes from South Africa where the first GM crop, BT cotton, was commercially introduced in the production season of 1997/1998 (Fok et al. 2007). Contentious voices clashed at the time over the safety and relevance of the technology to South African farmers' needs (Freidberg and Horowitz 2014). Though three other African countries have commercially adopted GM crops, Burkina Faso (2008), Egypt (2008),[13] and Sudan (2012), most of the reviewed studies elicit data only from South Africa. This is explained by the fact that South Africa has the largest total area of GM crops, 2.2 million hectares (Okeno et al. 2013)[14].

Focus of the paper. In this research project, I focus on studies arguing for labor and health benefits of biotechnology, e.g. saving on weeding, less labor for input, more labor for harvesting, and less exposure to toxic pesticides. The examination of pro-biotechnology arguments reveals their sources of evidence and investigative tools used to substantiate their stance. It studies how they represent their research findings, e.g. numerical representations, anecdotal analysis, and document analysis. Thus, the main research question is:

- How do pro-biotechnology studies derive and frame their arguments on social (labor and health) benefits of biotechnology?

I focus mainly on arguments propounded by biotechnology supporters in peer-reviewed articles and policy reports by major food policy institutes. Twenty-two studies examined for this paper use farmers as their sources of data. This number, I posit, represents most of the studies using African farmers as their sources of data and making claims on GM labor and health benefits.

[13] Conflicting accounts were found on whether Egypt still grows GM crops.
[14] Most recent data from the International Service for the Acquisition of Agri-biotech Applications (ISAAA),states : "In 2014, 2.14 million hectares of the total maize area in South Africa is biotech. 83% of total white maize area is biotech, and 90% for total yellow maize." From: https://www.isaaa.org/resources/publications/biotech_country_facts_and_trends/download/Facts%20and%20Trends%20-%20South%20Africa.pdf

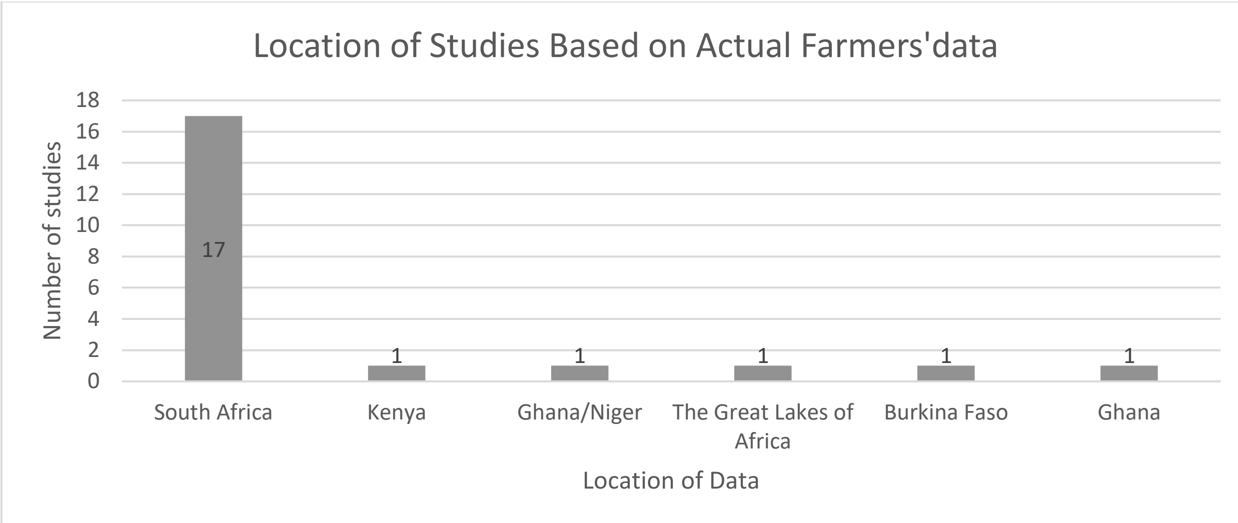


Figure 30 Location of data

Rationale of the Paper. Critiquing the conception of labor has been well-established in western scholarship (Marx,1983[15],Polanyi, 1944; Weber, 1958). This critique ranges from examining modes of production to unravelling the socio-cultural meanings associated with labor (Claudel 1984). Such critiques of Western labor constitute major avenues of discussion for both modern and traditional scholars, such as David Ricardo, Thomas Malthus, Adam Smith, Max Weber, Karl Marx, Karl Polanyi, Michel Foucault, Pierre Bourdieu and others. Such studies are lacking within the African context or are confined within academic disciplines, such as ethnography and anthropology, e.g. (Siegal 2016), and political science (studying African labor unions). I recognize that I make a grand claim about the scarcity of studies on African labor, namely farming labor; however, the peculiarities of African labor are not considered in the literature claiming labor benefits of biotechnology, and this is sufficient reason to question their findings. One clear indicator of how African farming labor's specificities are not born in mind is the criteria used to measure its status. These are the same criteria applied in other regions,

[15] Marx, K. (1983). The Portable Marx. Ed. Eugene Kamemka. New York and London: Penguin Books.

including wealthy countries, and typified by the annual data of the International Labor Organization. The homogenization and Westernization of the conception of African labor is an offshoot of what I call the "politics of homogenization" defined eloquently by Edward Said (1993):

> "No one today is purely one thing. Labels like Indian, or woman, or Muslim, or American are not more than starting-points, which if followed into actual experience for only a moment are quickly left behind. Imperialism consolidated the mixture of cultures and identities on a global scale. But its worst and most paradoxical gift was to allow people to believe that they were only, mainly, exclusively, white, or Black, or Western, or Oriental."

Thus, I can tentatively claim that terms like farming, harvesting, farmer, and farm labor cannot be taken for granted as bearing shared meanings across cultures. On the contrary, there is a need to situate them politically, economically, culturally, personally, and ecologically. This paper focuses mainly on the representations of African farming labor in the light of studies that advocate labor benefits of GM crops. As will be illustrated, labor benefits are also associated with health benefits in the arguments of proponents of GM crops.

METHODOLOGICAL APPROACH

Analytical Approach

This paper's approach to present and engage with arguments on labor benefits generated by the adoption of GM crops involves two analytical stages. The first stage outlines studies focused on labor and health benefits of GM crops; this involves providing contextual background for the studies as well as their major findings. In the second stage, the conclusions drawn from the discussion of these studies are critiqued from three perspectives: critical development studies, ethnographic and anthropological accounts of labor dynamics, and studies that directly critique how labor is conceived of by pro-biotechnology proponents.

Theoretical frameworks definition: Critical development studies, as one of the adopted theoretical frameworks, seeks to unravel the politics of international development. This involves delving into the intellectual and political conceptions of development, and how these conceptions lay the foundation for development projects at the national and international level. Central to critical development studies is the examination of international institutional arrangements and their influence on national policies and politics. Since development is mainly a modern concept, the main task of critical development studies is to refer to contemporary cases of failure and success. They also examine whether modern theories and projects of social change have been effective in attaining development as theorized by its proponents.

The second theoretical framework bases its arguments on ethnographic and anthropological works that attend to labor divisions as constructed by cultural and legal/customary law norms; major works of relevance to this framework are Clifford Geertz' works on Indonesia and Morocco and Chayanov's studies of peasant cooperatives in Russia/Soviet Union.

The two theoretical frameworks are methodologically informed by discourse analysis and critical discourse analysis as delineated by Norman Fairclough (2010) and Paul Gee (2014). This study adopts both discourse analysis and critical discourse analysis, though the two have been argued to be different in terms of their ultimate objective. Discourse analysis is more descriptive of the language used and its associated meanings, while critical discourse analysis (CDA) views language as "a form of social practice" which shapes and is shaped by social structures through power over meaning-making e.g. "text production," "text distribution," and "text consumption" (Fairclough 2013). Thus, discourse analysis analyzes the language and its derivative meaning-making features, e.g. sentence structure, intonation, word choice, and use of figures of speech.

Critical discourse analysis, in addition to analysis of language and its derivative meaning-making features, aims at unraveling how the very use of language informs social practices: identity claiming, domination, power assertion, knowledge legitimization, and “naturalization” and “denaturalization” of certain social practices (Fairclough 2013). Both discourse analysis and critical discourse analysis inform my analysis of examined data to provide a descriptive background information on the data, and to engage with its potential impact on informing social practices, e.g. international development projects and food security plans/policies.

Data Analysis Procedures

Background information of the analyzed texts. Providing background information on the analyzed texts is informed by Fairclough (1995) who stresses the importance of historical background of the analyzed data:

> **“**Critical discourse analysts sometimes fail adequately to historicize their data, that is, on the one hand to specify the particular historical conditions within which it was generated and what its properties and shape owe to these conditions, and on the other hand, to specify what part it plays in wider historical processes.**”** (Fairclough 1995).

Background information analysis involves data location and date, data sources (farmers/others (ex-ante analysis, review)), the studied genetically modified crop trait (BT, round-up ready), labor benefits arguments, and types of barriers (institutional, political) to attain labor benefits. All studies are published after 2000, and most of the studies (17) collected their data from South Africa. All the selected studies base their data on farmers’ agricultural information, such as inputs (labor, seeds, and pesticides), and output (yield, efficiency, revenues and losses).

Review of the literature on GM labor benefits. This review considers the extent to which the selected studies have impacted African countries' stance on GM labor effects. In the review of the literature, I discuss studies that report labor benefits of GM crops. Generally, I argue that the selected 22 studies inform various scholarly works' stance on GM crops, a point discussed on chapter two and expounded through citation network analysis.

REVIEW OF THE LITERATURE

Major Arguments on Labor Benefits Experienced by GM Growers

Most of the selected studies rely on data collected from Makhathini Flats, KwaZulu-Natal in South Africa. For this paper, several articles and policy reports were examined, paying special attention to arguments on social benefits experienced by African farmers who grow GM crops, namely BT cotton and BT maize. These studies range from review studies, including meta-analysis studies, to policy studies.

Review studies. Various review studies present arguments on the social benefits of GM crops by referring to studies conducted with farmers mainly in Makhathini Flats, KwaZulu-Natal in South Africa. Hillocks (2005) refers to "a study conducted between 1998/99 and 2000/01 [which]concluded that there were substantial benefits from BT adoption (Thirtle et al. 2003). Cost savings were made in decreased pesticide use and in decreased labour requirement for spraying, while average yields increased." (Hillocks, 2005). Similarly, In their meta-analysis study involving multiple regression analysis of major findings of the collected studies, Finger et al (2011) posit that "In South Africa, reduced labor and fuel costs were observed for large commercial farmers because less pesticide applications were needed and less time was spent scouting fields for pests" (Finger et al. 2011) . Using **"**multiregion general equilibrium model and multi country estimates of BT-induced productivity.**,"** Elbehri an Macdonald (2004) conclude that the "general equilibrium analysis shows that with 25% transgenic cotton adoption, welfare for WCA (West Central Africa) increases from 70 to 100 $US million annually.**"** Studies like Elbehri and Macdonald's (2004) deploy econometric models to project the potential benefits of GM crops based on farmers' experiences with GM crops in other parts of the world, namely Asia, South America and North America. Such studies seek to forecast scenarios of GM impacts on African countries that have not adopted GM crops. Some of these studies are Anderson & Jackson, 2005; Bouet & Gruere, 2011; Groote & Mugo, 2004. Major proponents of GM crops' social benefits base their arguments on review studies, and argue that labor benefits can be achieved by enabling the adoption of biotechnology in Africa (Borlaug 2000; Juma 2011a; Van de Walle 2008).

Review studies on food security in Africa refer also to arguments on labor benefits of GM crops which reduce labor needed to spray pesticides (Clarke and Zhang 2013; Leisinger 1999).

Policy studies. Food policy institutions play a major role in concentrating efforts to solve food security issues in Africa. Various food policy institutes have conducted collaborative research projects with seed corporations, namely Monsanto and Syngenta; philanthropic organizations, i.e. the Rockefeller foundation and Bill and Melinda Gates Foundation; and academic institutions in GM adopting and non-adopting countries. Examples of such collaborations are to be found in the works of IFPRI (International Food Policy Institute). Various IFPRI reports have been examined for this study. Most of these reports include chapters by researchers mentioned in the last section; they also include contributions from policy-oriented researchers belonging to other food policy institutes. In the report "*Genetically Modified Crops in Africa, Economic and Policy Lessons from Countries South of the Sahara*," 2013, a peer-reviewed publication, there are three routes of research on GM technology impact on labor benefits: first, results of data elicited from farmers growing GM crops namely in South Africa; second, estimates of biotechnology impact on Africa if the technology is adopted; and third, critiques of international trade politics' influence on African non-adoption of biotechnology. I give examples of each route of research below.

The first route of policy research includes policy studies that are based on data collected from farmers growing GM crops. For example, in the first chapter[16] of the IFPRI report mentioned above, Gouse (2013) presents results of data on South African farmers' experiences with BT maize and BT cotton. Gouse concludes that "*it would seem*" that farmers would prefer the labor-saving benefits of herbicide tolerant maize as weeds cause more burden than insects; farmers therefore would prefer herbicide resistant maize over BT maize. Gouse (2013) also concludes that thanks to the adoption of HT (herbicide tolerant) maize "farmers are able to save quite considerably on family labor person-days" in the face of the scarcity of labor due to emigration of able-bodied people to urban areas and HIV/AIDS epidemic.

The second route of policy research includes studies which estimate how GM labor benefits would be enjoyed by African farmers if the technology is adopted. For instance, in the third chapter[17] of the IFPRI report, the authors provide a nuanced position on the potential labor-saving benefits of BT cotton in Uganda using econometric models to project socio-economic benefits of introducing GM cotton to Uganda (a non-GM growing country). The authors argue, based on "an ex ante evaluation of the potential impact of GM cotton adoption in Uganda at the

[16] The full title of the chapter: Gouse, M (2013). Socioeconomic and farm-level effects of genetically modified crops: the case of Bt crops in South Africa. *Genetically modified crops in Africa: economic and policy lessons from countries south of the Sahara*, 25-41.
[17] The full title of the chapter: Horna, D., Zambrano, P., Falck-Zepeda, J., Sengooba, T., & Kyotalimye, M. (2013). Genetically modified cotton in Uganda: An ex ante evaluation. *About IFPRI*, 61.

farm level," that the introduction of GM cotton would bring labor-saving benefits to farmers. These authors, however, caution against potential "negative impact on employment and welfare in the community if there are not many off-farm labor opportunities," noting that "almost all the farmers make use of hired labor."

The third route of policy research includes critiques of international trade politics' influence on African non-adoption of biotechnology. In the eighth chapter, Paarlberg[18](2013) argues that "growers of maize… remain poor and food insecure because the productivity of their farming labor is so low" in addition to other reasons, such as population growth and human-induced climate change. In this chapter, Paarlberg (2013) also criticizes the European influence on Africa's non-adoption of GM technology.

Review of Labor Representations in the African Context

While the literature heavily emphasizes GM's labor benefits, there is no discussion of the socio-economic context of African farming labor within which GM crops are commercialized. Below is a review of literature discussing the socio-economic circumstances of farming labor in Africa with a focus on South Africa from which arguments on GM labor benefits are drawn.

The Representations of Labor Division and Relationships

Robbins (2011) posits that "development and environmental management initiatives, no matter how well intended, tend to be based on assumptions that are classed, gendered, and raced.," He adds "development plans tend to imagine the subjects of development – the local farmer, herder, or fisher – with assumptions about their outlook, behavior, and interests that

[18] The full tile of the chapter: Paarlberg, R. (2013). Genetically Modified Foods and Crops: Africa's Choice.*About IFPRI*, 207.

reflect the socially situated imaginaries of the planner." To elucidate how the construction of "the subject of development" informs how development takes place, Robbins (2011) refers to an example-or evidence- from Carney and Watts' research on agricultural intensification programs in Gambia (Carney and Watts 1991). Their research has demonstrated how lack of attention to labor divisions and gender dynamics by inter/national agricultural programs led to backlash and resistance to the newly implemented agricultural programs on the part of women who became burdened by more work generated by those programs. These agricultural intensification programs affected women negatively in two ways. First, additional farming work, coupled with ecological factors (heat and humidity) caused physical exhaustion which consequently affected women's status as the primary providers of child rearing. Second, prevalent gender relations left women's total labor value unrewarded. Under local socio-cultural compensation schemes men earn more than women, and the amount of labor is not the determining factor. Gender determines who earns what. This case demonstrates that labor's value is determined not solely by monetary value but mainly by socio-cultural valuation.

Labor in South Africa. Because the selected studies for this paper obtained their data from South Africa, it is beneficial to look at research which examines labor dynamics within the South African farming context. In this context, labor division can be understood only by considering how colonial policies and institutions have designed "socially engineered" labor value and labor relationships. For instance, the economic patterns instituted by colonial powers "tied land, residence and labour in a particularly disjointed but systemic way, with consequences for nutrition, for health and for forms of affliction." (O'Laughlin 2013). This means that the relation between labor and capital affects social relations, gender dynamics, and health. In South Africa, O'Laughlin (2013) provides historical explanations of rural labor divisions by discussing the intersectionality among structural inequalities, colonial legacy, and local social relations. Similarly, Neves & du Toit (2013) argue that "the decline of smallholder African agriculture for most of twentieth century was driven by racialized land dispossession and underdevelopment, in order to meet the labour demands of industrial capitalism." The significance and perceptions of farming among South African farmers were examined by Ferguson (2013) who argues that "The percentage of people farming 'seriously' (as they say) seems to be on the decline, while the dreams and ambitions of poorer South Africans focus less on small holder farming, and more on urban living, consumer goods and the ever-elusive 'business'."

Thus, any conception of African farming labor that fails to consider socio-economic, cultural and political conditions, as well as farming local peculiarities within which African farming labor has been evolving, lacks cogency.

FINDINGS

Because the way discourses on GM social benefits, namely labor and health benefits, are constructed, they can be analyzed through more than one framework. For this reason, I first define the analytical frameworks used to analyze the discursive practices of proponents of GM labor benefits before providing instances from the literature; these frameworks are: *Connections and interdiscursivity, Significance, and Conversationalization*.

- *Connections and interdiscursivity:* How are situated meaning/meanings of labor and health benefits being used to connect with other social issues, economic conditions, and challenges faced by African farmers? For Gee (2010) "connections" refers to "*us[ing] language to render certain things connected or relevant (or not) to other things, that is, to build connections or relevance* ." Using the concept of "interdiscursivity," Fairclough

(2013) calls for considering how texts are "intertextually" constituted through interactions with different "genres" and "discourses." Fairclough defines "genre" as a "*socially ratified way of using language in connection with a particular type of social activities;*" his "*concept of interdiscursivity highlights the normal heterogeneity of texts in being constituted by combinations of diverse genres and discourses*" (Fairclough 2013). Thus, the analysis of examined texts involves looking at how GM labor and health benefits are laid out in connection with other social and economic issues.

- *Significance:* How are situated meaning/meanings of labor and health being used to build relevance or significance for GM crops in the context of African farming? (Gee 2010)
- *Conversationalization*: means the "*colonization of public domain by practices of private domain by appropriation e.g. promotion*"(Fairclough 2013). It is important to examine how GM technology, which is a private sector solution, is presented as a technology which would address public problems, such as the shortage of labor due to diseases (HIV) and rural-out migration.
- *Style:* refers to how "*participant relations are constructed*" (Fairclough 2013). The selected studies refer to social relations and how they affect farming labor.

Instances of discursive practices: Each argument will be presented and discussed in the light of the analytical frameworks presented above.

First Instance:

> "The positive aspect of this research is that the disaggregated labour data show that neither of the GM crops seems to cause very large reductions in family labour use. The reduction in child labour may mean more schooling, that for women may leave more time for important child rearing tasks and that for men may allow more outside employment."
> (Gouse et al. 2009)

The statement assumes that off-farming labor is of secondary importance for men. It also assumes that women need more time for child-rearing and household work, and it assumes that farming labor is the main obstacle for children to attend school. None of the assumptions above would be validated unless socio-cultural and demographic as well as ecological information on the surveyed farmers is provided, which the authors did not do. Thus, from "style" analytical framework, "participant relations are constructed" on ill-founded assumptions. The citation above also shows how the significance of labor benefits is built on "imagined" interactions between GM technology and labor dynamics in the studied area, KwaZulu Natale, South Africa. Similar claims are asserted by Shankar & Thirtle (2005); Thirtle, Beyers, Ismael, & Piesse (2003); Ismael, Beyers, Thirtle, & Piesse (2002); Bennett, Buthelezi, Ismael, & Morse, (2003); Gouse, Kirsten, Pray, & Schimmelpfennig, (2006); Marnus Gouse, Kirsten, & Jenkins (2003); Morse, Bennett, & Ismael (2005); and Marnus Gouse (2012).

Second Instance:

> Gouse (2013),in (IFPRI 2013), concludes that thanks to the adoption of HT (herbicide tolerant) maize "*farmers are able to save quite considerably on family labor person-days*" in the face of the scarcity of labor due to emigration of able-bodied people to urban areas and the HIV/AIDS epidemic.

If emigration of able-bodied people to urban areas is prevalent, then those who would stay to farm presumably are not able-bodied. They, like people suffering from HIV/AIDS, would be unable to bear farming tasks. Under such structural problems--emigration of able-bodied and HIV--no technology would compensate for the need for more able-bodied farmers. As discussed in the review of literature on South African labor, health issues and rural-out migration are outcomes of governmental/colonial policies; structural approaches are required to solve them.

The instance above can also be analyzed through "conversationalization" (Fairclough,2010): "colonization of public domain by practices of private domain by appropriation, e.g. promotion." GM technology, as a "private domain," is presented as beneficial by arguing for its capacity to address public problems of labor shortage. Presenting private solutions to public problems is a "marketization" strategy through which private/capitalist solutions claim to address public/structural problems (Fairclough 2013).

Studies with similar arguments are (Smale et al. 2009) [not among studies selected for analysis]; and (Gouse 2012).

Third Instance:

> "The concern about Bt technology threatening the livelihoods of the poorest section of rural society, i.e. hired labourers, appears to be unfounded, since the expansion of harvest labour compensates for the reduction in spraying labour" (Shankar & Thirtle, 2005)

This statement erroneously assumes that farmers calculate in a futurological manner that the labor lost today will be compensated tomorrow, as if labor value is the same throughout the year. The validity of the aforementioned claim requires socio-cultural information on farmers' livelihood as well as insights into their perceptions of their farming practices and how these perceptions vary temporally and spatially. This shows that significance of GM labor benefits is built by addressing "unfounded" concerns ("about BT technology threatening the livelihoods of the poorest section of rural society") and by unfounded assumptions (about farmers' perceptions of their farming labor). The concern that BT technology threatens the livelihoods of the poorest section of rural society requires examination of how the technology manifests itself within a specific context as well as its interactions with other non/farming factors: the market, ecological factors, gender relations, farmers' perception of their farming practices and labor conditions.

Fourth instance:

> "Farmers seem to be willing to pay for the weed-control convenience; it appears as if farmers value the yield increase and (especially) the labor-saving benefit of HT maize more than the borer-control insurance of Bt maize. This inclination should be seen in the context of the relatively low borer pressure over the research period and the limited able-bodied labor force in rural KZN, caused by out-migration in search of employment, a high HIV/AIDS infection level, and elderly farmers. Future analyses and publications will focus on the labor-saving benefit of HT maize, potential expansion of production due to the decreased need for weeding labor, and gender implications of GM maize adoption and use." (Marnus Gouse, 2012):

Similar to Gouse(2013) (the same author, in IFPRI 2013), herbicide tolerant (HT) maize, which is a private technology, is argued to benefit farmers more than BT maize because it requires less labor; and since labor shortage is a major problem due to rural-out migration and HIV epidemic, which are public issues, HT technology is a potentially beneficial technology. As an instance of "conversationalization," proponents of GM labor benefits "appropriate" public problems to push for the adoption of the private technology. The instance above can also be analyzed through the "significance" analytical framework since GM technology significance is built by highlighting its capacity to address public problems.

Fifth Instance:

> "Similarly, herbicide resistant cotton would allow smallholders dependent upon manual labour to reduce time, energy or even cash spent on weeding." (Morse, Bennett, & Ismael, 2005).

Significance of HT maize adoption is argued based on assumptions that smallholders need to reduce time for manual labor, energy, and weeding expenses. There is, however, no examination of how the reduction of manual labor weeding expenses could exacerbate rural livelihood conditions such as unemployment and disruption of farming communal work[19].

Sixth Instance:

> "In addition to the yield gains from Bt yellow maize, large-scale farmers were also able to save on their plant protection operations. 70% of the large-scale yellow maize farmers in our survey indicated stem borers to be the dominant insect problem in maize production and, unlike USA, farmers seem to have sprayed substantial amounts of pesticide to control them – particularly in the irrigated areas. The reduction in pesticide cost measured in Table 4 is only part of the farmers' actual reduction in pest management costs. Other savings come in the form of lower costs of labour and fuel in the application process and less time spent scouting fields for pest build up. As we expected, the reductions in costs were highest in the irrigated regions where moist conditions are more favourable to insect growth and reproduction." (Marnus Gouse, Pray, Kirsten, & Schimmelpfennig, 2005)

The impact of BT yellow maize on reducing labor costs is seen solely from the large-scale farmers' perspective; no attention is paid to how labor reduction affects farmers hired by large-scale farmers for seasonal labor including weeding, spraying and harvesting. *Significance* is built by showing the advantage of BT yellow maize for large-scale farmers and the exclusion of any potential drawbacks that might be experienced because of labor reduction. It would be worth examining the number of farmers whose livelihoods depend on employment provided by large scale farmers.

Seventh Instance:

> "Extrapolation suggests that three sprays of cypermethrin [a pesticide] would cost around 200 SAR (approximately US$18). Growers of Bt could save this expenditure together with 14 hours of time and the unpleasant (and potentially harmful to health) task of walking 27 km per hectare carrying a heavy knapsack, usually spraying in high temperatures and with no protective clothing. Although men tend to undertake spraying, it is women and children who

[19] While I do not want to fall in the same mistake and generate assumptions about farming livelihood, I would prefer to emphasize that the authors' assumptions lack basic investigation of local farming context.

have the arduous task of collecting water for the sprays often involving long distances, and the reduction in sprays reduces this requirement." (Bennett, Morse, & Ismael, 2006):

This citation encompasses discursive practices of *connection or interdiscursivity, style and conversationalization, and significance.* Connection or interdiscursivity is made by linking GM (BT) labor benefits with how the technology reduces drudgery suffered by women and children who have the "arduous task of collecting water;" BT labor benefits are also connected to protecting farmers from "*the unpleasant (and potentially harmful to health) task of walking 27 km per hectare carrying a heavy knapsack, usually spraying in high temperatures and with no protective clothing*." *Style* reveals that the relations between men, children, and women are constructed as a narrative that shows the positive labor benefits of BT crops. *Converstationalization* in the citation above makes Bt labor benefits a key "private" solution to reduce pesticides sprays and eventually address drudgery experienced by men, women, and children. I argue that drudgery experienced by farmers is a public problem caused by lack of appropriate policies and plans to address the improvement of farmers' livelihood systems, and no single technology is capable of addressing the complex causes negatively affecting farmers' livelihood. The citation above builds significance of BT technology by showing its positive impact on farmers' quality of life (drudgery mitigation), cost reduction, and children's welfare. It would be an overstatement to present BT technology as a solution to the drudgery caused by pesticides application given that the solution of struggles faced by smallholders go beyond one technology. More importantly, some studies pointed to the fact that reductions in pesticides application is based on misunderstanding on the part of farmers: farmers assume mistakenly that BT is effective against non-bollworm pests, which means they might increase pesticides application if they become aware of the fact that they should use pesticides for non-bollworm pests (Bennett, Ismael, Morse, & Shankar, 2004; Bennett et al. 2004:19).

Eighth Instance:

> **"**Fewer insecticide sprayings reduced labor costs, but the higher yields obtained by growing Bollgard II resulted in higher harvest costs and no significant reduction in labor costs. While labor cost savings are often cited in the biotechnology adoption literature, they have been reported primarily in the developed country context where opportunity cost of operator time and machinery running costs are greater. For instance, in South Africa both Kirsten and Gouse [72] and Shankar and Thirtle [73] report no significant labor cost savings from Bt cotton due to higher harvest costs that offset the effects of reduced labor in pesticide application." (Vitale, Ouattarra, & Vognan, 2011)

Significance of GM technology is built in this study of BT adoption in Burkina Faso by referring to how the adoption of BT technology produced labor benefits to farmers in South Africa: the technology did not reduce labor (thereby exacerbating rural unemployment) because more labor was required at harvest. This instance is also an example of *interdiscursivity* because it evokes the discourse of GM labor benefits in the South African context and deploys it to argue for GM labor benefits in Burkina Faso. The blatant assumption made here is that South African and Burkinabe farming conditions are similar and that both countries would enjoy similar benefits once BT technology is adopted. This assumption requires deep examination of farming labor dynamics within both farming contexts prior to any comparison between the two contexts.

Ninth Instance:

> "The positive outcomes associated with Bt-cotton pertain to profitability gain (resulting from reduction of insecticide sprays and yield increase due to bollworm damage limitation) as well as to a net diminution in labour investment (for insecticide spraying, not considering greater labour requirement at harvest associated with higher yield) However extrapolation of these results are tricky as local contexts seldom are taken into account, in particular with regard to the organisation of the input and output markets and institutional arrangements that govern them, a factor of critical importance in smallholding production." (Fok, Gouse, Hofs, & Kirsten, 2007)

Though the citation calls for considering local contexts, it mainly emphasizes considering the contexts of market structures and institutional arrangements and does not call for considering political economy of farming, e.g. land distribution, labor division, and economic marginalization. This is an instance of *reflexivity* (Fairclough 2013) where experts systematically use their "*knowledge about social life for organizing and transforming it.*" Reflexivity builds significance where the experts express criticism of the structure within which they function, yet their criticisms are not developed outside their paradigm/worldview.

DISCUSSION: LABOR OR DRUDGERY?

Critical Development Studies and Economistic Representations of Labor

There is a well-founded tradition in western social theory that critiques economistic conceptions of socio-economic relations. Various thinkers examine the socio-cultural and spiritual characteristics marking as well as forming what seem to be material and economic. Weber (1958) and Bourdieu (1986) conceived of labor and consumption choices as "stylization of life" where social groups communicate their identity through their material choices: consumption, eating habits/etiquettes, and labor. Following the same line of thought, the modernization project/development project is not only an economic agenda; it is mostly a lifestyle that is paradigmatically different from other world lifestyles. Modernization as a lifestyle based on sustaining the treadmill of production and profit-making has brought ecological consequences that disproportionately affect livelihood systems at the global level. This has led to an unprecedented situation formed by ecological and human-induced causes: modernization through industrialization has led to climate change and air/water pollution of which most victims are from the periphery of the developed world and the periphery of the world in general (developing countries). The periphery of the developed world refers to marginalized and disempowered communities located within most developed countries, whereas the periphery of the world refers to countries that have not fulfilled the goals of modernization yet experience the detrimental effects of modernization enjoyed by most developed countries. This paradoxical situation is very relevant to GM technology whose capacity to engineer GM drought-resistant has been hyped nationally and internationally despite the fact that the generators of climate change, which is the major drought inducer, belong to the same socio-economic backgrounds of modernization proponents: the wealthiest and richest countries of the world. One may argue that it is not fair to lump together those who are developing GM technology to address climate change with those who are perpetuating climate change due to their reckless economic and industrial plans. This argument might be more legitimate within a different context where stakeholders are largely separated from each other. However, within the arena of GM technology, I find major global economic stakeholders and philanthropic organizations as well as most powerful political centers interconnected in a complicated yet easily trackable network of cooperation. I do not intend here to engage with what many studies have conceived of as an intentional plot to render the negative externalities of the development agenda to a marketable product for others: climate change causes drought = seed corporations engineer seeds to resist droughts = politicians are encouraged to promote drought resistant seeds = farmers are encouraged to buy drought resistant seeds = seed corporations profit by selling their latest drought-resistant seeds products.[20] I propose mainly that any conception of African farming labor requires social, cultural, political and economic lenses of analysis to account for the structural problems affecting farming labor. Moreover, I should be careful with naming certain farming practices using the term “labor,” the same term used to refer to farming practices in

[20]See the works of Jacobson & Myhr, 2013; Schnurr, 2013

contexts different from African farming, such as the US and Europe. More importantly, African farming labor, though governed by a shared history of exploitation by colonialism, is marked by high level of heterogeneity which should be taken into consideration. Thus, the very question remains persistent: are farming practices in Africa labor or an inescapable drudgery (in the absence of better alternatives)? This question, though overstated, should be taken seriously given the indisputable fact that poverty and hunger are strongly associated with being a farmer, especially in the sub-Saharan African context where farming is an inevitable livelihood choice. I therefore support the argument that in order to render farming economically appealing, one must convince farmers that they can attain their economic goals the same way or better attained by immigration or by working for the public sector. The World Food Prize Laureate, Akinwumi Adesina stated his goal to make farming in Africa a million-dollar business for small-holding farmers. This demonstrates that there is awareness that farming within the African context does not lift people out of poverty and does not provide opportunities for lifestyle improvement: health, education, and transportation.

CONCLUSION

Towards an Ethnographic and Anthropological Account of African Farming Labor Dynamics

The conception of labor has ethical and material implications. At the ethical level, conceptualizing farming labor from a certain perspective might disregard or misrepresent how the subject conceives of his/her actions, the very actions we call labor. The subject himself/herself might have a different conception which goes beyond the question of whether it is labor or not.

Labor or drudgery? This question requires "thick" examinations that defy the obstacles of language and entrenched analytical positionalities. These thick examinations require paying heed to the interlocked relation between farming as a physical act, ecological factors as natural actors, and socio-economic forces, e.g. structural inequalities.

To gain full insight into the socio-economic and cultural dynamics of African farming labor I propose, taking a cue from Geertz[21], an "*ethnography of thinking*," and I also propose adopting *Chayanovian*[22] approach to labor conception. These two analytical approaches are complementary and would lead to a more fully-fledged conception of African farming labor conception. Geertz's "ethnography of thinking," on the one hand, would call for examining in a metacognitive manner how one would conceive of African farming labor: how one interprets what he/she sees and what types of language are used (linguistic, statistical, non/verbal language) to express his/her interpretations of what he/she observes, senses, and hears. By doing this, meanings become no longer taken for granted but rather reached through inter/personal dialogic interactions. The Chayanovian approach, on the other hand, would provide practical information on farmers' livelihood systems through cultural and socio-economic lenses of analysis to predict how these livelihood systems would interact with state-planned development agendas. It is for such types of work that the Soviet scholar Chayanov became known and credited for, namely after the communist/collectivized agendas of farming programs failed in the former Soviet Union which proved right Chayanov's critiques of communist agrarian projects.

[21] From: Geertz, C. (2000). Local knowledge: Further essays in interpretive anthropology (Vol. 5110). Basic books.
[22] From: Chayanov, A. (1991). *The theory of peasant co-operatives*. IB Tauris.

CHAPTER 5: EU AND US GMOS POLICIES AND DEVELOPING COUNTRIES' SUSTAINABLE AGRICULTURE: MOROCCO AS A CASE STUDY

Both the EU and the US policy frameworks on genetically modified organisms (GMOs) face tremendous difficulties in accommodating the socio-economic policy realities of the "developing world." First, the heterogeneity of the developing world poses challenges that require customized solutions to address the peculiarities of each developing country[23]. Second, even if it is assumed that the developing world seeks to model its GM policies after the EU and the US, the very fundamental differences between the EU and the US GMO policies make the accommodation of the developing world difficult at the present time.

This chapter demonstrates that the EU stance on GMOs is contradictory and creates policy perplexity. Based on sustainability concerns, The European Union discourages its members and non-European economic partners from using agricultural genetic engineering technology in their national agricultural policies, yet it allows for the production and importation of GM crops by European countries. To demonstrate this contradictory behavior the policies on GM technology in Morocco (a major EU economic partner) are examined.

CLASHING GMOS POLICIES AND SUSTAINABILITY

This chapter seeks to understand how SD is invoked within the developing world context, namely Africa, to argue for the adoption/rejection of GM technology at the policy level. In the following sections, I discuss how the EU and US frame their policy stance on GM crops based on a sustainability framework.

The EU policy stance on GM technology. According to a working document by the European Commission,[24] various European Member States' governmental and civil society

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[23] I do not assume here that the US and EU policy stakeholders are aware of this heterogeneity. In fact, the very fact that these policy models are dominating reveals that the peculiarities of the developing countries are disregarded.

[24] See the French member's report where sustainable development is heavily stressed to argue for the potential drawbacks of GM technology: QUESTIONNAIRE relatif aux conséquences socio-économiques de la mise sur le marché d'OGM in: https://ec.europa.eu/food/sites/food/files/plant/docs/gmo_rep-stud_gmo-survey_2010_fra.pdf

stakeholders in collaboration with their counterparts from other parts of the world are committed to halt the dissemination of GM crops. They do so by mobilizing legal and socio-cultural resources to raise awareness about the risks of GMOs; some of the major anti-GMOs campaigns have taken place through global environmental advocacy non-profits, such as Friends of the Earth and Green Peace. In their "*Responses to the EC questionnaire on the socio-economic implications of GM cultivation - 2010*"[25], various EU Member States' national stakeholders emphasize the threats to SD as a result of the adoption of GM crops, while other EU Member States' national stakeholders had positive attitudes on GMOs' contribution to sustainable agriculture. Such opposing attitudes on GMOs in Europe are exemplified by the case of France where stakeholders, namely INRA (Institut National de Recherche Agriculturel) researchers argue for benefits of GM maize which used to be allowed for commercial cultivation. French environmental organizations and consumer associations oppose the cultivation of GM maize and warn against its negative impacts on farmers, the environment, and health.

US policy stance on GMOs. While the EU stance on GMOs has been promulgated by various international environmental groups as well as national governments, other opposing global voices emerged to critique and denounce the EU obstruction of GM technology whose benefits have been reported in various parts of the world (Elbehri and Macdonald 2004; Juma 2011c; Okeno et al. 2013; Paarlberg 2010). Moreover, the US policies on GMOs have been justified based on sustainability criteria which deem GMOs as an important tool for sustainable agriculture as publicly declared by US Department of Agriculture (USDA). [26]

[25] See: Responses to the EC questionnaire on the socio-economic implications of GM cultivation – 2010 in https://ec.europa.eu/food/plant/gmo/reports_studies/contribution_en
[26] See the USDA approval of GM potatoes which is founded on sustainability criteria(Waltz 2015).

Contrary to the European "precautionary principle," the US has adopted the "substantial equivalence" principle which "*sees GMOs as substantially equivalent to conventional organisms and imposes no special requirements for their approval.*" (Peel, Nelson, and Godden 2005). These two opposing legal principles regarding what constitutes a safe and sustainable GM food gave rise to protracted trade lawsuits between the US, Canada, Argentina and the European Communities (EC) lasting from May 2003until November 2006.

BEYOND GRAND POLICY EXPLANATIONS OF EUROPEAN STANCE ON GMOS

The EU stance on GMOs has been promoted by various international environmental groups as well as national governments. But opposing global voices have emerged which critique and denounce the EU's alleged obstruction of the dissemination of GM crops (Borlaug, 2000; Knight, Mather, & Holdsworth, 2005; Paarlberg, 2010; Trewavas, 2008; Wambugu, 1999; Zilberman, Kaplan, Kim, Sexton, & Barrows, 2014 ; Juma 2011; Okeno et al. 2013; Paarlberg 2010; Elbehri & Macdonald 2004). Contrary to dominant claims that portray the EU as anti-GM technology, this chapter argues that the EU stance on GMOs creates policy confusion due to its contradictory policies on GMOs. I test my claim by analyzing policy documents, relevant reports and interviews conducted in Morocco as a case study.

Four observations demonstrating EU perplexing policies on GMOs. First, EU members have drafted directives on GMOs by adopting the "Precautionary Principle" approach (Bonny 2003). "The precautionary principle" implies that any GM crop requires not only a "pre-market authorization" which involves examining its safety and nutritional value, but also "a post-market environmental monitoring" to examine the long-term effects of the newly developed GM crop on the environment and other species (European Commission - Fact Sheet, 2015). The EU precautionary principle has frequently been compared to the US substantial equivalence policy framework to grasp how differences between the two affect the adoption of GM crops in Europe and worldwide. While the EU precautionary principle regards GM crops as different from conventional crops and therefore requires exceptional safety assessments, the US "substantial equivalence" policy holds that if any GM crop has substantial characteristics (e.g. safety, protein content, nutritional value) equivalent to its existing non-GM counterpart then the GM crop does not require any additional safety tests (Bonny 2003; Schauzu 2000). Both the EU and US have opposing worldviews on how to determine the safety of a GM crop: Should a GM crop be subject to safety monitoring tests that are unique to GM technology, or subject to regular safety tests which have been applied to existing non-GM (conventional) crops? This question still creates continuous debates.

Second, through the Regulation (EC) No 1829/2003, the EU Parliament and Council drafted major regulations on GMOs (Regulation (EC),2003). All EU directives are mandatory for EU member states and encompass importation and marketing of GMOs, however, the decision to cultivate an EU permitted GMO is left to individual member states (DIRECTIVE (EU) 2015/412). This means that any member state is granted the right to permit commercial cultivation of GM crops so long as the EU approves it. It also means that member states have the right to reject the cultivation of a GM crop though it has been approved by the EU, yet member states cannot reject imported GM crops approved by the EU.

	EU approved GM crops for cultivation	***EU approved GM crops for marketing (Imported GM crops)***
Member states' legal capacity	Member states have the legal capacity to reject or adopt the EU approved GM crop for cultivation	Abidance of all member states is mandatory: every EU member state must admit EU approved imported GM crops to their markets.

Figure 31 EU members' legal capacity for cultivation and importation of GM crops

The table above explains EU members' legal capacity regarding the cultivation and importation of GM crops: for cultivation purposes, member states can permit or reject any EU approved GM crop for cultivation, but they must not reject the admission of imported GM crops if they are approved by the EU as it would violate EU trade agreements with GM crops exporters.

Third, the EU allows importation of GM crops for livestock feed and food derivatives. The European Commission has clearly authorized 49 GMO products, including maize, soybean for livestock feed and other GMOs for food and other uses, such as cotton, canola, sugar beets, and two microorganisms (European Commission, 2013). The authorization of imported GM food requires both traceability (member states should be able to trace back any GM crops) and labeling (food containing GMOs should bear a label stating "This product contains genetically modified organisms") (Regulation (EC) No 1830/2003).

Fourth, there is one GM crop--maize (MON 810) --that is currently permitted for commercial cultivation in Europe. However, most member states have decided to ban maize MON 810 invoking DIRECTIVE *(EU) 2015/412*), which grants member states the discretion to make national decisions on the cultivation of any EU permitted GM crop. The countries that have adopted GM maize MON 810 are Spain (1998), which is the largest grower, as well as Czech Republic (2005), Slovakia (2006), Romania, and Portugal (USDA, Foreign Agricultural Services, Europe Agricultural Biotechnology). The justifying reasons of member states who rejected the cultivation of GM maize MON 810 were deemed as "scientifically unfounded" by the European Food Safety Authority (EFSA). Worth-emphasizing is that though EFSA is founded and funded by the EU, its opinions are not legally-binding since the agency's main role is to provide scientific opinions and advice and inform European consumers about their food consumption.

These four observations indicate that the European stance on GMOs is contradictory. It is both anti- and pro-GM technology. More importantly, the EU influence on national GM policy is mixed and complex within member states since there are countries which have adopted GM crops and others that have vacillated between permitting GMOs and banning them at a later stage, such as the case of France.

This contradictory European policy has created confusion for non-EU agricultural producers who wish to export to EU countries. Thus, there is a need to gain insight into the main factors behind the adoption or rejection of GM crops by paying heed to how national policy institutions navigate the complex and contradictory European policies on GMOs. To this end, I examine how EU policies on GMOs play out within the Moroccan context and how Moroccan policy stakeholders regard them.

Moroccan Policies on GM Technology:

Types of contradictions: regulation and sentiments	EU Supportive Policies/attitudes on GMOs	EU Adverse policies/attitudes on GMOs
Regulation	Extensive European support of research on GMOs	Rejection of newly developed GM crops recognized by EU food safety authorities as safe: the case of genetically modified potatoes (amflora) whose approval was annulled by the General Court, though it was declared safe by the European Food Safety Authority (EFSA Panel on Genetically Modified Organisms,2012)
Regulation	The EU importation of GM crops	The infamous 2003 legal dispute of the EU against the US, Canada, Argentina, and Brazil over the importation of GM crops to Europe.
Sentiment/Regulation	The adoption of GM crops by European countries, namely Spain, and economic partners, namely South Africa, Burkina Faso, and Egypt	Fear of losing the EU market due to the EU alleged pressure to maintain non-GM food imports, namely from Africa, like in the case of Morocco (Knight et al. 2005).
Sentiment /Regulation	member states ‘refusal of EU approved GM crops for cultivation, namely MO810, and vandalization of GM crop field trials by environmental groups: pressure from European consumers who refuse GM crops.	European approval for the cultivation of GM crops: so far one GM crop is permitted, Maize MO810.

As portrayed by the table above, the EU is regarded as a major obstacle to the dissemination of genetic engineering at the European and global level, yet Europe does import GM crops and includes member states that are engaged in the commercial cultivation of one GM crop, Monsanto maize 810. In addition, European institutions, namely the European Commission and the European Food Safety authority (EFSA), espouse positive views on GMOs as is evident in their documents. And while the EU does regulate the cultivation and marketing of GM crops, member states are granted discretionary rights to permit or ban EU approved GM crops. This leads to EU member states and EU economic partners, namely developing countries, being confused about the EU stance on GMOs, which in turn impacts their national agricultural policies on GMOs.

For this reason, Morocco, a developing country and major EU economic partner, was selected to examine what policy routes it has taken on GM technology and whether its policy decisions are influenced by interaction with and interpretation of EU policies on GMOs. It is important to grasp how EU agricultural economic partners interpret the stance of European Union and member states on GMOs. This case study also tests the general claim that EU agricultural partners formulate their national policies on GMOs to sustain their markets within the European Union and EU member states. One study that examined the influence of the EU regulation of GMOs concluded that Eastern European countries joined Western European Countries in their decision to ban GMOs in order to sustain their European markets (Tosun 2014).

Moroccan Agriculture Background Information

Morocco is a member of the African Union. Its first economic partner is Spain. Morocco has been granted “advanced status” by the EU, a status which does not fully satisfy its aspiration to join the EU. Morocco has always rejected the cultivation of GM crops in its highly official discourses and communiques.

Indicator	***Percentage***
Agriculture contribution to national GDP	***15.42 percent***
Rural Population	***38.8 %***
Agriculture Labour	***37.47 %***
Women in Agriculture	***56.98 %***
Rural area	***38 %***
Number of people undernourished (millions) (3-year average)	***1.4 million (3.9%)***
Number of severely food insecure people (million) (3-year average)	***N/A***
Gross domestic product per capita, PPP (Purchasing Power Parity) (constant 2011 international $)	***7485 $***
Arable Land	***8,130,000 ha***

Moroccan Policy Stance on GMOs

In general, Morocco rejects GM technology as communicated by press communiqués of the ministry of agriculture (Moroccan Ministry of Agriculture press communique, 2012). Morocco has not even formulated its biosafety law though it ratified the Cartagena biosafety convention in 2011 (Corona 2015). This means that commercial cultivation of GM crops in Morocco is not permitted and research on genetic transformation is limited to lab tests. Greenhouse trials and field trials are prohibited. Morocco bans GMOs for human consumption but permits GMOs for animal feed. The permitted GMOs for animal feed are imported from major GM maize producers, namely the US and Argentina. These imported GM feeds are the varieties permitted by the European Union.

The major Moroccan press communique in 2012[27] came as a reaction to Moroccan public concerns on GMOs informed by the famous study of Séralini (2013). The communique clearly delineates the Moroccan stance on GMOs and its position towards Séralini study:

- The Moroccan policy on GMOs is based on the precautionary principle; and the country does not allow the importation and cultivation of GM food for human consumption.
- Morocco admits GM crops for animal feed, as is the case worldwide where GMOs have been proved safe for animal feed, especially maize.
- It should be emphasized that the GM varieties studied by Séralini (2013) are not authorized in Morocco.
- Morocco stays vigilant about any recent development regarding GMOs, especially the EFSA examination of Séralini's study results.

Regarding research on GMOs, Morocco does not permit greenhouse or field trials using GMOs due to the absence of biosafety laws. Research on genetic engineering in Morocco is limited to lab tests carried out by the Biotechnology Research Unit of National Institute of Agronomic Research, some of whose published studies are (Abdelwahd et al. 2014; Hakam et al. 2014; Tinak Ekom et al. 2013).

Research on genetic engineering of animals involves Moroccan researchers working on the development of pest control. OXITEC, a company known for developing genetically engineered insects that suppress the population of medfly pests, collaborated with Moroccan researchers using netted field trials of orange trees to test the efficacy of a genetically modified

[27] From the website of the Moroccan Ministry of Agriculture: https://tinyurl.com/yyaohdpn

Medfly used to stop the proliferation of the medfly through sterilization of female medflies (Oxitec,2016).

GM maize in Morocco

Because BT maize (MON810) is the only commercially cultivated GM crop in Europe, namely in Spain, a comparison regarding the importance of the crop to both Morocco and Spain is of central importance:

Compared Countries	***Commercial Cultivation of GM crops***	***Date of Adoption***	***Cultivated Area***	***GM trait***	***GM Crop share of total production***
Spain	Yes	1998	12,000	BT maize	35.7 %
Morocco	NO (Corona 2015)				

An official report by the Moroccan Ministry of Agriculture states that the growth of Moroccan imports of maize is due to the inability of Moroccan maize production systems to keep up with the needs of the growing poultry sector (L'agriculture Marocaine en Chiffres,2016). Morocco imports $550 million of corn products (USDA Foreign Agricultural Service, Morocco Agricultural Biotechnology Annual, 2018); and it currently produces less than it used to in 1961 according to FAOSTAT on Moroccan maize production which shows a downward trend (FOASTAT).

Unlike Morocco, Spain has significantly invested in scaling up maize production: the difference in maize production between Spain and Morocco was 936,800 metric tonnes in 1961; this difference has grown to reach 4,594,620 metric tonnes in 2015 (FAOSTAT). Keeping in mind that 35.7 % of Spanish maize is GM, it would be worth investigating why Moroccan stakeholders have not made a similar investment in GM maize.

With Spanish adoption of GM maize, various explanatory factors have been brought to the fore which include: the ideological inclinations of the Aznar Spanish government in 1998 which allowed for the commercial cultivation of GM crops (Fernandez-Wulff Barreiro 2013), farmers' appreciation of the benefits of BT maize to resist bollworm (Gomez-Barbero, Berbel, and Rodriguez-Cerezo 2008), and the Spanish investment in scaling up its "bio-economy," namely GMOs, to compete with other agricultural global powers.

Morocco's rejection of GM technology has been mainly attributed to fear of losing the EU market (Corona 2015), and the declaration of King Mohammed VI at the Paris UN Framework Convention on Climate Change that Morocco is committed to ban GMOs. This however should not divert us from the fact that Morocco has organized various debates and symposiums under the auspices of *Academy Hassan the Second* [28] and *Royal Institute of Strategic Studies* (Birouk 2014), to discuss agricultural genetic engineering within the Moroccan context (Sasson 2009, 2011). Morocco also imports GM maize and soybean from Brazil, Argentina and the US (USDA Foreign Agricultural Service, Morocco Biotechnology Annual, 2017).

INTERVIEWS WITH MOROCCAN KEY STAKEHOLDERS

Justification of The Case Study Selection

In research in general and qualitative research in particular, "the researcher is an instrument of data collection" (Cresswell 1998). This calls for a need to focus as much on the

[28] See cited publications supported by Hassan II Academy of Science and Technology, Rabat, Morocco.

researcher's positionality as on the research topic at hand. Below I present important points informing the selection of Morocco as a case study, research protocol, and limitations.

Why Morocco. The review of literature on the EU influence on the non-adoption of GM technology has covered the historical background of the EU stance on GMOs, the "GMOs food wars" between the EU and US, and the EU influence on Africa's stance on GMOs. There is however a lack of literature which seeks to explain how national policy stance determines the non-adoption of GM technology. This can be attributed to lack of literature that examines stance on GMOs from a national perspective rather than a regional/continental one (Stone 2010). The need to examine stance on GMOs from a more national standpoint would help to address the central paradox presented before: if The EU is anti-GM technology, why have five European countries adopted GM technology; and if the EU controls the African food market why have some African countries adopted GM technology and others not? In order to address these paradoxes, this research examined the Moroccan stance on GMOs. Morocco is an appropriate case to examine the dominant claim that the EU pressures African countries not to adopt GM technology for three reasons.

First, as discussed before, Morocco is a major economic partner to the EU. Morocco is also a member of the African Union. It therefore meets two critical criteria: strong economic partnership to the EU, and it is part of Africa.

Second, Morocco is a neighbor to Spain (first economic partner to Morocco), which grows 90% of the GM maize cultivated in Europe. lLike Spain, Morocco relies on maize for livestock feed. The Spanish case provides a striking example of how European countries, namely EU member states, engage with and interpret the EU policy stance on GMOs. Unlike most member states that opted to exclude GM technology in their agricultural sector, Spain is a global early adopter of GM technology (1998) and it grows 90% of the total European GM maize. Spain permits commercial cultivation of GM crops since it has a biosafety law (Todt and Luj 2000)**.** However, it bans GMOs for human consumption and permits GMOs only for animal feed. Performance of the first approved GM crop, maize, in Spain has been reported by the European Commission, citing studies analyzing the agronomic benefits of BT maize experienced by Spanish farmers. One study concludes that Spanish farmers are happy with yield benefits and reduction of pesticide use of both first approved GM maize (Gomez-Barbero et al. 2008). GM maize growers are mainly concentrated in the regions of *Catalogna* and *Aragon*. Regarding research, there is extensive research on GM technology in various Spanish private and public research centers (Lheureux et al. 2003). Morocco's position as the closest country to Spain, a major GM grower, presents a good case to engage with the question of whether Morocco forges its own policies on GM technology, as Spain and African countries that have adopted GM technology (South Africa, Egypt, Burkina Faso, and Sudan) have done.

Third, Morocco's agricultural sector plays a major economic role and has gained more importance thanks to the *Green Plan* since 2008. The plan stresses clearly the critical role of technological innovation to address agricultural challenges in Morocco, namely drought and pests.

RESEARCH METHODOLOGY

Guiding research questions

The research questions are designed to learn about policies and research on GM technology in Morocco. The assumption is that pursuing these research questions would assist in to examining the extent to which Morocco is influenced by the EU stance on GMOs. More importantly, these questions are meant to examine the extent to which SD informs Moroccan stance on GM technology. I seek to examine a) the history and current status of GM crops/products in Morocco , b) the major stakeholders involved in the formulation of GM policies and the legal and policy frameworks they use, c) whether research using GM technology targets specific Moroccan crops, and d) the extent to which SD informs Moroccan stance on GM technology.

Interview protocol (see appendix D). I used a semi-structured interview protocol that was approved by the University of Missouri Institutional Review Board. Questions centered on the status of GM policies in Morocco and how the Moroccan stance on GMOs is informed by SD. Daily reflections and thoughts on the interview process were recorded as well as notes from interviews. Twelve interviews were conducted; two stakeholders, who happen to be key, agreed to be recorded. The other 10 interviewees refused recording given the sensitivity of the topic and for professional reasons: job's requirements.

Research Methods. I used semi-structured interview questions. The development of appropriate questions went through two main stages. These stages reflect different assumptions refined throughout the realization of this research project. In the first stage, I assumed that interviewing stakeholders belonging to different sectors would give insight into the policy routes Morocco has taken about GM technology given my general assumption that Morocco is anti-GMOs. The conceptual model below delineates the first assumption:

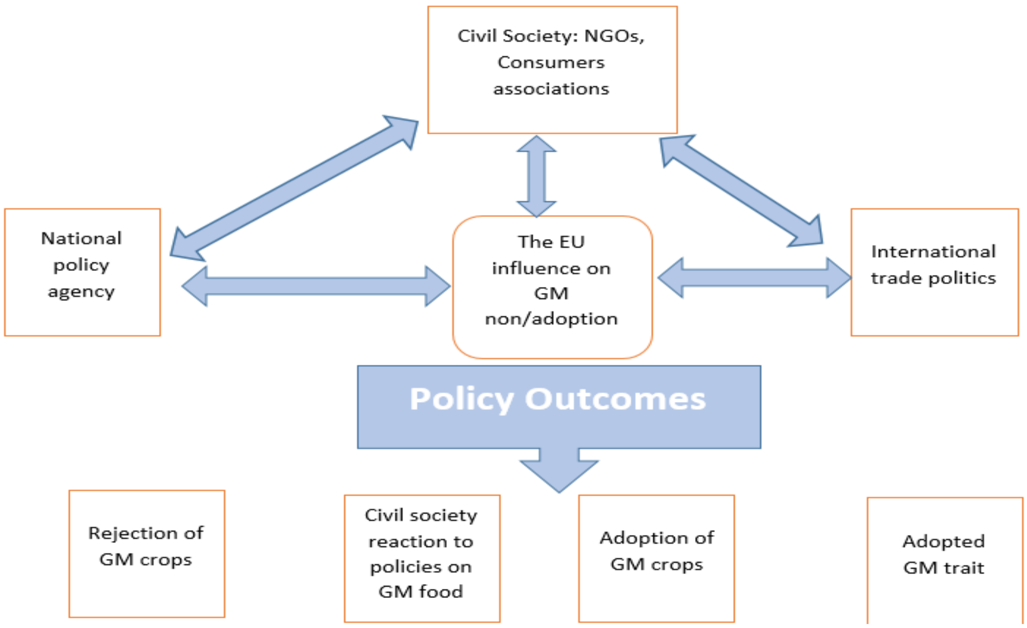

Figure 32 Conceptual model on Moroccan stakeholders' stance on GMOs

This assumption would not have yielded enough insights on how Morocco has developed its policies on GMOs for two reasons. First, not all stakeholders know about the Moroccan policy stance on GMOs and all have a very generic understanding on GMOs policy in Morocco, as will be presented below in the section on *types of stakeholders*. I realized this when I visited my first interviewees: one professor from an agricultural institute, and four agricultural engineers from a regional center of agricultural development. Responses from these interviewees were very useful to gauge how different Moroccan stakeholders perceive GMOs but uninformative to understand the historical background and decision-making process of GMOs policy in Morocco.

Second, interviewing stakeholders from different Moroccan sectors who are unfamiliar with the Moroccan stance on GMOs, would have derailed my research from addressing the fundamental policy questions of my research project: a) What is the current policy status of GM crops/products in Morocco? And who are the major stakeholders involved in it? Are there any specific crops which would benefit from the technology? And b) to what extent is Morocco's policy stance on GMOs informed by SD? These questions are more oriented towards policy analysis and therefore I needed primarily stakeholders who are involved in research and/ or policy-making processes on GMOs. This is important given that understanding the Moroccan policy stance on GMOs and its respective stakeholders would be required before examining perceptions of other stakeholders including consumers, traders, and activists. Below is a conceptual model which reflects the policy focused research informing this paper:

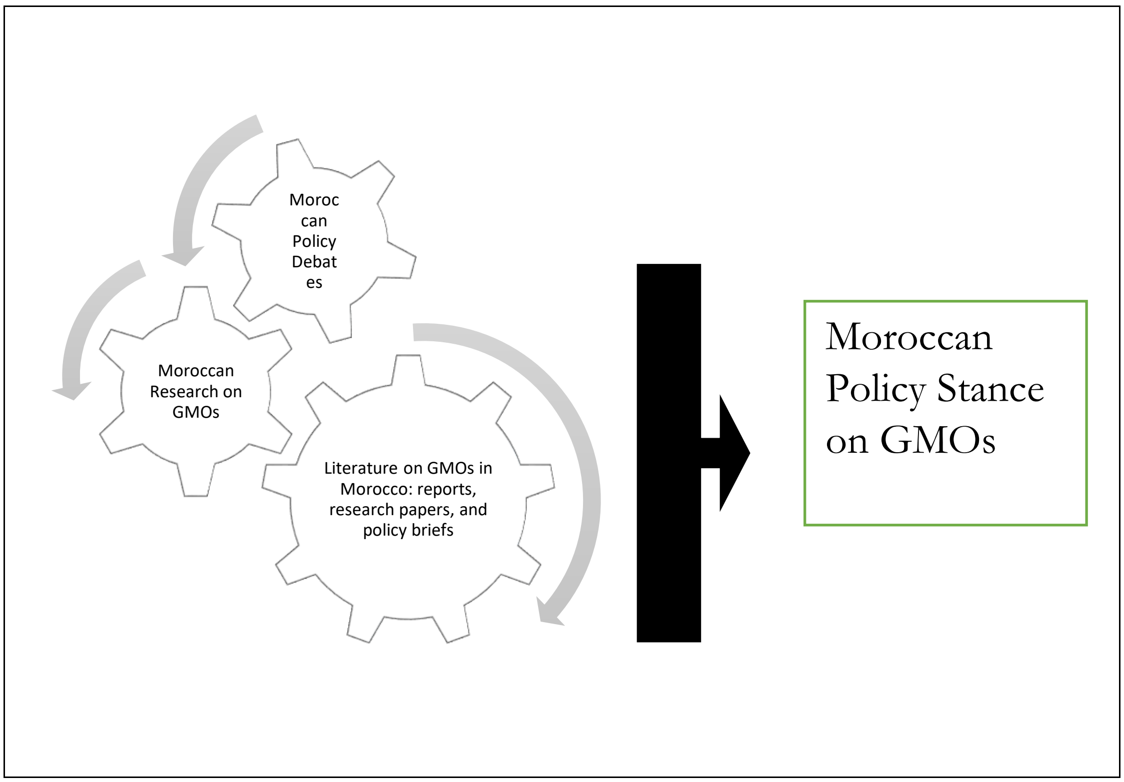

Figure 33 Moroccan policy stance on GMOs

Initial interviewees recommended to me a specific agricultural institute to learn more about GMOs in Morocco, which is the National Institute of Agricultural Research.

Data Analysis:

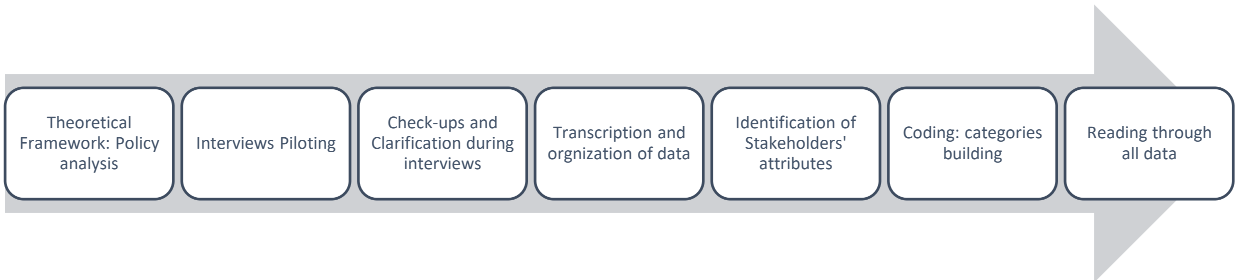

Figure 34 Stages of data analysis

Policy Theoretical framework: Various claims by GMOs proponents have suggested that the EU hinders its economic partners, namely African countries, from adopting GMOs technology (Borlaug, 2000; Knight, Mather, & Holdsworth, 2005; Paarlberg, 2010; Trewavas, 2008; Wambugu, 1999; Zilberman, Kaplan, Kim, Sexton, & Barrows, 2014 ; Juma 2011; Okeno et al. 2013; Paarlberg 2010; Elbehri & Macdonald 2004). Though this has been the dominant policy narrative on EU stance on GMOs, it has not addressed the complex and contradictory policy aspects of EU stance on GMOs: the EU engages extensively in research and importation of GMOs, yet there is an extensive ban of GMOs cultivation by member states. There is therefore a need for a more country-based policy analysis to examine the complex factors affecting policy stance on GMOs (Stone 2010).

Interviews Piloting. Interviews were piloted for further refinement and adjustments. One major adjustment made was to be specific by asking about GMOs instead of biotechnology. This was a critical change, as asking about biotechnology in general would have yielded different results since biotechnology includes components which are widely accepted and supported in Morocco: plant tissue culture, fermentation technology, and use of molecular markers. Genetic engineering is one component of biotechnology that has been widely controversial.

Check-ups and Clarification during interviews. After each interview, a summary of the interviewee's response was shared with him and/or her. This was very important to ensure that important details were not left out. For instance, I was sure to verify if the stakeholder supports all techniques of GMOs, e.g. transgenic versus cisgenic. Two researchers were emphatic that they only support cisgenic transformation.

Identification of Stakeholders attributes. The stakeholders belong to the following institutional categories. Their specific names are kept confidential here:

- Public Agricultural Research institute: where most Moroccan agricultural research is conducted and monitored. It is one of the oldest agricultural research institutes in Morocco.
- Public Agency of Ministry of Agriculture: it works directly with farmers to address their needs and ensure safety of their agricultural products and livestock.
- Public University, College of Sciences, Molecular Biology: It does not conduct research on GMOs but has a master's degree program on biosafety whose director was extensively involved in policy debates about GMOs in Morocco.
- National Academy of Sciences: a prestigious institute which organizes regular seminars and conferences on most recent global scientific breakthroughs.
- Innovation Center: located in the University of Sciences.
- National Office of Food Safety: a public institution under the ministry of agriculture. Its mission is to implement national laws on the safety of food, livestock, and seeds.
- Private College: the director is a former professor of nutrition at a public university.
- The International Organization of Agricultural Research to Combat Drought: an International organization that specializes in capacity building through the development of agricultural technologies to address drought.

There are four types of stakeholders:

1) **Key stakeholders:** Four stakeholders were identified as key stakeholders because they have been involved in policy debates around GMOs in Morocco. One key stakeholder teaches at public university (whose pseudonym is *Farid*), the second stakeholder is a retired employee (whose pseudonym is *Omar*) from the National Office of Food Safety (imported seeds monitoring service). The other two key stakeholders engage in research around genetic transformation; their publications were cited earlier (Abdelwahd et al. 2014; Hakam et al. 2014; Tinak Ekom et al. 2013). They work for the Public Agricultural Institute which I visited after learning about it through their website. Below is the background story of how I met the two key stakeholders (John and Aziz) from the Public Agricultural Institute:

   "*When I entered the Biotechnology building, I met a researcher at the center who informed me that all researchers are on vacation and will be back tomorrow. I requested if I could interview her about the topic, but she kindly declined and suggested to wait till the employees are back. While, I was leaving the Unit I met the security guard - who guided me to the building in the first place. The security guard asked me if I found the information I needed, I answered that I was told all employees are on vacation. He asked me if I would be interested to meet a visiting researcher who happens to work in the same building. I excitedly responded with "Yes, I would really appreciate that," though I was not told who this visiting researcher was or his profession; but I believed It could be a good learning experience. When he took me to his office, I found the researcher (whose pseudonym is John) busy with some stuff; and yet, he greeted me and allowed me to sit and wait while he finished some business with some of his partners. I was immensely happy and surprised by his hospitality. He happened to be a key stakeholder who has not only been involved in research about genetic engineering, but also a key stakeholder in policy debates in Morocco about GMOs policies, namely biosafety law. Thanks to him, I was introduced to the other researchers at the lab including the manager of the biotechnology lab (whose pseudonym is Aziz). I visited the unit multiple times."*

   The reason I am sharing this background story is to emphasize that interaction with research participants is key and yield deep insights. Through interaction one finds out experientially how research participants perceive the investigated topic, challenges to get insight into their perspectives, as well as development of more pressing questions. I cannot deny that it was difficult to get research participants to share what they think given the sensitivity of the topic, but I have to stress how much happy I was to learn experientially about the challenges related to researching this topic. I hold strongly that any research on GM crops that does not involve direct interaction with relevant stakeholders would yield superficial and irrelevant outcomes. My research journey in Morocco made me revisit the limitations of research done on GMOs using mainly survey methods which I discussed in the second and third chapters. As will be elaborated on, I discuss major findings learned through the interviews; these findings would not have been attained through surveys or methods not involving interaction with research participants. More importantly, through dialogue and questions of clarification, I learned that one statement made by an interviewee can never grasp his/her opinion; I therefore I had more than one hour with each stakeholder to ask clarifying questions and check my understanding of their answers.

2) **General stakeholders:** two stakeholders were identified as general because they have not been involved in research or policy activities around GMOs. One stakeholder (*Halima*) used to teach at the Public University for agricultural research, the other (*Said*) currently teaches molecular biology. The first, I had known her before this research. The second interviewee was recommended to me by *Farid*.
3) **In the field of agriculture but irrelevant:** Four stakeholders were identified. Three agricultural engineers, and one technician. They work for a public agricultural regional center. They do not have any knowledge on GMOs policies in Morocco, except that it is banned. They do however have general knowledge of issues around GMOs: its link to population growth, associated risks, and EU ban of it. Meeting these stakeholders was my priority given that they interact with farmers.

   My visit to the public agricultural regional center made me realize even more that GMOs policy debates in Morocco are esoteric. It came to my realization that in order to learn about policy attitudes on GMOs in Morocco, I need to interview stakeholders directly involved in research or policymaking around GMOs in Morocco. They all suggested I should contact the National Public Agricultural Research Institute. They have no pseudonyms since their interviews did not provide relevant data

4) **Influential but irrelevant:** One stakeholder identified. He holds the highest position at the national academy of sciences. He did not provide any specific information GMOs in Morocco since it is not his specialty though he has organized various seminars on GMOs as will be discussed later through the publications of the institute.
5) **Influential but reluctant to discuss Moroccan stance on GMOs:** these stakeholders work mainly for the National Office of Food Safety. It was hard to interview one of the officials who had just directed to an FAO document that states Moroccan stance on GMOs. However, a former employee at the institute agreed to meet and he is identified as Key stakeholder.

Stakeholders' attributes and attitudes. A few stakeholders embody more than one attribute.

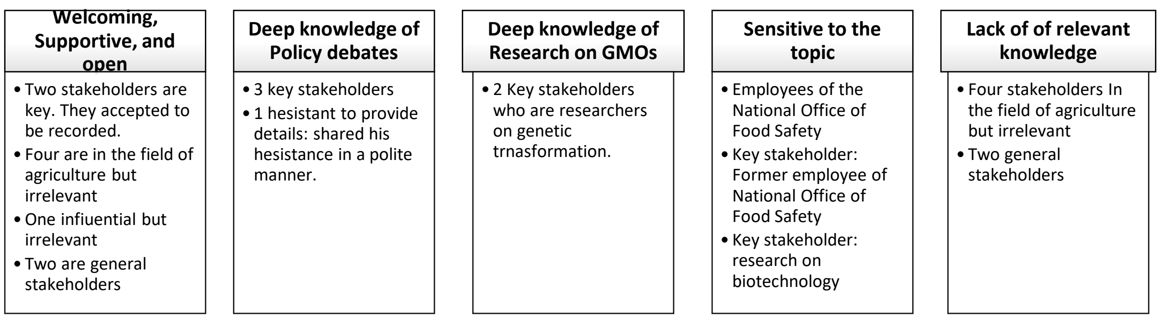

Figure 35 Stakeholders' attributes and attitudes

Below is the summary of interviewed stakeholders. Pseudonyms are provided for stakeholders who were interviewed and whose insights are central to the research questions.

Key stakeholders	
Pseudonyms	**Affiliations**
John	Public Agricultural Institute; The International Organization of Agricultural Research to Combat Drought
Aziz	Public Agricultural Institute
Farid	Public University, College of Sciences, Molecular Biology
Omar	Retired from National Office of Food Safety
General Stakeholders	
Halima	Former professor of nutrition at a public university
Saiid	Professor at a public university
In the field of agriculture but irrelevant	

Three stakeholders	public agricultural regional center
One Technician	public agricultural regional center
Influential but irrelevant	
Hassan	National academy of sciences
Influential but reluctant to discuss Moroccan stance on GMOs	
Staff member	National Office of Food Safety

Coding, Categories, and Themes

Codes were developed during and after each interview. The process was inductive: two codes were defined before the interviews. The predefined two codes are: the "Moroccan policy stance on GMOs," and "fear of losing the EU market." The code of "Moroccan policy stance on GMOs" was relabeled below as in the chart as "Policy debates on GMOs in Morocco" after learning that there have been many debates on GMOs in Morocco for quite a long time. Coding went through three stages: a) pre-interviews where I had two codes already defined, b) post-interview, which includes initial coding by reading through the data while adding emergent codes, and c) line by line coding through which utterances were more closely examined. Codes belong to four categories as delineated by the chart below:

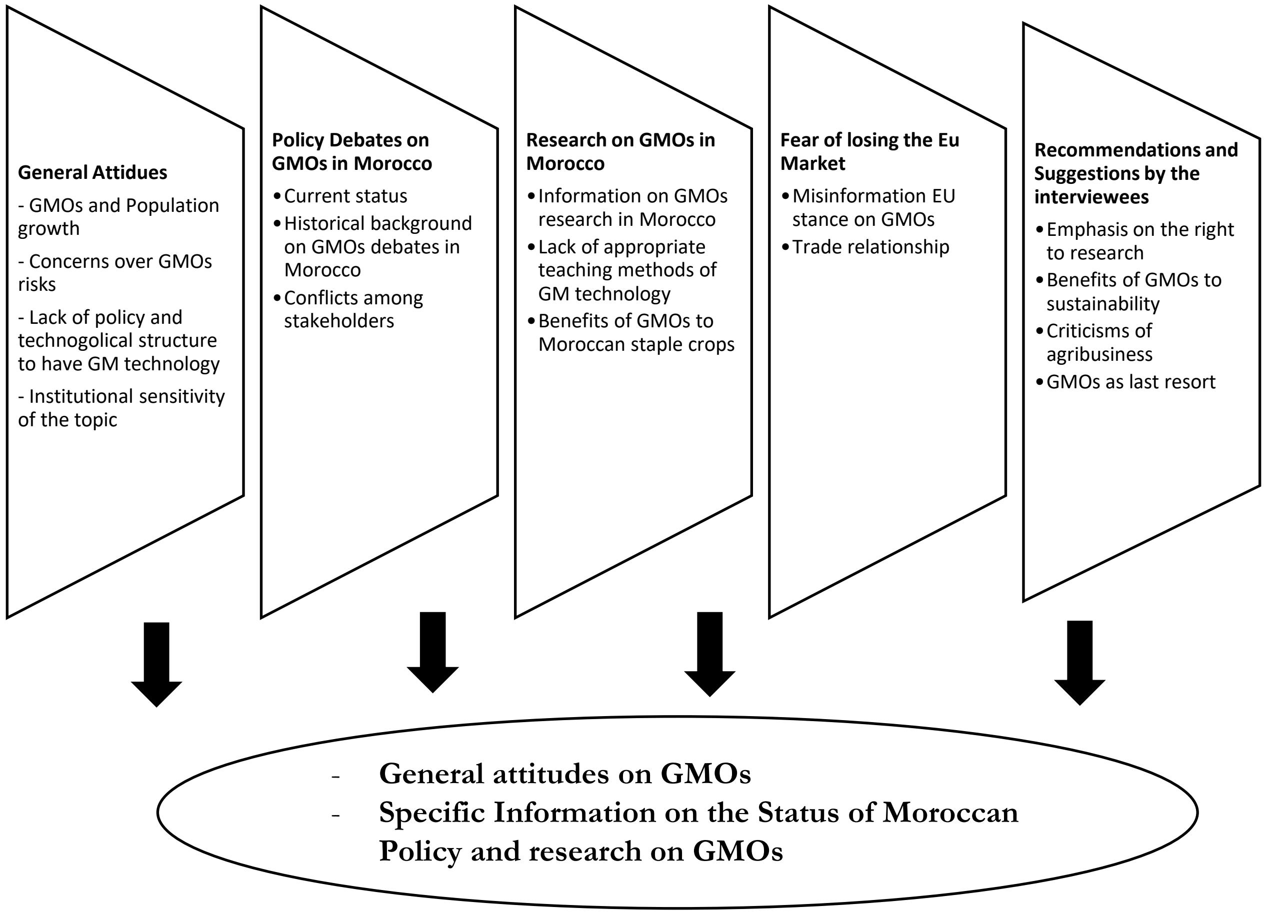

Figure 36 Four categories of codes

The categories cover two main themes: first, general attitudes on GMOs with no specific relation to the Moroccan context, and second specific information on the status of Moroccan policy and research on GMOs. Subthemes of each theme are presented in the finding section.

FINDINGS

General Attitudes on GMOs in Morocco

As stated in the research methods section, I realized during the initial interviews that not all stakeholders are familiar with policy or research situation of GMOs in Morocco even if they belong to the agricultural sector. In fact, many of them advised interviewing researchers from the

Public National Institute of Agriculture, who were later interviewed and whose ideas constitute major references on GMOs policy and research situation in Morocco.

GMOs and population growth

> *"GMOs are known to be good to address food security given the global growing population. However, it poses many risks which we have to be cautious with. We had a bad experience with mad cow disease and that is why we need to avoid such risks".* By one of the three stakeholders in the field of agriculture but irrelevant, she works at a Public agricultural regional center.

All interviewed stakeholders were familiar with the popular argument about the importance of GMOs to meet the needs of the growing population. Interviewed stakeholders would however raise concerns over GMOs in different stages of the interview: the statement above associates GMOs risks with mad cow disease, for instance.

Concerns over GMOs risks. All stakeholders called for being cautious with GMOs' potential negative effects on health and the environment, and on agribusiness, namely Monsanto's domination and monopolization of the seed supply.

Lack of technological and policy structure to monitor GM technology in Morocco. A few stakeholders stated that Moroccan authorities cannot be trusted with GMOs control or research; *Saiid* stated "Morocco is not prepared for that." *Farid* also stated that "We [Moroccans] lack strict monitoring methods of imported seeds." *Farid* added: "have you noticed how long-lasting tomatoes have become? They must be GMOs!" *Farid* also stated that farmers might be transporting their seeds in suitcases from countries where the seeds are purchased. Such doubts on Moroccan authorities' capacity to monitor seeds have been reported by national news media: one news report states that "Morocco has a permissive regulation on GMOs" (RISTEL TCHOUNAND 2013). The report presented results of GMOs detection tests done in the

Moroccan city, El Jadida, which found the existence of GM tomatoes. More surprising is that one of the coded studies in the first chapter states that there are field tests on transgenic tomatoes (Brink, Woodward, and Dasilva 1998).

The news report also mentions a study by the *Center for Food Safety* which ranks Morocco among countries with weak GMOs regulation systems (RISTEL TCHOUNAND 2013). Morocco's lax regulation on GM products has been attributed to its free trade agreement with the US and the presence of Monsanto businesses in Morocco (RISTEL TCHOUNAND 2013).

One surprising statement was made by *Omar*, who initially refused to meet with me:

> "I do remember I was once called by a researcher from France in 1996 to have field trials of a GM crop in Agadir and I refused though I was given all the guarantees that it is going to be monitored and controlled 100%."

Institutional sensitivity of the topic. This was mainly stated to me during my visit to *the National Office of Food Safety* and *the Public Agricultural Research Institute*. The stakeholders of the *National Office of Food Safety* agreed to meet but directed me only to an FAO document which outlines the Moroccan stance on GMOs. *Aziz* from the Public Agricultural Research Institute was welcoming but hesitant to answer most questions fear of that his statements would be misrepresented. He could not even state what kind of GMOs research his lab engages with, though his lab research has been publicly available in many international reports and studies, which I mentioned to him. *Aziz* suggested that I mention the peer-reviewed articles of his lab instead of saying that they do research on GMOs given the bad stereotypes attached to that in Morocco and fear of misuse of information.

Specific Information on the Status of Moroccan Policy and Research on GMOs

Current status of Moroccan policies on GMOs in Morocco. Information on the current status of GM technology in Morocco focused on absence of a biosafety law, ban of GM crops, and lack of research using GMOs except in one research unit. Understanding the current status of GMOs in Morocco was not a clear-cut policy issue: I was surprised by a few remarks. One remark by *Omar* denied that Morocco imports GM feed though he is a key scholar on Morocco's seed importation laws. I showed him references stating that Morocco imports GM feed which he still could not fathom. He replied that "it is impossible as the King said that Morocco is committed to the ban of GMOs at the Paris Climate Change Conference." Omar was right about the Kings' speech; however, he was still surprised by the fact that Morocco imports GM feed which is mentioned in national and international sources including the Moroccan Ministry of Agriculture. (See the Cartagena Biosafety Clearing house (https://bch.cbd.int/database/record.shtml?documentid=102594) and all US foreign Agricultural Service reports (Approved By: Morgan Haas; Prepared By: FAS/Rabat 2018; Sarah Hanson 2013)).

The timeline chart below is based on document analysis and interviews on GMO's policy history. Dates from documents are above the timeline while dates mentioned by interviewees are under the timeline:

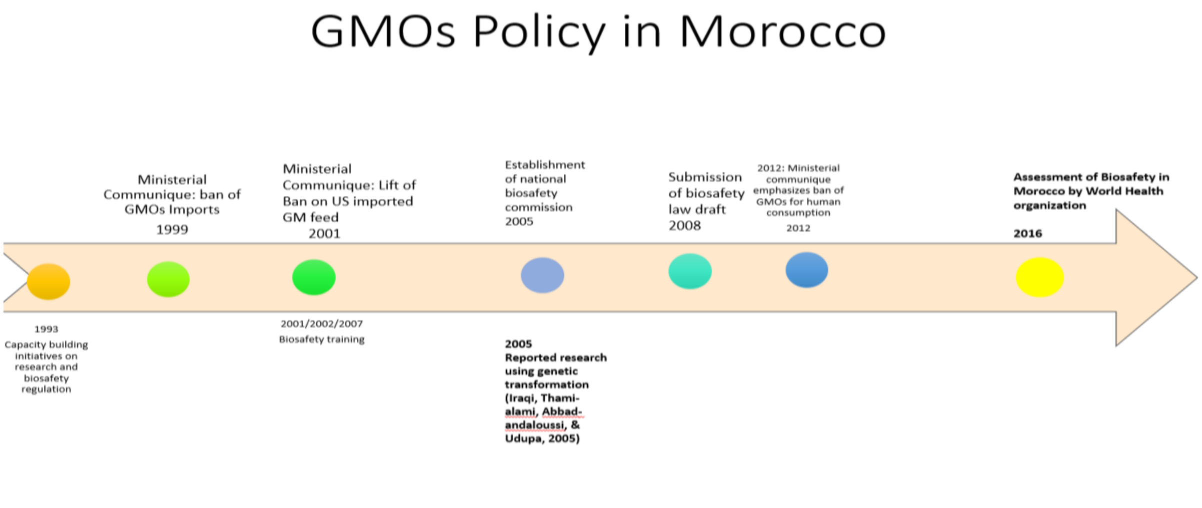

Figure 37 GMO policy in Morocco

Historical background on GMOs Policy debates in Morocco. Three key stakeholders (*John, Farid, and Omar*) focused on the history of policy debates around biosafety law. *John* mentioned that the first discussions on biosafety started in 1993 with workshops and trainings organized by FAO and the International Center for Agricultural Research in the Dry Areas (ICARDA). More trainings and workshops were organized in 2001, 2002 and 2007 on biosafety regulations.

The key stakeholders mentioned that during the workshops on biosafety law, they examined biosafety laws from many countries to identify best practices. The Moroccan ministry of agriculture drafted a biosafety law which was not introduced to the parliament and has been pending at the Prime Minister secretariat up until now. *Farid*, who was directly involved in the biosafety law debate, shared in detail the stakeholders who have been involved in the debate, and why the draft did not advance. The major reason is the conflict between the ministry of environment and the ministry of agriculture.

The key stakeholders outlined the following national and international initiatives and activities on biosafety. At the national level:

- Cartagena Protocol and biosafety in Morocco: *Farid* provided an account on how Morocco ratified the Cartagena protocol in 2011:

> We were asked to prepare state of the arts: vegetable and animal biodiversity, competences we have, ongoing research, and national capacity of research technology. All countries were asked that: Morocco signed the convention and ratified it. And that showed Moroccan commitment to abide by it; this also allowed Morocco to attend all meetings of COP. The focal point was the Ministry of Environment. The Ministry of Environment was given resources to provide an elaborate account of biodiversity in Morocco. I was one of the specialists in microorganism and had a contract with them as an expert to provide a survey of diversity, research capacity, and competences. We had a report about all of this whose preparation last for three years [I found the report: (De, l'Environnement, Secrétariat d'état auprets du ministère de l'énergie, and L'environnement 2009)]. So, according to Cartagena protocol, we needed a biosafety law, and appropriate research capacity: for research capacity building we can get it from PNEU (Program des Nations Unis pour l'Environment) but for law: they asked us about suggestions for national biosafety law. The Ministry of Environment invited all stakeholders: all ministries, Ministry of Islamic affairs, and others. They met for three or four times. All ministries sent their representatives to examine GMOs in terms planting, marketing, nutrition, and safety. So, for example we had to confer with ministry of Islamic Affairs because the cultural and religious aspects of GMOs are important. The problem did not come from these stakeholders. Why ?! because they don't have knowledge about GMOs. Even the Ministry of Higher Education had no problem with that. The problem was between the Ministry of Agriculture and Ministry of Environment. The problem was who should lead the national commission on biosafety and propose national biosafety law. So the debate remained like that: then we discussed having a national biosafety law; and we had a small committee to build national biosafety law and we gathered all laws from the world; IAV researchers and INRA had a draft and submitted it to the Prime Minister office.

At the international level:

- (account provided by Farid) Invitation of Morocco as an observing member by the Joint Research Commission, European Commission, to join their conference on GMOs analysis (JRC 2008) [I found the report later which is mainly focused on Europe]. *Farid* stated that a leader of the Joint research Commission believed that Morocco's participation as an observer could be an important step for Morocco to gain support for GMOs detection capacity building. According to *Farid*, because Morocco does not have a biosafety law, the Commission could not support it adequately. He added that the JRC supported Moroccan researchers through trainings offered in European labs, namely Italy.

Conflicts among stakeholders. Most interviewees mentioned conflicts among stakeholders involved in GM research and debates. *John* stated:

> "In Moroccan contexts, there are issues of institutional rivalries: some don't want to see the technology coming to another institute; the second reason is there are people like Green Peace, everything for them could be GMOs ; they don't understand technology and start misleading people. These debates should start in schools and colleges which could provide a good environment of dialogue"

Regarding conflicts around biosafety law draft, *Farid*, from a Public University, reiterated the fact that various stakeholders, including the Ministry of Islamic Affairs and all other ministries were involved to examine the multifaceted aspects related to biosafety law (same information provided by John). Discussions on biosafety law went smoothly among all stakeholders. However, there were strong disagreements between the Ministry of Environment and the Ministry of Agriculture. The main point of disagreement was about who should oversee the biosafety law.

RESEARCH ON GMOS IN MOROCCO

John who is the visiting key stakeholder from the Public Agricultural Research Institute provided a historical background on GMOs research projects in Morocco which goes back to 1993:

> in 1993, we had a project, at that time I was in Syria, Halab. At that time, we had a project, it was funded by the Arab Fund for social and economic development which is based in Kuwait. They gave us some fund to foster research in Arab states. So, under that project we gave a call for a small proposal. I think at that time, there was one project on biotechnology submitted

> by a [Public University]. At that time there was no biotechnology unit in this Public Agricultural Research Institute.

He added that they funded the submitted proposal by the Public University "on genetic transformation using agrobacterium in Fava Bean"; but they never heard back again about it.

Later, they started the unit which does research applying genetic transformation at the Public Agricultural Research Institute. This unit was started by sending a researcher to train Moroccan researchers in either 2000 or 2002. John added more details on the collaboration between the Moroccan Public Agricultural Research Institute and The International Organization of Agricultural Research to Combat Drought:

> We had the technology for chickpea and lentils. And we trained these people. And with these trainings, they started working on Fava bean. Fava bean is the number one legume in Morocco. So, they decided to work on it, and they made progress on it; then when I came here in 2006; so, I arranged a lot of gene constructs. You know the most important thing is to have a vector to transfer this gene: agrobacterium or whatever. And also, we need to have a gene construct in order to have the gene we need, it is very hard to get it. And we signed an agreement, [right?] negotiated with Cornel University. (by John)

John added that this collaboration took place thanks to Cornell's confidence in the mission of the International Organization of Agricultural Research to Combat Drought. The work of John was mentioned by *Farid* who stated that: "*a key researcher (referring to John) was brought to Morocco by the International Organization of Agricultural Research to Combat Drought to help with capacity-building on genetic transformation of wheat. However, I do not have updates on their research projects."*

With the absence of a national biosafety law, the Public Agricultural Institute has managed to develop its own policies to have a research unit which uses genetic modification technology. Its research is limited to lab tests. I was given a tour in the lab. This unit has extensively published its work on genetic engineering namely with Moroccan wheat and fava bean. Researchers at the unit prefer the phrase (genetic transformation) which is the translation of the French phrase "transformation génétique" (Abdelwahd et al., 2014; Iraqi, Thami-alami, Abbad-andaloussi, & Udupa, 2005).

Lack of appropriate research and teaching methods of GM technology: John complained about the lack of proper teaching methods, namely lack of scientific experiment tools, in Moroccan science universities to learn about GMOs:

> This is the problem we have with students, when they come here. We ask: how do you improve wheat line which becomes susceptible to rust? and students immediately would say: look for a gene, cut this gene, and put it inside. They do not think about other ways to do it, which are simpler to biological cross and transfer of the resistant gene. The mentality of student is that genetic engineering is very good, it is good !! but it should be used as a last resort; there are many other simple ways we can improve plants. So, they don't know. That means it is not taught well in university."

Lack of appropriate teaching and research methods on GMOs in Moroccan Universities was also confirmed to me by *Farid and Hassan*. All stated that students are exposed to GMOs topics through only PowerPoint presentations with no practicum.

Regarding lack of appropriate research methods, *Farid and Aziz*, from the only research unit which uses GM technology, indicated that their research on fava bean and wheat cannot be developed since they are not allowed to do field trials due to absence of a biosafety law.

Potential benefits of GM technology to Moroccan staple crop. One example of potential benefits of GM technology to Moroccan staple crops include: "Fava bean, especially control of Eurobanke which is a root parasite" mentioned by *John and Aziz*. The biotechnology unit conducts research projects on fava bean and wheat, which are highly important crops in

Morocco. They have published various works which present their results on wheat and fava bean genetic transformation (Abdelwahd et al. 2014; Hakam et al. 2014; Tinak Ekom et al. 2013).

Fear of losing the EU market/ US influence. *John* stated “Morocco exports to Europe. Europe does not like GMOs and Morocco wants to avoid problems with the EU. Europe doesn’t like to import any GMOs product, so Morocco does not want to go further with this.” With no exception, all stakeholders mentioned the crucial importance of sustaining the EU market as the main reason Morocco avoids GM technology. These responses however did not explain why Morocco cannot follow the research and legislative progress made by the EU regarding GMOs. I asked John why Burkina Faso, South Africa, and Egypt can adopt GM technology though the EU is their major economic partner. His answer was that Morocco is more of an exporter of food to Europe unlike the other countries who are more of importer of food from the EU. Most stakeholders would concur with the claim that the EU is well advanced in terms of research on GM technology and that there is no reason why the EU would prevent Morocco from pursuing at least its research and policy progress.

Farid added that “people who are against GMOs are empowered by what happens in Europe, specifically in France. Spain for example is for GMOs and grows GMOs and exports it. They have no problem, but in France this guy [Jose Bove] created the current controversy.” *Farid* attributed the pending situation of Moroccan Biosafety law draft to fear of losing the EU market. Below is his account explaining the reasons why the biosafety law draft remains pending at the Prime Minister’s secretariat:

> we were told by the Ministry Secretariat to give them some time for deliberation about the biosafety law draft (the request was not written). Whenever we check about its status, we are told that it is a sensitive topic and the situation of Morocco is a difficult one (between Europe and US); so we need more time. Since then Morocco’s position is the ban of planting, consumption and

> marketing of GMOs, except one year there was a "circulaire du Ministere de l'Agriculture" which allows transgenic maize to enter as feed for chicken. But, when it gets into the market, we don't know what happens with that."

The "circulaire du Ministere de l'Agriculture" cited by the key stakeholder is very interesting for two reasons. First, no national debate was started to discuss it prior to its issuance. Second, the "circulaire" was issued to permit transgenic feed from the US o the Moroccan market. The background story of the "circulaire" was also mentioned by US Foreign Agricultural Service report:

> The memorandum [1999 memorandum which bans GM crops], not widely disseminated, remained basically on standby until September 2000 and January 2001 when it was used by the Agadir port PPQ inspectors (a port that was not used to handle regularly corn imports) to stop two corn shipments. The shipments were then released and since then, to our knowledge, the memo has not been invoked to challenge imports of corn or soybeans in Moroccan port. Ministry officials informally indicated at that time that the 1999 memo was intended for imports of processed food with GMO ingredients, and not for animal feeds. In fact, an ad hoc committee from several ministries met in July 2001 to discuss GMO corn import and, evidently, took no preventative action. Since the beginning of 2001, Morocco imported in total over 10.7 MMT of corn (about 4.7 MMT from the United States) and 3.2 MMT of soybeans (1.44 MMT from the United States) with no noteworthy incidents (Hassna F.Ahmed, U.S. Embassy 2010).

One key stakeholder believed that the shipments were allowed because it benefits some Moroccan agricultural businessmen. The fact that the 1999 memorandum was used to admit the GM corn shipments, then quickly revoked, demonstrates the role certain individual actors play in formulating GM policies in Morocco. It also calls into question the clarity and consistency of Moroccan position on GMOs. *Farid* responded to the question of whether there is a Moroccan policy framework on GMOs which favors the US or the EU:

> Officially no, the problem of GMOs is that it has to do with money; and Monsanto plays key role. We are between EU which is against and US which is pro; and we tend to appeal to both of them; we don't make our own decision. We follow the European policy and at the same time we open our market to the US GM feed.

I asked Farid if it could be possible that there are internal factors keeping Morocco from advancing GM technology and policy, he stated:

> Yes true! We could not even come up with a biosafety law. We are stuck with Francophone research dependency; and for sure they don't provide us with highest technology. Contrary to that [Moroccan institutions dependent on Francophone system], the Public Agricultural Research Institute has been more advanced thanks to its openness to the US for a long time: its graduates go to Minnesota to do research for a year. In the 90s the Public Agricultural Research Institute was at its peak research thanks to its collaboration with Minnesota.

The statement above is made by *Farid* who obtained his PhD from France in Molecular Biology and works for a Moroccan public university.

Recommendations Made by Interviewed Stakeholders

Emphasis on the right to research/need for biosafety law. There is a consensus on the need for biosafety law to develop GM research in Morocco among the interviewed key stakeholders who belong to either GMOs research or policy. *John, Farid, and Aziz* emphasize the right to research. *John* emphasized the "need for dedicated research teams."

Benefits of GMOs to sustainability. Aziz, Farid and John stated that the technology must be used "with wisdom" by examining its health and environmental effects through "risk definition and risk management.," The stakeholders, namely GM researchers, emphasized that we should not aim at making all plants genetically engineered. *Aziz*, who does research on GM crops, emphasized that any GM crop which is safe and passed successfully all safety tests, should be released and commercialized. *Aziz* added that "There are good examples where GMOs contributed to sustainable agriculture: where it has decreased pesticides used, especially in cotton." *Aziz* also stressed the importance of using appropriate tools and practices to lower chances of resistance to the developed GM crops, namely refugia and gene stacking. From the social perspective, there was an emphasis on ensuring that farmers can afford to buy GM seeds. Similarly, *Farid* stated that in order to have GM technology as a sustainability tool, it

> Should be developed with transparency and freedom. It should not be controlled by one corporation. Obviously, it's not logical that you develop the product and intend to sell it with the price you want. Terminator seed was a very bad strategy. Basically, they're saying: "I am going to sell you the seed and sell it with the price I want" so where is sustainable development? So, if I don't have the means to buy it or you lend me the money to do so, once I cannot pay back, you will basically punish me for that, so where is sustainable development? So, this is controlled sustainable development and you do whatever you want with me.

Fear of "controlled sustainable development" using GMOs was stressed by all stakeholders irrespective of their level of familiarity with GM technology. *Farid* emphasized the right of communities to benefit from their genetic resources out of which research on GM crops is developed:

> So, as I said earlier there should be the rights of research and GMOs should be judged case by case. Moreover; The revenues from the developed genetically modified seeds should also be shared with the communities and countries from whom those genes were obtained.

Farid cited the Nagoya protocol "*on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity*," 2010. *Farid* added:

> In my opinion sustainable development and GMOs are related. One of the means to have sustainable development is the development of genetically engineered crops. For me GMOs is very important, and it would support sustainable development so what is the problem? Who will control the sustainable development? If it is Monsanto it's a problem!

Criticisms of agribusiness monopoly: Farid stated:

> "Because when you are part of Monsanto, they support you with funding. So, the problem is you develop research for them. As you know Monsanto controls

> all diversity from all over the world and do work on it themselves. So, this is done by the scientists they have whom they funded to go collect the data and the studies."

With no exceptions, stakeholders who support GM technology do not support major agribusiness involved in GM crops development, namely Monsanto, a corporation which is active in Morocco. *Omar* is critical of GMOs and the industry behind it though he was part of research programs in the US through which he visited US agribusinesses, namely Monsanto:

> Those promoting GMOs like agribusinesses would like to control the market; they don't care about global food security. I was once given a tour at Monsanto; they assumed we knew nothing about their negative impacts so they were telling us information as if we would easily be persuaded by it.

GMOs as last resort. Key researchers emphasized that GM technology should be seen as a last resort and that there are various biotechnologies which should be emphasized, such as plant tissue culture and conventional breeding techniques. There is however one key stakeholder, *Omar*, who deems GM technology totally irrelevant:

> "I believe that we do not need GMOs as we have alternatives and can rely on conventional breeding techniques; in addition, we are not capable of protecting ourselves from drawbacks of the technology."

Aziz who does research using GM technology, was clearly against the use of transgenic modification: gene transfer between unrelated species. He was rather supportive for cisgenesis: transfer between related species which includes intragenic (within the same genome) and famigenic (species in the same family). He gave examples of potatoes' gene transfer to potatoes or pepper to tomatoes.

The chart below maps out the major themes and subthemes presented in this section:

Major Themes	Subthemes
General Attitudes on GMOs	- GMOs and Population growth - Concerns over GMOs risks - Lack of policy and technological structure to have GM technology - Institutional sensitivity of the topic
Specific Information on the Status of Moroccan Policy and research on GMOs	- Current Status of Moroccan Policies on GMOs in Morocco - Historical background on GMOs Policy debates in Morocco - Conflicts among stakeholders - Research on GMOs in Morocco - Lack of appropriate research and teaching methods of GM technology - Potential benefits of GMOs to Moroccan staple crops - Fear of Losing the EU Market - Recommendations: emphasis on the right to research, Benefits of GMOs to sustainability, Criticisms of agribusiness, GMOs as last resort

CONCLUDING REMARKS

This chapter questions the prevalent claim that the EU discourages the adoption of GM technology. The chapter argues that the EU policy and legal frameworks on GMOs are contradictory and causes policy confusion for EU member states and developing countries. The contradictory nature of EU stance on GMOs is exacerbated by internal division regarding attitudes on GMOs within EU member states. This makes EU economic partners, including and mainly developing countries, confused about adopting the right policy stance on GMOs since they cannot grasp a clear European policy on GMOs. For example, the European Union permits cultivation of GM maize (MON 810) while some member states decide not to do so, European environmental groups burn GMOs field trials while Europe invests extensively on research about genetic engineering in agriculture, and European research and policy institutions have positive views on GMOs while they ensure the protection of consumers' preference of GMO-free products. It thus becomes difficult to grasp the EU stance on GMOs especially because the EU policy stance on GMOs is determined by both the EU institutions, namely the European Commission and the European Food Safety Authority, and national policy institutions. Developing countries are faced with the question whether they should give priority to the European Union or to member states or to European consumers or their own national conceptions of GMOs policies. Moreover, how would developing countries deal with most recent EU political developments, namely Brexit which will surely bear an impact on UK's national stance on GMOs?

The Moroccan case reveals how the EU stance on GMOs plays out within the Moroccan context. One major conclusion is that the EU influence on Morocco cannot be examined in isolation from US influence for three reasons. First, Morocco has, publicly and through the interviewed stakeholders, declared its commitment to sustain the EU market by banning GM crops. Second, the known Moroccan ban of GMOs seems to be misrepresentative of the nuances of the Moroccan stance on GM technology: Morocco imports GM feed, has a research unit which conducts GM research on wheat and fava bean, and conducts research collaboration on GM Medfly with *Oxitec*. Third, the Moroccan agricultural research institutes are heavily influenced by both US and French research and educational programs. This shows that Moroccan stance on GM technology is beyond the dichotomous positions of anti or pro, though the Moroccan king declared publicly the Moroccan commitment to ban GMOs.

However, the Moroccan case has revealed there are also internal reasons behind lack of a clear Moroccan stance on GM technology. These internal factors explain why Morocco has not even reached the level of research and policy development on GMOs attained by the EU:

- Internal conflicts: Interviewed stakeholders discussed how the draft of a biosafety law was subject to Ministerial conflicts over the question of who should oversee the law: Ministry of Agriculture or Ministry of Environment.
- Double hit by EU and US: Moroccan policy on GMOs seems to be oscillating between appealing to the allegedly anti-GM attitude expressed by the EU, yet open to US feed products by the US.
- Lack of understanding on GMOs policy in Morocco: stakeholders in agriculture had contradictory understandings of Moroccan stance on GMOs.
- Sensitivity of the topic: there is a high level of risk perception associated with GMOs topic. Various stakeholders perceive the issue of high political and economic sensitivity.
- Lack of trust on monitoring GM: low capacity of Moroccan research and policy institutions to monitor GM technology.
- Confusion regarding the EU Policy stance on GMOs: Stakeholders seem to embrace generally that the EU is ani- GM technology. A claim which is not valid given that the EU’s attitudes on GMOs go beyond anti or pro.
- Well-established policy-heavy discussion: Morocco has been advanced in GMO policy debates and continues to be so regarding other similar technologies such CRISPR (clustered regularly interspaced short palindromic repeats).
- Absence of biosafety law: Morocco has been heavily criticized by interviewed key stakeholders for depriving researchers of “the right to do research.”

- Attitudes on the spectrum of genetic modification: various stakeholders expressed their interest in GM technology which is cisgenic rather transgenic. This reveals that GMOs researchers have nuanced positions on the application of GM technology.

Finally, I believe that the Moroccan policy stance on GM technology, given the political and economic sensitivity of the technology, might become subject to royal arbitration. The royal arbitration has played significant role in similar issues of high political sensitivity, such as Sub-Saharan immigration to Morocco and the family code reformation.

CONCLUDING THOUGHTS: REMARKS AND RECOMMENDATIONS

GENERAL REMARKS: RESEARCH BACKGROUND, POSITIONALITY, AND REFLEXIVITY

Why this Research Topic?

There is a personal reason which is important to share in order to explain/justify my methodological, ethical, and epistemological motives behind the choice of this topic. Understanding my motives is also important to situate my conclusions in the right context. My interest in this research topic started on day one when I was conducting general literature review on GM technology in the world, before I focused on Africa at a later stage, as part of my assistantship. Prior to the literature review, I heard about GMOs in experiential education jobs I held around nutrition, food, and poverty. I also heard about it from my US friends and family members who happen to be critical of GMOs, namely of the corporations behind it. Generally, the people I had worked with in those jobs had negative perceptions of GMOs and the industry behind it. The organizations I worked with would highlight the great benefits of their organic and CSA (Community Supported Agriculture) programs as being GMO free. Personally, I did not have a clear position on GMOs, but I had the impression that there is a consensus on the adverse effects of GM crops at least in the US.

It was few days after I joined the University of Missouri and started conducting literature review on GMOs that I started finding out about the contentious nature of this topic. The dichotomous views on GMOs reflected by peer-reviewed articles, news media, policy briefs, corporate reports, and NGOs were very illuminating and enriching for my learning and research. However, my biggest and life changing AHA moment came thanks to my participation at the World Food Prize. The World Food Prize, in my opinion, is the number one event which assembles stakeholders from international major agricultural industries, academia, governmental agencies, and non-governmental organizations. The World Food Prize is known for the Borlaug Dialogue, named after Norman Borlaug, and the celebration of the laureate who is awarded the World Food Prize. This major agricultural event is known for being supportive/supported by major agribusiness corporations, namely Monsanto/Bayer, Corteva (DowDupont), and Syngenta.

To my big surprise, while I was heading to a conference room held at a hotel across the street, with other attendees of the conference, I saw people demonstrating with slogans which were anti-GMOs. The incident impacted me personally; I was contemplating: how come a few months ago I was with people who are critical of GMOs and now I am part of a conference which people are demonstrating against for promoting GMOs!? There was no other way for me to reconcile these two antithetical experiences but going back to the roots of my interest and research I conducted on inter-faith conflicts in Morocco and the Netherlands. It came to my realization that GMOs controversy is very similar to religious controversies. I wrote a paper where I demonstrated the pathways governing GMOs which are very similar to the ones governing interreligious conflicts. These are six main pathways:

- Delegitimization of the other’s argument
- Denying the other’s sincerity
- Power dynamics shaping the course of the dispute
- Self-criticism and recognition of one’s limitations
- Acceptance of difference
- Appeal to arbitration

Elaboration and illustrations of these six pathways are in the paper "*The Globalization of GM Controversy: Are Incommensurable Mental Models Affecting Food Security*?" which was presented at the Rural Sociological Society conference.

Like the evolution of my perspective on GMOs, my thoughts and reflections were constantly evolving while navigating the different Muslim groups in Morocco, and later Christian/Muslim groups in the US. The two issues, though they belong to completely different fields, share eight characteristics:

- Sensitivity of the topic
- Intersectionality with politics, power, and economy.
- Absence of open dialogue fear of repercussions or because of high risk perception: (surreptitious) exclusion, punishment, and potential threat.
- Fear of offending people with opposing position on the issue
- Perception of dialogue as futile: no chance to change opposing dogmatic mindsets.
- Dependence on like-minded allies and networks: this leads to emergence of tribal perspectives.

Like the approach I took on interreligious conflicts, I decided to navigate the GMOs issue within the African context by joining all possible research and science events to learn about the technology and the socio-economic dimensions of it. I did my best to be part of research and applied events which tend to be pro or anti GM technology.

What to make of this research findings and conclusions? I believe for methodological and epistemological reasons that this research can be subject to various interpretations and uses. History of science and research has demonstrated that any individual research or scientific venture in general can result in unintended if not undesired effects. These unintended and undesired effects can be at odds with the vision of its very original developer(s). These effects are expected since knowledge and science are never an individual act, they are rather founded on intergenerational web of science and knowledge. I do also believe that this research project might be used in a way that yield more building blocks of knowledge which would nurture it in so many ways, such as by addressing its limitations discussed throughout the chapters. For value-based and methodological reasons, I would like to warn against a flawed conclusion one might draw from reading this research project. It is the flawed assumption that this research supports anti-GM arguments. Though this research examines and critiques proponents of GM crops within the African context, I firmly stress that my findings are not intended for any scientific or personal reason to back up the critics of GMOs. Supporting or refuting either anti or pro GM technology research, does not constitute a research avenue; it also violates the principle that assessment of GM technology should go beyond binary judgments. Given that my research findings go beyond the publicly contentious dichotomous findings of GMOs as good or bad, safe or unsafe, and beneficial or harmful, my research conclusions might align with some specific points argued by critics of GMOs, but they are not intended to holistically support anti-GM attitudes for two reasons. First, though I am generally familiar with critics of GM technology, I have not invested in conducting systematic review of their arguments and research networks. Second, I hold firmly for scientific and logical reasons that there is no single discipline which can provide a conclusive answer of whether GM technology is safe or unsafe.

Towards Community-based definition of SD. While sustainability has been embraced by world governments through various UN legal and institutional instruments, namely the 17 Sustainable Development Goals in 2015, little has been done to define practical steps to attain

SDGs. This is attributed to the fact that SDGs are malleable goals whose definition varies depending on the context. More importantly, in the absence of a “real” community, there is no community-based conception of SD. For instance, examination of GM controversies shows that there is a strong need to build a community marked by a high level of interaction and diversity. Such a community is necessary for both proponents and opponents of GM technology. For proponents, this community would be key to inform industry decisions on the relevant crops to invest in. As known, various crops were rejected because they did not appeal to farmers or consumers, such as orange corn (not GM), and GM Matuka Banana. For GM opponents, it would be beneficial to build a clear understanding of the technology by interacting with relevant scientists. I also propose that scientists related to GM technology would benefit from other disciplines, namely philosophy and sociology of science, which are key to help them position their scientific knowledge within societal and cultural contexts.

While any discussion of science tends to be politically charged and involves identity politics, academic spaces should purge themselves from such dogmatic and essentialist understandings of science, e.g. accusation of anti-science, science is all good, scientists lie, and science has saved humanity. More importantly, it is important to remind ourselves that science is “a process of falsification” (Karl Popper); and the number one trait to have as a scientist is openness to accept limitations and refutation of one’s most deep seated convictions.

There is a misconception that being a scientist makes you entitled to explain science. That is not true ever. This claim is as erroneous as saying being a human makes you able to know everything about being human. The etymological root of science, which originally means to know, is enough to accept one fundamental principle of science which is not knowing. The not-knowing is the driving force for knowing. Knowing that we do not know should be the driving force to collaborate with diverse communities to build communities of learning. Communities of learning would protect us from classism of knowledge. To do so, I propose to keep in mind five conclusions drawn from this study. These conclusions may not be recommendations, but can be regarded as limitations of GM proponents:

Narrow and "thin" understanding of farmers' realities. As discussed, GM proponents' studies rely heavily on skimpy sources of information about farmers to the extent that the main source of information has been surveys administered by seed companies. I argue that surveys can never grasp the socio-cultural realities of farmers unless used in an integrated methodological approach which is founded on rich interactions, involvement of all stakeholders, and horizontal building of knowledge. What I mean by "horizontal" is that no type of knowledge is regarded as most valid, including farmers' knowledge since most farming communities might be marked by high level of heterogeneity of knowledge about their livelihood system. Horizontal building of knowledge can help identify various ways of collaboration among different types of knowledge, e.g. expert knowledge and local knowledge. I know it is easier said than done; for this reason, knowledge building requires constant practice, engagement, patience, and judicious honesty. Horizontal knowledge can lead to thicker and more elaborate understanding of rural realities. My interest in thick and elaborate understanding of rural realities started when I conducted research in four rural villages in Morocco. Thanks to my research in the four villages, I decided to investigate this question, which led to my work and research at Heifer International: How do economic development organizations bear in mind the socio-cultural and historical make-up of villages they work with before designing development projects? This question is pertinent to the great number of projects established in Africa to disseminate GM seeds. I can tentatively state the answer now: GM proponents barely consider local socio-cultural and historical contexts.

Diversification of disciplines. While conflicts among scientific paradigms have been extensively discussed within sociology of knowledge and science, society and technology topics, there is little engagement with such issues at the practical level among GM proponents. The need for sociology of scientific knowledge has been emphasized not only to understand science, but also to examine how scientific ideas are developed, adopted, rejected, supported, excluded, and how they become revolutionary. The sociology of scientific knowledge reveals valuable insights on how scientific impact might take unintended routes of influence. More importantly, in addition to the key role played by a "hard" scientist in terms of conducting scientific experiments, there is an important role for a philosopher of science to help grapple with the representation of science results. For instance, based on scientific claims, later considered pseudo-scientific, racism and ethnocentrism were founded on the works of scientists. Eugenics as practiced during the Holocaust cultivated political agendas that sought to "purify" the human race based on scientific "facts" by referring to "natural" practices such as weeding (Bauman 1993). History cites plenty of examples when science contributed to the extermination and exclusion of entities (non/human): exclusion of women from science as scientists and subjects, atoms of peace project which later led to nuclear threats proliferation, environmental disasters due to harmful chemicals. Obviously, science should not be reproached for human-induced disasters, but it is important to ask how science is implemented. Questioning how science is done has been a risky practice, and it is unfortunately generally discouraged. According to Baumann (1993): "Ernst Gellner put it twenty years ago with his usual brevity and straightforwardness, 'if a doctrine conflicts with the acceptance of the superiority of scientific-industrial societies over others, then it really is out'.."

GM proponents' claims should purge themselves from the demagogic politics of language. As illustrated before, GM proponents, namely agribusiness hold that every crop has been genetically modified since the creation of the universe, and that GM technology is more of a natural continuum which makes gene transfer more precise through "re-combinant DNA technology." As much as this statement is true, it is fallacious for two reasons, one technical and the other philosophical. The technical reason is that GE offers a type of genetic modification which is unprecedented: genetic transfer between unrelated species, e.g. between an animal and a crop; this has become more revolutionized through CRISPR technology. The dangers are recognized by scientists; that is why ethics codes are integral parts of GM experiments (Haydon Ian 2018). The second reason, equating GM with the concept of "natural" is unscrupulous, since the same logic can wickedly be used to justify various technologies which threaten human life and other beings: nuclear energy comes from nature, and hazardous chemicals are extracted and developed out of "natural" materials. History has plenty of examples where oppressive social and scientific practices were justified based on the belief that they are natural outcomes.

Pigeonholing does not help dialogue. Pigeonholing critics of GM as anti-science, "zealots" and "luddites" would only widen the abyss between proponents and opponents of GM technology. I have been immensely surprised listening to communication stakeholders who are involved in the dissemination of GM technology: they simplistically attribute people's resistance to GM technology to ignorance and dogmatism. This made me often wonder: if one is going to characterize people's resistance to GM technology as ignorant then what is the point of some disciplines, such as sociology of knowledge, philosophy of science, and political economy/ecology!? There is no better application of these disciplines than in issues like GM technology in order to understand how the technology interacts with societal and political phenomena. History has revealed that no scientific endeavor can be isolated from socio-economic and political forces within which it is developed: most of the time a technology is neither bad nor good; it is its use which renders it useful or harmful.

Debunking Grand claims. The examination of the Moroccan experience with GM technology demonstrates that we need to question grand claims, however institutionally empowered and embraced they are. As discussed, the Moroccan stance on GM policy is complex and goes beyond anti or pro.

I cannot emphasize enough that these conclusions are not about specific people, they are rather about mindsets or “tropes” from which I am not immune. More importantly, I do not pigeonhole those who support GM technology as holders of all those mindsets. My analysis is based mainly on inferences developed through examination of influential studies, interaction with stakeholders through interviews and participant observations, and experiential learning which includes the opportunity to conduct GM experiments using both techniques of agrobacterium and gene gun. My future goal, if I stay in this field, is to learn more about CRISPR including conducting experiments with it since it is now even available for high school students. Learning about GM from the technical side has been empowering. I am grateful for my department and CAFNR who have given me these opportunities. More importantly, I am grateful to my plant science friends who were supportive and engaged to learn about my comments and ideas. They helped me tremendously to understand the technology in deeper ways. I am also not only grateful but appreciative of the trust and confidence shared by highly influential GM proponents I met in various events and with whom I discussed questions about specific topics I had in mind. Such interactions were very helpful in learning about the background story of so many examined studies and their authors. I cannot emphasize enough here that these interactions should not be regarded as probing tactics; they were meant to embody the main goal of attending conferences which is the creation of communities of learning. They were also meant to embody the spirit of interdisciplinary dialogue, and exchange of information. I reached out to anyone that I read about or who is influential in this arena to train myself to have dialogue even with those with whom I might have fundamental disagreements. Such interactions trained me to distinguish between criticizing the idea vs criticizing the holder of the idea.

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APPENDICES

Appendix A: meta-analysis typology of proponents of GM SD benefits

						Emphasis on sustainable development (work used)	sustainability definition						
Title	**Author(s)**	**Peer Reviewed (Y/N)**	**Source**	**Discipline**	**Stance on Gm**	**1= significant emphasis 2= some emphasis 3= little emphasis**	**The approach: 1=neoliberal 2= Social Democratic 3= Radical 4= do not apply**	**Recognizes Limits to Growth: 1: Yes 2= NO 3= to some extent 4= do not apply**	**Role of technology 1= emphasized 2= not emphasized 3= fairly emphasized**	**Capitals substitutability: 1=Yes 2=no 3= to some extent 4= do not apply**	**Considers power relationships: 1=Yes 2=No 3= to some extent**	**emphasize Environmental protection: 1:YES 2: NO 3: do not apply**

1. Typology on Pro-biotechnology and sustainability in Africa:

2. Completion of typology on Pro-biotechnology and sustainability in Africa:

Sources of Date						Funding sources:
media	**Review**	**politicians**	**Farmers**	**Excerpt of Data Explanation**	**Unit of Analysis (Land yields ,stakeholders, small-scale farmer, politicians, general, market, policies, consumers**	

Appendix B: disciplinary backgrounds of proponents of GM SD benefits

Title	***Author(s)***	*Peer-Reviewed (1/0)*	***Discipline***
The Economic Impact of Genetically Modified (GM) Crops in South Africa.	Marthinus Gouse	0	Agricultural Economics
Africa's Inevitable Walk to Genetically Modified (GM)crops: Opportunities and Challenges for Commercialization	James A. Okeno Jeffrey D. Wolt Manjit K. Misra, Lulu Rodriguez	1	Agricultural economics
Agricultural Biotechnology and Small-scale Farmers in Eastern and Southern Africa	Virgin, I., M. Bhagavan, J. Komen, A. Kullaya, N. Louwaars, E. J. Morris, P. Okori and G. Persle	1	Biochemistry
*******mentions sust a lot:Stakeholder attitudes towards the Risks and Benefits of Genetically Modified Crops in South Africa.*	Philip Aerni	1	Agricultural economics
Enhancing Sustainability of Cotton Production Systems in West Africa: A Summary of Empirical Evidence from Burkina Faso	Jeffrey Vitale Marc Ouattarra Gaspard Vognan	1	Agricultural Economics
Tomorrow's Table: Organic Farming, Genetics, and the Future of Food	Pamela C. Ronald R. W. Adamchak	Book	Genetic engineering and Organic Farming
Starved for Science: How Biotechnology Is Being Kept Out of Africa	Robert Paarlberg	Book	international agricultural and environmental policy
The New Harvest: Agricultural Innovation in Africa	Calestous Juma	Book	International development
Status of biotechnology in Eastern and Central Africa	Godliving Y. S. Mtui	1	Molecular Biology and Biotechnology

Genetically modified crops in Africa Economic and policy lessons from countries south of the Sahara	IFPRI	1	Science and technology
Food security for Africa: an urgent global challenge	Albert Sasson	1	Biotechnology
Stakeholders' Perceptions of GM Technology in West Africa: Assessing the Responses of Policymakers and Scientists in Ghana and Nigeria	Ademola A. Adenle	1	Biochemistry
The cult of the amateur in agriculture threatens food security	Anthony Trewavas	0	Biotechnology
Global Socio-Economic and Environmental Dimensions of GM Maize Cultivation	József Popp, Zoltán Lakner	1	Agricultural development
Why Africa needs agricultural biotech	Florence Wambugu	1	Agricultural Biotechnology
GM agricultural technologies for Africa: A state of affairs	IFPRI: International Food Policy Institute	Report	Food and agricultural policy
The role of biotechnology for agricultural sustainability in Africa	Jennifer A Thomson	1	Molecular Biology
Biotech Crops in Africa: The Final Frontier,2009	Karembu, M., F. Nguthi and H. Ismail(a report by isaaa: international service for the acquisition of agri-Biotech applications)	1	Biotechnology and agricultural economics
A Meta Analysis on Farm-Level Costs and Benefits of GM Crops	Finger R, El Benni N, Kaphengst T, Evans C, Herbert S, Lehmann B, Morse S, Stupak N	1	Agri-Food and Agri-Environmental Economics + Multidisciplinary
Morris, E. J. (2011). Modern biotechnology-potential contribution and challenges for sustainable food production in sub-saharan africa. Sustainability, 3(6), 809–822. http://doi.org/10.3390/su3060809	Morris, E. J. (2011)	1	Gene Technologies

Biotechnology: Eastern African Perspectives on Sustainable Development and Trade Policy: ICTSD and ATPS (2007) Biotechnology: Eastern African Perspectives on Sustainable Development and Trade Policy, International Centre for Trade and Sustainable Development, Geneva, Switzerland and African Technology Policy Studies Network, Nairobi, Kenya	ICTSD and ATPS (2007) Biotechnology: Eastern African Perspectives on Sustainable Development and Trade Policy, International Centre for Trade and Sustainable Development, Geneva, Switzerland and African Technology Policy Studies Network, Nairobi, Kenya.	report	Diverse stakeholders
Plant biotechnology: a tool for development in Africa	Johan A. Brink, 1997 Director, UNESCO/BAC, BETCEN, ARC Roodeplaat, P/Bag X293, Pretoria, Republic of South Africa Barbara R.Woodward Research Officer, ARC Roodeplaat, P/Bag X293, Pretoria, Republic of South Africa Edgar J. DaSilva1 Director, Life Sciences Section, UNESCO, 1 rue Miollis, 75732 Paris cedex 15, France E-mail: e.dasilva@unesco.org		Director, UNESCO/BAC Lifescience
Biotechnology for sustainable banana and plantain production in Africa: the South African contribution	A Viljoen1*, K Kunert2, A Kiggundu2,3 and JV Escalant, 2003	1	micro-biology
South Africa—blazing a trail for African biotechnology	Marion Motari, Uyen Quach, Halla Thorsteinsdóttir, Douglas K Martin, Abdallah S Daar & Peter A Singer, 2004	1	Molecular biology , health, and genomics
Kenya: Biotechnology in Africa: Why the Controversy?	Ndiritu, C. G. (1999, October). Kenya: Biotechnology in Africa: why the controversy. In Agricultural Biotechnology and the Poor: Proceedings of an International Conference, Washington, DC (pp. 21-22).	Proceeding from conferences	Veterinary medicine

Biotechnology in South Africa	Cloete, T. E., Nel, L. H., & Theron, J. (2006). Biotechnology in South Africa. TRENDS in Biotechnology, 24(12), 557-562.	1	Department of Microbiology and Plant Pathology, University of Pretoria, Pretoria 0002, South Africa
Biotechnology, genetic conservation and sustainable use of bioresources	Uyoh, E. A., Nkang, A. E., & Eneobong, E. E. (2003). Biotechnology, genetic conservation and sustainable use of bioresources. African Journal of Biotechnology, 2(12), 704-709.	1	Department of Genetics and Biotechnology, University of Calabar, Nigeria. 2Department of Botany, University of Calabar, Calabar, Nigeria. 3School of Applied Sciences, Cross River State University of Technology, Calabar, Nigeria
Sustainable biotechnology for sub-Saharan Africa: Can it be implemented and maintained?	Bornman, C. H., Grace, O. M., & Van Staden, J. (2004). Sustainable biotechnology for sub-Saharan Africa: can it be implemented and maintained?. South African Journal of Botany, 70(1), 1-11.	1	Botany; Ethnobotany,and plant growth
Biotechnology for sustainable agriculture, food security and poverty reduction in Africa	Nyange, N. E., Kingamkono, R. R., Kullaya, A. K., & Mneney, E. E. (2011). Biotechnology for sustainable agriculture, food security and poverty reduction in Africa. Access Not Excess ed Charles Pasternak, 19-30.	1 book	1Tanzania Commission for Science and Technology , Dar es Salaam, Tanzania; 2Mikocheni Agricultural Research Institute, Dar es Salaam, Tanzania.

Agricultural genomics and sustainable development: perspectives and prospects for Africa	Machuka, J. (2004). Agricultural genomics and sustainable development: perspectives and prospects for Africa. African Journal of Biotechnology, 3(2), 127-135.	1	Centre for Complimentary Medicine and Biotechnology, Kenyatta University, P.O. Box 43844, Nairobi, Kenya. E-mail: ccmb@avu.org.
Can genetically modified cotton contribute to sustainable development in Africa?	Morse, S., & Mannion, A. M. (2009). Can genetically modified cotton contribute to sustainable development in Africa?. Progress in Development Studies, 9(3), 225-247.	1	Corresponding author. Department of Geography
Status of Biotechnology in Africa: Challenges and opportunities	Diran Makinde* Luke Mumba** Aggrey Ambali***	1	Director, West African Biosciences Network (WABNet), NEPAD Biosciences Initiative, Senegal. Email: wabnet@nepadst.org; diran.makinde@nepadbiosafety.net ** Director, Southern African Network for Biosciences (SANBio), New Partnership for Africa's Development (NEPAD), South Africa, Email: LMumba@sanbio.co.za *** Coordinator, African Biosciences Initiative (ABI) and Acting Adviser, New Partnership for Africa's Development (NEPAD), Office of Science and Technology (OST), Pretoria, South Africa. Email: aggrey@nepadst.org
Agricultural biotechnology and smallholder farmers in developing countries	Vivienne M Anthony	1	Syngenta Foundation for Sustainable Agriculture, Schwarzwaldallee

			215, 4002 Basel, Switzerland
Biotechnology, Agriculture, and Food Security in Southern Africa	Omamo and Grebmer,2005	1	IFPRI
Sustainable development and bioeconomic prosperity in Africa: Bio-fuels and the South African gateway	Dorsamy (Gansen) Pillay, 2009 Edgar J. Da Silva	1	Department of Biotechnology and Food Technology ; biochemistry genetics and microbiology

Appendix C: GM proponent's augments on GM benefits

Article citation	*Data location/date*	*Data source: farmers/others (ex-ante analysis, review)*	*GM crop trait*	*Productivity benefits*	*Environmental benefits*	*Health benefits*	*Labor benefits*
(Gouse, Pray, et al. 2005)	South Africa: 1999/2000 and 2000/2001 production seasons	-Larger scale farmers - Smallholder farmers	*BT white maize*	*Higher yields*	Pesticide-use reduction	Reduced exposure to mycotoxins in maize	Lower costs of labor
(Gouse et al. 2009)	South Africa: 2006/07 the Hlabisa, Dumbe and Simdlangentsha districts in KwaZulu-Natal	Smallholder farmers	*(Bt) and herbicide tolerant (RR) maize*	*Yield benefits depends on the adopted GM trait e.g. BT maize and Herbicide tolerant (RR) maize, seed cost, and fertilizer use.*	No reported benefits	No reported benefits	Labor benefits e.g. labor reduction and drudgery mitigation depend on the adopted GM crop trait: herbicide tolerant crops and BT crops.
(Bennett et al. 2006)	South Africa, Makhatini	Smallholder farmers	*The BT cotton variety*	*Higher yields*	Pesticide-use reduction	Protection against pesticide poisoning. Reduction of arduous tasks e.g. pesticide spraying, water collection and long distance of walking for spraying.	Labor reduction for pesticides application + more labor for harvesting+ drudgery mitigation
(Vitale et al. 2011)	Burkina Faso/2003 to 2009	*Burkina Faso cotton producers*	*BT cotton*	*Higher yields*	Pesticide-use reduction	Reduced exposure to pesticides	reduction of Labor costs
(Pray et al. 2013)	South Africa, KwaZulu-Natal /	*Smallholder farmers*	*BT maize*	*NO reported benefits*	NO reported benefits	"Reduced exposure to *mycotoxin fumonisin*"	No reported benefits

(Groote, W. a Overholt, et al. 2011)	Kenya/2000	Smallholder farmers	*BT maize*	*Projection of high yield benefits of GM maize*	"*allows widespread use of conservation agriculture*"	"Reduce negative health effects of chemicals"	No reported benefits
(Groote and Mugo 2004)	Kenya/2001	Smallholder farmers	*Bt maize*	*Projection of high losses due to non-adoption of BT maize*	Pesticide-use reduction	No reported benefits	Reduction of labor costs
(Jacobson and Myhr 2013)	South Africa/2006,2008,2009	Smallholder farmers	*BT maize*	*Higher yields*	No reported benefits[29]	No reported benefits	No reported benefits
(Fok et al. 2007)	South Africa	- Smallholder farmers - Large scale farmers	*BT cotton*	*Institutional arrangements curb the yield benefits of BT cotton*	Pesticide-use reduction	No reported benefits	Reduction of labor costs
(Karembu et al., 2009)	African GM growing countries in general (Egypt, Burkina Faso, South Africa)	- Smallholder farmers - Large scale farmers	*General*	*Higher yields*	Pesticide-use reduction	"reduce pesticide poisoning"	No reported benefits
(Gouse, Kirsten, et al. 2005)	South Africa, Kwazalulu natal/1998/99 and 1999/2000 seasons	Smallholder farmers	*BT cotton*	*Higher yields*	Pesticide-use reduction	"Improve health"	Less labor for spraying+ addresses labor shortage+ more labor for harvesting
(Y Ismael, Bennett, and Morse 2002)	South Africa/1998/1999 (first year of Bt introduction) and 1999/2000 (second year)	Smallholder farmers	*Bt cotton*	*Higher yields*	Pesticide-use reduction	"reduction in pesticide poisoning"	Reduction in labor costs+ addresses labor shortage
(Thirtle et al. 2003)	South Africa /Makhatini flats	Smallholder farmers	*BT cotton*	*Higher yields*	Pesticide-use reduction	Less exposure to harmful chemicals	Reduction in labor costs+ addresses labor shortage
(Shankar and Thirtle 2005)	South Africa/ Makhathini flats, KwaZulu-Natal	Small holder farmers	*BT cotton*	*Higher yields*	Pesticide-use reduction	Reduced health costs of pesticides use	Reduction of labor costs+ more labor for harvesting+

[29] Reports benefits as claimed by other studies : (Borlaug, 2000; Wambugu, 1999).

							drudgery mitigation+ addresses labor shortage
(Y Ismael, Beyers, et al. 2002)	South Africa/ Makhathini flats, KwaZulu-Natal/2000	Smallholder farmers	*BT cotton*	*Higher yields*	Pesticide-use reduction	"less health hazards"	addresses labor shortage
(Bennett et al. 2003)	South Africa/Makhathini Flats January 2002.	Smallholder farmers	*BT cotton*	*Higher yields*	Pesticide-use reduction	Reduced incidents of "accidental insecticide poisoning"	Reduction of labor costs+ drudgery mitigation+ free time for off farm tasks
(Ainembabazi et al. 2015)	The Great Lakes Region of Africa	Smallholder farmers	*GM Banana (not commercially released yet)*	*Projects higher yields due to the adoption of GM technology*	Pesticide-use reduction	GM bananas do not pose health risks	Reduction of labor costs
(Adenle et al. 2014)	Ghana/Nigeria in January 2011	Smallholder farmers	*GM technology in General*	*Projects high yield benefits due to the adoption of GM technology*	Pesticide-use reduction	Surveyed farmers expressed views in favor of GM technology health benefits	No reported benefits
(Bennett et al. 2004)	South Africa (1998/99, 1999/2000, 2000/01)	Smallholder farmers	*BT cotton*	*Higher yields*	Pesticide-use reduction	"reduction in damage to human health"	Reduction of labor costs
(Horna et al. 2008a)	Ghana/2006	Smallholder farmers	*(potential) GM crops: tomato,cabbage, garden egg*	*Projects high yield benefits due to the adoption of GM technology*	Pesticide-use reduction	Reduced "health risks from application of hazardous chemicals"	Reduction of labor needed for spraying
(Gouse, Pray, & Schimmelpfennig, 2004)	South Africa/	Smallholder farmers	*BT cotton*	*Higher yields*	Pesticide-use reduction	Health benefits which are "difficult to measure"	Reduction of labor costs
(Gouse, Kirsten, Pray, & Schimmelpfennig, 2006)	2001/South Africa	Smallholder farmers	*BT maize*	*Higher yields*	Pesticide-use reduction	No reported benefits	GM technology addresses labor shortage

(Hofs et al. 2006)	South Africa	Smallholder farmers	*Bt cotton*	*Higher yields*	Pesticide-use reduction	BT cotton can "slightly ….. diminish the probability of poisoning, especially with continued OP [organophosphates] use"	Reduction of labor costs
(Gouse et al. 2003)	South Africa	Smallholder farmers Large-scale farmers	*BT cotton*	*Higher yields*	Pesticide-use reduction	"less exposure to chemicals"	Drudgery mitigation+ reduction of labor costs
(Morse et al. 2005)	South Africa/Makhatini Flats	Smallholder farmers	*BT cotton*	*Higher yields*	Pesticide-use reduction	Reduced "toxic load"	Drudgery mitigation+ reduction of labor costs+
(Gouse 2012)	South Africa	Smallholder farmers	*GM maize*	*Higher yields*	No reported benefits	No reported benefits	Addresses labor shortage+ and drudgery mitigation
			Data NOT Based on Farmers' practices				
(Sengooba et al. 2009)	2007, a workshop report	General	General	Higher yields	Pesticide-use reduction	"Reduced exposure of farmers to chemicals"	Reduction of labor spraying costs
(Okeno et al. 2013)	Africa/2013	Review of former studies	General	Higher yields	No reported benefits	No reported benefits	No reported benefits
(Juma, 2011)	2011	General: review	general	Higher yields	Pesticide-use reduction	Production of healthier foods	Drudgery mitigation
(Virgin et al. 2007)	2007/ Eastern and Southern Africa	General: review	general	Higher yields	Pesticide-use reduction	Decrease "the use of highly toxic	No reported benefits

						insecticides" + no evidence of negative health effects of GM	
(Aerni 2005)	South Africa/2004	Perception survey	General	No reported benefits	No reported benefits	Positive perceptions of GM health effects	No reported benefits
(Qaim and Zilberman 2003)	General/developing world	Data based on field trials from developing countries, namely India, and pest pressures statistical information	Bt GM crops in Particular	Higher yields	Pesticide-use reduction	No reported benefits	"Reduced effort for pest control"
(Paarlberg 2010)	General/Africa	General/review	General	Higher yields	Pesticide-use reduction	"no documented risks to human health"	Reduced labor for weeding
(Adenle 2011)	General	Review	General	Higher yields	Pesticide-use reduction	"reduced number of illnesses that is associated with pesticide applications" + reduce exposure to mycotoxins	No reported benefits
(Abidoye and Mabaya 2014)	africa	general	review	Higher yields	Pesticide-use reduction	No reported benefits	No reported benefits
(Ronald and Adamchak 2008)	general	general	general	Higher yields	Pesticide-use reduction	Reduced exposure to Mycotoxins+ capacity of GM technology to address Vitamin A deficiency	No reported benefits
(Paarlberg 2008)	General	general	general	Higher yields	Pesticide-use reduction	Capacity of GM technology to	Reduced labor for weeding

						address nutrition and health problem	
(Juma 2011c)	general	general	general	Higher yields	Pesticide-use reduction	"improve nutritional value of crops"	No reported benefits
(Mtui 2011)	Eastern and Central Africa: Kenya, Uganda, Tanzania, Ethiopia, Rwanda, Burundi and Democratic Republic of Congo	General/review	General	Higher yields	Pesticide-use reduction	Improvem ent of healthy and nutritious food	No reported benefits
(Falck-Zepeda et al. 2013)	Africa	Various studies on the status of GM crops in Africa :	Differed cases	Higher yields	Pesticide-use reduction	Reduction in pesticides applicatio n and enhanced nutrition	Benefits depend on the adopted GM crop trait
(Stephen Mugo et al. 2005)	Kenya	Reporting IRMA(Insect Resistant Maize for Africa) project	BT Maize	Higher yields	Pesticide-use reduction	More efforts needed to raise awareness about erroneous negative perception of GM health effects	No reported benefits
(Novy et al. 2011)	Africa	Econometric modelling	general	Higher yields	Pesticide-use reduction	Reduced pesticide use	No reported benefits
(Sasson 2012)	Africa	Review		Higher yields	No reported benefits	No reported benefits	No reported benefits
(Adenle 2014)	West Africa(Ghana and Nigeria)	Policy makers and scientists	general	Higher yields	Pesticide-use reduction	Reduction in pesticides applicatio n	Reduction of labor spraying costs
(Ozor and Urama 2013)	Africa	Review		Higher yields	No reported benefits	No reported benefits	No reported benefits
(Trewavas 2008)	General (refernce to Africa)	Review	general	Higher yields	No reported benefits	No reported benefits	No reported benefits

(Azadi and Ho 2010)	General: reference to Africa	review	general	Higher yields	No reported benefits	Enhanced nutritional value	Reduction of labor spraying costs
(Popp and Lakner 2013)	General: reference to Africa	Review	GM maize	Higher yields	Pesticide-use reduction	No reported benefits	Drudgery mitigation+ No reported benefits
(Borlaug 2000)	General: reference to Africa	Review	general	Higher yields	Pesticide-use reduction	No evidence on health risks of GM crops	No reported benefits
(Wambugu 1999)	Africa	Review	general	Higher yields	Pesticide-use reduction	No reported benefits	No reported benefits
(Obonyo et al. 2011)	Africa: sub-Saharan Africa	Review	general	Higher yields	No reported benefits	No reported benefits	No reported benefits
(Chambers et al. 2014)	Africa	Review	General	Higher yields	Pesticide-use reduction	“no significant risk to human health” + less exposure to chemical hazards	Reduction of labor costs+ more labor for harvesting+ drudgery mitigation
(Thomson 2008)	Africa	Review	general	Higher yields	Pesticide-use reduction	Saving on arduous task of pesticides application + protection against toxic chemicals	Reduction of labor costs+ more labor for harvesting
(Kimenju and De Groote 2008)	Kenya	Survey on consumers’attitudes	GM maize	Higher yields	Pesticide-use reduction	Need to address consumers’ fear of GM health effects	No reported benefits
(Carpenter 2013)	General: reference to Africa	Review of available data	General	Higher yields	Pesticide-use reduction	Reduced cases of pesticides poisoning	Reduction of labor costs
(Anderson and Jackson 2005)	Sub-saharan Africa	Econometric modelling	General	Higher yields	Pesticide-use reduction	Saving on health costs of pesticides application + enhanced nutritional value	GM food (golden rice) would improve “productivity of unskilled labour”

(Bouët & Gruère, 2011) *55*	Seven sub-Saharan African countries: Benin, Burkina-Faso, Mali, Senegal, Togo, Tanzania, and Uganda	Econometric modelling: computable general equilibrium model	GM cotton	Higher yields	No reported benefits	No reported benefits	GM Labor effects depend on country characteristics
(Elbehri and Macdonald 2004)	West and Central Africa	Econometric modelling: General Equilibrium Approach	GM bt cotton	Higher yields	Pesticide-use reduction	Reduced exposure to harmful pesticides	Reduction of labor costs+ more labor for harvesting+ drudgery mitigation+ addresses labor shortage
(Takeshima 2010)	Africa	review	GM cassava	Higher yields	No reported benefits	No reported benefits	No reported benefits
(Vitale et al. 2007)	Mali	Econometric modelling:	GM Bt crops	Higher yields	Pesticide-use reduction	Reduced exposure to harmful pesticides	No reported benefits
(Grure and Takeshima 2012)	Africa	Econometric modelling	general	Higher yields	No reported benefits	No reported benefits	No reported benefits
(Smale et al. 2009)	Developing countries context/2009	Review of data on GM adoption in developing countries including Africa	general	Higher yields	Pesticide-use reduction	Potential reduced exposure to harmful pesticides	Drudgery mitigation+ addresses labor shortage
(Finger et al. 2011)	General: includes data (meta-analysis of studies on African adoption of GM) on Africa	Meta-analysis: econometric moelling		Higher yields	Pesticide-use reduction	Potential reduced exposure to harmful pesticides	Reduction of labor costs+ more labor for harvesting+ drudgery mitigation
(Hillocks 2005)	Africa	Review	BT cottom	Higher yields	Pesticide-use reduction	reduced exposure to harmful pesticides	Reduction of labor costs
(Smale and Groote 2003)	East Africa: Kenya and Uganda	Review		Higher yields	Pesticide-use reduction	No evidence of negative health effect of GM crops	NO reported benefits

(Zilberman et al. 2014)	Developing world: mention of African need for biotechnology	Review	General	Higher yields	Pesticide-use reduction	No evidence of negative health effect of GM crops	No reported benefits
(Thomson 2015)	Africa	Review	Potential GM crops: GM maize GM Cassava GM Banana	Higher yields	Pesticide-use reduction	No evidence of negative health effect of GM crops	Reduction of labor costs + drudgery mitigation
(Brookes and Barfoot 2015a)	Global: includes data on Africa	Analysis of available data through econometric modelling		Higher yields	Pesticide-use reduction	No reported benefits	Reduction of labor costs
(Ezezika et al. 2012)	the Water Efficient Maize for Africa Project	interviews with Ag-biotech stakeholders	general	Higher yields	No reported benefits	No reported benefits	No reported benefits
(Cabanilla et al. 2004)	West Africa: Mali, Burkina Faso, Benin, Cote D'ivoir, and Senegal	Econometric modelling	BT cotton	Higher yields	Pesticide-use reduction	No reported benefits	Reduction of labor costs+ more labor for harvesting
(Kikulwe et al. 2011)	Uganda	banana-consuming households	GM Banana	Higher yields	Pesticide-use reduction	No evidence of negative health effect of GM crops+ Need to address consumers 'fear of GM health effects	No reported benefits
(Ozor and Igbokwe 2007)		review	general	Higher yields	Pesticide-use reduction	No reported benefits	Reduction of labor costs
(Gouse 2009)	South Africa/2009	Review of former datasets findings		Higher yields	Pesticide-use reduction	No reported beenfits	Reduction of labor costs+ more labor for harvesting+ drudgery mitigation

(Langyintuo and Lowenberg-DeBoer 2006)	West and Central Africa/2006	Econometric modelling	BT cowpea (not commercialized yet)	Higher yields	Pesticide-use reduction	Reduced exposure to harmful chemicals	NO reported benefits
(Gruère and Sengupta 2009)	Review	Review	general	Higher yields	No reported benefits	No reported beenfits	No reported benefits
(Jeffrey Vitale et al. 2008)	Burkina Faso/2008	Econometric modelling	BT cotton	Higher yields	Pesticide-use reduction	No reported benefits	Reduction of labor costs
(Abraham 2014)	Ethiopia/2014	Review	general	Higher yields	No reported benefits	The capacity of regulatory institutions to address health safety concerns of Gm crops	Reduction of labor costs

N.B Excluded studies from original developed list of 82 studies are: Gouse thesis (2004); (Brookes and Barfoot 2013a) which is similar to (Brookes and Barfoot 2015a) coded here; (Freidberg and Horowitz 2014) on clashing views about GM; (Takeshima and Gruère 2011) focuses on pressure groups which are anti GMOs ; (Tripp 2001) which is on GM seed delivery and farmers' access to information. Except Gouse (2004) thesis, those articles support GM technology but their studies do not focus on GM benefits.

Appendix D: Interview Questions and Recruitment Script

Interview Topic: AGRICULTURAL BIOTECHNOLOGY AND SUSTAINABLE DEVELOPMENT IN THE AFRICAN FOOD SECURITY CONTEXT

Interviewer: Yassine Dguidegue, PhD Student, Rural Sociology, University of Missouri

***Instructions**: Good morning (afternoon). My name is Yassine Dguidegue. I appreciate you taking the time to interview you today about Biotechnology status in Morocco. In this interview, I would like to ask you about your experiences with and perceptions of biotechnology, namely genetic modification technology. The purpose is to get your perceptions about biotechnology as well as recommendations you deem as important to have fruitful discussion about the technology. There are no right or wrong or desirable or undesirable answers. I would like you to feel comfortable with saying what you really think and how you really feel. Any question you do not want to answer, I would be happy to skip.*

***Consent Form Instructions:** Before we get started, please take a few minutes to read this consent form; please do not hesitate to let me know of any questions or objections you have about it.*

TAPE RECORDER INSTRUCTIONS: If it is okay with you, I will be tape-recording our conversation. The purpose of this is so that I can get all the details but at the same time be able to carry on an attentive conversation with you. I assure you that all your comments will remain confidential. I will be compiling a report which will contain all students' comments without any reference to individual's names or any indicators of who they are. Tape Recording serves also the purpose for transcription and organization of collected data.

Interview Questions

Background Information of the Interviewee:

1) **To get us started, can you give me a bit of information on your educational background, involvement in agriculture, agricultural policy, and advocacy?**

2) **Questions on perceptions of GMOs:**

What is the current status of GMOs in Morocco?

- **Who are the major stakeholders involved in it?**
- **Are there any specific crops which would benefit from the technology? (this is for those researchers in the policy/research arena)**
- **What is your opinion about the application of genetic modification?**
- **Do you have concerns about GMOs application in Morocco?**
- **How do you foresee them being addressed?**

- **What is the current state of biosafety in Morocco?**
- **Are there any GMOs trials?**
- **Are there any major GMOs policy frameworks (e.g. European or US,) which influence/inform the Moroccan policy stance on GMOs? Do you prefer anyone of them and why?**
- **What are the major factors hindering or enabling the adoption of biotechnology in Morocco?**
- **What do you think about biotechnology applications and sustainable agriculture?**

3) **Do you have any recommendations to make debates about biotechnology more fruitful? What factors causes debates on biotechnology to be unproductive?**

Recruitment script for the snowball recruitment

Hello, my name is Yassine Dguidegue. I am a graduate student at University of Missouri, in the Rural Sociology Department. I am conducting a research study about genetic engineering technology perceptions- what people think about its importance and debates it has created, and I am inviting you to participate because you know about the technology and its applications.

Participation in this research includes a one hour interview about your views on genetic engineering technology, especially within the Moroccan agricultural context. The interview will take approximately 60 minutes or less in case it is not convenient to you.

If you have any questions or would like to participate in the research, I can be reached at ,573-289-2237 or yd5yb@mail.missouri.edu.

Best regards,

VITA

Yassine Dguidegue was born in Morocco, Sidi Moussa, where he finished his elementary, secondary, and high school education. He earned his bachelor's degree in language and pedagogy from The Faculty of Education in Rabat, Morocco, and a master's degree in cross-cultural studies from the University of Mohammed the Fifth in Morocco.

Dguidegue has been actively involved in the Rural Sociological Society, the Borlaug Dialogues Program and Universities Fighting World Hunger program. He speaks four languages — Moroccan Arabic, English, classical Arabic and French — and is an avid soccer player and fan. He also enjoys cooking traditional meals with his family, organizing volunteering programs with community members and organizing outdoors and sports activities with colleagues and students.

Dguidegue completed his Ph.D. in rural sociology in July 2019 from the University of Missouri, Columbia. He has served as a graduate teaching and research assistant at Mizzou since 2014 and was also the director of the university's Deaton Scholars Program, a process-based peer mentorship program.

A native of Morocco, Dguidegue's academic interests include, society science and technology, African food security, rural community development, experiential learning education, policy analysis and intercultural communication.

Dguidegue worked as a teacher and program leader in experiential education programs in Morocco, Vietnam and California. He also spent a year (2012-13) teaching at Heifer International in Perryville, Arkansas. He has also collaborated in international research with Leiden University, policy consultancy with the British Council, and trainings with the Chatham House.