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GMOs for Development: To what extent is EU's GMO policy coherent with its international development objectives?

Linking GMOs and GMO regulation in sub-Saharan Africa to the Millennium Development Goals and Policy Coherence for Development

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Abstract

Given the increasing world population, prices and greenhouse gas emissions, there is a need to innovate agriculture in order to accelerate crop productivity sustainably. These issues are compounded in developing countries, which often face severe droughts, famine, and have limited access to drinking water. Genetically modified organisms (GMOs) are the proposed solution to these concerns, with an increasing number of countries reaping the benefits of the new technology.

GMOs are a hotly debated topic in the European Union (EU), but for very different reasons. Namely, a negative public perception on GMO safety and ethics has led to a restrictive and precautionary approach to GMO regulation. EU's GMO policy has shown an international impact, mainly in the poorest countries, many of which are in sub-Saharan Africa.

To bring a fresh perspective to EU's GMO debate, this thesis will analyse the coherence of EU's GMO policy with its international development objectives, outlined in EU's framework Policy Coherence for Development. Linking GMO's to the Millennium Development Goals, data suggests that they can have a positive effect, e.g. on reducing hunger and poverty. Conversely, EU's GMO policy can act as a deterrent to developing country GMO acceptance, which would suggest that it is not coherent with its international development objectives.

Key words: *European Union, Genetically Modified Organisms, Policy Coherence for Development, Millennium Development Goals, sub-Saharan Africa.*

Word count: *17724*

List of abbreviations and acronyms

Biotech – Biotechnology
BSE – Bovine Spongiform Encephalopathy
Bt – Bacillus thusingiensis
CAP – Common Agricultural Policy
Commission – European Commission
CTNBio – Brazilian National Technical Biosafety Commission
DAC – Development Assistance Committee
DALYs – Disability Adjusted Life Years
DFID – UK Department for International Development
EASAC – European Academies Science Advisory Council
EFSA – European Food Safety Agency
EMBRAPA – Brazilian Agricultural Research Corporation
EPA – Economic Partnership Agreement
EU – European Union
FAO – Food and Agriculture Organization
GAERC – General Affairs and External Relations Council
GM – Genetically Modified
GMO – Genetically Modified Organisms
HIV/AIDS – Human Immunodeficiency Virus Infection/ Acquired Immune Deficiency Syndrome
HT – Herbicide Tolerant
IDEC – Institute for Consumer Defence
IFPRI – International Food Policy Research Institute
IR – Insect Resistant
IRRI – International Rice Research Institute
ISAAA – International Service for the Acquisition of Agri-biotech Applications
KARI – Kenya Agricultural Research Institute
MDG – Millennium Development Goal
NAFTA – North American Free Trade Agreement
Nerica – New Rice for Africa
NGO – Non-Governmental Organisation
ODA – Official Development Assistance
OECD – Organization for Economic Co-operation and Development
PCD – Policy Coherence for Development
PhilRice – Philippine Rice Research Institute
PPP – Public-Private Sector Partnership

R&D – Research and Development
SADC – Southern African Development Community
SEA – Single European Act
SPS – Sanitary and Phyto-sanitary Standards
SSA – Sub-Saharan Africa
UN – United Nations
US – United States
VAD – Vitamin A Deficiency
WEMA – Water Efficient Maize for Africa
WFP – World Food Programme
WHO – World Health Organization
WTO – World Trade Organization

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1. Introduction

Despite strenuous international development efforts, 870 million people in the world today are chronically hungry and 2 billion are malnourished (James 2014). The global population currently stands at 7.2 billion and is expected to rise to 9.6 billion by 2050 (United Nations 2014). In addition, the development of biofuels as a more viable energy option has increased the demand for crops. Consequently, the land for growing food crops is becoming scarcer, putting upward pressure on food prices. Today, 70% of the world's fresh water is used in agriculture, which is very unsustainable considering severe droughts and limited access to drinking water, which are commonplace in many of the poorest developing countries, including much of sub-Saharan Africa (SSA) (James 2014). The United Nations' (UN) Food and Agriculture Organisation (FAO) predicts that global agricultural production will need to increase 60% by 2050, compared to 2005 levels in order to meet increased demand (FAO 2012). Hence, there is a dire need to increase crop productivity sustainably, using resources such as land, water, fertilisers and pesticides in a more efficient way (EASAC 2013).

Genetically modified organisms[1] (GMOs) are the newest advancement in agricultural technology. They are crops that have been genetically altered by the insertion of genes 'borrowed' from other species, in order to make them display traits such as resistance to pests or herbicide tolerance. GMO-proponents argue that biotechnology is the future of agriculture, and that genetically modified crops will facilitate faster and more sustainable development by decreasing costs for farmers, while benefiting their health and protecting the environment (EASAC 2013). All of the mentioned concerns: food shortages, self-sufficiency, increasing food prices, land saving, environmental protection, in short, sustainable development, can arguably be aided by agricultural biotechnology (James 2014).

Nevertheless, the European Union (EU) has adopted a precautionary approach to GMOs despite the fact that the global scientific community states that conventional agricultural technology alone will not able to sustain the growing global population in the long run. They propose a 'best of both' approach, using the best conventional and other farming methods in combination with biotechnology to increase crop productivity and achieve sustainable intensification. Yet, in response to the negative domestic public opinion on GMOs, the EU has implemented strict regulatory measures on domestic GM production as well as GM imports. This can become problematic if these measures have a negative spillover effect on developing

[1] For the purpose of this thesis, genetically modified organisms (GMOs) will pertain to agricultural genetically modified crops. GMOs can also be used in other sectors, e.g. pharmaceuticals.

countries. If so, it would be conflicting with EU's political framework Policy Coherence for Development (PCD) and its wider international development objectives, e.g. the Millennium Development Goals (MDGs).

Accordingly, this thesis will analyse existing research on the effects of GMOs in developing countries, notably in sub-Saharan Africa, and on EU's impact on GMO regulatory choices in these countries; linking them to the Millennium Development Goals. Thus, it aims to produce new insight in highlighting the discussion surrounding the PCD of EU's GMO policy and inform future research and policy making on this topic. This issue has been largely omitted from EU debates and scholarly literature, but it is likely to increase in salience the more GMO research is conducted, and the more countries in sub-Saharan Africa realise the potential benefits of agricultural biotechnology.

This thesis will proceed as follows. Chapter 2 will provide the motivations for this thesis and its various elements. Chapter 3 will offer a contextual background to this topic, including the legal frameworks of EU's GMO policy and Policy Coherence for Development. Chapter 4 will present the existing literature on GMO effects in developing countries and on factors impacting GMO regulatory choices in developing countries, with a focus on sub-Saharan Africa. The research considered in this chapter will also serve as data for the discussion outlined in chapter 5. The discussion will focus on the role GMOs can play in contributing to the Millennium Development Goals, and reflect on EU's GMO policy in terms of Policy Coherence for Development. Finally, Chapter 6 will present the conclusions.

2. Motivations

2.1 Statement of purpose

This thesis aims to critically assess the European Union's restrictive GMO policy in regards to how coherent it is with EU's international development objectives. GMOs are a very current and contested topic in EU debates, in light of the recent reform of the EU's GMO policy and the decades of preceding disagreement among EU member states on the issue, given a large negative public opinion in Europe. The EU is committed to ensuring that its policies do not have negative spillover effects on developing countries, as outlined in its political framework Policy Coherence for Development. Moreover, one of the EU's international development objectives is to contribute to the achievement of the Millennium Development Goals. This thesis will evaluate existing research on the impact of GMOs in developing countries, especially countries in sub-Saharan Africa, with the aim of identifying the role GMOs might play in contributing to the Millennium Development Goals 1 to 7. Additionally, it will evaluate existing research on the EU's influence on GMO regulatory choices in countries in sub-Saharan Africa, and link it to Millennium Development Goal 8. In doing this, this thesis aims to bring a fresh perspective to the European GMO debate, and address whether existing research supports the notion that EU's GMO policy is aligned with Policy Coherence for Development.

2.2 Relevance

To the author's knowledge, there are no previous studies on the Policy Coherence for Development of EU's GMO policy, at the EU level or in academia. By addressing this issue, the objective of this thesis is to contribute to literature on policy coherence of EU policies with broader development objectives, and on the nature of the EU's GMO policy in this respect.

2.3 Research questions

In order to analyse the coherence of EU's GMO policy with EU's wider international development objectives, i.e. the PCD of the policy, the following questions will be addressed:

What role do GMOs in sub-Saharan Africa play in contributing to Millennium Development Goals 1 to 7?

How has the EU influenced GMO regulatory choices of countries in sub-Saharan Africa, and are its actions in line with Millennium Development Goal 8?

2.4 Approach

On the one hand, there has been extensive research assessing the impact of GMOs ever since the technology came about. On the other, the Millennium Development Goals, including specific targets for each one, have been outlined in several international documents, and have been the basis for much scholarly work. Thus, this thesis will link existing research on the two topics in order to produce new insights on the development impact of EU's restrictive GMO policy. In the face of the recent explosion of information in social sciences, a growing number of social science methodologists have called for various types secondary analysis, using existing qualitative research to engender new findings and inform policy making (e.g. Thorne 2004; Heaton 2004, 2008; Sandelowski 2006; Finlayson and Dixon 2008; Major & Savin-Baden 2010; Irwin 2013).

Still, it is crucial to acknowledge that using secondary sources has its limitations, as they can be biased, do not always fit the needs of the research and may provide inadequate information. Therefore, conducting surveys or interviews might have increased the validity of this research. It could also have benefitted from a larger number of cases. However, the objective of this thesis is not to contribute to literature on the impact of GMOs in developing countries, which, as mentioned, is vast. Rather, it is to highlight the discussion about the EU's GMO policy in connection to Policy Coherence for Development.

Nevertheless, in order to mitigate the mentioned constraints of secondary sources, the documents chosen to serve as main data in this thesis: a) are extensive in covering a large number of relevant topics; b) address the topic of the impact of GMOs in sub-Saharan Africa; c) address the topic of EU's impact on GMO regulatory choices in sub-Saharan Africa; d) are prepared by international scientific organisations or have undergone extensive peer reviews; and e) their authors are widely referenced by other GMO researchers. Hence, they will be able to answer the mentioned research questions and are assumed to be independent of political affiliation, speaking to their validity and reliability.

2.5 Sources

After extensive research into the topic of GMOs in developing countries, the following secondary sources were chosen to serve as data to answer the said research questions: two publications prepared by the International Service for the Acquisition of Agri-biotech Applications (ISAAA): the 2009 report "Biotech Crops in Africa: The Final Frontier" co-written by Margaret Karembu, Faith Nguthi and Ismail Abdel-Hamid; and the latest report on the "Global Status of Commercialized Biotech/GM Crops 2014", authored by Dr Clive James, the founder and Emeritus Chair of ISAAA.

Furthermore, the 2013 Policy Report 21: "Planting the future: opportunities and challenges for using crop genetic improvement technologies for sustainable agriculture" prepared by the European Academies Science Advisory Council (EASAC) will be used. Finally, the book "Genetically Modified Crops in Africa: Economic and Policy Lessons from Countries South of the Sahara", published in 2013 by the International Food Policy Research Institute (IFPRI) and co-edited by José Falck-Zepada, Guillaume Gruere and Idah Sithole-Niang, which includes eight studies[2] of GMOs in sub-Saharan Africa, was chosen. They will be supported with other relevant research.

2.6 Focus

The Millennium Development Goals were established in 2003 following the United Nations' (UN) Millennium Declaration in order to ensure better-coordinated policies internationally. This was a response to negative perceptions on aid effectiveness, which had failed to substantially tackle poverty. They comprise 1. Eradication of extreme hunger and poverty; 2. Achieving universal primary education; 3. Promoting gender equality and women's empowerment; 4. Reducing child mortality; 5. Improving maternal health; 6. Battling HIV/AIDS, Malaria, Tuberculosis and other diseases; 7. Ensuring environmental sustainability; and 8. Developing a global partnership for development (United Nations 2014). The UN's 2014 Millennium Development Goals Report outlines the specific targets for each MDG and informs on the progress of developing countries to date. When investigating the abovementioned sources, the focus will be the link between GMOs and MDGs 1 to 7, and EU's impact on GMO regulatory choices and MDG 8.

The UN defines extreme hunger and poverty as having less than one basket of food per day and living on an income of less than US$1 per day (ibid.). Individuals not able to obtain enough food to conduct an active and healthy life are considered undernourished. According to UN's MDG report, several regions in Asia, Latin America and the Caribbean have almost halved their hunger rate, while sub-Saharan Africa shows limited progress, and undernourishment of children has actually increased from 1990 to 2012. In order to answer the question whether GM crops have helped reduce hunger, data on GM crop productivity will be examined, as higher yields can have implications for lowering hunger. For GMOs to have an impact on hunger, eventual increased yields would have to stay in the country and not be

[2] These are: Falck-Zepeda et al. 2013; Gouse 2013; Pray et al. 2013; Horna 2013; Kikulwe et al. 2013; Wafula & Gruere 2013; Paarlberg 2013; and Gruere et al. 2013.

exported. If it is exported it would be interesting to know where, as it may impact the recipient country's food security. Increased profits are of course connected, as they enable the purchase of more food.

Overall, poverty reduction has been uneven across different regions of the world, and sub-Saharan Africa is unlikely to meet the target of halving poverty by the end of 2015 (ibid.). Therefore, in order to answer the question if GM crops have contributed to reducing poverty, GM farmers' incomes will be considered, along with agricultural food prices, which would speak to the level of disposable income to spend on food of non-farmer households in developing countries. Additionally, sales of other goods such as mobile phones, animals or bicycles are interesting to consider as they would not only point to increased incomes, but could have implications for other development benefits.

The target for the second MDG, achieving universal education, is for boys and girls everywhere to able to complete a full course of primary school (ibid.). A developing country study of 61 households "shows that children of primary-school age from the poorest 20 per cent of households are over three times more likely to be out of school than children from the richest 20 per cent of households" (ibid., p.17). Thus, if improved GM crop productivity increases farmers' incomes and lowers food prices, it could imply that more people can afford to pay for their children's school fees.

In sub-Saharan Africa 85% of women are engaged in vulnerable employment compared to 70% of men (ibid.). Also, despite a 18% increase in net school enrolment between 2000 and 2012, 33 million primary school aged children are still out of school and 56% of them are girls (ibid). It can prove difficult to establish a causal relationship between GM crops and the third MDG: gender equality and women's empowerment. However, in order to evaluate whether there is some correlation, profits of female GM farmers will be considered, as well as school enrolment of girls.

There is evidence of a link between a country's income level and child and maternal mortality (ibid.). Thus, higher incomes obtained from GM crop production can be expected to help decrease mortality and improve maternal health in farmer households because they could be more able to afford healthcare. Additionally, higher incomes often mean better means of transport, which could improve access to healthcare. Moreover, assuming GMO production results in increased domestic food supply, non-farmer households could also benefit from lower levels of undernourishment and disease, which would have positive implications for child and maternal health.

Combatting HIV/AIDS, malaria and other diseases is of course connected. GMOs cannot cure sexually transmitted diseases or malaria, but they can help prevent mass starvation; and the development of second-generation GM technologies can provide additional nutrients to a sick population. Furthermore, improved access to healthcare can facilitate treatment of other diseases and the provision of medicine. Thus, to evaluate the correlation between GMOs and the Millennium Development

Goals 4, 5 and 6, country profits from GM crops and the development of output traits in GM crops will be considered.

Ensuring environmental sustainability pertains to the reduction of carbon dioxide emissions, protecting ecosystems and improving sources of drinking water. Carbon dioxide emissions increased by 35% from 2000 to 2011 and the main contributors are developing regions (ibid.). Reduced pesticide and herbicide spraying and decreased soil degradation from GM crops could not only benefit farmer and consumer health, but also reduce carbon dioxide emissions and contamination of drinking water. “Many people, usually women or young girls, often need to join long queues or walk long distances to get to an improved water source” (ibid., p.43). Increased incomes and in turn improved transport can help better water access. Moreover, pesticide and herbicide use in GM agriculture and figures of water and soil degradation will be evaluated as compared to conventional agricultural methods.

Finally, the eighth MDG: developing a global partnership for development refers to official development assistance (ODA) to developing countries, and working towards an open, rule-based, predictable, non-discriminatory trading and financial system, and lowering developing country debt (ibid.). Apart from possibly helping lower country debts as a result of increased export earnings from higher crop yields, there it is difficult to establish a link between GM crops in developing countries and this MDG. It rather pertains to developed country actions, so what will be considered is EU’s impact on developing country regulatory choices with regards to GMOs, as well as EU’s assistance to agricultural research and institutional development in countries in sub-Saharan Africa.

As seen, the adversities addressed by the Millennium Development Goals Report largely affect countries in sub-Saharan Africa. A large part of the SSA population lives in rural areas and 70% of it depends on agriculture for its livelihood, as more than half of SSA’s export earnings and 35% of its GDP come from agricultural products (EASAC 2013; Zepada et al. 2013; Wafula & Gruere 2013). Yet, its per-capita food production is decreasing (Karembu et al. 2009). Poverty and hunger in Africa have been attributed to low land and labour productivity. Shy innovation of agriculture perpetuates this trend: in 2009 only 4% of Africa’s agricultural land was irrigated, the use of innovative agricultural technology was limited, and they used ten times less fertiliser than developed countries (ibid.). Its hardships are fuelled by political and institutional instability, disease, population growth, droughts, and low investment in agricultural research (Karembu et al. 2009; Gouse 2013). It is also the region that has least developed GMO capacities in the world. For these reasons the discussion will focus mainly on sub-Saharan Africa. Under the pretext of the assumptions made in the mentioned existing research, this thesis will critically evaluate the role played by GMOs in SSA countries in their progress towards achieving the Millennium Development Goals, with a view to shedding light on the development coherence of EU’s restrictive GMO policy.

3. Contextual background

3.1 EU and development

The European Union is the largest donor of development aid in the world and it considers its development policy to be a cornerstone of its external relations (European Commission 2015a). EU's development action is outlined in the Treaty of Lisbon and the European Consensus on Development, a policy statement that guides EU institutions and member states in their implementation of development policy (ibid.). It sets out to a) reduce poverty through the Millennium Development Goals; b) promote European values, such as democracy, the rule of law, good governance and respect of human rights in developing countries, as means of enabling global sustainable economic, social and environmental development; and c) help developing countries achieve nationally led development (European Commission 2015d). In 2011, the EU reformed its development strategy with the policy Agenda for Change, which emphasises better aid and budget support.

"Aid, in itself, is, of course, only part of the solution" (Holland 2008, p. 354). Non-development policies of the European Union, including trade, environment, agriculture and fisheries, can have a negative effect on developing countries. In accordance with the principle of 'do no harm', promoted by the Organisation for Economic Co-operation and Development (OECD), there is thus a need to harmonize non-development policies with wider development objectives (OECD 2015). In recognising this, the EU has made Policy Coherence for Development a key pillar of its development policy (Schaik et al. 2006), vowing to ensure it "takes account of the objectives of development cooperation in all policies that it implements which are likely to affect developing countries, and that these policies support development objectives" (European Council 2006, p.2).

The notion of Policy Coherence for Development increased in salience in mid-1990s (Schaik et al. 2006). It was major topic of discussion at the meeting of OECD's Development Assistance Committee (DAC) in 1991, which addressed the link between non-aid policies and development aid. In 1996, DAC published a report "Shaping the 21st Century", urging developed countries to ensure that the "entire range of relevant… policies are consistent with and do not undermine development objectives" (OECD 1996, p.18). In European cities, non-governmental organisations (NGOs) campaigned against the EU's Common Agricultural Policy (CAP), which had negative spillovers on developing countries, such as 'dumping' of heavily subsidised agricultural products and putting developing country farmers 'out of business' (Carbone 2008). "Foreign aid was not enough, but better synergies between aid and non-aid policies needed to be explored" (ibid., p.324). This contributed to raising awareness on the importance of PCD, but there was no major headway on establishing specific PCD objectives. Policy Coherence for Development "reached several 'hard' policies, such as trade, [and] agriculture" (ibid.) and governments prioritise internal goals in order to satisfy their electorates and civil society, meaning that development interests frequently succumb to interests that better serve the national public. Consequently, high-level policies, such as trade and agriculture, were swept under the carpet in discussions relating to PCD. The objective of this thesis is to expand the discussion on the EU's GMO policy.

OECD reiterated its message in subsequent publications, such as "The Development Dimension" series, which analysed a range of policies with respect to PCD (e.g. OECD 2005). Also, several EU member states showed an interest in PCD, in conducting studies that focused on the 'de-compartmentalisation' of their decision-making infrastructure, and creating synergies within and across governments (DFID 1997; 2000). For instance, a study of the UK, Germany, the Netherlands and Sweden's experiences in PCD highlighted the importance of political will and leadership in the face of multifaceted pressure points for decision-makers (Ashoff 2005). In 2005, PCD was finally brought to the EU agenda in connection to the Millennium +5 Summit, the mid-term review of the Millennium Development Goals (Council 2005; Carbone 2008). The deadline for achieving the MDGs is set for the end of 2015, thus the EU and its international partners are outlining a successor framework, the "Post-2015 Development Agenda" (FAO 2015). The importance of PCD is highlighted by the eighth MDG: establishing a global partnership for development, which together with environmental sustainability, is considered a "prerequisite[s] for all the other goals" (Holland 2008, p.346).

3.2 Policy Coherence for Development

Policy coherence was first discussed in studies of sovereign states (Schaik et al. 2006). It is defined as "The non-occurrence of effects of policy that are contrary to the intended results or aims of policy" (Hoebink 2004, p.37). Achieving policy coherence is an important goal for policy-makers "from a legal, societal and efficiency point of view" (Schaik et al. 2006, p.10), but it is difficult to attain. National political environments are characterised by the interaction between numerous actors representing different values and interests, some of which are perceived as more important than others (Forster & Stokke 2013). Thus, some policies are more likely to be pursued than others, which can lead to inconsistency (Hoebink 2004).

Globalization has blurred the borders between countries and the lines between internal and external policy dimensions, and this effect is even more evident in the European Union (Carbone 2008). The EU's complex, multilevel governance system is characterised by the interaction between the Council of Ministers, the European Parliament and the European Commission, not to mention the different DGs of the

Commission, industry interests and NGOs. All of these actors pursue their respective goals and objectives, making policies extremely difficult to coordinate (Nugent 2006). The compartmentalised nature of EU's interests makes absolute coherence impossible, the best possible outcome being to avoid unnecessary incoherence (Hoebink 2004). Still, policy coherence constitutes both a political and economic imperative for the EU; and the lack of it could lead to loss of credibility as an international actor, and a waste of scarce resources as a result of various inconsistencies such as duplication (ibid.).

Policy coherence has been given a strong legal basis in the EU, especially regarding external action (ibid). The Single European Act stated that EU member states "shall endeavour to avoid any action or position which impairs their effectiveness as a cohesive force in international relations" (Single European Act 1987, Article 30.2(d)). Furthermore, in an effort to strengthen the EU's single institutional framework, the Treaty of Maastricht introduced the three Cs: the principles of coherence, cooperation and complementarity, making European institutions responsible for ensuring consistency across three pillars of the Union's activity and, in particular in external policies, namely development (European Union 1992, Article 130). Complementarity means that since the European Union and member states share competence in development policy, these must complement each other. Coordination suggests that the EU and its member states should consult with each other, and the wider international community, on their aid programmes. The partly forgotten, coherence, entails that the EU should take account of its development objectives in other policies that might have spillover effects on developing countries (Carbone 2008). Adhering to the principle of coherence is important for the EU due to the "magnitude of its assistance to poor countries" and because "many of the policies affecting development objectives are developed, formulated and finally decided at EU level" (Schaik et al. 2006, p.1).

Realising the need for better coordination of its policies with development objectives, the EU made efforts to strengthen PCD. In 2005 the "Commission adopted three Communications on the MDGs, one of which focused entirely on PCD" (ibid, p.6). It recognised policies where greater synergies with development objectives was needed and proposed specific PCD commitments. Additionally, the Commission highlighted the importance of "three areas: financing for development, policy coherence for development and the focus on Africa" (Commission of the European Communities 2005a, p.5). Consequently, the EU Council on General Affairs and External Relations (GAERC) concluded that it would monitor PCD progress in twelve policy areas, including agriculture, which has traditionally been considered the prime example of policy incoherence (Krätke 2013).

Moreover, Policy Coherence for Development is enshrined in the Treaty of Lisbon (European Union 2007, Article 208), and serves as a basis for EU's development policy, European Consensus on Development (European Commission 2015d) and the Agenda for Change (European Commission 2015f). In further efforts to strengthen PCD, the European Commission has produced four biannual reports on member states' progress on Policy Coherence for Development (European Commission 2015b). The first report showed meagre progress on PCD due to the low level of commitment of national non-development ministries, however subsequent reports have been more positive. Notably, the reports discuss sanitary and phyto-sanitary (SPS) standards (GMOs are a SPS-issue) as an area in which more support to developing countries is required; but GMOs *per se* are only briefly mentioned in the 2013 report (see section 4.3 below).

3.3 GMOs for development

Issues such as tackling hunger and poverty have been widely covered by the field of development. Agriculture is often seen as the foundation of the development process for the poorest parts of the world, and historically poor countries have been able to transition out of poverty by raising productivity in their agricultural sector (World Bank 2008). Agriculture can have an immediate impact on reducing hunger and poverty due to increased food production and in turn increased incomes for farmers. It stimulates the economy from within, when farmers spend their incomes; and from outside when agricultural products are sold on the international market. Additionally, agriculture works simultaneously with other sectors to produce faster growth, reduce poverty and sustain the environment (ibid.). "The returns on investments in agriculture are high and furthermore they directly impact on poverty alleviation, particularly small resource-poor farmers and the rural landless dependent on agriculture, representing the majority of the word's poorest people" (James 2014).

As aforementioned, genetically modified organisms, also called transgenic or GM crops, are the newest innovation to agriculture provided by biotechnology. They have been genetically altered in order to display traits 'borrowed' from other species (Smits & Zaboroski 2001). Around thirty genetic traits have been inserted into plants for commercial use, but by far the most popular ones are those conferring herbicide tolerance (HT) and insect resistance (IR) (James 2014). Insect resistant crops have been implanted with a gene (e.g. *Bacillus thusingiensis* or Bt) that makes them resistant to pests, meaning that there is no need to apply poisonous insecticides. Herbicide tolerant crops, on the other hand, are not affected by toxic weed killing herbicides (James 2014). Other added traits include tolerance to drought, diseases and other stresses (Stewart 2009). These are 'input traits' (ibid.), used in first generation GM crops, designed to reduce costs and increase yields for farmers (Zarrilli 2004). Second generation GM crops typically contain a higher nutritional or caloric value, e.g. added vitamins or nutrients that would not usually be present (Smits & Zaboroski 2001). These are 'output' or quality traits that mostly benefit consumers, which could be particularly useful in developing countries (ibid.). 'Stacked' crops contain more than one trait simultaneously. For now, first generation technologies dominate the GM crop market, while second generation GM crops are still largely under development and undergoing field-testing (Anderson 2010; Smith et al. 2013).

Undoubtedly GMOs have been a hit (Andersen & Schioler 2000), as indicated by the massive increase in the global land area since 1996, when pioneer GM crops were planted, from 1.7 million hectares to 181.5 million hectares in 2014 (James 2014). Soybeans, maize and cotton are the most popular GM crops; comprising 47%, 32% and 15% of the global GMO market in 2011, respectively (Smith et al. 2013). Eighty-one per cent of the world's soybeans are transgenic, along with 35% of maize and 81% of cotton (James 2013). Eighteen million farmers in 28 countries, particularly agricultural net exporters (Smits & Zaborski 2001; Gupta 2004), produce GM crops and approximately four billion people live in GM-planting countries (James 2014). The largest GM producing countries are the United States (US), Brazil, Argentina, India and Canada, with the US leading the pack with 43% of the global land area in GMOs (James 2014).

Conversely, concerns regarding agricultural biotechnology are rife, and are often cited by European policy-makers and NGOs. GMO-pessimists maintain GM crops represent a relatively new technology and science is not sufficiently evolved to aptly explain the real dangers to human beings, animals and the environment; ergo the potential impact of GMOs is in fact unknown (Smits & Zaboroski 2001). A cause for concern is the fact that "the majority of testing has been conducted on rats and other animals as opposed to humans" (ibid., p.115). It has also been discussed that effects to human DNA from GMO consumption might not become apparent for generations. An increasing number of national and independent research agencies are studying effects of GMOs, e.g. universities (though they are often funded by biotech companies); but mainly, it is the biotechnology firms themselves that conduct such research, which constitutes a clear conflict of interests and can undermine its legitimacy (ibid.).

In fact, the common use of insect resistance and herbicide tolerance traits in GM crops has led to resistant insects and weeds, and increased use of herbicides, running the risk of seriously disrupting whole ecosystems and diminishing profits for farmers (Smits & Zaboroski 2001; Stewart 2009; EASAC 2013). Other concerns include threats of novel gene flow resulting from cross-pollination of crops, which occurred *inter alia* in Canada: "in 1995 the first genetically modified canola was planted in western Canada, just three years later, it has been estimated that as much as 70% of the canola fields in the western provinces were genetically modified" (Smits & Zaboroski 2001, p.114). This is considered to be a threat to traditional and organic farming methods (Nelkin et al. 2000; Stewart 2009). There is also risk of allergenicity or toxicity resulting from consumption of GM crops to both humans and insects that have not previously been exposed to transgenic crops (Gupta 2004; Smits & Zaboroski 2001). Additionally, GMOs can diminish biodiversity of a country if only few strains of a certain GM event are used (Smits & Zaboroski 2001). This argument travels to the most popular GM species, in that they might flood markets due to increased benefits to farmers from producing them, while other species (for which GM varieties have not been developed) are undermined. Potentially, GM crops can change national food cultures and threaten the extinction of a large number of crop species. Management of these concerns is very costly for policy-makers, as they must properly research and test GMO effects on the environment and human health, and take measures to ensure the separation of GM and conventional crops.

Likewise, a number of socio-economic and ethical concerns have been raised in connection to agricultural biotechnology (Gupta 2004; Zarrilli 2004). The main argument is that few large international biotechnology corporations will monopolise markets due to intellectual property protection, increasing farmer dependence (Stewart 2009; Anderson 2010). This would have implications for the “nature, structure and ownership of food production systems and could aggravate food security problems that are allegedly caused not so much by food shortages as by inequity, poverty and concentration of food production” (Zarrilli 2004, p.2). It could bear heavily on the poorest farmers, who might not be able to afford to purchase patented seeds. For example, in choosing the world’s largest biotech company - Monsanto’s pesticide resistant crops, farmers must pay acreage fees and commit to using only Monsanto herbicides, as well as give the company the right to perform surprise inspections (Smits & Zaboroski 2001). Furthermore, private firms inevitably prioritise financial returns, so they might be inclined to invest in crops suitable for environments of richer markets, rather than those better suited for poor countries (Zarrilli 2004; Matthews 2005; Anderson 2010). This being said, there are also a number of examples of private biotech companies donating relevant GM technologies to developing countries through royalty-free licenses. For example, Monsanto has donated drought tolerant maize technology to R&D organisations in South Africa, Kenya, Uganda, Mozambique and Tanzania, allowing them to produce a stacked, drought tolerant and pest resistant maize. It was the first one produced by the Water Efficient Maize for Africa (WEMA) project and has been undergoing field-testing, expecting commercialisation in 2017 (James 2014). Finally, there is the “the moral dilemma of tampering with nature. Are humans playing God?” (Smits & Zaboroski 2001, p.114). Many consumers perceive GM crops as unnatural and disagree with “interfering with the genetic structure of species through the introduction of genes from unrelated species” (Sheldon 2001, p.4). Hence, numerous NGOs have urged for labelling of GM products arguing that the consumers have a “right to know” what they are purchasing and consuming (Sheldon 2001, p.6).

A more long-term concern is that since biotechnology facilitates production of certain crops outside of their natural habitats, there is a risk of major exports being wiped out. “For example, some developing nations rely almost extensively on vanilla and high-yielding cocoa plants as exports. GMO science now enables these crops to be produced in countries that previously could not grow such crops” (Smits & Zaboroski 2001, p.114). In theory, developed countries could choose to expand their agricultural palette, decreasing the comparative advantage of developing countries. This is particularly worrisome considering that developing-country farmers most likely would not be able to compete with rich and heavily subsidised developed-country farmers (ibid.).

3.4 GMOs in developing countries

Although biotechnologies were originally developed in rich and industrialised countries, according to the current trend, developing countries are taking over. In 2014, developing countries produced 53 per cent of the world's GM crops and this is expected to increase in the future (James 2014). Of the 28 countries that have commercialised planting of GM crops in 2014, twenty are developing countries. Eight of them are in the top ten GM planting countries. Also, yield gains of GM crops are reportedly higher in developing countries than in developed nations (ibid.). Furthermore, around 90 per cent of total 18 million GM-farmers are small and poor developing country farmers. Around half of GM crops undergoing field trials today are being tested in developing countries. A quarter of these are new GM varieties, including bananas, citrus, chickpeas, mustard, sugarcane and wheat, with a range of GM traits such as drought and salinity tolerance, and better nutrition and food quality (ibid.). Clearly, there is no North/South divide when it comes to GMOs (Stewart 2009).

Developing countries have more to gain from investing in GM technology than do developed countries, but they also endure bigger risks from doing so (Meijer & Stewart 2004; Stewart 2009). Firstly, "agriculture plays a comparatively much larger role in developing country economies in terms of GDP, employment and, for many countries, international trade" (Stewart 2009, p.5). Secondly, developing countries often face serious food shortages and malnutrition problems, which reduces the size of their workforce and its productivity, perpetuating poverty. Finally, developing countries commonly lack: the legal and administrative infrastructure with which to regulate GMOs; research and development (R&D) facilities with which to boost national GM studies; risk assessment institutions to manage health and environment risks both for domestic consumption and to meet international trade standards; as well as human resources with proper technical expertise for all of these (Millstone & Zwanenberg 2003). "Areas for [GMO] regulation include: (a) R&D, e.g. conditions under which laboratory experiments take place and conditions for testing in contained facilities or in the field; (b) approval processes for commercial release, including prior scientific assessment of health and environment risks, minimum distance from organic agriculture or non-GM fields, labelling, post-commercialization monitoring, liability; and (c) import regulations" (Zarrilli 2004, p.8).

This being said, developing countries have adopted a gamut of differing approaches to regulating GMOs, ranging from completely restrictive to completely permissive (Stewart 2009). Argentina, Brazil and South Africa are early developing country examples with full-fledged GMO adoption. They are large agricultural producers globally, cultivating and trading GM crops on a mass scale, and have invested substantially in extensive research and development programmes (Millstone & Zwanenberg 2003; Stewart 2009). For example, in 2014, Brazil invested US$1 billion towards the development of national GMO R&D institutions (James 2014). EMBRAPA, the main institution for agricultural research in Brazil, aims to address national priorities, and has developed a number of GM crops, of which a virus-resistant bean has been approved for commercial planting, scheduled for 2016 (EASAC 2013). National R&D facilities often produce GM crops using local germplasm, which is better suited to local conditions (ibid.), increasingly with the help of public-private sector partnerships (PPPs). For example, a number of universities collaborate with GMO research institutions in Brazil, China and India (ibid.). PPPs have proven beneficial as they help resource-poor countries acquire the relevant know-how to produce safe GM crops in a timely manner, minimising costs, and facilitating the development and deployment of new GM products (Karembu et al. 2009; Spielman & Zambrano 2013; James 2014).

The second group of developing countries includes China, India, Thailand, Indonesia and Columbia. They have developed their GMO R&D programmes, but have pragmatically chosen to either limit GMO commercialisation or approved only non-food GM crops, notably cotton (Aerni & Bernauer 2006; Falkner & Gupta 2009). For instance, India's public investment in agricultural R&D has doubled since the mid-1990s and it is currently the largest producer of GM cotton in the world (EASAC 2013). It has developed its own GM aubergine, which is still pending approval (ibid.) This strategy allows them to develop their domestic regulatory infrastructure and alleviate domestic agricultural stresses, such as drought and pest infestation with GM crops, while keeping their market access to the EU (Aerni & Bernauer 2006).

The third group consists of the majority of developing countries. Usually, they have not developed proper regulatory frameworks to govern GMOs, hence GM crops cannot legally be approved for cultivation. Their R&D programmes, if they exist, are small. Lastly, there are few country examples such as Zambia that have completely rejected GM-technology "as an instrument of neo-colonialist exploitation and subordination fostered by Western multinational corporations and their governments" (Stewart 2009, p.11). Conversely, with the growing GMO presence in international trade and in response to their international legal obligations, such as ensuring sanitary and phyto-sanitary standards of food products, more developing countries are establishing GMO regulations (Karembu et al. 2009; EASAC 2013).

It is evident that Asia, North and Latin America are leaders in modern biotechnology, while Africa lags behind (Karembu et al. 2009). Currently, only South Africa, Egypt, Sudan and Burkina Faso cultivate commercial GM crops (James 2014). A number of African countries including Cameroon, Egypt, Ghana, Uganda, Kenya, Malawi, Nigeria and Zimbabwe are conducting field trials of a variety of GM crops such as rice, maize, sorghum and bananas (Karembu et al. 2009; Falck-Zepeda et al. 2013). Mali, Mauritius, Tanzania, Togo, Zimbabwe, Kenya and Ghana have adopted biosafety laws in order to regulate GM applications (EASAC 2013; Spielman & Zambrano 2013).

3.5 EU's precautionary approach

The European Union implemented its first pieces of GMO legislation in 1990. Complex risk assessment and authorization processes for cultivation, marketing of food and feed and GM-derived products were established, with the aim of protecting human and animal health and the environment (European Commission 2015e). Prior to this, GM products were not coordinated at the EU level and legislation food safety and environment protection were quite lax (Sheldon 2001). In the early 1990s, the EU experienced a series of food scares, notably the Bovine Spongiform Encephalopathy (BSE), more commonly known as the 'Mad Cow' disease. Scientists connected it to the Creutzfeld Jacob Disease, which caused numerous deaths in Europe (Neyer 2000; Smits & Zaborski 2001). This politicised the issue of food safety in EU member states and due to an "active cover-up" (Neyer 2000, p.5) by the Commission, led to mass public distrust in food-safety authorities and resistance to GMOs.

The result was the adoption of the precautionary approach applied to GMOs due to the perceived uncertainty about their long-term risks (Sheldon 2002; Matthews 2008). The precautionary principle upholds "that the justification of protective measures does not necessarily need to rely on the scientific proof of danger to public health" (Neyer 2000, p.13). In fact, EU's regulatory framework included a 'safety clause' that allowed member states to ban the cultivation of GM products based on a proven scientific risk. A number of EU member states invoked the safety clause, albeit without proper scientific proof, blocking the approval of other GM crops for cultivation and refusing imports of GM crops (Sheldon 2001; Pollack 2013). On several occasions, the European Commission and the European Court of Justice challenged national bans since the European Food Safety Agency (EFSA), formed in 2002, found them to be scientifically groundless and unlawful, but to no avail (Pollack 2013; EASAC 2013). This led to the famous EC Biotech case in 1998, whereby the USA, Canada and Argentina launched a complaint with the World Trade Organisation (WTO) against the EU's *de facto* moratorium on their GM maize imports (Anderson 2010). The European Union then stopped the moratorium, replacing it with strict regulations on the deliberate release of GMOs into the environment, and traceability and labelling (Directive 2001/18/EC and Regulations 1829/2003 and 1830/2003), amending its previous GMO legislation (Anderson 2010).

The majority of Europeans consider food security very important (Smits & Zaborski 2001) and want GM crops to be completely excluded from production and consumption (Costa Font 2011). The rationale behind this is: should unexpected adverse effects of GMOs arise, consumers bear all the risk with little direct benefit (Sheldon 2001). Spain and Portugal, the largest and second largest producers of European GMOs, respectively (James 2014), and the United Kingdom, which seats the headquarters of many international biotech organisations, along with a few other smaller scale GM producers (Anderson et al. 2001; Stewart 2009) are examples of European GMO-optimists (Costa Font 2011). The EU considers GM foods as inherently different from their conventional counterparts (in contrast to the US), because it judges a product based on the process by which it was made, rather than on the virtues of the product itself (Pollack & Shaffer 2009; EASAC 2013). In line with the precautionary principle, applicants wanting to introduce GM crops into the environment, i.e. start cultivating GM crops, are responsible for demonstrating the safety of each product individually. In the EU, GMOs are guilty until proven innocent, i.e. until it is scientifically proven that it poses no risk to people or to the environment, the GM product will be deemed as dangerous (Zarrilli 2004). Stacked GM products are treated as new products subject to approval, even if its individual traits are already authorised (Matthews 2013). However, "even if scientific procedures have been carried out in conducting risk assessments of GMOs, the existing results cannot be treated as conclusive" (Sheldon 2001, p.160). The EU's justification for this is that it is better to prevent damage rather than allowing it to then deal with the consequences (ibid., p.159).

From 1992 to 1998, ten GM events were approved for commercial marketing in the EU, including GM maize and soybeans (ibid.). Currently only two GM crops are approved for cultivation in the EU, the pest resistant MON810 maize and the Amflora potato with modified starch composition for industrial use (EASAC 2013). Applications for cultivation are made to national authorities; the European Food Safety Agency (EFSA) then assesses health and environmental risks on a case-by-case basis; and the final decision is made by EU member states on a proposal by the Commission (Matthews 2013). This process has been characterised by backlog, as member states have been unable to come to agreement on this sensitive issue (EASAC 2013). EU's GMO regulations encompass coexistence between GM and non-GM products, traceability at all stages of production and distribution, a post-marketing monitoring system, as well as compulsory labelling (Sheldon 2001; Zarrilli 2004). This facilitates the withdrawal of a given product from the market should unexpected adverse effects arise (European Parliament and Council 2003). Labelling rules apply to all GMOs in the EU: GMO products as such, those that contain GMOs, are produced from GMOs or contain ingredients produced from GMOs. EU-authorised food and feed products that contain less than 0.9% of GMOs are excluded from labelling requirements, if it can be proven that GM presence is adventitious or unavoidable. Similarly, products derived from animals fed with GM feed, such as meat, milk or eggs, are excluded from the requirements (Zarrilli 2004; Disdier & Fontagné 2009). Imports of GM food products, unapproved in the EU are strictly prohibited. Conversely, the zero-tolerance requirements for adventitious traces of unapproved GMOs in feed products were relaxed in 2011 (Pollack 2013). This was largely due the fact that European livestock farmers, dependant on imports for the majority of their animal feed, suffered severe costs, thus pressuring their governments to raise the threshold to 0,1% (ibid.).

Due to difficult commercial conditions for GMOs in the European Union, the German chemical producer BASF announced it would be moving its GMO division to the USA in 2011 (ibid.). Moreover, Monsanto announced in 2013 the withdrawal of five applications for cultivation "due to the lack of commercial prospects – yet another example of commercial adaptation by American companies to political realities in Europe" (Pollack 2013, p.24). Over the years, numerous media and NGO campaigns warning against the dangers of GMOs have fuelled public concerns in the EU (Roberts 2011). One example is the French study that showed rats being fed a type of Monsanto's herbicide resistant maize had developed tumours. EFSA and six national risk-assessment agencies later called its conclusions into question based on methodological problems (Pollack 2013). Even private food companies in Europe often insist on GM-free products (Matthews 2013). EU's stringent reporting procedures for farmers have a discouraging effect on the planting of GM maize, as portrayed by the 3% reduction of EU plantings from 2013 to 2014 (James 2014).

After decades of disagreement at the EU level, on 11 March 2015, the EU finally adopted Directive 2015/412, allowing member states to restrict or prohibit the cultivation of GMOs on their territory (European Parliament and Council 2015). The directive states "that cultivation of GMOs is an issue which is more thoroughly addressed at Member State level. Issues related to the placing on the market and the import of GMOs should remain regulated at Union level to preserve the internal market. Cultivation may however require more flexibility in certain instances as it is an issue with strong national, regional and local dimensions, given its link to land use, to local agricultural structures and to the protection or maintenance of habitats, ecosystems and landscapes" (ibid., paragraph 6). It is implied that in allowing member states this right, they will refrain from blocking future approvals of GMOs at the EU level.

4. Previous research

4.1 Impact of GMOs in sub-Saharan Africa

Literature on the impact of agricultural biotechnology in developing countries is broad. It comprises numerous studies, both public and private, from a number of countries including the USA, EU (member states and EU institutions) and developing countries. Overall, researchers agree that commercialised GM crops do not cause major adverse effects to humans, animals or to the environment, at least not any more than other farming methods (EASAC 2013). However, considerably more research is needed on the effects of non-commercialised GM crops.

According to the "Global Status of Commercialized Biotech/GM Crops Report 2014", prepared by ISAAA, farmers have seen substantial gains in choosing GM technologies. Firstly, GM crops are associated with higher crop productivity than conventional breeds and other farming methods. They tend to bring higher yields, as they are able to tackle the limitations associated with conventional breeding techniques, such as damage from pests and weeds. James (2014), states that crop yields increased by 22% and that farmer profits increased by 68% from year 1995 to 2014. This translates to US$ 68.1 billion in cumulative provisional economic benefits in developing countries from 1996 to 2013 (ibid.). For these reasons, James maintains that although GM crops are not a panacea to world hunger, they contribute to food, feed and fibre security, and sustainable intensification of crop production (ibid.).

In another ISAAA publication, Karembu et al. (2009) focus on biotech crops in Africa. They provide a number of success stories of GM crops. For instance, confined field trials of Bt cotton in Kenya, which started in 2004, have shown that transgenic cotton yielded 25% more than conventional cotton; and needed fewer pesticide applications, resulting in a 20% reduction in costs compared to conventional cotton varieties. Using less pesticide is not only an economic benefit, but reduces toxic exposure for farmers, and contamination of soil and water sources (ibid.). Results were even better in field trials in South Africa, where Bt cotton yielded 40% more than conventional cotton, and farmers' insecticide costs reduced by 42%. It is estimated that the use of Bt cotton in South Africa from 1998 to 2009 contributed US$ 21 million to farmers' incomes (Gouse 2013). This is consistent with other studies in South Africa and other countries growing Bt cotton (ibid.). Horna et al.'s (2013) study of Ugandan transgenic cotton suggests that higher crop productivity can be achieved compared to conventional cotton, provided that the government develops its institutional capacity and negotiates with biotechnology providers the technology fee that will be charged to farmers, which can significantly reduce their profits. As the authors point out, cotton is a labour-intensive crop, meaning that 50% of production costs goes to workers, most of whom conduct manual weeding. Also, there is a belief that women are mainly in charge of weeding. Hence, adoption of herbicide resistant cotton can reduce labour costs and free workers and family members from weeding, allowing them to take part in other economic activities or education (ibid.). On the other hand, this is not advisable in areas that do not have many non-agricultural work opportunities.

A 2005 study of Bt maize in South Africa showed that it resulted in a 11% yield increase, 60% reduction in insecticide costs and an income increase of US$35 per hectare, compared to conventional maize breeds (Karembu et al. 2009). For smallholder farmers there was a 31% yield gain for Bt maize compared to conventional hybrid maize varieties (ibid.). Gouse explains the significance of this, namely that “Maize serves as stable food for the majority of the South African population and also as the main feed grain for livestock” (2013, p.32); not to mention for more than 300 million sub-Saharan Africans, many of whom also grow maize (Paarlberg 2013). Paarlberg notes that a typical seven-member rural household needs fourteen 80-kilogram bags of maize meal per year to be food secure and additional harvests from transgenic maize can help to provide this (ibid.). If pests damaged only 10% of South Africa’s conventional maize, it would translate to almost a million tonnes of maize and approximately US$68 million in losses (Gouse 2013). On the other hand, GM farmers’ profits can decrease in seasons with lower pest infestations because of the high price of Bt maize seeds and the technology fee paid to the biotechnology company (ibid.). Nevertheless, Gouse estimates the increase of Bt maize farmers’ incomes between years 2000 and 2008 was US$ 476 million (ibid.). Paarlberg states that drought-resistant GM maize is “emerging from the research pipeline” (2013, p.212) and is expected for commercialisation in 2017 in sub-Saharan Africa (James 2014). This is likely to have positive effects considering a third of the African population lives in areas with very little rainfall and that only 4% of agricultural land in sub-Saharan Africa is irrigated (Karembu et al. 2009; Paarlberg 2013).

Other noteworthy biotechnological developments in Africa include the Ethiopian drought-tolerant and weed-resistant sorghum plant. With sorghum being a common food crop consumed by 500 million southern Africans, this stacked sorghum variety can increase the food supply of hundreds of millions of people (Karembu et al. 2009). Furthermore, scientists at the Africa Rice Centre have developed the so-called New Rice for Africa (Nerica), which does not need to grow in paddies, “thus enabling African farmers to grow rice in environments not previously thought possible” (Karembu et al. 2009, p.6). Nerica quickly spread to Nigeria, Guinea, and Uganda where the number of rice farmers increased from 4,000 to over 35,000 between 2005 and 2007 (ibid.). During the same period, Uganda’s rice imports decreased from 60,000 to 35,000 tonnes saving the country around US$ 30 million (ibid.).

Furthermore, a project led by the Kenya Agricultural Research Institute (KARI) in collaboration with ISAAA worked on the improvement of bananas, which are highly important crops in Africa in both rural and urban areas. In fact, Kikyulwe et al. (2013) state that around 65% of urban consumers in Uganda consume a meal of cooking banana per day. This project reportedly resulted in increased food production and reduction of poverty for one million smallholder farmers in east Africa achieved by the 38% increase in household incomes (Karembu et al. 2009). In addition, Karembu et al. state that the majority of small-scale farmers in Uganda are women, who "have been able to contribute to family welfare by paying school fees for their children" (2009, p.6). They have also been able to expand their farming businesses to dairy farming or goat keeping, ensuring more profit still. Subsequently, more farmers, including women, can afford to purchase mobile phones and bicycles, which improves their mobility and access to development services (ibid.).

Literature also suggests that farmers are not the only winners from higher productivity of GM crops, and that consumers can also benefit in the long run (Smits & Zaboroski 2001; Karembu et al. 2009; Anderson 2010). They reason that higher crop yields and lower costs associated with farm management over a longer period of time will ultimately lead to lower food prices in world markets. "Policy Report 21" prepared in 2013 by the European Academies Science Advisory Council, EASAC, estimates "that world food price increases would be higher by 10-30% in the absence of GM crop cultivation" (2013, p.26). Somewhat paradoxically, this may result in lower incomes for GM farmers despite their choice to cultivate the more efficient transgenic crops. Increased competition for food crops by the biofuel industry has contributed to increased food prices, and biotechnology can help offset these effects (Karembu et al. 2009).

However, consumers can also benefit from biotechnology in the short-to-medium term. Pray et al. (2013) investigated the health impact of GM maize in South Africa in reducing fumonisin levels in maize. Fumonisin is a type of mycotoxin produced by maize fungus, and scientists have found a significant correlation between oesophageal cancer and high levels of fumonisin exposure (Pray et al. 2013, p.42). Evidence also indicates that fumonisin can cause neural tube defects in babies, a particularly salient concern in rural areas of the Eastern Cape and Limpopo Provinces in South Africa (ibid.). "Insect damage predisposes maize to mycotoxin contamination, because insects create kernel wounds that encourage fungal colonization, and insects themselves may serve as vectors of fungal spores" (ibid., p.43). Thus, the insect resistant Bt maize can reduce the risk of fungal contamination. The results of the study varied depending on the year and location of the maize tested, however the average pest-resistant maize contained 60% less fumonisin than conventional hybrid varieties (ibid.). The authors suggest that the South African government should encourage the uptake of Bt cotton with a view to reducing fumonisin exposure.

Such consumer benefits are likely to increase even more with the development of second-generation GM technologies (Falck-Zepeda et al. 2013; James 2014). James (2014) notes that there are approximately 190 to 250 million preschool children in the world suffering from a Vitamin A deficiency (VAD), which can lead to blindness and an underdeveloped immune system, making them more susceptible to diseases and ultimately an untimely death. National research agencies the Philippine Rice Research Institute (PhilRice) and the International Rice Research Institute (IRRI), in the Philippines, Indonesia and Bangladesh are currently developing the so-called Golden Rice, enriched with Vitamin A or beta-carotene (James 2014). It can lower VAD, thus preventing childhood blindness and disease, lowering child mortality by 24-30%, in addition to battling malnourishment (Smits & Zaboroski 2001; James 2014). Moreover, studies show that introducing it in "the Philippines could decrease the number of disability adjusted life years (DALYs) lost because of Vitamin A deficiency between 6 and 47%" (Anderson 2010, p.561); and assuming other second-generation GM crops, e.g. wheat, follow suit, it could increase the productivity of unskilled labour in Asia and Africa by 2% (ibid.).

As mentioned, the adoption of pest-resistant GM crops has lowered pesticide sprayings. James (2014) states that the global use of chemical pesticides decreased by 37 per cent from 1995 to 2014 as a result of GM crops (ibid.). Cotton alone has been held responsible for approximately 25% of insecticide use in the world, hence "Bt technology has offered a cost-saving and environmentally friendlier alternative" (Gouse 2013 p.26). This benefits farmers, consumers who eat the products, animals and, of course, the environment. It can also reduce the effects of climate change through lower levels of carbon dioxide and greenhouse-gas emissions associated with savings from conservation tillage and less sprayings (Stewart 2009; Karembu et al. 2009; EASAC 2013; James 2014). In 2013, this accounted for approximate savings of 28 billion kilograms of CO2, the equivalent of "removing 12.4 million cars off the road" (James 2014) for a year. On the other hand, the EASAC report, points out that common use of GM crops with insect resistance and herbicide tolerance traits has sometimes led to increased resistance in insects and weeds. In turn, this reduces crop yields and increases the use of herbicides, diminishing profits for farmers (EASAC 2013). However, such unwanted side effects can be reduced or prevented with good farming practices. For instance, post-release monitoring for early detection of resistance (James 2014), or planting refuges of conventional crops alongside GM crops can prevent pests becoming resistant (Gouse 2013). It has also been highlighted that farmers are often not properly informed on how to manage their GM crops, which results in overuse of herbicides and other unwanted side effect. Scholars suggest that an improved system facilitating information exchange on GM crops can reduce these losses (e.g. Falck-Zepeda et al. 2013; Gouse 2013).

4.2 International impact on GMO choices

Considering the mentioned benefits of GMOs in sub-Saharan Africa mainly from field trials, one might pose the question why so few African countries have commercialised GMOs. In fact, several scholars have explored the factors influencing developing country regulatory choices concerning GMO adoption, internationally.

First it was assumed that developing countries would mirror either the US or EU approach, since they are the two most powerful trading blocs and have coincidently adopted completely opposing positions on GMOs; but this has not been the case. Developing country approaches have been varied and calculated based on domestic and international considerations (Millstone & Zwanenberg 2003; Clapp 2006; Falkner & Gupta 2009). These include the perceived benefits of GMOs, domestic institutional capacity, reliance on food aid, dependence on agricultural imports and exports, and wider trade considerations (Zarrilli 2004; Clapp 2006; Stewart 2009; Falkner & Gupta 2009).

GM crops can easily cross borders leading to unauthorised plantings (Clapp 2006; Stewart 2009). The so-called ‘stealth seeds’ have appeared in many developing countries, regardless of their political system, structure or level of development (Herring 2007). Some contributing factors to the emergence of stealth seeds are: “monopoly prices of official transgenic seeds – enabled by bio-safety regulations more than market power; structural power of agriculture as a sector and local power of farmers as political actors; permeable bureaucracies; regulatory confusion and delay; [and] weak institutions” (ibid., p.145). Two commonly cited examples of stealth seeds actually resulting in a switch to a more permissive GMO policy are India and Brazil (Clapp 2006). In these instances, the release of GMOs into the environment becomes *fait accompli* and governments are left with the option to manage risk to human health and the environment.

In 2014, 95% of Indian cotton farmers, that is 7.7 million, reportedly cultivated *Bt* cotton, earning them approximately US$ 16.7 billion in the period from 1996 to 2013 (James 2014). Moreover, insecticide applications have reportedly halved, reducing the use of water and exposure to toxic insecticides. (James 2014). This is all in spite of strong opposition to GMOs by domestic interest groups, both at ministerial and NGO levels (Herring 2007). An Indian seed company smuggled in the first GM seeds, bollworm-resistant cotton, and mixed it with a local germplasm, ignoring the restrictive government GMO regulation. At first, nobody noticed a difference until the “massive bollworm rampage of 2001” (ibid, p.132) came and those were the only crops that survived (Roy et al. 2007). This led to numerous suicides by poor Indian farmers who had lost everything. In the next season, the planting of illicit cotton seeds substantially increased (ibid.). The Indian political discourse on GMOs framed multinational corporate ownership of ‘suicide seeds’ as a “bio-cultural abomination” (Herring 2007, p.131) of traditional agriculture. Furthermore, Monsanto’s Indian branch was falsely accused of selling ‘terminator’ seeds that cannot be reused, which is standard practice in India, making Indian farmers dependent on foreign private business (Roy et al. 2007). Monsanto denied that such seeds exist and stated that GM technology could in fact have prevented widespread suicides of Indian farmers. Since then, it has been found that there was in fact no link between Bt cotton and farmer suicides. Despite this, activists continued the movement “Operation Cremate Monsanto” by burning down field tests of GM cotton (Herring 2007). In 2002, the government was forced to approve GM crops, however it outlawed the Indian GM hybrid, which was both cheaper and more effective in local conditions than Monsanto's seeds. This decreased its supply on the market, but farmers continued using it through seed saving and seed exchange, again, standard practices in India.

Similarly, in Brazil "regulations were rendered irrelevant by the capacity of farmers to find and breed transgenic seeds underground" (ibid., p.140). Brasilia approved the use of GMOs in agriculture and pharmaceuticals in 1995, granting authority to implement biosafety, ethical and risk assessment policies to the National Technical Biosafety Commission (CTNBio) (ibid). Brazil also had regulation on intellectual property rights "granting legal protection to inventions related to pharmaceuticals, food processes, and biotechnology" (ibid., p.141), which attracts private sector biotechnology firms into a country, but also helps protect locally produced GM varieties. In 1998, Monsanto's herbicide tolerant soybeans were approved, but after a federal suit filed by Greenpeace and the Institute for Consumer Defence (IDEC), they were legally banned, as it was ruled they had not been sufficiently tested. Additionally, in 2000, CTNBio's decisions to release of GM crops were sanctioned because there were still no proper rules on biosafety. Finally, in 2002 all field tests of pest-resistant GM crops were suspended pending the enforcement of pesticide legislation (ibid.). Despite these judicial moratoria, however, farmers had been growing GM soy smuggled in from neighbouring countries, notably Argentina, since 1997 (ibid.). Interestingly, even Argentina had acquired Monsanto's pesticide resistant soybeans through questionable channels. Namely, it refused to protect the patent of Monsanto's 'Round-Up Ready' soybean in 1995, but Argentina's largest seed firm acquired the seed from an Argentinian partner company to Monsanto (ibid.). Farmers were buying local hybrids without technology fees, and could sell them to their neighbours (ibid.). When the anti-globalisation Workers' Party took office in Brazil in 2003, a precautionary approach to GMOs was expected, supported by a number of NGOs. Instead as a result a shortage of conventional soybeans, the new government issued a Presidential Decree permitting the cultivation GM crops for one year, which was then extended and eventually converted into law (Zarrilli 2004; Herring 2007). GM soy quickly spread, proving that farmers were clearly in favour of the technology as they reportedly saved 20% of their fertiliser costs in addition to obtaining higher yields and applying less herbicide. They argued that their using GMOs served as leverage against subsidised agricultural products in industrialised countries (Herring 2007).

These internal factors are not the only 'gateway' to GMO adoption, however. Most often developing countries are influenced by their trading partners' choices. For example, Mexico first adopted a precautionary approach and banned GMOs in 1998 (at least officially), as a way of preventing gene flow to domestic crops. However, being a member of the North American Free Trade Agreement (NAFTA), Mexico was highly dependent on US-maize imports, which increased substantially after the EU imposed a ban on US GM maize in 1998. The US would certainly face significant losses from Mexico's GMO ban, so it exerted pressure on its NAFTA-trading partner, prompting Mexico to have a change of heart (Clapp 2006). Labelling of GMO products is now only required in Mexico if their GMO content exceeds 5% (Falkner & Gupta 2009). Similarly, countries in South America, which are almost completely dependent on the US and Canada for their cereal grain imports, have mainly been open to GMOs (Anderson et al. 2001; Clapp 2006). Grain is usually traded whole, as opposed to being milled, as this gives it a longer shelf life, which means that recipients oftentimes plant imported seeds (Clapp 2006). Thus, it is widely believed that US grain trade is the main reason for the spread of GMOs in the region and for their pro-GMO positions (ibid.). Moreover, since most countries in the Americas trade their agricultural products regionally, there is little pressure on them to restrict GMOs (ibid.). Domestic institutional capacity should be noted, however, because without it, Mexico and countries in South America might have been more cautious to biotechnology (ibid), as has been the case in many SSA countries (Falck-Zepeda et al. 2013).

Agricultural imports of African countries south of the Sahara are much more varied, as they come from all over the world; but most of their agricultural exports go to the EU, six times more so than to the US (Paarlberg 2013). Many African countries have historical ties with EU member states, have been given preferential treatment in trade with the EU through several Economic Partnership Agreements (EPAs), not to mention that they are the main recipients of EU's development aid (EASAC 2013). Therefore, losing the GM-free status was perceived as negative in several African countries and scholars have argued that this decreased their acceptance of GMOs (e.g. Falkner & Gupta 2009; Paarlberg 2013; EASAC 2013). Aside from trade issues, African countries also have health and environmental concerns, due to the lack of institutional capacity to manage GMO risks. Famously, in 2002, Zambia, Zimbabwe, Malawi, Swaziland, Mozambique and Lesotho, refused to accept 500,000 tonnes of US food aid, in spite of a serious danger of famine, because it was estimated that 75% of it contained GMOs (Clapp 2006). Health concerns involved safety of the food aid in light of the fact that a large majority of their population had weakened immune systems due to HIV/AIDS (ibid.). Environmental concerns were connected to the threat of gene flow, should some of the aid be planted (Zarrilli 2004; Clapp 2006). This meant that the trade, health and environment ministries in these countries were in agreement over the GMO issue so they reasserted a strong policy stance against GM crops (Clapp 2006). However, where interests do not converge, as in the Americas, trade interests seem to take precedence over domestic considerations or even international legal obligations (Clapp 2006; Falkner & Gupta 2009).

Zambia (whose exports made up a large percentage of its GDP) completely refused the food aid, while the other countries eventually accepted, albeit milling it before distributing it to its population. Following this incident, the World Food Programme (WFP) pronounced that donors of food aid must respect the recipients' wishes regarding GMO content (Zarrilli 2004; Clapp 2006). After initial protests by the US that milling food aid before sending it is extremely costly and reduces shelf life, it agreed to send 30,000 tonnes of non-GMO food aid to southern Africa (Clapp

2006). In 2004, Angola also announced that it would only accept milled food aid, and it was supported by the WFP. However, in a demonstration of the fact that developing countries can be pressured into accepting GMOs, the US then cut its funding to the WFP, which in turn halved Angola's aid (Clapp 2006). Nonetheless, milling of food aid remains a requirement of most SSA countries, and it is outlined by the Southern African Development Community's (SADC) 2003 recommendation on handling food aid (see Zarrilli 2004).

4.3 EU's impact on GMO choices in SSA countries

The European Union seemingly has the power to influence developing country GMO regulatory choices due to its large market; and this effect is compounded in African countries by historical trade ties with a number of European member states and its high dependence on agricultural exports and development aid. But how does EU's GMO policy *per se* impact on countries in sub-Saharan Africa? Several scholars have addressed this question (e.g. Falkner & Gupta 2009; Disdider & Fontagné 2009; Anderson 2010; EASAC 2013). Essentially, it has direct and indirect international implications.

According to the EASAC Policy Report (2013), bans on GM-imports by a number of EU member states have a direct and negative impact on GM-crop exporters; they are a direct cause of lower income resulting from a lack of sales of GM crops. For instance, China's soy sauce was denied access in 2001 because it was believed that it was produced from GM soybeans imported from the US (Anderson 2010). Large GM-producing countries such as Argentina and Brazil have been able to circumvent the threat of exclusion from lucrative GM-free markets, while benefitting domestic consumers, by separating their GM and non-GM productions. Non-GM products are exported to the EU and Japan for example, while GM-imports and domestic GM crop production are distributed domestically and exported to GM-friendly markets (Stewart 2009). However, this strategy requires a large investment and good institutional capacities to manage the coexistence of GM and non-GM crops, which many SSA countries lack. Merely losing their GM-free status is, again, perceived as a threat to EU-market access, which has made many SSA countries hesitant to allow GMOs (Falck-Zepeda et al. 2013; Paarlberg 2013).

In a similar vein, Argentina and Brazil have also employed the tactic of cultivating GM varieties that have already been approved at the EU level. For example, Argentina sustained much lower losses than the US or Canada when the EU banned imports of GM maize in 1998 because it cultivated EU approved varieties; and Brazil waited to approve its new strain of GM soybeans until 2011 when the EU approved it for imports (Disdider & Fontagné 2009; EASAC 2013). This strategy is also evident in a number of African cases. For instance, Egypt and South Africa stopped developing their pest-resistant potato, because the EU has not approved it for import (EASAC 2013). In fact, of the large number of GM crops commercialised in

South Africa, only GM cotton, a non-food crop is exported to the EU (Falkner & Gupta 2009). Conversely, scholars argue that SSA countries incur much higher social and economic losses from not adopting agricultural biotechnology, than they would incur from losing access to the European market by embracing it (Anderson 2010; Wafula & Gruere 2013). In fact, most GM products in Africa are traded with other African countries (Wafula & Gruere 2013).

On the other hand, EU's strict labelling and traceability requirements on GM agricultural products have indirect effects on developing countries (Disdider & Fontagné 2009; Paarlberg 2013). They substantially increase GM-exporting countries' administration and management costs of GMOs, especially since the certification of products and production processes was moved to the country of origin (Otsuki et al. 2001). "Although these are not intended to prevent imports, the very high standards demanded by EU consumers often make it more difficult for developing countries to export agricultural and food products to the EU" (Matthews 2008, p.396). To meet EU standards, exporters must ensure upgraded production systems with certification capabilities and proper inspection and storage of food (Otsuki et al. 2001). Furthermore, they must fund laboratories and hire trained technical and managerial personnel (ibid.). Most SSA countries lack the necessary resources to provide technical assessments "to the satisfaction of EU authorities" (Matthews 2008, p.397). In other words, their products might not necessarily be unsafe, but due to lack of technical infrastructure their safety cannot be demonstrated (Matthews 2005). Moreover, the requirement of mandatory labelling for GM food puts a large strain on SSA countries, because labelling rules are often not applicable for them, as a lot of domestic trade takes place at markets where crops are not packaged at all (EASAC 2013). The cost of establishing or bringing existing institutions up to par, or separating GMO and non-GMO products would be enormous and the process would be time consuming (Stewart 2009). These costs have served as a deterrent to GMO-acceptance in the poorest SSA countries (EASAC 2013).

To help alleviate these negative effects and increase institutional capacity in developing countries, the EU has established various funds, projects, initiatives, bilateral foreign assistance from EU member states, and multilateral technical assistance (Matthews 2008; EASAC 2013). According to the EU's aforementioned 2013 report on Policy Coherence for Development (the only one that mentioned GMOs), the European Commission established the Joint Research Centre Contribution to Food Security, which funded the project "Towards Global Harmonisation of GMO Analysis by Creating and Supporting Regional Networks of Excellence". The aim of this project is to inform about EU's legal GMO framework and food-safety requirements, and train laboratories in developing countries "to check compliance with EU requirements prior to exports, thus reducing the risk of trade conflicts" (European Commission 2013, p.124). Furthermore, the report states that the EU facilitated the creation of the Latin American Network of GMO Laboratories by holding four international workshops on the Harmonisation of GMO Detection and Analysis, in South Africa, the Philippines, Jordan and Colombia (ibid.). It also strengthened the cooperation between existing GMO laboratories in the ASEAN and African countries, and provided ad hoc support to a lab in sub-Saharan Africa. However, scholars have brought into question the actual uptake of information and the implementation of proper procedures by such bodies in developing countries (e.g. Matthews 2008).

Conversely, Falck-Zepeda et al. (2013) highlight the fact that both public and private investment in agricultural research in SSA from European donors has dwindled, resulting in delays of the R&D and deployment of new GM products (Paarlberg 2013). Moreover, since there is little investment in agricultural biotechnology research even in the EU, European actors are less likely to participate in PPPs with developing country R&D centres than their North American and Asian counterparts (EASAC 2013). Adding to this, the policy debate surrounding GMOs in SSA countries has been undermined by “external (and in some cases […] internal) pressures to move away from science and rational debate and discussion, toward either antagonistic or unconditionally supportive vires on [GM] crops” (Falck-Zepeda et al. 2013, p.3). International NGO networks have been known to finance the extreme views in developing country GMO debates in an effort to mobilise domestic interests (Aerni and Bernauer 2006). Several anti-GMO campaigns in developing countries are organised by local branches of major European NGOs, following the discourse of their headquarters without accounting for local circumstances (ibid.). Non-governmental groups and social movements such as Greenpeace, Oxfam, GRAIN and Friends of the Earth have fought against GMO research trials and regulatory approvals in SSA, often by distributing inaccurate information and myths about biotechnology (Paarlberg 2013; Falck-Zapeda et al. 2013; EASAC 2013). In Zambia for example, officials were warned that if GMOs were allowed, its exports to the EU would collapse, and “that GM corn could form a retrovirus similar to HIV” (Paarlberg 2013, p. 215). Greenpeace has even taken punitive action “against local Greenpeace offices that refuse to participate in certain international campaigns they consider inadequate for their respective countries” (Aerni and Bernauer 2006, p.569). Moreover, EU institutions and some European governments, supported by their national agribusinesses, have funded anti-GMO activism in developing countries (EASAC 2013). They have also “used their official development assistance to encourage African governments to draft and implement European-style regulatory systems for agricultural GMOs” (Paarlberg 2013, p.214). Being highly dependent on foreign assistance, most SSA countries are donor-driven. Seeing as how EU’s assistance is three times larger than that of the US, “it is the voice of European donors in Africa that tends to be more dominant than any American voice” (ibid.).

These efforts have led to “the growing trend in consumer concerns in African countries, especially among urban consumers” (Falck-Zepeda et al. 2013, p.16). Kikyulwe et al.’s empirical study of Ugandan Bt bananas suggests that the better-educated consumers are more likely to be opposed to biotechnology (2013). Their views are based on health and environmental concerns, and European connections rather than on the profits that GM crops can bring their rural countrymen (ibid.). The

African Union (AU) described the situation in 2006: “The two extreme positions have tended to confuse many African policymakers and sections of the public because of the lack of reliable information and guidance available to these groups… The absence of an African consensus and strategic approaches to address these emerging biotechnology issues has allowed different interest groups to exploit uncertainty in policymaking, regardless of what may be the objective situation for Africa” (quoted in Falck-Zapeda et al. 2013, p.18).

5. Discussion

5.1 MDG 1: Eradicating extreme hunger and poverty

Based on the discussed previous research on the effects of agricultural GMOs in developing countries, this thesis now turns to a discussion surrounding their contribution to the Millennium Development Goals 1 to 7 in sub-Saharan Africa.

With regards to MDG 1: eradicating extreme poverty and hunger, it has been indicated that agricultural GMOs have been beneficial. The cases analysed in the data outlined in the previous chapter (Karembu et al. 2009; EASAC 2013; Falck-Zapeda et al 2013; James 2014) suggest that higher productivity of GM crops has increased the amount of food produced and decreased farmer costs, i.e. increased their profits. The increased production of GM food crops can have a direct effect on food security since farmers are better able to feed their families. Considering that 70% of the SSA population is involved in agriculture, the cultivation of GM crops has the potential to impact a huge number of people. Interestingly, the discussed gains in most cases resulted from GM field trials, as most SSA countries have not commercialised GMOs.

Additionally, increased production of GM feed crops can contribute to more people being able to keep livestock, which can potentially increase the presence of eggs, dairy and meat in their diet. All of these products: food and feed crops, eggs, milk or cheese and meat can also be sold, which can increase farmer incomes. GM maize for example is particularly relevant for this part of the discussion, because it is part of a staple diet for the majority of southern Africans and is the main feed crop for feeding livestock and the most popular GM crop, meaning that its potential for hunger and poverty. As mentioned, there was also a reported increase in mobile phone and bicycle purchases in Uganda by GM farmers (Karembu et al 2009), which would suggest higher incomes.

Biotechnology also enables the cultivation of various crops in drought and high salinity conditions. These traits can be particularly useful for sub-Saharan Africa because as mentioned it is a region with very little rainfall and irrigation of agricultural land. Field trials of drought-resistant crops such as sorghum, and the New Rice for Africa have shown positive effects on hunger and poverty reduction in the discussed cases of SSA countries, but these varieties are yet to be commercialised on a large scale (ibid.). Nevertheless, even in field trials, the number of Ugandan rice farmers increased dramatically and the fact that Uganda managed to almost half its rice imports and save US$ 30 million in rice imports (Karembu et al. 2013), suggests that most of the rice was used locally. The expected commercialisation of more drought tolerant GM varieties will facilitate further research into their effects on hunger and poverty reduction in sub-Saharan Africa and elsewhere, which is necessary in order to draw concrete conclusions.

Non-farmer households can benefit from increased GM crop production due to reduced food prices. They enable people to purchase more food and feed products for the same price. This means that they too can have more food, be more able to invest in livestock, to then consume or trade the products they produce. Hence, GM food and feed crops can indirectly contribute to food security and reduction of poverty of non-farmer households. The long-run effects of this could include lowering food prices internationally, which would useful for consumers everywhere, but particularly for net food-importer countries, i.e. the majority of sub-Saharan Africa. On the other hand, this effect might be detrimental for farmers and net food-exporter countries. More empirical research on this issue would be both interesting and valuable.

Moreover, increased production of non-food crops, such as GM cotton, can have an indirect effect on food security as it again increases farmer incomes, enabling them to purchase more food. It should be noted however that herbicide tolerant cotton varieties might decrease the need for labour, as it reduces manual weeding. Though this could benefit farmers by reducing their labour costs, it could hurt agricultural workers if they reside in areas lacking non-agricultural work opportunities. Thus, the spread of HT cotton in such regions would be ill advised. This affirms the need for governments to evaluate GM varieties on a case-by-case basis in accordance with local circumstances and needs. In order to do this, there is of course a need to develop their regulatory and institutional capacities, to establish a legal basis for the cultivation of GM crops and provide risk assessments and R&D of the technology.

In sum, the chosen secondary data revealed evidence of domestic benefits from GMOs in in countries in sub-Saharan Africa, including increased incomes and food and feed quantities for farmers. Moreover, lower food and feed prices can potentially benefit non-farmer households. They also showed evidence that these benefits might facilitate the diversification of farming businesses to livestock keeping, which can indirectly contribute to more varied and nutritious diets for sub-Saharan Africans, and lead to further increases in income levels. These increases in domestic small-scale economic activities imply that SSA economies can be stimulated from within. Furthermore, as mentioned GM crops are mainly traded regionally, which implies other countries in sub-Saharan Africa, even those that do not cultivate GM crops, can benefit from biotechnology due to lower prices and possibly better quality products. This might lead to increased inter-regional trade, which could stimulate the economies of GM-producing countries from the outside. However, additional research is needed into the effects of GMOs on the levels of regional trade and there would be a clear benefit from strengthened institutional capacities.

5.2 MDG 2: Achieving universal education

As regards the second MDG, it is more difficult to establish a causal relationship between GM production and achieving universal education; although, the chosen secondary data indicates a correlation between increased incomes from GMOs and increased education. Notably, Karembu et al. (2009) stated that more farmers have been able to pay for their children's school fees, but only for the case of Uganda. Still, school fees are not the only factor worth considering, especially since a lot of schools in rural Africa are state run. This is not to say that increased incomes do not impact the number of children in school, because naturally they do. Oftentimes distances between villages in sub-Saharan Africa are vast and not every village will have a school, in fact, most do not. Hence increased incomes can enable more parents to pay for their children to take the bus to school. This both reduces children's risks of walking to school (especially for little girls, due to high levels of rape, not to mention high levels of HIV/AIDS in SSA), and can mean that they have more energy when they arrive at school, which is likely to increase their productivity, concentration levels and uptake of knowledge.

In a similar vein, increased food levels and better nutrition, resulting from GM production, can help children in education. Firstly, being alive substantially increases a child's chances of attending school. This may sound silly, but it is in fact a huge problem in sub-Saharan Africa, where infant mortality rates are high. Secondly, undernourished and sick children might not be able to attend school, and if they do, their energy levels may be low; consequently their ability to concentrate would be limited. In sum, increased incomes and food availability resulting from agricultural GMOs could contribute to achieving universal education, as suggested by Karembu et al (2009). However, more research is required to establish a clearer connection between GMOs and education in sub-Saharan Africa.

5.3 MDG 3: Promoting gender equality & women's empowerment

Again, it is difficult to establish a direct link between GM crops and gender equality. Nevertheless, the discussed mentioned in Karembu et al. (2009) the majority of small-scale Ugandan farmers, for example, are women. Higher GM crop productivity would imply increased incomes, which could have positive effects on the standard of living of female GMO farmers. In the case of Uganda, it seems that they have been able to expand their agricultural businesses to dairy farming or goat keeping, which could further increase their incomes. Hence, as discussed, they might be able to send their children to school, including girls, which could contribute to women's empowerment. In addition, the mentioned increase in mobile phone and bicycle purchases by female farmers in Uganda could facilitate a better connection and access to other work opportunities.

Moreover, as mentioned in Horna et al.'s (2013) study of Ugandan cotton farming, women are often in charge of weeding. A widespread switch to herbicide tolerant cotton could thus enable these women to engage in other economic activities or education. On the other hand, this could also have a negative effect on the livelihoods of these women, if there is a lack of non-agricultural employment opportunities in their areas. Thus, the evidence provided in the chosen cases does not substantiate the notion that GMOs contribute to gender equality and women's empowerment, and more research is required to evaluate this linkage.

5.4 MDGs 4, 5 and 6: Health

Millennium Development Goals 4, 5 and 6 pertain to reducing child mortality, improving maternal health, and battling HIV/AIDS and other diseases, respectively. The chosen secondary data suggests that GMOs have contributed to these MDGs in a number of ways in the region of sub-Saharan Africa. For example, as discussed in Pray et al.'s (2013) study of South African pest resistant maize, mycotoxin levels are on average 60% lower in Bt maize compared to conventional hybrid varieties. The spread of Bt maize could thus lead to fewer cases of oesophageal cancer. Considering that Bt maize is one of the most popular and widely used GM crops, the implications for health could be substantial, and could have positive effects on countries that adopt the technology. However, more research of this kind is necessary to confirm positive health impact. In addition, all studies implied that reduced pesticide use in agriculture facilitated by biotechnology can: improve farmers' health by reducing exposure to toxic chemicals; and improve consumer health, as they would be less likely to ingest these chemicals.

Moreover, second generation GM crops with an increased nutritional value can provide health gains such as increased consumption of vitamin A and other nutrients, as discussed by James (2014). Vitamin A deficiency, for instance, can lead to blindness, compromised immune systems and disease. The spread of Golden Rice in sub-Saharan Africa could thus reduce the instance of the mentioned adversities, battling undernourishment and lowering mortality rates. This could in turn increase productivity of the workforce, which could have positive implications for SSA economies and poverty reduction.

These are not the only health benefits of agricultural GM technology. Increased production of GM crops, for one, can increase the food supply for farmers and the wider population. In turn, GM crops could reduce famine, increase consumption of more varied food products, strengthening weakened immune systems and lowering the spread of disease of SSA's population. The subsequent lower food prices noted in EASAC (2013) could provide similar benefits, for the region as a whole. Moreover, both could ultimately lead to an increase in the productivity of the population, allowing more people to enter the workforce and earn a living.

Higher incomes resulting from agricultural GMOs can have indirect positive effects on health of the SSA population. First, increased incomes can impact on the ability to afford healthcare and medicine. This could help more sick farmers and their family members obtain anti-retroviral therapy, malaria or tuberculosis medicine, or other necessary treatments. Second, increased wages can also facilitate access to healthcare facilities through better means of transport. If sick farmers can afford to pay for the bus to the nearest healthcare facility, they can obtain the necessary treatment to make them better. Consequently, higher wages can, for instance, facilitate for the presence of skilled personnel during childbirth, which significantly reduces the risk of maternal mortality.

To sum up, increased food supply, wages and lower food prices resulting from agricultural GMOs can lead to better health and lower mortality rates in sub-Saharan Africa. Accordingly, SSA countries could benefit from increased productivity of the workforce, which would strengthen their economies from within. However, the health benefits of Bt maize technologies, for example, are not very well known so governments in sub-Saharan Africa may be unaware of them. More studies on the impact on Bt maize on oesophageal cancer rates in other SSA countries would be useful, as would the dissemination of information to increase awareness about such health benefits. In addition, though they show promise in contributing to health issues, second generation GM technology is still in its infancy; hence, more investment in R&D is needed in order to bring about health benefits more quickly.

5.5 MDGs 7: Ensuring environmental sustainability

All chosen cases argued that GM crops have positive environmental effects, even in sub-Saharan Africa, where the technology is relatively limited and often constrained to field trials. As mentioned, reduced insecticide spraying of insect resistant crops is not only beneficial for farmer and consumer health; it could also contribute to lowering the contamination and degradation of the soil and of water sources (James 2014). This is particularly useful in sub-Saharan Africa as access to clean drinking water in many countries is limited in the first place. On that note, drought tolerant GM crops could facilitate the reduction of water use in agriculture, which would be a major benefit to two thirds of Africans who live in severely dry regions with little rainfall (Karembu et al 2009). However, as discussed the commercialisation of drought tolerant GM crops is expected in 2017, until when the true effects on environmental sustainability cannot be determined.

Furthermore, due to their increased per-hectare productivity, GM crops can make better use of agricultural land area, hence they have been dubbed land-saving technology. Such benefits could reduce the need to cut down forests, for instance, in order to make space for more agricultural land, when facing population growth and increased food demand. These are very much relevant issues in sub-Saharan Africa. Finally, according to James (2014) *inter alia*, agricultural GMOs have contributed to a reduction of carbon dioxide emissions into the atmosphere, due to reduced pesticide and herbicide spraying. These benefits combined can reduce the effects of climate change, improve the health of a population and ensure sustainable development.

In sum, agricultural GMOs have the potential to reduce the environmental footprint of agriculture in sub-Saharan Africa. The chosen data indicates several environmental benefits of GM crops in terms of land saving, which protects biodiversity and reduces deforestation; reduction of insecticide and herbicide spraying, which can contribute to the reduction of contamination of soil and water sources, and the reduction of greenhouse gas emissions. Case studies that specifically focus on these effects would be beneficial. Drought tolerant GM varieties could be particularly useful for the SSA region, and more research on this is likely to become available after 2017, when the commercialisation of drought tolerant technologies is expected.

5.6 MDG 8: Developing a global partnership for development & PCD

The MDGs are ultimately objectives to guide developed country actions in helping developing countries' advancement. The eighth MDG is more convoluted than the rest. It sets out targets for developed countries to provide official development assistance to developing countries, and work towards an open, rule-based, predictable, non-discriminatory trading and financial system, while working to lower developing country debt. Though more research is required, as outlined in previous sections, scholarly literature seems to support the notion that agricultural GMOs can contribute to at least five out of seven MDG's (MDGs 1, 4, 5, 6 and 7) and can have indirect effects on MDGs 2 and 3, in the discussed SAA cases. This indicates that GMOs can potentially be used as a tool for development. With EU's framework Policy Coherence for Development in mind, what has been the EU's role in promoting development in sub-Saharan Africa with regard to GMOs? And has its GMO regulatory framework had a role to play in achieving the said targets of MDG 8?

ISAAA (2014), EASAC (2013) and a number of scholars in Falck-Zepeda et al. (2013), notably Paarlberg (2013), have argued that the EU has had a negative impact on acceptance of GM crops in SSA countries. This is connected to historical trade ties between many SSA countries and EU member states, which essentially translates to preferential treatment in accessing the EU market through EPAs, and the EU being the main donor of development aid, and technical assistance. As discussed, SSA countries are often dependent on agricultural exports to the EU and on EU aid. Thus, they have been hesitant to either allow GMOs in the first place, or commercialise additional GM varieties. The infamous refusal of GMO food aid in 2002 due to health and environment concerns is an example. Firstly, the fact that they refused it at all, despite a serious danger of starvation, clearly goes against development objectives. Secondly, the fact that all countries apart from Zambia ultimately accepted the food aid, provided it was milled, insinuates that health concerns were unlikely to be the issue. If there were a genuine concern over the safety of the food aid, it would have been banned completely; milling it only prevented planting. Planting could of course lead to gene flow, which could ultimately bar agricultural exports to the EU. This is concerning, especially in light of the fact that farmers, a number of governments and, as it appears, scholars are supportive of GMOs. In considering MDG 8, this is not line with targets of establishing an open and rules-based trading system.

Turning to PCD, what are the effects of EU's restrictive GMO policies in SSA countries? The backlog in EU's GM approval system and member state bans on GMO imports have continued despite the efforts of the European Commission and the European Court of Justice, mainly resulting from the politicisation of GMO risks and a large negative public opinion in the EU. While larger and more technically equipped developing countries such as South Africa and Brazil can avoid losses by separating GMO and non-GMO crop production or mirroring EU's GM approvals, the poorest developing countries, most of which are in sub-Saharan Africa, cannot. As discussed and corroborated in the chosen data, they often lack the necessary administrative and managerial infrastructure, which means that rather than risking loss of EU-market access, they opt for banning GMOs.

Additionally, even the 'mirroring' strategy can have negative effects. Essentially what it could do is reduce domestic benefits (economic, social, environmental), waste the resources spent on developing new technologies that then cannot be commercialised, and encourage other countries to follow suit, which can ultimately lead to lower or delayed investment in the development of new technologies. This can potentially engender the realisation of one of the risks of GMOs, (outlined in section 3.3 above) namely that a few GM events (those first generation GM technologies approved by the EU) flood markets, while other GM events are undermined, e.g. second generation technologies, which could arguably be more useful for SSA conditions. This also goes against the predictable trading system target of GMO 8.

As regards EU's labelling and traceability requirements, they to disadvantage the poorest SSA countries, as they are unable to meet EU's stringent requirements due to lacking administrative and technical resources. Moreover, in many SSA countries labelling of products is not required, and in many rural areas non-existent because trading often takes place at food markets. Again, the outcome is often banning GMOs rather than risking loss of EU market access. By doing this, SSA policy makers choose to forego the mentioned domestic benefits of GM crops, such as reduced hunger and poverty. This implies that EU's GMO regulatory framework is disproportionately harder on the poorest SSA countries, paradoxically the ones that need the most help, which is not at all in line with PCD. Neither does it meet the targets of MDG 8 of a non-discriminatory trading system.

The discussion thus far implies that scholarly literature does not support the notion that the EU has contributed to the eighth MDG by developing a global partnership for development, as far as its GMO policy is concerned. In addition, the negative impact of the policy on potential development benefits from GMO adoption in the poorest SSA countries would be in opposition to PCD. Conversely, it should be noted, that SSA countries are largely constrained from adopting agricultural biotechnology by lacking technical, administrative and institutional capacities, which puts them in a position of having to choose between potential benefits of GMOs and EU market access. This is of course not the fault of the EU or its member states. But has the EU taken actions to offset the discussed effects of its GMO policy on SSA countries?

According to EU's 2013 PCD report, it has helped build institutional capacities in developing countries, including South Africa, with the aim of informing about EU's legal GMO framework and food-safety requirements (see section 4.3 above). However, while informing about its GMO requirements may indeed reduce the risk of trade conflicts; it is not the same as helping build up capacities. The report vaguely describes EU's ad hoc support to a lab in sub-Saharan Africa, but it does not mention any other southern African countries. In fact, public and private investment in agricultural research and innovative development from the EU to sub-Saharan Africa has been decreasing as discussed by Paarlberg (2013), EASAC (2013) and Falck-Zapeda (2013). This could be connected to the fact that such investment is lacking even at the EU level. However, the big difference is that EU farmers are well off (at least compared to SSA farmers), and recently there have even been efforts to constrain food production in Europe. In contrast, much of SSA is living in poverty and suffering from famine.

Aside from this, the EU has explored a number of channels (ministerial, NGO, development assistance) to actively discourage certain SSA countries from allowing GMOs (Falck-Zapeda et al. 2013; Paarlberg 2013). Coincidently, since the EU is the largest donor to SSA, it tends to be influential (Paarlberg 2013). Kikyulwe et al. maintain that this has mainly had an effect on opinions of urban populations and decision makers, while rural populations, that are more likely to experience first-hand benefits of GMOs are supportive of the technology. Considering the relative ease of access to stealth seeds in some developing countries with restrictive GMO regulations, this phenomenon could appear (if it has not already) in SSA countries. In contrast to Brazil and India, however, this may have negative effects in SSA considering limited knowledge and resources.

Thus, the chosen data does not seem to support the notion that the EU has contributed to MDG 8, in promoting the best solutions for SSA in regards to GMOs; instead it suggests that the EU has promoted its own precautionary approach to GMO regulation. Accordingly with the provisional inferences made in this chapter based on secondary analysis of cases of GMOs in SSA, it would appear that the Policy Coherence for Development of EU's GMO policy is weak.

8. Conclusion

With the aim of providing a modest contribution to the largely under researched question of whether EU's GMO policy correlates with Policy Coherence for Development, this thesis has sought to address the following research questions:

"*What role do GMOs in sub-Saharan Africa play in contributing to Millennium Development Goals 1 to 7?" and "How has the EU influenced GMO regulatory choices of countries in sub-Saharan Africa, and are its actions in line with Millennium Development Goal 8?"*.

This was done first by linking existing research on GMO impact in developing countries, focusing on sub-Saharan Africa, to Millennium Development Goals 1 to 7. The chosen literature seems to support the notion that current and future benefits of GMOs in sub-Saharan Africa can play a role in contributing to at least five out of seven MDGs, namely eradicating extreme poverty and hunger; improving health, including reducing infant and maternal mortality, and lowering the instance of various diseases; and ensuring environmental sustainability. However, there was not enough evidence to support a direct connection between GMOs and achieving universal primary education, and promoting gender equality and women's empowerment.

With the purpose of answering the second question, existing research on the impact of EU's GMO policy on SSA's GMO regulatory choices, and additionally EU's actions in promoting SSA's institutional capacity building, was linked with MDG 8. In this respect, literature proved to be more negative towards EU's contribution to developing a global partnership for development. This was mainly due to SSA's dependence on the EU as an export destination and as a major provider of development aid. Moreover, regarding the impact of EU's GMO policy on SSA's GMO regulatory choices, it appears to have limited acceptance and commercialisations of GMOs in SSA, especially the poorest countries in the region. This was largely due their fear of losing EU market access and scarcity of technical, institutional and administrative capacities for managing and ensuring environmental safety of GMO's. There was also evidence of decreasing EU technical assistance for the purposes of agricultural research and development in SSA. This is not only problematic from a GMO perspective, but also for innovation of agriculture as such, which is badly needed if it is to achieve sustainable intensification due to numerous biotic and abiotic stresses in the region, not to mention population growth.

Thus, inferences drawn from the chosen data in this thesis suggest that EU's GMO policy restricts the acceptance of GMOs in SSA countries, which could mean that they are potentially foregoing substantial domestic benefits. Moreover, EU's GMO policy in itself discriminates against the poorest SSA countries due to their capability gap to e.g. separate their GMO and non-GMO productions, and in this way reap dual benefits from both domestic gain and maintained EU market access. Hence, based on these sources of data, it would seem that the Policy Coherence for Development of EU's GMO policy is weak.

Nevertheless, as stated before, the data analysed here is in no way comprehensive, and there are numerous other factors that can interrelate with GMOs to impact the MDGs. There is a need for further study of the linkages between GMOs and the Millennium Development Goals in countries south of the Sahara and elsewhere. This is especially with regard to MDG's 2 and 3, pertaining to achieving universal primary education and women's empowerment. Moreover, existing studies would certainly benefit from future research. For instance, future research could investigate the impact of drought tolerant GM crops on lowering extreme poverty and hunger in drought-stricken areas, or the impact of secondary generation crops on health. The impact of GMOs on regional trade and food prices, i.e. benefits for third countries, or even comparative studies of poverty in big GM producers and small GM producers to ascertain the different trickle down effects, would be valuable. Also, GM crops on environmental benefits such as lower levels of contamination of water sources and greenhouse gas emissions seeing as CO2 emissions are increasing.

As for the PCD of EU's GMO policy, given the sensitivity of this topic in Europe, it is unlikely that national strategies will undergo a major change in the near future. However, the 2015 reform of EU's policy and the renationalisation of GM cultivation rules, may allow for more approvals of GM crops at EU level, which could in turn help GM developing countries like South Africa. One thing is certain, more technical assistance is needed to help close the capability gap in the poorest SSA countries. On this note, an interesting topic for future research could be the impact of EU's policy on European agricultural innovation, given the decreasing investment in R&D. In conclusion, this discussion should be interpreted as a foundation for future research to build knowledge on the PCD of EU's GMO policy; and should hopefully serve as a base to inform EU policy makers of the need to observe GMOs and other policies through the lens of Policy Coherence for Development.

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