Sowing the Seeds of Insecurity: The Impacts of Agricultural Biotechnology in Canada and India

by

Tricia S. MacLennan

Submitted in partial fulfilment of the requirements
for the degree of Master of Arts

at

Dalhousie University
Halifax, Nova Scotia
December 2015

Table of Contents

List of Tables

Abstract

Global food production must increase by fifty percent to meet the food security demands of nine billion people by 2050. It is argued that agricultural biotechnology is a potential solution for addressing global food security concerns. This study compares central claims made in support of agricultural biotechnology against the case study of Bt maize in Ontario, Canada and Punjab, India. While results indicate that these claims are empirically founded, as this technology is controlled by the private sector, food security is being eroded not strengthened; particularly in developing nations where socio-economic conditions create immense pressure to adopt foreign technology. For agricultural biotechnology to be an effective strategy for addressing global food security, the state must regain its role in research, development and oversight efforts. If used in conjunction with strategies that promote a favourable policy environment, agricultural biotechnology could serve as a powerful tool for addressing global food security concerns.

List of Abbreviations Used

DNA	Deoxyribonucleic acid
GM	Genetically modified
GMO	Genetically modified organism
GE	Genetically engineered
PG	Polygalacturonase gene
FAO	Food and Agricultural Organization of the United Nations
WTO	World Trade Organization
IMF	International Monetary Fund
IPR	Intellectual Property Rights
TRIPS	Agreement on Trade-Related Aspects of Intellectual Property Rights
GATT	General Agreement on Tariffs and Trade
WIPO	World Intellectual Property Organization
OECD	Organization for Economic Cooperation and Development
PPPs	Public-private partnerships
MDGs	Millennium Development Goals
SDGs	Sustainable Development Goals
UNDP	United Nations Development Programme
HDI	Human Development Index
ISAAA	International Service for the Acquisition of Agri-biotech Applications
CWB	Canadian Wheat Board
GDP	Gross domestic product
FTA	Free Trade Agreement
NAFTA	North American Free Trade Agreement
MOSST	Federal Ministry of State for Science and Technology
NABST	National Advisory Board on Science and Technology
OMFA	Ontario Ministry of Food and Agriculture
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
PLUARG	Pollution from Land Use Activities Reference Group
EGAI	Expert Group on Agricultural Indebtedness

Chapter One: Introduction

> In a world where knowledge-based industries are the future, ensuring that new technologies can be patented and sold around the world is a tremendous advantage. Property rights no longer mean just owning land; they also mean the commercial exploitation of scientific discovery. When it is recognized that a small group of companies control the process of turning ideas into products, the terms under which these intellectual property rights become available to the rest of humankind become a central political issue, subject to power relations and translatable into law. (Cameron 1993, xxii)

Since the discovery of the molecular nature of genetic material in 1944, geneticists and businessmen alike have been fascinated by the potential of using DNA to modify the characteristics of living organisms; a process otherwise known as transgenics. While something of a pipe dream in 1944, four decades later the process of transgenics made the commercial production of genetically modified (GM) plant varieties a reality. Lucien Ledoux of Mol, Belgium first discovered the process of transgenics in 1968. His published findings in *Nature* and the *Journal of Molecular Biology* proved for the first time that foreign DNA could be integrated and replicated in barley (Ledoux et al. 1968; Lorquin 2001, 2). However, in spite of Ledoux's work, the effect of exogenetic DNA in plants was poorly understood. In 1969, Dieter Hess and his colleagues at Hohenheim University in Germany published findings from their study of the effects of exogenetic DNA on flower colour in *Petunia Hybridia* (Lorquin 2001, 33-35 & 86). Their findings were considered highly contentious throughout the 1970's and, in spite of a number of subsequent experiments, by the end of the decade there was little public evidence to suggest that DNA mediated transformation of plant matter was even possible.

The most widely accepted demonstration of direct gene transfer in plants was documented by a group of scientists in 1984 in Basel, Switzerland. Their work with GM tobacco and petunia clones quelled the controversy surrounding the field of foreign DNA uptake and integration in plants (Lorquin 2001, 93). A little over a decade later in 1995, the California based company Calgene introduced the first commercialized genetically engineered (GE) food in the form of the *FlavrSavr* tomato[1] (Harvey 2004; Lorquin 2001, 109). Although production ceased in 1997 and the *FlavrSavr* was a marketing failure, its introduction paved the way for other companies to develop and market their own strains of economically viable, genetically altered food products; a processes commonly referred to as agricultural biotechnology.

Agricultural biotechnology, which is best understood as the use of genetic engineering to make commercially useful products, is said to generate crop varieties that will make deserts bloom and improve the wellbeing of farmers everywhere. GM or transgenic crops, created through the use of genetic engineering or "the DNA based molecular technique used to modify the genetic composition of agriculturally useful plants, animals and microorganisms of any kind" are often touted as an effective development strategy to address production constraints and ever increasing national and global food security concerns (Herdt 2006, 266). While population growth has slowed in a number of regions, the global population continues to increase, further exacerbating global food production pressures. This is an unprecedented challenge for addressing global food security, a highly complex and often contested concept that has evolved significantly over the last fifty years while being defined in excess of over two hundred different ways (Smith et. al, 1992; Lee 2007, 3; Clay 2002, 1). While it is most commonly associated with efforts at the national level, food security can also be

---

[1] Calgene used recombinant DNA techniques to introduce the antisense polygalacturonase (PG) gene associated with the breakdown of pectin. Introduction of the PG gene suppressed the production of deconstructive enzymes, resulting in tomatoes that stayed firm longer (US Food and Drug Administration 2014; Harvey 2004).

measured at a global, local and even household level; serving as an effective lens for examining the pervasive nature of global food production issues (Lee 2007, 3). The concept of food security first appeared in international development discourse in the aftermath of the Second World War. During the post-war period, the principle concern was increasing food production capacities to meet the needs of a growing population (Schanbacher 2010, vii; Beniston 2009, 374-375). Throughout the 1970s, the concept evolved during discussions concerning international food production pressures and constraints at the height of the global food crisis[2] (Clay 2002, 1). By the mid 1990s, the definition of food security had been significantly expanded and it became widely recognized as an issue that could be examined from a number of different levels.

While food security is a highly flexible concept, it is best understood as a situation "when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 2009, 3; Beniston 2009, 374-375; Ericksen 2008, 234-236; Vyas 2003, 105). For centuries, human beings have struggled to produce enough food. In spite of hundreds of years of technological innovation, struggles over food security are more prevalent today than ever before. In fact, over the next fifty years, the world will consume twice as much food as the total amount consumed since the beginning of agricultural production over 10 thousand years ago (James 2011, 262).

According to World Bank projections, food production will have to increase by fifty percent to feed an increasingly affluent global population of nine billion people by

[2] The 1970s was a turbulent era for agriculture. The global production of agricultural products, particularly staple grains, declined in 1972 and again in 1974 due to poor weather conditions in major food-producing regions. This resulted in widespread food shortages throughout the first half of the decade (FAO 2000, 138-139).

the year 2050 (World Bank 2012b; Martin and Sauerborn 2013, 302; Wezel and David 2012, 18; Road and Bhavan 2011, 1). Due to ever mounting global food production pressures and resource constraints, proponents of agricultural biotechnology are touting it as a solution for addressing global food security issues through the promotion of sustainable, pro-poor development strategies (Gupta and Chandak 2004, 1-5; Herdt 2006, 270). The technocratization of agricultural sectors globally, epitomized by the widespread implementation of transgenic crop varieties, is being peddled to farmers in developed and developing nations by a network of highly influential actors. State governments, transnational corporations and international development institutions including the Food and Agricultural Organization of the United Nations (FAO), the World Trade Organization (WTO), the World Bank and the International Monetary Fund (IMF) are all promoting agricultural biotechnology as a way to dramatically increase productivity, reduce the level of required inputs and generate an increase in farm level profits globally. According to its most fervent supporters, the potential for agricultural biotechnology to improve global food security is unequivocal and as such, the merit of these new technologies simply cannot be denied.

Since the mid 1990's, the total area of GM crops cultivated globally has increased exponentially, making agricultural biotechnology the fastest growing crop technology in the world. In 2005, a decade after the first commercialization of transgenic crop varieties, 90 million hectares were planted on 6 continents in 21 countries – 10 in the industrialized world and 11 in the developing world (Thomson 2007, xvii). Between 1996 and 2012, the cultivation of GM crops globally experienced a double digit increase from 17 million hectares to 170 million hectares (Shrivastav 2013). Currently, over 17 million farmers cultivate GM crops world wide and nearly 60 percent of them reside in developing nations (Shrivastav 2013). Due to the unprecedented increase in agricultural biotechnology over the past three decades, it is important that the impacts of this new technology be examined and compared against the major arguments that are used in support of its widespread implementation.

Research Question

The purpose of this study is to examine the impacts of biotechnology on agricultural sectors in Canada and India. It will do so in an attempt to discern whether or not three key arguments that are used in support of the widespread implementation of agricultural biotechnology are empirically founded: the ability to generate an increase in overall yields, a decrease in the level of required inputs and an increase in farm level profits. The experiences of farmers cultivating Bt maize in the province of Ontario, Canada and the state of Punjab, India will be analyzed. Data on crop yields, external input usage and farm level income generation for conventional and Bt maize crops grown in both countries will be analyzed and compared over the last three decades (1985-2015). The results of the analysis will illuminate the various impacts that agricultural biotechnology has had on these vastly different socio-economic regions. To fully examine the impacts of this new technology, this study will also provide a historic overview of the development of agricultural and biotech sectors in Canada and India, serving as an analysis of the current governance structure surrounding agricultural biotechnology.

If the hypothesis underpinning this study is correct, results will indicate that farmers in Canada and India experience similar effects as a result of implementing agricultural biotechnology. However, due to pre-existing socio-economic conditions, the impacts of agricultural biotechnology are felt more starkly by farmers in developing nations like India. As scholars like Peter Drahos (1995a, 1995b) and David Harvey (2003) have theorized, agricultural development through the use of biotechnology can be defined as a form of post-modern feudalism that is being pushed, with the help of state governments, international development institutions and transnational biotech corporations, on farmers in the developed and the developing world. Traditional feudalism is best understood as a social order in which, through vassalage, a king is the ultimate owner of the land. As such, interference in the lives of those who live on the land is both institutionalized and tolerated (Drahos 1995b, 220). As Drahos' *Information Feudalism in the Information Society* illustrates, "drawing an analogy between the ownership of generic resources by private corporations and traditional feudalism is appropriate because in both cases, the owner has control over a form of capital on which many others inescapably depend" (1995b, 220). In a modern context, the basis of feudal power in relation to agricultural biotechnology is private ownership and control over genetic resources, which is maintained and protected by the state through the international Intellectual Property Rights (IPR) regime.

The purpose of IPR is "to provide protection for the results of investment in the development of new technology; thus giving incentive and means to finance research and development activities" (WTO 2015a). The most comprehensive multilateral agreement on intellectual property to date is the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) which came into effect on January 1st 1995 in tandem with the official commencement of the WTO. Built upon the Paris and Berne Conventions of

1883[3] and 1886[4], the TRIPS agreement was first negotiated at the Ministerial Conference on the General Agreement on Tariffs and Trade (GATT) in Punta del Esta, Uruguay in 1986 (Yu 2009, 797-798; Downes 2004, 366). It was at this conference that the objectives of the Uruguay Round[5] of multilateral trade negotiations were established, including the creation of a multilateral intellectual property agreement. On April 15th 1994, the Marrakesh Agreement was signed, marking the end of the Uruguay Round and the establishment of the WTO. Annex 1C of the Marrakesh Agreement, otherwise known as the TRIPS agreement, outlined the main parameters of the IPR regime including patents, legally binding documents that give the creators of an invention the exclusive right to produce and sell their product for a finite period of time, typically twenty years (Callinicos 2004, 258-259; Reichman 2000, 442; Correa 2000, 6; Downes 2004, 366; Drahos 1995a, 6-13). Under the TRIPS agreement, WTO member states are required to "make patents available for any inventions, whether products or processes, in all fields of technology without discrimination, subject to the normal tests of novelty, inventiveness and industrial applicability" (WTO 2015a). Section 5 Article 27 of the TRIPS agreement specifically states,

---

[3] Adopted in 1883, the Paris Convention for the Protection of Industrial Property applies to industrial property including patents, industrial designs and trademarks. It was "the first major step taken to help creators ensure that their intellectual works were protected in other countries" (World Intellectual Property Organization (WIPO) n.d.a; Reichman 2000, 442).

[4] The Berne Convention for the Protection of Literary and Artistic Works, an international copyright agreement that was reached in Berne, Switzerland in 1886, set the foundation for modern copyright law. It provides creators with "the means to control how their works are used, by whom, and on what terms" (WIPO n.d.b; Reichman 2000, 442).

[5] The Uruguay Round was the eighth round of multilateral trade negotiations that lasted for nearly eight years (1986-1994), twice as long as originally anticipated (WTO 2015b). It is arguably the largest and most influential trade negotiation to date, particularly in relation to agriculture, as trade related policies in this sector were subject to few multilateral disciplines prior to the completion of this round (Josling, Tangemann and Warley 1996; Hertel et al. 2000; Ingco and Kandiero 2003).

> subject to the provisions of paragraphs two and three, patents shall be available for any inventions, whether products or processes, in all fields of technology, provided that they are new, involve an inventive step and are capable of industrial application…patents shall be available and patent rights enjoyable without discrimination as to the place of invention, the field of technology and whether products are imported or locally produced. (WTO 1994)

This agreement can now be extended to living organisms as a result of the highly influential Diamond versus Chakrabarty case of 1980[6] in which the United States Supreme Court declared that GE oil eating microorganisms and any other living organisms that can be considered the product of human intervention are patentable in the United States under the authority of the United States patent office (Glover 2008, 10; Herdt 2006, 277; Downes 2004, 367). As a result, transnational corporations are able to exploit once public resources and use the process of genetic modification to obtain legally binding patents on the transgenic varieties that are created. Similar to traditional feudalism, patent privileges awarded to transnational corporations are reinforced through state mechanisms, allowing the owners of valuable resources to interfere in the liberty of others, most notably those who are cultivating this new technology.

While the major arguments in favour of agricultural biotechnology, including an increase in overall yields, a decrease in the level of required inputs and an increase in farm level profits, may be empirically founded in the case of Bt maize in Ontario and Punjab, the implementation of GM technology has had similar effects on the agricultural sectors of both countries in relation to food security and food sovereignty. In both countries, food sovereignty or "the right of each nation to maintain and develop its own

[6] In this monumental case, genetic engineer Ananda Chakrabarty, an employee of General Electric, developed a bacterium capable of breaking down crude oil to be used in treating oil spills (Kelves 1994). The patent application was originally rejected, as living organisms were not considered patentable material at the time. When the United States Court of Customs and Patent Appeals overturned the case in favour if Chakrabarty, Sydney Diamond, Commissioner of Patents and Trademarks, appealed to the United States Supreme court which, on June 16th 1980, ruled that living, human-made microorganisms were patentable under United States patent laws (Glover 2008, 10; Herdt 2006, 277; Downes 2004, 367).

capacity to produce its basic foods while protecting its productive diversity" (Via Campesina 1996, 1) has been significantly eroded and placed in the hands of transnational biotech corporations whose primary concerns are generating profit and pleasing stake holders. This is the same as "giving responsibility for guarding the chicken coop to the fox in the belief that the fox has both the wherewithal and public concern to secure the survival, if not the wellbeing, of the helpless chickens" (Petras and Veltmeyer 2011, 66).

The concept of food sovereignty is frequently used to discuss, analyze and measure the extent to which a state has control over the means to produce the level of food that is required by its citizens (Pinstrup-Andersen 2009, 5; Wittman, Desmarais and Weibe 2010, 2-5; McMichael 2004b, 3-6). It emerged as a direct challenge to the economically driven notions of food security that are dominant in modern development discourse. As Windfuhr and Jonsen state, "while food security is more of a technical concept, food sovereignty is essentially a political one" (2005, 15). The concept first appeared in 1996 at the second international conference of Via Campesina[7] in Tlaxcala, Mexico. According to Via Campesina's position statement entitled *Food Sovereignty: a Future without Hunger* (1996), food sovereignty is simply "the right of each nation to maintain and develop its own capacity to produce its basic foods while protecting its productive diversity. Citizens have the right to produce their own food within their own territory and as such; food sovereignty is a precondition to genuine food security" (1).

[7] Founded in 1993 in Mol, Belgium, Via Campesina is an international movement comprised of 164 local and national organizations in 73 countries. It represents 200 million farmers in the developed and developing world and has become widely recognized as an influential actor in food and agricultural debates (Via Campesina 2011; Wittman, Desmarais and Wiebe 2010, 2 & 12; McMichael 2004b, 14).

While critics like Bernstein (2006, 2013 & 2014) condemn the concept of food sovereignty as being an unrealistic and unattainable goal filled with pie-in-the-sky, feel good rhetoric, critiques like Kees Jansen's *Food Sovereignty: a Critical Dialogue* (2014) demonstrate that while certain claims stated by proponents of food sovereignty theory are misplaced in their optimism, as a concept, food sovereignty is both credible and relevant. According to Jansen, while the productive capacities of localized alternatives and strategies are often overstated[8], "many activities of the food sovereignty network can also be related to a different approach; that of socializing the larger economy rather than focusing on niche alternatives" (2014, 228). As a central part of this approach, the notions of accountability, open source principles that challenge private property rights and the collective role of the scientific community in tandem with state governments are all addressed in relation to food security and the governance of agricultural biotechnology. Criticisms that target the 'unrealistic' nature of food sovereignty do not invalidate the central hypothesis of this study. Instead, they are primarily a critique of the productive capacities of traditional, low input, regionally centered agricultural production systems, not about the merit of states controlling their own productive processes. As McMichael states, while often defined as such, food sovereignty is not an antithesis, but rather a premise for realizing genuine food security (2004b, 14). While a central purpose of this study is to analyze the impacts of GM technologies in Canada and India to determine if proponents' central claims are empirically founded, it also aims to illuminate

[8] Jansen references the example used by Altieri (1999), the introduction of the velvet bean in Guinope, which led to a reported tripling of maize yields and reduced labour requirements. He argues that the success of the strategy is not supported empirically in other regions and has not resulted in widespread adoption. As such, Jansen argues that this may be an exceptional case or, at the very least, it may illustrate the potential follies of knowledge-transfer networks, a central component of food sovereignty theory (2014, 222-223).

the pressing need to rearticulate food security and the role of the state and transnational biotech corporations in addressing global food security concerns.

The widespread adoption of GM crops alone will not achieve global food security, which is instead being steadily eroded. This is due to the fact that the control and ownership of valuable genetic resources is being placed in the hands of an apathetic private sector that is ill equipped to address national and global food security concerns. Since transnational biotech corporations are not contractually bound to any level of government, they have no legal obligation to protect the well being of those who cultivate or consume their products. As such, they have little incentive to promote genuine food security and instead focus on the creation of commercially viable products.

It is likely that the results of this study will indicate that the impacts of agricultural biotechnology are far starker in India due to socio-economic conditions and the fact that neoliberal development policies affect the developed and the developing world differently. The later is inherently dependent on foreign capital, technology and expertise and as a result, the neoliberal development paradigm looks more coherent (Harvey 2003; Mudge 2008, 724). Canadian farmers, although far less dependent upon this new technology, have also experienced international as well as domestic pressures to adopt it under the guise of improving efficiency and productivity. As such, the implementation of agricultural biotechnology has impacted food production in Canada and India alike and must be examined in detail. As the next section will discuss, the case study of Bt maize in Ontario, Canada and Punjab, India will be examined in an attempt to discern whether or not the major arguments used by proponents of this new technology are empirically founded.

Methodology

Agricultural biotechnology, much like Green Revolution technologies of the 1960s, is promoted in the developing world as a means of renewal; a way to rejuvenate stagnant agricultural production through the use of genetic manipulation. As the National Portal of India (2015) suggests, new GM crop varieties are considered sustainable technologies that are "essential to holistic rural development". For farmers in the developed world, agricultural biotechnology is often touted as a way to improve agricultural production by making it more efficient and cost effective. While food security concerns are stressed to a greater degree in the agricultural development strategies of developing nations, there are several key arguments that are used in both regions in support of the widespread implementation of agricultural biotechnology. The main arguments that are used by proponents of transgenic crop varieties are that they will lead to an increase in overall yields, a decrease in required inputs and an increase in farm level profits. In order to effectively examine the impacts of agricultural biotechnology in Canada and India, it is first important to examine these arguments in detail.

An increase in overall yields means an elevation in the ratio of index of output to that of area (Srinivasan 1979, 1284). As Rao and Deshpande assert in *Agricultural Growth in India* (1986), agricultural growth is often difficult to measure. Due to the highly volatile nature of production, determining the average growth rate of crop yields becomes increasingly difficult. As such, the era being studied must be a sufficiently pronounced and prolonged period of time in order to distinguish it from variations caused by weather related factors (1986, 101). A central claim of biotech proponents is that it generates an increase in yields through the creation of more stable growing conditions.

This improves productivity and makes cultivation more efficient, as farmers can produce the same amount, or in some cases more, using fewer resources. This argument is often invoked in discussions of the increasing global population and in relation to the finite amount of arable land available for agricultural production, particularly in the developing world. Land surface remains fixed and has, according to scholars like Sarkar and VanLoon, already reached a crucial tipping point (2015, 3). As such, much like Green Revolution technologies, a major argument used in favour of agricultural biotechnology is the ability to cultivate more food sustainably using fewer resources (Tripathi and Prasad 2009, 75; Srinivasan 2007, 2; Ahuja 2006, 33; Swain 2014; Road and Bhavan 2011, vii; Alam 1994, 65).

A decrease in required inputs simply means that farmers are producing the same amount of crops in relation to the amount of required external inputs including fertilizers, insecticides and pesticides (Shiva and Jafri 2003, 12, 95 & 248; Mallick et al. 2011, 445). A central argument that is used in support of the adoption of Bt maize is that it will make agricultural production more sustainable and efficient by reducing insecticide use. This is due to the fact that the seed itself contains the protein bacillus thuriengensis, a bio-pesticide that targets stem borers, European corn borers and a number of other target insects. This efficiency argument centers on the notion that farmers will experience an increase in overall output as a result of reduced product losses from target insects, making maize production more efficient and sustainable. Due to the reduction in harmful inputs it is often argued that Bt maize is "part of a powerful package of sustainable, environmentally friendly technologies" (Alam 1994, 11).

It is argued that through an increase in overall yields and a reduction in required inputs, this technology generates higher farm level profits. Although farmers pay more for initial seeds inputs, the claim is that a reduction in insecticide use, coupled with higher yields, makes the implementation of Bt technology highly profitable for farmers in both the developed and the developing world. To examine the impacts of agricultural biotechnology and discern whether or not these central arguments are empirically sound, the experiences of farmers cultivating Bt maize in the province of Ontario, Canada and the state of Punjab, India will be analyzed. Data on crop yields, external input usage and farm level income generation for conventional and Bt maize crops grown in Ontario and Punjab will be analyzed and compared over the past three decades (1985-2015). The results of the analysis will illuminate the impacts that this new technology has had in these vastly different regions. Before the impacts of this technology can be analyzed however, it is important to examine why Bt maize serves as an effective case study.

Why Bt Maize?

As a highly important staple crop, maize serves as an appropriate focus for this study. More maize is produced globally than any other cereal crop and it is heavily cultivated throughout central Canada and northern India. Maize is highly susceptible to pests including corn earthworms and corn borers. The costs associated with damages attributed to the European corn borer are significant and can significantly affect crop production and farmers' income. In North America alone, costs associated with the European corn borer are in excess of (US)$1 billion every year (Witkowski et al. 2008). As such, it is widely considered to be one of the most detrimental pests for global maize production. In the 1980s, Monsanto, a transnational life sciences and biotech company originating in the United States, began experimenting with the creation of biotechnological options to more effectively combat maize destroying insects (Weasel 2009, 19). Through genetic engineering, or the transfer of genes into plants to introduce one or more defined traits into a particular genetic background, the protein bacillus thuriengensis, officially registered as a bio-pesticide in the United States in 1961, is transferred into conventional maize plants, producing transgenic Bt maize varieties (Thomson 2007, 3-6; Shiva and Jafri 2003, 11; Alam 1994, 47). When ingested by target insects, alkaline conditions in their gut cavity release poisonous properties which paralyze the intestine and block the absorption of nutrients; causing what Weasel refers to as "a fatal version of caterpillar diarrhoea" (2009, 20).

In 1996, Monsanto produced the first strand of GM Bt maize in the United States and a total of 0.3 million hectares were planted (Thomson 2007, 20). Through the introduction of IPR through patents, which are maintained and protected by the state, Monsanto legally owns and controls the rights to Bt maize. Patents give the owner of the seed the exclusive right to multiply, sell and develop further varieties which, according to a number of prominent scholars, transforms seeds, the primary and arguably most important link in the food chain, from a free resource into a costly input to be purchased (Shiva and Jalees 2006, 3). Through the development of the TRIPS agreement, transnational corporations like Monsanto are able to usurp traditional seed resources and create a monopoly by claiming them as private property (Shiva 2000, 8). Through the creation of this agreement, the WTO solidified monopoly protection for transnational biotech corporations who are able to capitalize on once public resources and exploit them for their own benefit. Currently, just over 15 million hectares of Monsanto's Bt maize are grown annually around the world and it is estimated that over 30 percent of all of the maize cultivated globally is of the transgenic variety (Thomson 2007, 20; James 2003). As of 2011, Canada and India were ranked 11th and 6th respectively out of the top twenty maize producing countries (Hamel and Dorff 2015). Bt maize has been cultivated in the province of Ontario, Canada and the state of Punjab, India, making it an effective focus area for this study.

Organization of the Paper

Chapter one serves as an introduction to the highly controversial topic of agricultural biotechnology. It outlines the emergence of this new technology through the process of transgenics and its proliferation on the global market. It establishes the purpose of the study, which is to examine the impacts of agricultural biotechnology in Canada and India, and outlines the methodology that will be applied in an attempt to discern whether or not the major arguments used by biotech proponents are empirically founded. It describes the comparative case study that will be used to analyze the impacts of biotechnology on the agricultural sectors of Canada and India, demonstrating the applicability and relevance of the case study of Bt maize in both of these regions. It also examines the creation of Bt maize by the transnational biotech corporation Monsanto, its various traits, its designated purpose and its commercial viability on the global market. The second chapter outlines the theoretical framework of the study, focusing on the reinvigoration of classic 19th century liberalism in the form of the now prominent neoliberal development paradigm governing the creation and implementation of agricultural biotechnology. By reviewing relevant literature related to this topic, this chapter serves as an examination of the highly polarized nature of arguments used in support of and against the widespread implementation of agricultural biotechnology. The third chapter examines the rise of agricultural biotechnology in Canada, beginning with a historic overview of the development of Canadian agriculture. It focuses on agriculture's economic importance and the stark policy transformations within this sector since the neoliberal turn beginning in the 1980s. It outlines the rise of agricultural biotechnology in Canada and the various actors responsible for the push for this new technology. It analyzes the impacts of the implementation of Bt maize in Ontario, Canada against the central arguments used by biotech proponents. The fourth chapter examines the rise of agricultural biotechnology in India, beginning with a historic overview of the development of Indian agriculture. It focuses on the sector's economic significance and the policy transformations it has undergone as a result of the neoliberal reform period of the early 1990s. It outlines the rise of agricultural biotechnology in India, focusing on the actors responsible for the push for this new technology. It analyzes the impacts of the implementation of Bt maize in the state of Punjab against arguments used in favour of the widespread adoption of agricultural biotechnology. The fifth chapter focuses on comparing the various impacts of Bt maize in the province of Ontario, Canada and the state of Punjab, India against the arguments used in support of agricultural biotechnology: the ability to generate an increase in overall yields, a decrease in the level of required inputs and an increase in farm level profits. The sixth and final chapter concludes the study, reiterating the fundamental issues that have been addressed and establishes the need to rethink the role of the state in the research, development and oversight of agricultural biotechnology to ensure that it is achieving its goal of addressing global food security concerns.

As this chapter has outlined, due to the pervasiveness of agricultural biotechnology globally, it is important that its impacts be examined and compared against the major arguments used by its most fervent supporters. Due to stark socio-economic differences, it is important that the impacts of Bt maize be analyzed in both the developed and developing world in relation to its ability to address ever increasing global food security concerns. Before the impacts of this technology can be analyzed however, the theoretical framework underpinning this study must be examined in detail.

Chapter Two: Theoretical Framework

As established in the previous chapter, the widespread adoption of agricultural biotechnology is often touted as a solution for addressing global food security concerns, particularly in developing nations where they are already highly prevalent. Three major arguments that are used in support of the widespread implementation of agricultural biotechnology are: the ability to generate an increase in overall yields, a decrease in required input levels and an increase in farm level income. Before the impacts of Bt maize in Ontario, Canada and Punjab, India can be examined against these major arguments to discern whether or not they are empirically founded, it is first important to establish the underpinning theoretical framework of this study. This chapter will examine the emergence of the neoliberal development paradigm in the late 1980s and early 1990s and its relation to the governance of agricultural biotechnology. It will also provide an overview of relevant literature on this topic, situating the paper within the intellectual tradition of critical analysis regarding agricultural production and development.

While neoliberalism is a broad concept, commonly associated with the common sense revolutionary ideals of Prime Minister Margaret Thatcher (1979-1990) in Britain and President Ronald Reagan (1981-1989) in the United States, its foundation and lineage can be traced back to the laissez-faire economic theories of 19th century liberalism and the work of Adam Smith. The fundamental assumptions underpinning Smiths' *Wealth of Nations* (1778) have served as the foundation for classic liberalism and contemporary neoliberal theory, specifically the promotion of an unfettered, self-regulating free market economy. Rising in tandem with the Enlightenment movement of the late 17th and early 18th century and its proclamation that reason is the foundation of individual freedom, classic liberalism is built on the fundamental principle of the superiority of "individualized, market based competition over other modes of organization" (Mudge 2008, 707). The advent of neoliberal theory was essentially a revival of classic liberalism and its guiding principles.

The intellectual origins of contemporary neoliberal theory are closely associated with Austrian neoclassical economist Frederich von Hayek who founded a network of passionate thinkers known as the Mont Pelerin Society in 1947 (Larner 2000, 711; Harvey 2005, 19-20; Lapavitsas 2005, 30; Steger and Roy 2010, 15; Aitken 2009, 323). Along with Ludwig von Mises, Milton Friedman, Karl Popper and other like-minded theorists who rejected a state centered framework for decision making, Hayek laid the framework for the political and economic doctrine known as neoliberalism (Hayek 1944). Hayek's work was popularized during the 1970s largely as a result of the efforts of Milton Friedman, head of the *Chicago School of Economics* at the University of Chicago, Illinois (Palley 2005, 20; Steger and Roy 2010, 17; Aitken 2009, 323). As Steger and Roy state, Friedman's hand was highly influential, guiding neoliberal theory from "a minority view in the 1950s to a ruling economic orthodoxy by the 1990s" (2010, 17). According to Freidman, profit making was the essence of democracy. As such, any policy that can be labelled as anti-market is, by default, undemocratic (1962). His work, *Capitalism and Freedom* (1962) revived the economic and political assertions of classic liberalism and served as an ideological response to the economic crisis and the dismantling of Keynesianism during the late 1970s and early 1980s.

Based on the framework proposed by British economist John Maynard Keynes in his work *The General Theory of Employment, Interest and Money* (1936), Keynesianism arose during the post-war reconstruction period at the end of the Second World War. Although it took a variety of different forms, it was fundamentally a combination of fiscal and social policies intended to balance and even unite the capitalist market economy with state policies designed to protect citizens from the dangers of the open market (Bakker and Scott 1997; Shields and Evans 1998; Clarke 2005, 58; Steger and Roy 2010, 6-9). Government intervention and social spending was increased and the role of the state remained highly central until the economic crisis of the late 1970s made Keynesianism and its policies highly contentious. Stagflation, a combination of stagnation in wages and a high rate of inflation, amplified by the 1973 oil crisis in member countries of the Organization for Economic Cooperation and Development (OECD), led to rising public debt and an assumption that state involvement in economics was the root of the problem. As Munck asserts, government intervention was deemed undesirable on the premise that it "conspired against and had deliberate consequences for market efficiency and individual freedom and liberty" (2005, 61). It was believed that through the elimination of bureaucratic red tape, markets would function more efficiently; increasing productivity while improving service quality and decreasing costs (Harvey 2005, 65). As a result, the late 1970s and early 1980s marked the beginning of the neoliberal transition from 'government to governance' (Shields and Evans 1998; Lapavitsas 2005, 33) in which the role of the state was limited in favour of a laissez-fair, market based approach to decision making.

As Dumenil and Levy, and Petras and Veltmeyer state, this transition marked the beginning of a new social order based on the unhindered belief in the efficacy of the self-regulating market (2005, 9; 2011, 64). The emergence of this new social order has been marked by the tightening of fiscal policies through a reduction in government spending, the retrenchment of the state away from its involvement in the regulation of markets and a redirection of its once central role in development and decision making processes. For neoliberal theorists, the merit of state retrenchment centers on the assumption that "powerful interests groups inevitably distort and bias state decision making processes and market interventions for their own selfish benefit" (Harvey 2005, 2). As a result, the role of the state has changed significantly. Under the previous system of Keynesian 'embedded liberalism', capital was constrained and state intervention, ownership and control were highly prevalent (Harvey 2005, 10-11). Conversely, the contemporary stage of neoliberalism has been marked by a retrenchment of the state through privatization, or the selling off of once public institutions and assets, coupled with the promotion of competition amongst private sector actors to fill the roles once filled by the state (Harvey 2005, 65). As a result, there has been an increase in public-private partnerships (PPPs) between state governments and private sector corporations in which public assets and services are sold off or contracted out to private interests who assume the financial and operational costs, while governments assume the risks and potential rewards. Governance through PPPs allows private interests to obtain a privileged and intimate role in policy decisions and the setting of regulatory frameworks (Harvey 2005, 76). As Harvey states, through the proliferation of these partnerships, "the coercive arm of the state has been augmented to protect corporate interests, causing the boundary between state and corporate power to become all the more porous" (2005, 76).

Only serving to exacerbate this issue is the unfettered promotion and deregulation of the global market through policies designed to remove barriers that serve as an impediment to free trade. Under neoliberalism, free enterprise is essential for spurring development, innovation and wealth creation in the developed and developing world (Harvey 2005, 3 & 64). As a result, over the past three decades, the transition to contemporary neoliberalism has been marked by the growth of foreign direct investment, the international mobility of capital, the expansion of transnational corporations, the influential role of international financial institutions such as the WTO, the IMF and the World Bank and the rise of multilateral development agencies like the FAO (Dumenil and Levy 2005, 10; Lapavitsas 2005, 38). The centrality of these international development institutions marks the "institutionalization of neoliberalism as the dominant school of economic and political thought" (Mudge 2008, 716). According to trickle down economics, an embedded theory within contemporary neoliberalism, by strengthening the role of the market and spurring international free trade, poverty can be eliminated since "a rising tide lifts all boats" (Harvey 2005, 65). However, for many theorists, representative democracy has been called into question as, through the widespread adoption of contemporary neoliberalism and its focus on economic growth, it has been corrupted by vested corporate interests that use their power and clout to infiltrate state policy and decision making processes. It can be argued that in addition to representative democracy, state authority and state sovereignty have also been steadily eroded through the promotion of an unfettered global market and the supremacy of private sector corporations that, unlike public sector institutions, cannot be held accountable for their actions.

Essentially, contemporary neoliberalism is an ideology, a set of theoretical principles, a policy framework and a collection of social and political practises all of which are “directed towards extending and deepening capitalist market relations in nearly all spheres of life” (Colas 2005, 70). It is a form of market governance that encourages both institutions and individuals to conform to the norms of the market (Larner 2000, 13). While definitions vary, neoliberalism is best understood as “a heterogeneous set of institutions consisting of various ideas, social and economic policies and ways of organizing political and economic activity including minimalist state involvement, decentralized capital and the absence of barriers to sectoral, regional and international capital mobility ” (Harvey 2005, 66). Contemporary neoliberal theory owes its renewed relevance to President Ronald Reagan of the United States (1981-1989) and Prime Minister Margaret Thatcher of Britain (1979-1990). As Thorsen and Lie state, due to their relentless promotion and public advocacy, “we currently live in the age of neoliberalism, as its logic now permeates the policy making process at the national and international level” (2008, 194). The result has been a fundamental transformation of the relationship between the state, its citizens and the transnational corporations that dominate the global market economy. The focus of the state has shifted significantly away from protecting the social welfare of citizens to the promotion of economic investment and growth at all cost. As a result, public good is increasingly being defined by private interests that are able to skirt public oversight and collective scrutiny. As Wolf and Bonanno state, over the past three decades, neoliberalism has also “shaped the production and consumption processes in agriculture and food production” (2014, 1). This is apparent in the widespread adoption of agricultural biotechnology.

As David Harvey states, an integral cog in the contemporary neoliberal paradigm is the ‘commodification of everything’ including “productive assets and the rights to productive assets that were once held in trust by the state for the people it represents"; a process he refers to as 'accumulation by dispossession' (2003; 147-148 & 161; 2005, 116). Proponents of neoliberalism believe that a price can be placed on previously un-capitalized aspects of nature and society, which can in turn be traded for capital and subject to legal contracts. As a result, the bounds of commodification have been inexplicably weakened and the reach of legal contracts has been extended (Harvey 2005, 165). New markets are being created where none existed before, introducing market competition and the generation of private capital into previously sacred institutional spaces (Harvey 2003, 147-148 & 158; Mudge 2008, 718; Carroll and Greeno 2013, 122). According to Noam Chomsky, neoliberalism is "a process whereby a relative handful of private interests permeate to control as much as possible of social life in order to maximize personal profit" (1999, 7). The agricultural sector is no exception.

As a result of the inherent need to generate capital, the shift to neoliberalism has been accompanied by a shift to what Jessop refers to as a "competition state attitude" promoting the pursuit of strategies that are vital for states' success in competition with other global economic actors (2002, 94-119; Carroll and Greeno 2013, 127). As such, the role of the state has changed significantly as it must now promote investment in lucrative sectors by ensuring optimal conditions. Subsequently, private interests are able to exercise their power and clout to gain influence in the policy making process. For transnational corporations like Monsanto, the advent of agricultural biotechnology was a chance to extend the modern neoliberal development paradigm in which they were already heavily invested (Otero 2014, 239). While the role and power of the state have undoubtedly changed as a result of the shift to neoliberalism, it still plays an integral role in its solidification as it establishes the conditions that are necessary for private investment.

The widespread implementation of agricultural biotechnology as a result of the prevailing neoliberal development paradigm has awarded a privileged position to transnational biotech corporations; creating a context of technological hegemony. Non-state actors are pushing a top-down agricultural restructuring or 'passive revolution' in which the technologies that are being implemented are seen as both neutral and necessarily progressive (Dumenil and Levy 2005, 10; Plehwe, Walpen and Neunhoffer 2006, 3; Joseph 2003, 32-33). As Carroll and Greeno state, hegemony is more than an ideology as it is inherently linked with capital accumulation and the profit seeking process. It is actively reinforced through institutions that "support and expand these concepts as the common sense of an era" (2013, 122). The United States plays a central role in the creation and permeation of the contemporary neoliberal development meta-narrative, exerting ideological dominance through institutions like the WTO, the IMF and the World Bank that remain firmly under its control (Imber 2004, 299). Under this system, international trade and investment are touted as the most successful formula for development and states are encouraged to implement structural adjustment programs to promote foreign investment.

This form of modern technological hegemony is reinforced by IPR and the TRIPS agreement that preserve private property rights, an integral cog in the contemporary neoliberal development paradigm (Harvey 2003, 147-148; Callinicos 2004, 258-259 & 263; Reichman 2000, 442; Correa 2000, 6; Downes 2004, 366; Drahos 1995a, 6-13). As American economist Joseph Stiglitz asserts, while the importance of IPRs cannot be denied, the underlying problem with the established regime is that it overwhelmingly reflects the narrow perspectives and interests of producers, many of which are transnational corporations (2002, 8; Reichman 2000, 457). For many farmers, this new technology is a fait accompli and to question its worth becomes an act of transgression. As Jansen and Gupta assert, in light of the onrushing future we are convinced that there is simply no time to ask questions (2009, 437). As a result, under the prevailing neoliberal development paradigm, resistance to new technology is difficult and even morally reprehensible. Particularly in the case of agricultural biotechnology, as a failure to peruse policies aimed at improving agricultural production and minimizing the consumption of finite resources implies a willingness to turn a blind eye while food security pressures become all the more stark. This is particularly true in the developing world, where food security issues are already highly prevalent. As scholars like Clarke state, neoliberalism presents itself as “a doctrine based on the inexorable truths of modern economies and their ability to improve the well being of individuals in the developed and the developing world; however, its strength lies in its ideological appeal and not its analytical rigor” (2005, 50 & 58). While ‘Iron Lady’ Margaret Thatcher famously claimed that neoliberalism is the only option, as Munck asserts, “against any necessitarian political theory, we must understand that there are always political alternatives” (2005, 67). This study will serve to shed a powerful light on the facets of contemporary neoliberal theory in relation to the rise and widespread implementation of agricultural biotechnology, illuminating the changing role of the state in relation to the governance of this new technology. In order to do this effectively, the existing body of literature on this topic must be examined.

Literature Review

Debates surrounding the creation and implementation of agricultural biotechnology are highly polarized. As Babinard and Josling assert, opponents of these new technologies see little merit while proponents see few faults (2001, 81). Supporters of this new technology see its widespread implementation as the only solution to address current and future food security concerns. As McGloughlin states, biotechnology is, "by default our best and possibly our only option for improving the productive capacities of farmers everywhere for the purpose of improving production and meeting future food needs" (1999, 163). For those who are in stark opposition to the widespread cultivation of agricultural biotechnology like Indian activist Vandana Shiva however, this new technology is part of "an engineering paradigm that offers technically simplistic fixes to highly complex problems by ignoring institutional complexities and generating unforeseen externalities" (2000, 193-194). In an attempt to understand the conflicting nature of arguments surrounding agricultural biotechnology, one must examine the body of existing literature and the foundation of various arguments used in support and in opposition to this technology.

Arguments in Support of Agricultural Biotechnology

The establishment of the Millennium Development Goals[9] (MDGs) in 2000 reinforced global desires to address the challenge of sustainable development in a number of vital areas including hunger, poverty and the exploitation of finite natural resources

[9] The MDGs were established at the Millennium Summit in September 2000. They are the world's time-bound and quantified targets for addressing extreme poverty, hunger, disease, lack of adequate shelter while promoting gender equality, education, environmental sustainability and the rights of each person to adequate health, education, shelter and security with a set date of 2015. They are to be succeeded by the Sustainable Development Goals (SDGs) with a set date of 2030 (UN Millennium Project 2006; Ki-Moon 2011; Vandermoortele 2011 13-15).

(UN Millennium Project 2006; Ki-Moon 2011; Schanbacher 2010, 2; James 2011, 2). The MDGs serve as reinforcement for many pro-agricultural biotechnology arguments that emerged in the 1980s and 1990s as they focus on addressing poverty, hunger and security, and the importance of ecologically sustainable development initiatives. In order to meet ever increasing global food demands, it is imperative that agricultural production becomes more efficient and sustainable, improving farmers' ability to produce more while conserving finite land, water and energy resources (Brookes and Barfoot 2006 & 2014; Qaim 2010; Swaminathan 1999). The global population, which continues to increase at a rate of approximately 80 million people per annum (Park et al. 2011, 2), places immense pressure on states' productive capacities and thus requires innovative solutions to address food security concerns now and in the future. Due to the burden posed by conventional agriculture on finite resources and available land, the widespread adoption of agricultural biotechnology is often touted as a much needed, environmentally sustainable solution to address global food production constraints and food security issues. It is claimed that the cultivation of transgenic crop varieties will promote sustainable agricultural development globally and serve as a catalyst for increasing farm level productivity and the economic welfare of farmers everywhere, particularly those in developing nations. As such, proponents of agricultural biotechnology, backed by the support of international development institutions, claim that new GM technologies are essential for addressing current as well as future food security concerns (McGloughlin 1999; Qaim 2010; Qaim, Pray and Zilberman 2008). The United Nations Development Programme (UNDP) *Human Development Report*[10] *2001* as well as the FAO's *State of*

[10] Beginning in 1990, the first *Human Development Report* introduced the Human Development Index (HDI) as a "measure of achievement in the basic dimensions of human development across countries"

Food and Agriculture Report[11] *2004* both broadly endorse the potential for agricultural biotechnology to reinvigorate global agriculture. As a result, the widespread implementation of this technology has become an integral part of the new international development paradigm that advocates the technocratization of agriculture to promote sustainable development and address global food security concerns.

A claim that is often made in support of agricultural biotechnology is the ability to address national and global food security issues by spurring productivity and generating an increase in overall yields. According to biotech proponents, while increases in productivity have a high degree of spatial and temporal variation, if accompanied by the establishment of favourable institutional conditions, "data suggest that across a wide range of agro-ecological zones the four main transgenic crops have, at worst, been neutral in relation to yields and in the majority of cases they have actually increased" (Park et al. 2011, 5; Raney 2006, 1-2; James 2011, 2). For scholars like Thompson, Qaim and Swaminathan, the adoption of transgenic seed varieties enhances the potential for addressing food security concerns by creating more stable growing seasons as crops are less susceptible to seasonal variation and biotic and a-biotic stresses (2007, 270; 2010, 552; 1999, 37). By creating stable, more predictable growing conditions, it is argued that farmers who adopt new GM technology will experience an increase in farm level productivity. This argument can be easily quantified and tested empirically by measuring changes in average crop yields.

(UNDP 2015). Since then, these annual reports have explored different themes through the human development approach.

[11] First published in 1947, the *State of Food and Agriculture* is the FAO's major annual publication that "aims to bring a wider audience balanced science-based assessments of important issues in the field of food and agriculture" (FAO 2015). The 2004 report specifically explores the potential for agricultural biotechnology to address the needs of poor, food-insecure individuals (FAO 2015).

In addition to improving farmer's productive capacities by increasing yields, transgenic crop varieties require fewer external inputs, making them an integral tool for sustainable agricultural development. According to scholars like James, agricultural biotechnology plays an integral role in the promotion of sustainable development as it requires fewer resources to generate the same, or in many cases, increased yields (2011, 262; Swaminathan 1999, 37-41; Park et al. 2011, 5). Bt maize and other insect resistant crop varieties require less arable land due to a reduction in yield gap[12] caused by crop losses and require fewer costly inputs. By reducing the level of required inputs through what Swaminathan refers to as precision agriculture or "the use of the right inputs at the right time in the right way", new transgenic crop varieties are said to be inherently more efficient than conventional cultivars, requiring a smaller economic investment to produce the same amount of final product (1999, 41; Park et al. 2011, 5; Qaim, Pray and Zilberman 2008, 330-333). According to Brookes and Barfoot, a reduction in the level of insecticides used to target corn boring pests has been the most significant impact of this new technology, generating an average farm level saving of 0.43 kg/ha and a 598,000 kg reduction in insecticide use globally (2014, 55). In addition to making production more sustainable, as scholars like Qaim others assert, the reduction in harmful inputs also makes agricultural biotechnology a more socially responsible development strategy. The adoption of new transgenic crop varieties reduces farmers' labour requirements and limits their exposure to potentially harmful chemicals and mycotoxins caused by spoilage (Qaim, Pray and Zilberman 2007, 26; Park et al. 2008, 341-342). As a result, it is

[12] The difference between irrigated or rain-fed crops and actual yields at any given time (Global Yield Gap Atlas n.d.).

frequently argued that in addition to playing an integral role in sustainable development, GM crops improve farmers' quality of life as well as their economic standing.

The additional farm level income argument is also frequently invoked throughout pro-biotechnology literature and during discussions concerning the need to address rural poverty in developing nations. As a result of their ability to increase yields and reduce the level of inputs used, it is often argued that farmers who cultivate transgenic crops will experience an increase in farm level profit, which will positively impact their poverty level, health and wellbeing. In their study on the impacts of biotechnology globally, Brookes and Barfoot claim that through the widespread adoption of GM crops between 1996 and 2012, farmers in Canada have experienced farm level income benefits of (US)$ 4,851 million while farmers in the developing nations of India and Argentina have experienced farm level income benefits of (US)$ 14,557 million and (US)$ 15,564 million respectively (2014, 11). As scholars like Park and his colleagues state, there is mounting evidence to suggest that "in both the developing and developed world, adoption of agricultural biotechnology can have a positive impact on farm level income, alleviating rural poverty and positively impact farmers' quality of life" (2011, 7; Brookes and Barfoot 2014, 9; Qaim, Pray and Zilberman 341-342). According to Brookes and Barfoot, as a direct result of the widespread implementation of agricultural biotechnology, global farm level incomes have increased by (US)$ 116.6 billion since 1996, particularly in the maize sector which generated (US)$ 32.3 billion in 2014 (2006, vii; 2014, 9).

As a result of the propensity for transgenic crops to increase productivity and yields, reduce the need for costly external inputs and generate an increase in farm level profit, they are often touted as a pro-poor technology designed to improve the wellbeing of farmers everywhere, particularly those in the developing world. As titles like McGloughlin's *Ten Reasons why Biotech will be Important to the Developing World* (1999) and Qaim's *Benefits of Genetically Modified Crops for the Poor* (2010) suggest, new agricultural technologies are often viewed as being a potential solution for addressing rural poverty in developing nations. While critics are often sceptical of pro-poor arguments, highlighting the conflicting nature of the private sector's focus on profit generation and the protection of genuine food security, for pro-biotech scholars like McGloughlin, "needs and profit are intrinsically linked" (1999, 165). Transnational biotech corporations have played a major role in shaping pro-poor biotechnology rhetoric; utilizing their significant resource base to launch rigorous campaigns aimed at easing public concerns and generating positive responses to this new technology.

A pertinent example is the transnational biotech corporation Monsanto, which frequently posits itself as "an organization that is helping the world face the challenges of food self-sufficiency by creating products designed to produce more food, conserve resources and improve the lives of farmers everywhere" (Monsanto 2014; Weasel 2009, 67). The corporation initially began promoting agricultural biotechnology as a way to increase food production and farm level profits in 1979, when the company approached Dr. Howard Schneiderman, a professor at the University of California, Irvine, with a (US)$ 275 million budget to head a research and development program on molecular biology, recombinant DNA techniques and genetic modification (Glover 2010, 73; Gilbert 1994, 494). As their chief scientist and Senior Vice President, Schneiderman embarked on a concerted effort to paint Monsanto's products as both attractive and favourable. Throughout the 1980s and 1990s, he began using rhetoric promoting GM technology as a benefit to all of mankind, capable of providing "a quick technological fix to address critically important food production challenges while promoting sustainable agricultural development" (Schneiderman and Carpenter 1990; Monsanto 1984, 4; Glover 2010, 69-70; Gilbert 1994, 494). In a publicized speech he made in 1985, Schneiderman identified genetic engineering and the emergence of agricultural biotechnology as "the most significant science and technological discovery ever made" (Gilbert 1994, 494). Various publications and campaign materials including information pamphlets and television and print ads were released depicting the rise of agricultural biotechnology as remarkable, revolutionary, and inherently natural, while still being considered a scientific triumph and improvement upon nature (Glover 2010, 74-77; Babinard and Josling 2001, 85). Between 1998 and 2000, led by their chief executive officer Robert Shapiro, Monsanto expanded its multi-million dollar campaign, increasing the span and scope of their publications, many of which featured images of smiling farmers and their overjoyed families standing in front of crops grown using Monsanto's GM seed technology (Lorquin 2001, 111; Babinard and Josling 2001, 85). Over the past three decades, Monsanto has publicized GM crops as safe, environmentally sustainable technology that can "double or even triple outputs in an economically and ecologically sustainable manner with no further abuse to nature" (Glover 2010, 84; Shapiro 1999, 28). The work of Brooks and Barfoot serves to solidify these claims as according to them, the use of Bt maize alone has generated a global average yield impact of 10.4 percent while the overall environmental impact associated with insecticide use has been simultaneously reduced by 47.9 percent (2014, 12-14). The sustainability argument, originally developed by

Monsanto in tandem with the creation of new transgenic crop technology, has become highly influential in pro-biotechnology literature and debates centered on sustainable development policies, food security and the role of smallholder farming, particularly in developing nations.

In addition to the pro-biotechnology literature that has been published by vested private interests and western proponents of GM crop technology there is also a significant body of work that explores the potential benefits of this new technology from the perspective of developing nations. As Jennifer Thompson's *Genes for Africa: Genetically Modified Crops in the Developing World (*2002) and Florence Wambugu's *Why Africa Needs Agricultural Biotech* (1999) assert, in developing nations like those in Africa for instance, discussions of food insecurity often coincide with those outlining the potential benefits of the widespread implementation of agricultural biotechnology. While this study will examine the developing nation of India in particular, there are several other nations in the developing world, in Africa in particular, that are turning to the promise of agricultural biotechnology to ease food production pressures and enhance food security. According to Florence Wambugu of the International Service for the Acquisition of Agri-biotech Applications' (ISAAA) regional office in Africa, "the African continent, more than any other, urgently needs agricultural biotechnology, including transgenic crops, to improve food production" (1999, 15). Discussions of the potential to increase food security in countries in Africa are passionately charged, contesting the arguments of opponents in the western world. As many have never experienced hunger, starvation and death as a result of widespread food insecurities like those in the developing world, it is often argued that biotech opponents can never fully understand the nature of African priorities that center first and foremost on the need to feed the population while sustaining agricultural production and the environment (Wambugu 1999, 15). While the countries of Burkina Faso and Sudan have implemented GM crop technology as an integral part of their new agricultural development strategies, South Africa has adopted more transgenic crop varieties than any other African nation. Farmers in South Africa have been growing GM crops since 2000 and currently 90 percent of all maize and soybean crops grown in South Africa are of the transgenic variety (Brookes and Barfoot 2014, 25). As the work of Thompson and Wambugu illustrates, while the potential advantages of implementing agricultural biotechnology in developing nations are frequently discussed throughout pro-biotechnology literature, these arguments often highlight the importance of avoiding exploitation through the creation of "a balanced formula for how local institutions can participate in transgenic product development so that they can share the benefits, risks and profits of the technology" (Wambugu 1999, 16). As a result, while many scholars outline the potential of agricultural biotechnology to address food security issues in developing nations like those in Africa, many of them echo the concerns of opponents who outline the follies of transferring food security away from the state and into the hands of private sector biotech corporations.

Arguments against Agricultural Biotechnology

The five main categories of arguments against the widespread adoption of agricultural biotechnology are: health, ethical, environmental, technological and socio-economic (Gupta and Chandak 2004, 5; Shiva and Jafri 2003, 13; Shiva and Jalees 2006, 95-105). The strongest arguments that appear in anti-biotechnology literature are not centered on ethical or moral considerations, as they appeal to human emotion and draw very little from scientific research and empirical evidence. Instead, socio-economic arguments, as well as those highlighting the environmental and technological limitations of this new technology, serve as the strongest and most reputable critique of the widespread implementation of agricultural biotechnology. Many scholars are critical of the pro-poor rhetoric that is used as a framework for arguments that support the widespread implementation of transgenic crop varieties. For Glover, the promotion of agricultural biotechnology by transnational corporations like Monsanto under the guise of benign intervention is a thin veneer that is used to hide the true motivations of the company. According to he and other like minded scholars, Monsanto has simply exploited their position in the agricultural chemical industry to establish a viable business opportunity arising from the challenge of efficient and sustainable food production (2010, 80; Ryan and Phillips 2004, 221; Jansen and Gupta 2009, 443). Their core focus is the promotion of economically viable products, not the inherent food security concerns and struggles of farmers around the globe. As Glover states, the follies of pro-biotechnology rhetoric are highly prevalent, arising from the tendency of experts to depict new technology as a 'silver bullet' for addressing global food production pressures (2008, 3). New technologies are rarely silver bullets. Defining them as such ignores possible alternatives and overshadows the political, economic and social complexities of their governance structures.

In stark contrast to the majority of pro-biotechnology arguments, Vandana Shiva (1997, 2000), David Harvey (2003, 2005), Anil Gupta (2002, 2004) and Philip McMichael (1997, 2004b) have helped shed an important light on the complexities of agricultural biotechnology; highlighting its various impacts and the importance of pre-existing socio-economic conditions and institutional arrangements. Arguments used against the widespread implementation of agricultural biotechnology frequently discuss the unequal nature of this new technology, the proliferation of IPR and the domination of private interests under the guise of promoting national and global food security. As such, scholars that take an anti-biotechnology stance are weary of supportive rhetoric which centers on what Shiva refers to as technologically simplistic, 'magic wand' solutions that depict new technologies as miracles while ignoring the complexities of global food security issues (2000, 193-194).

Since the late 1990s, biotechnology has been invoked as a critical tool for agricultural development, particularly in relation to indebted farmers in the developing world. As scholars like Glover assert, the pro-poor rhetoric of GM crop varieties emerged alongside the technology itself through the same underlying corporate processes. As a result, the commercial, institutional and technical considerations and interests of corporations influence their advertising and marketing strategies (2010, 69). For Scholars like Gupta and Chandak, opportunity undermines sustainability, as global biotechnology markets are "markets without morals, dominated by private interests that secure patent rights and promote the circulation of short-term, economically viable 'goodies' which cost farmers and greater society far more in the long-term" (2004, 10). While the widespread adoption agricultural biotechnology is marketed as a sustainable, pro-poor development strategy, corporations who own this new technology are concerned with profit and pleasing shareholders first and foremost, not the alleviation of global food security concerns as their mission statements claim. In fact, it is often argued that the private sector is simply ill equipped to address global food security concerns as they have little motivation to ensure the validity and success of their products. This is due to the fact that they cannot be held accountable by the farmers who cultivate or the citizens who consume their products. As such, while transnational biotech corporations like Monsanto may market their products as a sustainable method for addressing global food security concerns, it does not mean that they are committed to the cause. If certain transgenic strains prove to be less than commercially viable, regardless of their potential to address national and global food security concerns, it is likely that they will be abandoned in favour of more lucrative projects.

For opponents of agricultural biotechnology, the key to achieving global food security cannot be found in the pockets of transnational biotech corporations. As the work of David Harvey (2003, 2005) illustrates, the implementation of transgenic crop varieties has had immense socio-economic impacts globally, particularly in the developing world. Harvey's work underpins a number of crucial arguments used against the widespread adoption of agricultural biotechnology, as it highlights the dangers of privatization and the commodification of productive assets or resources once held in trust by the state. He refers to this process as 'accumulation by dispossession' in a system in which private interests are able to capitalize on once publicly held assets like seed bank resources (2003, 161, 181-182). Critics of transgenic crop varieties question their very merit, seeing them as inherently destructive and a detriment to addressing national and global food security concerns. As opposed to being defined as a pro-poor, ecologically and economically sustainable development strategy, scholars who are critical of this new technology often label it as ecologically constraining, inherently destructive and a pertinent example of the fact that "agricultural knowledge and innovation are only widely recognized when they generate profits, not when they meet social needs" (Shiva 1997, 7; Scoones 2006, 42; Herdt 2006, 284; Perriere and Seuret 2000, 16).

While a number of critics examine the normative aspects of agricultural biotechnology, there is a significant body of literature that examines the empirical validity of the claims asserted by its most ardent proponents, including the ability to increase farmers' yields and profits. As scholars like Perriere and Seuret (2000) state, "GMOs pave the way for a new intensified agriculture in which the use of proprietary seed technology and their respective contracts have driven up costs with no commensurate decrease in production costs, nor in market prices" (14-16; Shiva and Jafri 2003, 9-12; Moore 2010, 390). The work of Miguel Altieri and Walter Pengue *GM Soybean: Latin America's new Colonizer* (2006) is frequently cited throughout anti-biotech literature, as the authors' examination of the impacts of the implementation of GM soybeans in Argentina, Brazil, Bolivia and Paraguay highlights the pitfalls of pro-biotechnology arguments that claim that GM crop varieties are universally applicable and inherently beneficial. As the results of their study indicate, the impacts of GM soybeans in Latin America are a stark contradiction to the results predicated by proponents (2006, 15-17). Specifically, the authors discovered that far from improving the well being of farmers, the expansion of GM soybean cultivation in Brazil has caused an increase in land and income concentration, displacing 11 agricultural workers for every 1 who finds employment in this sector (2006, 14). Likewise, in Argentina where the situation is more dramatic, between 1998 and 2002, one quarter of the farms in the country were lost and there was a reduction in maize and sunflower production by 2.9 million and 2.15 million hectares respectively, spurring an increase in basic food imports and igniting food security concerns (2006, 14-15). The results of their study serve as a reminder of the importance of examining the impacts of transgenic crop varieties on a case by case basis, rather than assuming their success based on prevalent normative assumptions.

This chapter has served as an examination of the theoretical framework underpinning this paper, situating it within the intellectual tradition of critical analysis regarding contemporary neoliberal approaches to global agricultural production and development. As was established in the literature review, debates surrounding agricultural biotechnology are highly polarized. As such, it is important that the empiric validity of the major arguments used in support of new technologies be tested using an applicable case study like the implementation of Bt maize in Ontario, Canada and Punjab, India. In order to effectively do so, the next chapter will examine the rise of agricultural biotechnology in Canada and analyze the impacts of this new technology.

Chapter Three: Agricultural Biotechnology in Canada

Having established the theoretical framework for the study in the previous chapter, situating it within the intellectual tradition of critical analysis regarding agricultural production and development, this chapter will focus on the implementation of Bt maize in Ontario, Canada. The central purpose of this chapter is to examine agricultural development in Canada, focusing on the historic and economic relevance of the sector, the changing role of the state, the rise of agricultural biotechnology and the various factors that have led to its proliferation. It will begin with a brief history of Canadian agriculture, outlining the rise of agricultural biotechnology before analyzing the various impacts that Bt maize has had on Canada's agricultural sector.

A Brief History of Canadian Agriculture

Agriculture has been a staple of the Canadian economy since colonization. As prominent Canadian scholar Grace Skogstad states, agricultural commodities, particularly staple grains, were closely associated with Canadian social, economic and political development throughout the 19^{th} and 20^{th} century (2007, 27). Ideally suited for the dry, semi-arid climate of the Canadian prairies (Alberta, Saskatchewan and Manitoba), staples products such as wheat and flour became a source of great wealth and had a profound impact on western development. Rapid developments in western infrastructure and transportation were marked by the necessity to ship bulk agricultural staples products as domestic and foreign markets were abundant, particularly in Europe. Substantial investments in major railways like the Grand Trunk and the Canadian Pacific led to the expansion of the prairie economy. Representing one half of Canadian exports in 1870, agriculture, especially wheat and flour, would dominate the Canadian economy in the post-industrial era (Ankli 1982, 272; McCallum 1980, 10-11; Fowke 1957, 8 & 283). It was through the creation of the *National Policy* in 1879 and its emphasis on nation building that agriculture became a central component of the Canadian national identity. The cultivation and export of bulk staples products was integral in the development of Conservative Prime Minister Sir John A. MacDonald's *National Policy* that was designed to create jobs, promote western investment and economic prosperity and attract immigrants to settle in western Canada (Skogstad 2007, 27). As a result, the prairies became an economic powerhouse as the cultivation and export of staples was of vital importance to the prosperity of not only the west, but the country as a whole.

From the very beginning, there was a strong agreement amongst the provinces that a level of federal protection and involvement in nationally important agricultural sectors would be desirable to ensure the success of the economy and the wellbeing of Canadian citizens. Until the neoliberal transformation in the late 1980s, the state played an active role in the agricultural sector and its markets due to the inherent volatility of agricultural production and the inequalities present in uncertain and fluctuating commodity markets. Agriculture was regarded as an 'exceptional sector' and the prevalent cognitive and normative beliefs underpinning its policies were based on the notion that state intervention was necessary to realize sectoral goals including productivity and profitability. Without it, it was argued that "producers, consumers and society at large would be adversely affected" (Skogstad 2008, 9). Since the national government was "better positioned than the provinces to ensure that production demands were met and negotiate more lucrative terms of trade" (Skogstad 2007, 28 & 43), it played a central role in protecting the economic interests of farmers and the country as a whole, providing subsidies to stabilize farmers' income, marketing boards with the ability to control supply and fix prices, state trading enterprises and export subsidies.

Federal involvement in agriculture began in 1887 with the creation of The Winnipeg Grain and Produce Exchange. The exchange, a non-trading body that provided facilities for its members to assist them in conducting business, was established by a group of Winnipeg grain merchants and was responsible for passing by-laws and implementing regulations for systematizing trade among its members. Through the exchange, the prices that farmers received for their crops were the full value of the grain as based on the world's markets at the time (Pentland 1959, 301). The strength of the Winnipeg Grain and Produce Exchange persisted throughout the First World War and eventually led to the creation of the Canadian Wheat Board (CWB) in 1935. Since there was no guarantee of wheat prices during the First World War, the federal government inevitably intervened in agricultural trade through the support of the CWB (Fowke 1945, 374; Skogstad 2007, 27). Thirty years after its initial creation, field crops had increased by 200 percent to 58 million acres and wheat acreage increased by more than 500 percent to 26 million acres (Fowke 1957, 44). However, federal involvement in the wheat economy stalled after the war and a young CWB was dismantled in 1921.

Federal involvement in agriculture did not resurface until the depression of the 1930's, which once again created a necessity for the establishment of federal protection policies. During the depression of the 1930's, the agricultural sector was of high national importance and 1 in 3 Canadians lived on farms (Statistics Canada 2001). Since the grain industry was heavily dependent on exports, it was aggravated by a lack of domestic and foreign demand and Canadian wheat exports fell drastically to 550 million bushels by the mid 1930s (Fowke 1957, 171; Skogstad 2007, 28). Out of sheer necessity, the federal government had to retain its involvement during this period. In 1935, the federal government passed the *Canadian Wheat Board Act* that reinstated it as an organization. The re-establishment of the CWB centered on the re-organization of its various wheat pools and emphasized the federal government's responsibility to stabilize commodity prices and cover any losses suffered by the board and its respective members. Essentially, the purpose of the CWB was to:

> formalize stabilization operations; impose a buffer between wheat producers and the possible chaos of world markets. It assisted with internal regulations, bulk trading agreements, and protected both farmers and consumers against increase in costs, the fall in commodity prices of perceived crop scarcity. (Fowke 1957, 295)

Over the 1930s and 1940s, Canadian agricultural production was central to the economic welfare of the country, accounting for an average of 11 percent of total gross domestic product (GDP) (Skogstad 2007, 28).

The protection of the grain industry by the Canadian government was at its highest point after the Second World War and persisted until the 1970's. Between 1951 and 1967, public investment in Canadian farming more than doubled in an effort to promote efficiency in the agricultural sector and make it more competitive in world markets (Canadian Agriculture in the 1970s; Skogstad 2007, 29). Due to the economic importance of Canadian agriculture during this period, the strength of the CWB was increased through the establishment of state assisted income stabilization policies such as *the Western Grain Stabilization Program*[13] of 1976. These policies proved to be

---

[13] Introduced in April 1976, the purpose of this program was to help farmers growing the six major grains in the CWB region (wheat, oats, barley, rye, flax and rapeseed) stabilize their crop incomes and protect them from uncertainty and variation in returns due to fluctuations in production costs. The program gained a wide base of support amongst producers and ran until 1978 (Agriculture Canada 1980; Proloux 2012, 10; Schmitz et al. 2010, 166-167).

incredibly beneficial to cereal grain producers as they emphasized the mutual responsibility of the producer and the state to stabilize farmers' incomes. These changes were spurred by *Canadian Agriculture in the 1970's*, a report by the Federal Taskforce on Agriculture. This report reaffirmed long standing beliefs by arguing for the need to develop policies designed to protect producers from the dangers of markets domestically and abroad (Coleman and Skogstad 2007, 248). During the 1980's, even prominent neo-classical thinkers believed that the CWB's "central and commanding role in regulatory matters in the grains industry, its historical performance, and its wide acceptance by producers made its disappearance from the scene unthinkable and unsupportable" (Skogstad 2005, 530-535). This way of thinking began to disappear in the late 1980s and early 1990s however, when Canadian agricultural policy underwent a stark neoliberal transformation.

Developments in Canadian and international political economies in the late 1980s resulted in the ideologically driven, pragmatic transformation of Canadian agricultural sectors. The shift to neoliberalism in Canada is most closely associated with the government of Progressive Conservative leader Brian Mulroney (1984-1993). It came about as a result of international pressures from Republican President Ronald Reagan (1981-1989) in the United States and Conservative Prime Minister Margaret Thatcher (1979-1990) in the United Kingdom, who sparked the rise of a 'common sense revolution' marked by extensive changes in a number of policy sectors (Harvey 2005, 9). Based on free market theories and an opposition to state intervention, members of the Mont Pelerin Society including Frederich Von Hayek, Milton Friedman and Karl Popper, shaped neoliberal theory, which did not enter the policy realm until receiving the support of Margaret Thatcher, who famously claimed that there was simply no alternative (Harvey 2005, 8, 22 & 39; Marchak 1991, 95; McBride and McNutt 2007, 186; Albo 2002, 47). As a result of the neoliberal shift in Canada, the role of the federal government and the relevance of state intervention in the agricultural sector were drawn into question.

Based on contemporary neoliberal arguments outlining the inefficiency of bureaucracies and government intervention and the assumption that bureaucrats and powerful interest groups distort and bias state interventions for their own benefit, it was argued that state involvement in agricultural should be limited (Harvey 2005, 36). Many government programs were seen as being a direct challenge for domestic fiscal realities. An example that is often cited is the significant plunge in prairie farmers' incomes that occurred in the mid-1980s. As a result of poor growing conditions, the Western Grain Stabilization Program was exhausted, forcing the government to bail out its deficit of $ 250 million (Skogstad 2008, 75). Through the retrenchment of the state and the promotion of laissez-faire alternatives, it was widely believed that agricultural production could become more efficient by eliminating wasteful policies and federal spending. In 1985, Minister of Agriculture John Wise (1984-1988) supported a reduction in government spending in this sector in light of Canada's international trade obligations and an accumulate federal debt of over $ 500 billion (Skogstad 2008, 85). The nature of Canadian agricultural governance changed significantly as a result of these arguments. This era was marked by a period of agricultural trade liberalization policies and a stark retrenchment of the state and its once central role in Canadian agriculture. This was all in spite of empirical evidence from the FAO indicating that the production of staples grains was consistently high during this period. In 1980, Canadian farmers produced 19,292 million tons of wheat and in 1986 there was a significant increase to 31,378 million tons (FAO Stat 2015). Even though production fell to 24,796 million tons in 1988 (FAO Stat 2015), wheat production in Canada saw no significant drop in the years leading up to the neoliberal reform era of the late 1980s.

Changes in the agricultural sector began in 1989 during the reign of Progressive Conservative Prime Minister Brian Mulroney (1984-1993) when Minister of Agriculture Don Manzankowski presented a case for extensive neoliberal reform. It was centered on the reduction and elimination of state assistance and market intervention in favour of reform policies designed to promote efficiency and global competitiveness. These reforms, based on assumptions that public, state funded assistance had led to agricultural overproduction, high public sector costs, international trade tensions and were ultimately responsible for an accumulated federal debt of over $ 500 billion in 1985 (Skogstad 2008, 85), were supposed to promote market responsiveness, greater self-reliance, more equity between commodities and regions and increase economic as well as environmental sustainability (Coleman and Skogstad 2007, 258; Skogstad 2005, 530; Coleman et. al 1996, 275). Mounting global pressures, the emergence of a highly competitive agri-food sector and domestic strife in the form of high public expenditures and debt led to the stark transformation of Canadian agriculture.

At this time, Canada's status as a medium-sized power with a comparatively small domestic market made it a strong supporter of multilateral trade agreements. In September 1985, the Royal Commission on Economic Union and Development Prospects for Canada (the MacDonald Commission[14]) proposed the Canada-United States Free Trade Agreement (FTA), a bilateral trade agreement with the United States that came into effect in 1989 (Cameron 1993, ix; Skogstad 2008, 63). A central goal of this agreement was the promotion of economic integration between these two nations through the liberalization of investment flows and the deregulation of corporate mobility and foreign direct investment (Cameron 1993, xi; Campbell 1993, 21). Six years later, the agreement was expanded to the North American Free Trade Agreement (NAFTA), incorporating Mexico and parts of Central America including El Salvador, Guatemala, Honduras, Costa Rica and Nicaragua (Cameron 1993, xxi; Clarkson 1993, 16-17). As a result of the emergence of these regional trading blocs, the governance of trade in Canada changed significantly, marked by the elimination of tariffs and other trade barriers (Skogstad 2007, 30). Likewise, the GATT, a multilateral agreement designed to regulate international trade that led to the creation of the WTO in 1995, exacerbated agricultural reform pressures in Canada by pressing for greater agricultural trade liberalization and the creation of an open, laissez-faire economy that would be more conducive to foreign trade and investment. While agriculture had previously been exempt from GATT negotiations and rules, the conclusion of the Uruguay Round of negotiations in 1994 and the creation of the *Agreement on Agriculture* which came into effect with the establishment of the WTO on January 1st 1995, irreparably changed the face of global agricultural trade. As Skogstad states, along with NAFTA, this agreement

> enshrined the new competitive paradigm of agriculture; the belief that it should move towards the promotion of free markets and that government should try to remove their expenditure and regulatory support for this sector. As a result, this

[14] Chaired by former Minister of Finance Donald S. MacDonald, the Macdonald Commission was the largest in Canada. It was appointed in 1982 for the purpose of "examining the future economic prospects of the country and the effectiveness of political institutions" (Banting 2013).

> agreement curbed a number of domestic agricultural policies, caused a reduction in the scope, volume and value of government subsidies, prohibited the creation of input controls and limited government expenditure on all trade-distorting domestic support measures, effectively eroding the previous paradigm of state assistance in favour of the promotion of market liberalism. (2007, 31)

This shift represents the end of an epoch in Canadian agricultural history. Except for a brief period following the First World War, the Canadian state historically played a strong interventionist role and adopted a protectionist stance in relation to its agricultural sectors, particularly staples grains. By the early 1990s, this historical role had been substantially diminished.

The Rise of Agricultural Biotechnology in Canada

As Abergel and Barrett state, the Canadian government has "historically walked a fine line between promoting GM crops as innovative, economically beneficial technology and enforcing a regulatory system based on the notion that GM products are not inherently different from their non-GM counterparts" (2002, 147). As the previous section outlined, the 1990s was a highly influential decade for Canadian agriculture, marked by significant neoliberal restructuring in major agricultural sectors. It was also marked by efforts to promote national competitiveness for the purpose of exploiting Canada's agricultural competitive advantage or the ability to become competitive in the global market by providing a good more effectively or efficiently than other nations (Anderson 2003, 6). For scholars like Jessop, it was during this era that Canada adopted what he refers to as a "competition state attitude" that aims to secure economic growth and competitive advantage for capital within its borders by promoting and pursuing strategies that are vital for success in competition with other global economic actors (2002, 94-119). As a result of a shift away from a resource based economy towards a knowledge based economy and in an effort to remain competitive in this burgeoning sector, the federal government began funding research in agricultural biotechnology and encouraging Canadian farmers to adopt this new technology for the purpose of increasing their productivity and international competitiveness. As Eaton states, from the very beginning, Canada has been an ardent proponent of agricultural biotechnology, adopting "a top down approach to biotechnology with regulatory agencies that are only belatedly and superficially engaged with public concerns" (2013, 31). Touted from the beginning as a strategy to promote international competitiveness and economic development, the Canadian stance on biotechnology is a stark contrast to other countries' precautionary ones. In 2009, (US)$ 677.9 million were spent on public biotechnology research and development in an aggressive effort to develop new, viable GM crops (Beuzekom and Arundel 2009, 31). Biotechnology's share of the total public research and development expenditure is currently 6.7 percent in Canada, placing them 4th among all OECD member countries after Korea at 18.7 percent, Spain at 14.8 percent and Norway at 7.7 percent (Beuzekom and Arundel 2009, 31).

Although the 1990s was a significant era for the development of agricultural biotechnology in Canada, the initial development of these technologies began a decade earlier. The economic recession of the late 1970s and early 1980s significantly impacted the economies of all industrial nations at the time, Canada included. Subsequently, by the early 1980s there was a major push to stimulate the economy and promote Canadian international competitiveness, particularly through research intensive, high-technology industries. At that time, Canada did not have a cohesive, systematic national policy for science and technology and the OECD exacerbated pressures to place science and technology on the policy agenda. Canada chose to invest heavily in biotechnology and in 1980, the first national biotechnology strategy emerged as a result of the Federal Ministry of State for Science and Technology's (MOSST) report entitled *Biotechnology in Canada.* The report stressed the opportunity to develop new plant varieties but also emphasised a lack of investment in and growth of biotechnology industries in the United States and Europe. To ensure Canada's 'full advantage' in biotechnology, MOSST established a private-sector taskforce on biotechnology for the purpose of informing the minister of agriculture regarding the potential to institute specific policies and programs and to "review mechanisms for encouraging and promoting research, development and implementation" (MOSST 1980; Abergel and Barrett 2002, 137). The MOSST report and task-force set the tone for the future of biotechnological development and regulation in Canada. Between 1983 and 1985, the Canadian government spent $ 22 million establishing the *First National Biotechnology Strategy* and over $ 100 million funding national biotechnology research centers (Abergel and Barrett 2002, 138).

The year 1983 was marked by a number of reforms that established a broad new policy for technological development. MOSST was reorganized into the National Advisory Board on Science and Technology (NABST) bringing together forty public and private sector advisors under the chairmanship of the prime minister (Abergel and Barrett 2002, 139). In 1988, it was established that new plant varieties and seeds produced through the use of DNA and other genetic techniques are covered under the existing provisions of the *Seed Act* and administered by Agriculture Canada (Abergel and Barrett 2002, 143). Coordinating regulatory frameworks and harmonizing policy approaches with trading partners, particularly the United States, was of key importance in an attempt to reduce trade barriers. In January 1993, the Canadian government announced a broad new framework for biotechnology designed to "reduce environmental risks while fostering competitiveness through the timely introduction of biotechnology products onto the market place" (Abergel and Barrett 2002, 147). In 2014, Canada produced a total of 11.6 million hectares of GM crops, making it the 4th largest global producer (James 2014; Abergel and Barrett 2002, 135).

The Impacts of Agricultural Biotechnology in Canada

In order to effectively examine the impacts of biotechnology in Canada, this section will analyze the implementation of Bt maize in the province of Ontario to see if the major arguments used in favour of this new technology can be supported by empirical evidence. To do so, statistics on conventional and transgenic Bt maize varieties will be examined over the last three decades and compared against claims stating that the implementation of agricultural biotechnology will lead to an increase in overall yields, a decrease in the level of required inputs and an increase in farm level profits.

Although wheat is often considered to be the lynchpin of Canadian agriculture, the production of maize also plays an important role. In fact, after wheat and canola maize is the third most vital crop. Of the 885,289 million metric tons of maize produced globally in 2011, Canada was responsible for 10,688 million metric tons, placing them 11th in the world (Hamel and Dorff 2015). Climate is a highly decisive factor in determining which areas of Canada are ripe for growing maize, as the greatest production occurs in the warmest regions. Unlike other staple crops, the cultivation of maize takes place in central Canada in the provinces of Ontario, Quebec and Manitoba. In 2011, Ontario accounted for just over 61 percent of the total seeded area, followed by Quebec with 30 percent and Manitoba with just over 6 percent (Hamel and Dorff 2015). This study will focus on the province of Ontario as maize is the number one crop in terms of production and farm cash receipts[15], and it is grown in the eastern, southern and central regions of the province. In Ontario in 2011, 71.3 percent of maize area was seeded with crops of the transgenic variety (Hamel and Dorff 2015). To assess the impacts of Bt maize in Ontario, the central arguments used in support of the implementation of agricultural biotechnology will be compared against statistical data spanning the last three decades (1985-2015). As farmers have been planting commercially approved Bt maize since it first appeared in Ontario in 1996 (Hategekimana and Beaulieu 2002, 2; Qaim, Pray and Zilberman 2008, 329) the last two decades (1995-2015) will be of particular importance. As outlined in the first chapter, three of the major arguments associated with the implementation of agricultural biotechnology are: an increase in overall yields, a decrease in the level of required inputs and an increase in farm level profits. As such, it is important that each of these arguments be compared against data on conventional and transgenic crop varieties available through Statistics Canada, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and the FAO.

Arguably, the strongest argument used in favour of the adoption of Bt maize in Canada is an increase in overall yields. Farmers adopt this new technology under the assumption that it will increase their overall yields as a result of a reduction in crop losses caused by target insects. Like many maize producing regions, the greatest threat in Ontario is the European corn borer, an invasive insect species that has plagued the

[15] Represent the cash income received from the sale of agricultural commodities as well as direct program payments made to support or subsidize the agricultural sector. The primary reason for compiling farm cash receipts is to estimate, on a provincial basis, a sector's contribution to GDP. The value of farm cash receipts for maize reached $ 2.8 billion in 2011 (Hamel and Dorff 2015).

production of maize in the province since the 1920s (Farm and Food Care Ontario n.d.). Destructive corn borer larvae have a significant impact on farmers' overall yields, causing harvesting difficulties as a result of broken stalks, infection and mycotoxins that make products unfit for human consumption. Entomologists estimate that corn borers cost farmers in North America over (US)$ 1 billion annually, and costs to Ontario maize producers alone exceed $ 40 million (Farm and Food Care Ontario n.d.; Bhatia, Grant and Powell 2000, 1). While the traditional remedy to combat crop loss is the regular spraying of Bt insecticides, by adopting transgenic crop varieties already containing the Bt gene, Ontario farmers can target corn borer infestations at the source which will stabilize production conditions and spur an increase in overall yields.

Table 1 - Average Crop Yields of Conventional Maize in Ontario (1985-2015)

Year	Average Crop Yields (Kg/Ha)	Year	Average Crop Yields (Kg/Ha)
1985	6,400	**2001**	6,500
1986	6,300	**2002**	7,100
1987	7,300	**2003**	8,000
1988	5,300	**2004**	8,200
1989	6,600	**2005**	9,100
1990	7,000	**2006**	9,400
1991	6,900	**2007**	8,400
1992	6,000	**2008**	9,800
1993	6,800	**2009**	9,000
1994	7,600	**2010**	10,300
1995	7,300	**2011**	9,500
1996	7,000	**2012**	9,600
1997	7,100	**2013**	10,100
1998	8,100	**2014**	10,100
1999	8,100	**2015**	9,900
20000	6,600		

Source: Statistics Canada 2015a.

As table 1 indicates, average crop yields for conventional maize produced in Ontario have experienced significant fluctuations over the last three decades. Between 1985 and 1995, before the arrival of Bt maize on the Canadian seed market, yields of conventional maize crops averaged around 6,680 kg/ha. Between 1985 and 1990, conventional maize yields increased from 6,400 to 7,000 kg/ha, falling slightly in 1991 to 6,900 kg/ha and remaining below 7,000 kg/ha until the record 7,600 kg/ha produced in 1994. Between 1995 and 1999, in the years immediately following the arrival of Bt maize on the Canadian seed market, the average yields of conventional crops fell slightly before experiencing a significant increase of 1,000 hectares from 7,100 kg/ha in 1997 to 8,100 kg/ha in 1998/1999. However, this trend would not last more than two years as they fell once again to 6,600 kg/ha in 2000 and by 2001, a year after Statistics Canada began gathering information on Bt maize yields in Ontario, the average crop yield for conventional maize yields had reached a record low since 1988 at 6,500 kg/ha. Contrary to arguments suggesting that farmers would experience an immediate increase in overall yields, the average yield of transgenic Bt maize crops in 2001 was only slightly higher at 6,800 kg/ha.

Table 2 – Average Crop Yields of GM Maize in Ontario (1985-2015)

Year	**Average Crop Yields (Kg/Ha)**	**Year**	**Average Crop Yields (Kg/Ha)**
1985	N/A	**2001**	6,800
1986	N/A	**2002**	7,400
1987	N/A	**2003**	8,200
1988	N/A	**2004**	8,600
1989	N/A	**2005**	9,200
1990	N/A	**2006**	9,700
1991	N/A	**2007**	8,500

Table 2 Continued – Average Crop Yields of GM Maize in Ontario (1985-2015)			
Year	**Average Crop Yields (Kg/Ha)**	**Year**	**Average Crop Yields (Kg/Ha)**
1992	N/A	**2008**	9,900
1993	N/A	**2009**	9,000
1994	N/A	**2010**	10,500
1995	N/A	**2011**	9,700
1996	N/A	**2012**	9,700
1997	N/A	**2013**	10,100
1998	N/A	**2014**	10,100
1999	N/A	**2015**	N/A
20000	6,800		
Source: Statistics Canada 2015b.			

However, like many new technologies, it is unlikely that information on Bt maize in the first few 'transition' years is indicative of its productive capacity. As the information depicted in table 2 indicates, between 2001 and 2015, much like its conventional counterpart, the average crop yields of Bt maize experienced significant fluctuations. Between 2001 and 2005, average yields increased from 6,800 kg/ha to 9,200 kg/ha. Although average yields fell slightly in 2007 to 8,500 kg/ha, the overall positive trend in Bt maize production continued throughout the mid-2000s, reaching a record 10,500 kg/ha in 2010. However, the last four years have been marked by a significant decrease in transgenic maize yields to 9,700 kg/ha in 2011 and 2012, and only a slight increase to 10,100 kg/ha in 2013 and 2014. What becomes immediately apparently through a careful examination of the statistics outlined in tables 1 and 2 is the folly of major arguments which posit that the adoption of transgenic maize varieties will serve as a catalyst for the production of more stable yields. While results appear to indicate a generally positive increase in yield averages, they remain highly fluctuant and susceptible to biotic and a-biotic stresses that adversely affect overall yields.

In addition to illustrating the weakness of the crop yield stability argument, the information depicted in tables 1 and 2 also indicates that while proponents of Bt maize argue that the adoption of this new technology will generate a visible and significantly positive impact on yields, their predictions have been overstated. While it cannot be argued that the adoption of Bt maize in Ontario has not had an impact on average crop yields, an effective argument can be made suggesting that yield improvements have not been as significant as proponents of this new technology claim. In fact, between 2001 and 2014, increases in average yields for Bt maize farmers were less than significant, reaching their peak over a decade ago in 2004 at 400 kg/ha higher than farmers growing conventional varieties. While annual crop yields have generally been higher for Bt maize cultivators since 2001, on average, farmers did not experience more than 200 kg/ha increase compared to their counterparts growing conventional varieties. In some cases, average crop yields of conventional maize producers were on par with those cultivating transgenic varieties. For instance, in 2009, average crop yields for both conventional and transgenic maize were 9,000 kg/ha and in 2013 and 2014, both varieties generated the same results at 10,100 kg/ha respectively. While the ability to enhance crop stability and generate an increase in overall yields is often used in support of the widespread adoption of this new technology, as this particular case study has shown, these bold assertions are often overstated and simply do not hold up under empirical scrutiny.

Another key argument that is used in support of Bt maize hinges on sustainability and the assumption that transgenic crop varieties require fewer external inputs to target pests like the European corn borer. As Jacqueline Moxley of the Economics and Policy Coordination Branch of the Ontario Ministry of Food and Agriculture (OMFA), now the OMAFRA states, “organic pesticides have been used in Ontario since the end of the Second World War. Due to concerns expressed over the potential for contamination and the need to identify and quantify pesticides used in the Great Lakes Watershed, the *Great Lakes Water Quality Agreement* was signed by the United States and Canada in 1972” (1989, 1-3). As part of this agreement, the Pollution from Land Use Activities Reference Group (PLUARG) was established and charged with the task of quantifying inputs and assessing their impacts. Beginning in 1972, the PLUARG group requested the establishment of a survey of pesticide use to be carried out every five years in Ontario to gauge the effectiveness of the ministry’s efforts to reduce the levels of the potentially destructive inputs used by farmers (Moxley 1989, 1; McGee, Berges and Callow 2004, 1; McGee, Berges and Beaton 2010, 1). Published a total of eight times since 1973, these surveys and subsequent reports on agricultural pesticide use in Ontario, in addition to the 2011 *Survey of Pesticide Use and Evaluation of the Changes n Pesticide risk on Agricultural Crops in Ontario,* serve as an effective tool for measuring pesticide use by provincial farmers.

In light of provincial efforts to reduce pesticide use and in lieu of the growing salience of the sustainable development paradigm, the OMFA began advocating the adoption of Bt maize as a sustainable development strategy and it became an integral part of the *Food Systems 2002* program initiated in 1980 (Farm and Food Care Ontario n.d.). The objective of the program was to reduce pesticide use of all kinds in Ontario by 50 percent by 2002 and use the results of provincial pesticide use surveys to measure its success. In 1997/98, as their business plan states, the OMAFRA began promoting the widespread adoption of agricultural biotechnology as an integral part of efforts to promote sustainable development and reduce provincial pesticide usage (MacRae and Cuddeford 1999). As previously mentioned, the losses incurred by Ontario farmers as a result of pests like the European corn borer are significant, averaging more than $ 40 million annually (Farm and Food Care Ontario n.d.). To combat potential losses, farmers traditionally turn to the spraying of organic and synthetic insecticides. As Farm and Food Care Ontario (n.d.) states, due to the productive patterns of European corn borers, farmers must typically spray their crops an average of two or more times every season to prevent crop losses. As such, it is often argued that "the adoption of Bt maize provides a safe and effective means to control the European corn borer and its use will enable an almost total elimination of the use of insecticide" (Farm and Food Care Ontario n.d.). By targeting pests at their very source, it is argued that this new agricultural biotechnology plays an integral role in the reduction of pesticide use in Ontario.

It is important to note that although the implementation of Bt maize and other agricultural biotechnology enjoy a great deal of federal and provincial support, and sustainability arguments are often invoked as an incentive for Canadian farmers, Statistics Canada does not collect information on GM crops in any area other than yields. As such, surveys of pesticide use in Ontario (1973-2011) conducted by the OMAFRA serve as an effective tool for measuring the ability of transgenic Bt maize to reduce required input levels. In the period leading up to the proliferation of Bt maize on the Canadian seed market (1985-2001), three surveys of pesticide use were conducted and reports on the findings were released. As the results of the 1988, 1993 and 1998 survey indicate, ministry efforts to reduce the level of insecticides used by Canadian farmers were achieving more than moderate successes before the implementation of Bt maize. In fact, as Hunter and McGee and McGee, Berges and Callow state, between 1993 and 1998 there was a significant reduction in overall pesticide use at a rate of 1,000 tonnes, a trend that persisted throughout 2003. In total, between 1993 and 2003 there was a 52 percent reduction in total pesticide use in Ontario (2004, 5; 1999, 5). In terms of the amount of insecticide used specifically, as the 1988, 1993 and 1998 surveys indicate, there was an 85,738 kg reduction over the course of a decade, well before the adoption of Bt maize was widespread (Moxley 1989, 27; Hunter and McGee 1994, 10; Hunter and McGee 1999, 9).

However, the role of Bt maize in the reduction of insecticide use in Ontario cannot be overlooked. As the 2003, 2008 and 2011 survey results indicate, not only has insecticide use continued to decline after the emergence of Bt maize on the Canadian seed market, the amount of Bt insecticides sprayed in particular has also decreased (McGee, Berges and Callow 2004; McGee, Berges and Beaton 2010; Gallivan 2011). In 2003, seven years after the first Bt maize plants were cultivated in Ontario, the amount of insecticide used was 4,964 kg (McGee, Berges and Callow 2004, 9). Between 2003 and 2011, this amount fell significantly once again to 1,151 kg (McGee, Berges and Callow 2004, 9; Gallivan 2011). As the results of the last three surveys indicate, it can be argued that the implementation of Bt maize by Ontario farmers has contributed to an overall decrease in required input levels.

However, much like pro-biotechnology arguments that center on the promise of increased yields, while assumptions regarding the ability of Bt maize to dramatically reduce farmers' required input levels appear to enjoy some level of empirical support, they often overstate this new technology's potential. As the Ontario pesticide use surveys indicate, maize farmers in Ontario were already engaged in a concerted effort to limit the level of inputs used well before the introduction of Bt maize as an option for promoting sustainable agricultural development. For example, the greatest reduction in inputs occurred between 1993 and 1998 when insecticide use declined from 60,662 kg to 8,062 kg (Hunter and McGee 1994; Hunter and McGee 1999). In comparison, between 2003 and 2011, the decline in insecticide use was marginal, falling from 4,964 kg to 1,151 kg (McGee, Berges and Callow 2004; Gallivan 2011). While it can be argued that Bt maize continues to serve as an integral tool for the reduction of required inputs, its success is difficult to quantify as it is simply one of many strategies adopted by Ontario maize farmers.

While a reduction in required inputs is also invoked as an economic incentive for Ontario farmers to adopt Bt maize over conventional varieties, as scholars like Bhatia, Grant and Powell assert, adopting Bt maize over conventional varieties is only economically beneficial for farmers when borer infestations are moderate to severe, costing farmers an average of (US)$ 27 an acre. Due to inconsistent pest levels annually, "as with any type of natural resistance, Bt corn only delivers an economic benefit when outbreaks occur" (2000, 1-2). As such, the implementation of Bt maize over conventional varieties alone does not guarantee a reduction in required input levels or the economic advantage that allegedly accompanies it.

Another economic argument that is often used in support of Bt maize is that the widespread adoption of this new technology will result in an increase in farm level profit.

As Brookes and Barfoot (2014) state, at the national level, the adoption of insect resistant maize has generated (US)$ 849 million in additional farm income since 1996 (9).

Table 3 – Farm Income Benefits of GM Insect Resistant Maize in Canada (1997-2012)

Year	Income Benefit (Million US Dollars)	Year	Income Benefit (Million US Dollars)
1997	3.2	**2005**	28.1
1998	11.3	**2006**	45.3
1999	15.3	**2007**	79.5
2000	11.0	**2008**	73.3
2001	15.6	**2009**	65.7
2002	23.8	**2010**	138.7
2003	25.7	**2011**	118.1
2004	31.4	**2012**	163.2

Source: Brookes and Barfoot 2014, 56

As table 3 illustrates, proponents of Bt maize claim that Canada has experienced a significant increase in farm level income benefits as a result of its widespread adoption. Between 1997 and 2007, they claim that national farm income benefits increased exponentially from (US)$ 3.2 million to (US)$ 79.5 million (Brookes and Barfoot 2014, 56). According to statistics Canada, since 61.7 percent of maize grown in Canada is grown in Ontario (Hamel and Dorff 2015), maize farmers in the province should see the greatest farm level income benefits implied by Brookes and Barfoot in table 3. However, upon careful examination of the evidence it becomes increasingly clear that, much like the other two arguments used in support of Bt maize in Ontario, the benefits of this new technology have been greatly overstated. Since Statistics Canada does not gather economic information on Bt maize farmers specifically, farm cash receipts for all maize crops in Ontario must be examined in an attempt to discern the economic impact that this new technology has had on farmers in Ontario.

Table 4 – Farm Cash Receipts for all Maize Crops in Ontario (1985-2015)			
Year	**Farm Cash Receipts (US Dollars x 1000)**	**Year**	**Farm Cash Receipts (US Dollars x 1000)**
1985	420,157	**2001**	388,167
1986	276,540	**2002**	478,728
1987	317,666	**2003**	440,693
1988	368,961	**2004**	436,195
1989	313,870	**2005**	360,935
1990	341,176	**2006**	460,832
1991	340,422	**2007**	658,733
1992	332,217	**2008**	906,681
1993	266,355	**2009**	820,567
1994	333,102	**2010**	1,029,955
1995	474,347	**2011**	1,340,287
1996	509,535	**2012**	1,617,862
1997	435,216	**2013**	1,429,450
1998	385,059	**2014**	1,155,599
1999	458,786	**2015**	N/A
20000	408,393		
Source: Statistics Canada 2015c.			

As the information presented in table 4 demonstrates, farm cash receipts, or the cash income received from the sale of this particular commodity, suffer from a high degree of volatility and are subject to many factors that significantly impact their value. For instance, commodity prices as well as domestic and international market conditions can impact the income levels of maize farmers in Ontario. Between 1985 and 1996, farm cash receipts of Ontario maize farmers were, on average, $ 357,862 million. The value of farm cash receipts were strong in the mid-1980s, but fell significantly from $ 420,157 million in 1985 to $ 276,540 million in 1986, hovering around $ 335,718 million before falling once again to $ 266,355 million in 1993. Between 1994 and 1996, farm cash receipts for Ontario maize farmers increased once again to $ 509,535 million. In 1997, the year Brookes and Barfoot argue that Canadian farmers began experiencing the economic benefits of cultivating Bt maize, farm cash receipts had fallen slightly to $ 435,216 million and in 1998, two years after widespread cultivation in Ontario, they had fallen once again to $ 385,059 million. In spite of arguments suggesting that farmers would experience almost immediately the economic benefits of cultivating transgenic maize, over the decade spanning from 1997 to 2007, the farm cash receipts for Ontario maize farmers were highly inconsistent and did not reflect proponents' initial predictions. In fact, while they reached a high of $ 458,786 million in 1999, they fell to $ 388,167 million in 2001, recovering slightly in 2002 only to fall once again to $ 360,935 million in 2005, a record low since 1994. A positive upward trend in farm cash receipts received by Ontario maize farmers in the post-Bt maize era can be identified however, beginning in 2006. At this time, farm cash receipts began to increase significantly from $ 460,832 million to $ 1,029,955 billion in 2010 and $ 1,429,450 billion in 2013. However, in 2014 they fell once again, albeit slightly, to $ 1,155,599 billion, representing the inherent volatility of commodity production in Canada.

While the generally upward trend in farm cash receipts would seem to suggest that Ontario maize farmers are experiencing an increase in farm level profits as a result of the widespread adoption of Bt maize throughout the province, upon careful examination it becomes apparent that, far from being as significant as proponents like Brookes and Barfoot (2006, 2014) imply, the economic benefits incurred by maize farmers in Canada have been sporadic and moderate at best. In fact, the significant increase in farm cash receipts from $ 1,029,955 billion in 2010 to $ 1,617,862 billion in 2012 was largely caused by favourable market conditions and had little to do with the type of maize being cultivated. Prices that Ontario maize producers receive for their products are highly dependent upon the United States, as they dictate the market as the world's largest maize producing nation (Atkins 2014). In 2012, severe drought conditions in a number of maize producing areas in the United States, combined with poor growing conditions in Europe and Australia, drove the price of Canadian maize to a historical high (Agriculture and Agri-Food Canada 2013). Similarly, as Atkins (2014) states, once growing conditions in the United States and the maize market stabilized, between 2013 and 2014, prices fell 27 percent, causing many Ontario farmers to sell their crops for less than the cost of production.

As Skogstad (2007), Brinkman (2002) and other Canadian scholars ascertain, although farmer's productive capacities may have increased as a result of the technocratization of this agricultural sector, not all of them have reaped the supposed economic benefits of adopting new technologies. This is also evident in relation to a decrease and sharp fluctuations in farmers' net incomes[16] over the last three decades. While Statistics Canada does not gather information on net income according to farm type, due to the prevalence of maize production in Ontario and the fact that as of 2011, 61.7 percent of all maize cultivated in Canada was grown in Ontario (Hamel and Dorff 2015) the net farm income of Ontario farmers in general further indicates that the economic potential of this new agricultural biotechnology may have been over estimated.

Table 5 – Net Farm Income of Ontario Farmers (1985-2015)

Year	**Net Farm Income (Dollars x 1000)**	**Year**	**Net Farm Income (Dollars x 1000)**
1985	674,726	**2001**	408,032
1986	638,971	**2002**	439,838
1987	853,359	**2003**	211,989
1988	790,339	**2004**	643,266
1989	865,981	**2005**	435,064
1990	558,678	**2006**	-10,677

[16] The difference between a farmer's cash receipts and operating expenses (Statistics Canada 2008).

Table 5 Continued– Net Farm Income of Ontario Farmers (1985-2015)			
Year	**Net Farm Income (Dollars x 1000)**	**Year**	**Net Farm Income (Dollars x 1000)**
1991	356,446	**2007**	142,662
1992	395,659	**2008**	370,068
1993	472,282	**2009**	9,818
1994	333,463	**2010**	527,090
1995	276,295	**2011**	1,343,518
1996	450,295	**2012**	1,184,438
1997	236,688	**2013**	1,404,187
1998	170,337	**2014**	N/A
1999	164,956	**2015**	N/A
20000	215,481		
Source: Statistics Canada 2014			

As table 5 illustrates, in 1985, net farm incomes were $ 674,726, 000, over two times the $ 236,688, 000 they were in 1997, the year after Bt maize appeared in Ontario. Between 2010 and 2011, over a decade after the widespread implementation of Bt maize, the net farm income of maize farmers in Ontario rose from $ 527,090,000 to $ 1,343,518,000 but fell once again to $ 1,184,438,000 in 2012. While economic arguments may have some degree of semblance, overall, much like yield impact and sustainability arguments, the claims made in support of Bt maize have been overstated by the proponents of this new technology.

In addition to outlining the changing role of the state and the rise of agricultural biotechnology, this chapter has also illuminated the impacts of this new technology on the Canadian agricultural sector. As a careful review of the evidence suggests, while the major arguments used in support of the widespread implementation of agricultural biotechnology have some degree of validity, it becomes increasingly clear that their merit is often overstated. The next chapter will focus on the case study of Bt maize production in Punjab, India.

Chapter Four: Agricultural Biotechnology in India

As outlined in the previous chapter, while arguments used in favour of the widespread implementation of Bt maize appear to have some degree of empirical validity, the merits of this new technology are often overstated by proponents. To determine whether or not this is the case in Punjab, India, this chapter will begin with an examination of the economic relevance of the agricultural sector, the changing role of the state and the rise of agricultural biotechnology. It will then examine the impacts of Bt maize in relation to major supporting arguments, drawing upon relevant examples from Argentina, another developing nation that has been cultivating Bt maize since 1998.

A Brief History of Indian Agriculture

India, the second most populous country in the world, places a great deal of importance on its agricultural sector. With a population of just over 1 billion, or 16 percent of the global population, India has a demographic make-up that is prominently rural in nature. In 2004, 150 million households in India, over 70 percent of the total population, lived in rural areas. 80 percent of labourers in these rural areas are employed in agriculture; many of them rely on this sector for the provision of their basic subsistence (Shiva and Jalees 2006, 57 & 260; Topalova 2007, 311; Dev 2003, 133). In fact, every 4th farmer in the world is Indian (Shiva 2000, 7). While the rural population of India has decreased significantly since gaining independence in 1947, as a result of urbanization, agricultural production still plays a significant role in the Indian economy and is a source of wealth and employment. Although agriculture's contribution to GDP has decreased from 23.0 percent in 2000 to 17.0 percent in 2014 (World Bank 2015a), it plays a far more important role in the economy than its share of GDP suggests.

According to the World Bank, India is still considered a global agricultural powerhouse (World Bank 2012a; Swain 2014). To examine the impact that agricultural biotechnology has had in India, it is important to begin with a brief history of Indian agriculture starting with the pre-colonial era.

Prior to colonization by the British, agriculture in India was plagued by labour alienating feudal land relations and primitive technologies, causing it to be highly labour intensive. As a result, it is often argued that during the pre-colonial era, Indian agriculture was highly inefficient and in a state of stagnation. Three quarters of the population was dependant on agricultural production for their livelihood and the provision of their basic subsistence. As such, the majority of the food that was produced in villages was consumed by the population residing in that area (Ahuja 2006, 1). Since farming was a subsistence occupation, food crops dominated agricultural production, specifically paddy rice, wheat and millet or cereal grains. Traditional agriculture was based on locally available inputs, particularly seeds, which farmers saved, replanted and gradually improved upon over time. For many scholars, Indian agriculture in the post-colonial era was backwards in every respect, which resulted in low productivity levels per hectare and numerous famines between 1870 and 1900 that claimed a total of 30 million lives (Ahuja 2006, 4; Tripathi and Prasad 2009, 64; Swaminathan 2006, 171).

While food production pressures were indicative of the pre-colonial era, India also suffered a number of famines under colonial rule. For several decades prior to independence, agricultural growth lagged behind population growth. Between 1900 and 1945 the population increased by 38 percent while agricultural production only increased by 12.6 percent (Nath 1969, 353). Between 1860 and 1908, 20 famines were reported by the *Famine Commission* and in 1943, the Bengal famine, one of the worst famines in India's recorded history claimed the lives of between 1.5 and 3 million people (Ahuja 2006, 3).

After gaining independence from Britain in 1947, agriculture remained the main source of national income and occupation in India, comprising 55 percent of GDP and 70 percent of the workforce (Tripathi and Prasad 2009, 63; Bhaumik and Rashid 2013, 125; Nath 1969, 348). However, slow agricultural growth and stunted rural development were daunting issues that persisted throughout the 1950s and 1960s. While government interventions in agricultural sectors in India date back to the Grow More Food Campaign(s)[17] of the early post-independence period, under Prime Minister Jawaharlal Nehru (1947-1964), public sector efforts to spur agricultural outputs and yields increased significantly. For Nehru, agricultural productivity was not simply a matter of economics. He believed that it was inherently dependent upon the political, economic and social transformation of rural life in India, which would be guided by the hands of the state through a clear set of ideological and political goals designed to spur agricultural development (Varshney 1998, 30; Brass 1994, 36). As Varshney states, during the time of Nehru's rule the situation of farmers was austere and food production output was low. As a result, his agrarian model was based on a strategy of production, equality and was centered on three key policies: the promotion of local self government at the village level, land and tenancy reforms designed to incentivise tillers to produce more, and the creation

[17] This campaign originated in 1942 as a way to increase the production of foodstuffs in India. In 1943, the central government promised to assist with the supply of inputs including manure and improved seed varieties, as well as the use of tractors and small irrigation schemes. Although the campaign was a short-term measure to increase food production during wartime, it was the first step in planning for a long-term increase in food production in India, emphasizing the centrality of the state in achieving this goal (Srinivasan 2007, 25; Knight 1954, 122-148; Mooij 1998, 80; Chopra 1988, 67-75).

of farm and service cooperatives that provided farm machinery, credit, seeds and other inputs (1998, 30-34). Even after Nehru's death in 1964, government expenditure in the agricultural sector continued to increase. Between 1961 and 1966, public sector expenditure on agriculture and its allied activities was 12.7 percent, however it increased significantly to 16.7 percent and only fell slightly to 14.7 percent between 1969 and 1974 (Government of India 2011, A40-46). Between 1965 and 1967, there was a steep drop in agricultural output and the production of food grains caused by widespread drought and unfavourable weather conditions in primary food producing regions (Nath 1969, 348). The production of food grains fell from 89 million metric tons to 72 million metric tons in less than two years (Nath 1969, 348). Due to the severity of food shortages at this time, imports of food grains were brought in from the United States. Between 1961 and 1969, 3 million tons of American wheat arrived in India as a result of the PL-480 Programme[18]. Mujumdar refers to the 'nightmare and tragedy' of the absolute shortage of food grains supplies in the 1960s which, as he states, "led to an almost obsessive concern of development policy with the attainment of food self-sufficiency" (2006, 31-32). Beginning in 1967, the country witnessed several agrarian reforms and institutional changes aimed at "regeneration after a period of stagnation" (Tripathi and Prasad 2009, 66). The adoption of a new agricultural strategy based on modern farming practises and biochemical and mechanical innovations led to an overall increase in yields from 710 kg/ha in 1961 to 1,382 kg/ha in 1991 and was responsible for the generation of self-

[18] Also known as the *Agricultural Trade Development and Assistance Act* or 'food for peace' the PL-480 Programme was an American foreign aid policy initiated during the Eisenhower administration. It permitted the president to authorize the shipment of surplus commodities to 'friendly' nations on concessional or grant terms (Mujumdar 2006, 31; US Department of State 2013). The establishment of this aid program paved the way for continued foreign intervention by the United States in the Indian agricultural sector.

sufficiency in the production of food grains, which grew at an average rate of 2 percent per annum during this period (Rao and Deshpande 1986, 102; Alam 1994, 11). Due to the pressing need to feed a rapidly growing population, increasing per capita food production was a daunting task and Green Revolution technologies were heavily advocated by governments at the national as well as the state level. This preoccupation shaped agricultural development policies during the 1960s and 1970s, overshadowing the costs of new hybrid technologies, the starkest of which were environmental. While heavily promoted as being an effective strategy for improving the stability and viability of agricultural production, Green Revolution technologies have adversely affected the environment. They have done so through the promotion of intensive mono-cropping, resulting in a reduction in biodiversity, an increase in invasive pest, disease and weed problems, an unsustainable dependence on non-renewable resources and an increased reliance on dangerous synthetic inputs that reduce soil quality, pollute ground water tables and impact the health of farmers who face regular exposure (Pinstrup-Andersen and Hazell 1985, 20-21; Conway and Barbier 2009, 11 & 21). However, as the ecologically destructive nature of new hybrid technologies would not become clear until much later, the government of India, blissfully unaware of what was to come, maintained their involvement in the promotion of the Green Revolution and the proliferation of its technologies.

The Green Revolution in India was initially spurred by the notion that "the implements and tools used by farmers were crude, primitive and obsolete; impeding the development of modern agriculture" (Tripathi and Prasad 2009, 77). Hybrid dwarf and high yield varieties of rice and wheat as well as industrial fertilizers and pesticides were implemented with the ultimate goal of increasing agricultural production. It was argued that this technology would improve production by making it more efficient through the use of time saving technologies, by reducing the cost of production and by limiting the expansion of land required for cultivation. While private investment in agricultural sectors was significant at this time, the state still played an active role. Public investment for agricultural development increased during the Green Revolution and persisted throughout the decades that followed it. Government interventions were numerous, extensive, and varied in scope during this era. The major categories of intervention were related to public food grain distribution systems, the attainment of self-sufficiency in food grain production by improving productivity, the adoption of high yield seed varieties and external inputs, and international trading, agricultural markets and taxation (Srinivasan 2007, 21-22). The rationale for government interventions during this era was based on the notion that the potential costs and benefits of adopting high yield technologies were not fully known or understood by farmers. As such, without state support through generous subsidies, along with coercive measures, it was feared that farmers would choose not to adopt them (Srinivasan 2007, 26; Oya 2005). The most prevalent examples of Indian agricultural development and transformations over the past fifty years, even those considered to be destructive or discriminatory, have relied on some form of state support measures.

Throughout the 1970s and early 1980s, both the central and state governments played an integral role in agricultural sectors. In the period between 1974 and 1979, the share of public sector expenditure on agriculture and its allied activities was 12.3 percent (Government of India 2011, A40-46). While agriculture is constitutionally the jurisdiction of state governments, during this period, the central government intervened on a far larger scale than ever before. Due to the importance of agricultural production for economic development, the central government played an active role in a concerned effort to “strengthen policies…for the provision of agricultural credits, inputs, the promotion of new technologies and the stabilization of agricultural prices and incomes” (Rao and Deshpande 1986, 102). Due to the scale of agricultural operations and fluctuations in demand, supply, output, commodity prices and farmers’ income, many economists (Rao 1998; Patnaik 1998; Balakrishnan 2000) have argued that state involvement in agriculture is justified, as it should never be left completely at the mercy of the free-market (Eashvaraiah 2001, 133). As such, state intervention took several different forms. There was a considerable increase in support subsidies, particularly in the areas of technical infrastructure development, water and irrigation, farm inputs and electricity (Tripathi and Prasad 2009, 68; Eashvaraiah 2001, 331; Road and Bhavan 2011, 335; Srinivasan 2007, 25; Murgai, Ali and Byerlee 2001, 212). A great deal of funding went into research, development and the promotion of human capital and understanding in burgeoning technological sectors (Eashvaraiah 2001, 133; Murgai, Ali and Byerlee 2001, 212).

However, beginning in the late 1980s and early 1990s, Indian agricultural sectors experienced sweeping economic reforms that were a stark deviation away from the previous post-independence interventionist paradigm that emphasized the importance of food security and national food sovereignty in the adoption of agricultural policies (Storm 1997, 426; Topalova 2007, 293-295; Dev 2003, 133). Between 1980 and 1985, the share of public sector expenditure on agriculture and its allied activities dropped significantly to 6.1 percent and remained stagnant at 5.8 percent between 1985 and 1992 (Government of India 2011, A40-46). In 1997, agriculture comprised a mere 5.2 percent of total government expenditure and by 2002 it had fallen once again to 4.8 percent (Government of India 2011, A40-46). These sweeping economic and policy reforms came as a response to India's external payment problems and the depreciation of the rupee. By 1991, India had garnered poor capital outflows and an inability to obtain commercial bank loans due to their poor credit rating; placing the country in a difficult and rather desperate situation (Topalova 2007, 295; Ingco and Kandiero 2003, 8). In August 1991, the government of India reached a standby agreement with the World Bank and IMF under the World Bank Structural Adjustment Loan that was granted based on the condition that India adopt widespread economic and structural reforms (Topalova 2007, 295-296; Nayyar and Chang 2005, 7). Many scholars refer to what happened in India as an economic 'shock therapy' (Topalova 2007, 305) as the new policy package, centered on trade liberalization, was implemented swiftly to avoid debate and opposition.

While India maintained a credible record during the 1980s, production of food grains began to wane once again in the 1990s and the annual growth rate fell from 3.5 to 1.7 percent (Eashvaraiah 2001, 337; Tripathi and Prasad 2009, 65; Bhaumik and Rashid 2013, 130). Spurred by the implementation of macro-economic stabilization policies, state involvement and investment in agricultural began to disappear. The very notion of state intervention became vexatious, portrayed as a drain on the economy and subsequently reduced in favour of a neoliberal, market driven development strategy. Between 1980 and 1997, the outlay of funds dedicated to agriculture and allied activities dropped from 16.4 to 4.9 percent of the total state expenditure (Shiva and Jalees 2006, 61). As Mathur, Das and Sircar's (2006) examination of the retrenchment of the state and its involvement in Indian agriculture suggests, the stagnation in government expenditure has contributed to a slowing of agricultural production.

Currently, over 60 percent of the workforce in India is engaged in agriculture (Tripathi and Prasad 2009, 64; Mathur, Das and Sircar 2006, 5327; Mujumdar 2006, 32) while the government continues to minimize its involvement in this sector. Between 2002 and 2007, the share of public sector expenditure on agriculture and its allied activities was only 3.9 percent, falling once again between 2007 and 2012 to 3.7 percent (Government of India 2011, A40-46) According to Mather, Das and Sircar, between 2003 and 2006, government subsidies in this sector were nearly cut in half (2006, 5330). Shortly after being elected to office in 2014, Prime Minister Narendra Modi cut the minimum government support-price for staples, successfully curbing inflation but doing little to ensure transitional support for farmers affected by the adjustment (The Economist 2015). With India's emphasis on a liberalized, market based system, public investment in agriculture has been steadily declining while private sector investments have increased dramatically. Private investments are significantly higher than the investments made by the public sector, the latter contributing 25.4 percent in 2006 (Road and Bhavan 2011, 334; Mather, Das and Sircar 2006, 5330).

While public sector institutions played a dominant role in bringing the technologies of the Green Revolution to farmers, "private corporations have come to occupy a central place in the production of GM seeds" (Road and Bhavan 2011, 445). As Mallick et al.'s (2011) *Industrialization of Seed Production: Implications for Agriculture in India* illustrates, although the biotechnological revolution is often cited as a second

Green Revolution, there are three stark differences that have bearing on the risks and benefits of adoption. While research for Green Revolution technologies was highly concentrated in the public sector, patents are now placed on processes and products, indicating a shift towards a proprietary research process. Unlike Green Revolution technologies, which focused on problems in developing countries, the biotech or 'gene revolution' focuses on research that in many cases is arguably more suitable for industrial countries (445-446). A major contrast between the previous and current agricultural revolution in India is that modern research is concentrated in the private sector, which is dominated by transnational corporations who use IPR and patents to create a monopoly within the Indian seed sector. Contrary to its predecessor, the current agricultural revolution has fewer characteristics of a national project. While the Department of Biology, established in 1986, is at the center of the agricultural biotechnology nexus in India, its influence in research and development and in the regulatory realm has become marginal and highly polluted by conflicting interests as members of their committees hold esteemed positions at transnational biotech corporations like Monsanto (Scoones 2006, 73 & 257-258; Alam 1994, 15). As such, a new relationship between farmers, the state and seed companies has been created and must be examined.

The Rise of Agricultural Biotechnology in India

Seeds are the primary means of production in agriculture; the first and arguably the most important link in the food chain. As such, it is often argued that those who dominate the seed market control the food supply. Beginning in 1988, the World Bank waged an attack on the seed sector in India, a sector that it once funded through national seed projects, demanding that it be dismantled in favour of private sector seed banks

(Shiva and Jalees 2006, vii). It was through the liberalization of the seed sector that transnational corporations gained an unprecedented foothold in this sector. For many scholars, this shift represents the capitalization of this once public sector and is considered to be a form of corporate feudalism, “a handing over of the seed sovereignty of the country to foreign participation” (Shiva and Jalees 2006, vii & 4).

The introduction of this new seed policy liberalized imports and encouraged foreign investment in the seed sector. Over the course of the 1990’s, extensive agricultural reforms led to a rapid increase in the presence of transnational corporations, placing an emphasis on corporate profit over food security. In 1993, the World Bank concluded that investing in public sector seed banks was inherently unproductive, which provided private seed companies with the unhindered ability to generate a monopoly. In 1985, only 9 private seed companies were engaged in research and development. By 1995, the number had increased to 40 and by 2006 there were more than 80 (Shiva and Jalees 2006, 7; Scoones 2006, 35). Transnational biotech corporations like Monsanto have significant research budgets, some of which are greater than the budget of the entire Indian Union (Sahai 1996, 443; Gupta 2002, 2767; Herdt 2006, 269). Between 1995 and 1996, Monsanto spent (US)$ 9 billion in a crusade to acquire interests in biotechnology and seed companies globally (Glover 2008, 27; Glover 2010, 82; Scoones 2006, 160). As Shiva and Jalees state, the *Seed Act 2004* has “further undermined the role of state governments and offered the promise of a monopoly to private seed industries” (2006, 27). While the central purpose of public investment in agricultural sectors, including the seed sector, is to sustain the livelihood of the Indian population, the goal of the private sector is to maximize profit first and foremost. The result of the emergence of agricultural biotechnology has been, as Moore states, a robin hood reversal in which one steals resources from the poor to give to transnational biotech corporations (2010, 391-395).

Prior to 1988, an established network of public institutions, including agricultural research centers and universities dominated the seed sector, making significant contributions in research and development and ensuring that conventional and even some hybrid seed varieties remained as a public resource. Significant government efforts also went into research and development to ensure national competitiveness and exploit the country's agricultural competitive advantage in the area of research intensive, high-technology industries. This was particularly important in India since, as Anderson and others state, "developing nations' comparative advantage, or their ability to become competitive in the global market by providing a good more effectively or efficiently than other nations, hinges on the development and exploitation of their agricultural sector" (2003, 6; Storm 1997, 425; Bureau et al. 2005, 8; Beirle 2002, 1090; Vyas 2003, 106-107). In an effort to remain competitive in this burgeoning sector the federal government began funding research in agricultural biotechnology through a number of Indian universities. It was originally believed that becoming globally competitive in the field of biotechnology and seed production required extra support to government institutions and the preservation of a vision of science led development and modernization that would generate a lean, efficient and competitive agricultural sector in the new global knowledge-based economy (Road and Bhavan 2011, 20; Sahai 1996, 444; Scoones 2006, 27). When research and development was centered in Indian institutions and funded by the central government, the public sector had significant control over new technologies.

This was steadily eroded throughout the 1990s as research and development became dominated by the private sector.

The reduction of public sector investment in research and development has had an adverse impact on agriculture in India. This is due to the fact that, as Alam states, "local research and development and the capability of generating and adapting agricultural biotechnology greatly increases the ability for developing countries to benefit from this new technology" (1994, 65). Additionally, when agricultural technology is developed in the public sector, the government can be held accountable for its potentially adverse effects and unintended consequences. When developed in the private sector, there is no way to hold companies liable or accountable for their products and they absolve themselves of responsibility. As Srinivasan and others state, the gradual withdraw of the state has resulted in the stagnation of agricultural research and development in India (2007, 3; Jansen and Gupta 2009, 437). Transgenic technologies developed using pubic research would likely be compositionally different and serve a fundamentally different purpose than those generated by private sector efforts.

Along with China and the Philippines, India accounts for 80 percent of small scale farmers planting biotech crops globally (Shrivastav 2013). Incentives for farmers are frequently used to entice them into adopting new technologies (Gupta and Chandak 2004, 4). Currently, the authority to regulate GMOs is divided between the Department of Biotechnology, a subset of the Ministry of Science and Technology, and the Ministry of Environment and Forests and the deliberate release and commercialization of GM products is overseen by the Genetic Engineering Approval Committee under the Ministry of Environment and Forests (Gupta 2002, 2763). However, as a result of the stark neoliberal transformation that began in the early 1990s, transnational biotech corporations like Monsanto are able to exploit their power and clout, permeating state policy and decision making processes to protect their own vested interests.

The Impacts of Agricultural Biotechnology in India

Maize is a highly important staple crop in India. It is cultivated by more than 12 million farmers scattered throughout the country (James 2003, 48). Although it is often overshadowed by wheat and rice production, maize is one of India's three most prevalent crops. Currently, India is 6th in the world for maize production and accounts for 2.5 percent of the total global production (Hamel and Dorff 2015). Maize is prominently grown in the northern part of the country. Consequently, Punjab, a state in the northwest, is the focus of this study. In Punjab, which is the 4th smallest state in India, 72 percent of the population live in rural areas, 60 percent of the labour force in employed in agriculture, and crop production is the dominant sector (McGuirk and Mundlak 1991, 16). Maize production plays a significant role in this region, as it has been grown here since the end of the Second World War when a breeding program was launched by the Indian Council of Agricultural Research (The Rockefeller Foundation n.d.). It is estimated that currently, 90 percent of the maize market in India is controlled by the private sector (Shiva and Jalees 2006, 16).

The population of India continues to grow, as does per capita income. As a result, it is projected that demands for food grains will increase from 192 million tons in 2000 to 345 million in 2030 (Road and Bhavan 2011, 4). To meet this demand, food grain production must increase at a rate of 5.5 million tons annually (Road and Bhavan 2011, 4). For many scholars, agricultural biotechnology is the way to do this. However, while the adoption of agricultural biotechnology is touted as a way to ensure greater food security, the number of undernourished people in India is amongst the highest in the world, increasing by over 18 million between 1990 and 2000 (Srinivasan 2007, 2-3; Mujumdar 2006, 31). As Ghatak and others state, it can be argued that India has yet to reap the full benefits of agricultural biotechnology (2010, 132). As such, it is important that the impacts of Bt maize in Punjab, India be examined against the claims proponents use in support of the widespread adoption of this new technology: an increase in overall yields, a reduction in required inputs and the generation of higher farm level profits.

Maize has been an important staple crop for the entirety of India's agricultural history. As the population continues to grow and becomes more affluent, food security concerns become all the more prevalent, spurring an increased demand for maize production. In 2000, the production of maize increased significantly to 11.5 million tons compared to the 4.1 million tons cultivated four decades prior in 1960 (Joshi et al. 2005, 4). This increase is greatly attributed to the widespread adoption of hybrid varieties In India, major maize growing areas are divided according to their level of production into traditional maize growing states (Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh), which account for the majority of crop production and non-traditional maize growing states (Karnataka, Andhra Pradesh and Punjab). In 2001, as much as 70 percent of all maize grown in India was grown in traditional maize growing states (Joshi et al. 2005, 4). Efforts to increase production in non-traditional maize growing states has resulted in the unfettered promotion of transgenic varieties throughout the 1990s and early 2000s and their production increased at an annual rate of 9.25 percent (Joshi et al. 2005, 5). In fact, evidence put forth by Indian scholar Joshi and his colleagues (2005) suggests that yields in these areas were significantly higher than traditional maize producing states as a direct result of the promotion of alternative production methods and privately owned agricultural biotechnology.

While trials of Bt maize have not be cultivated in India as long as in Canada, the environment ministry's Genetic Engineering Approval Committee first gave the green light to field trials of Monsanto's Bt maize in December 2010 when the government of Punjab began showing an interest in introducing it as a commercial option for farmers (Yadav 2012). In 2012, the government of Punjab allowed Monsanto to establish extensive research and development efforts and begin field testing of the new technology within the province (Yadav 2012). However, before the result of those trials could be released publically, Prime Minister Manmohan Singh (2004-2014) placed a moratorium on transgenic crop trials, marking the suspension of this controversial technology. This decision was made in light of extensive protests from advocacy groups expressing their concern for the unknown health, environmental and social impacts of these new technologies; particularly the threat of placing food production in the hands of transnational biotech corporations like Monsanto (Chandrashekhar 2014). As Sanjay Kumar's article in *Nature* in May 2015 states however, the new Indian government led by Prime Minister Narendra Modi (2014–present) has begun to ease its stance on GM crop technology and has once again allowed trials to commence after a two year hiatus. While the results of Bt maize field trials were scheduled for public release this year (2015), the politically charged nature of the GMO debate in India has stalled the release of this information, making it difficult to truly measure the impacts of Bt maize in Punjab for the purpose of this study (Kumar 2015, 138-139). Over the past year, extensive crop trials have recommenced in the state of Punjab. However, as Kumar states, the government appears reluctant to engage in transparent debates about the nature of these trials and their results have not yet been released to the public in spite of previous promises (2015, 138-139). The suspension of field trials in India does not invalidate the central purpose of this study. However, as a result, it must examine the nature of Bt maize in India using alternative means. Many researchers are fuelling the debate by solidifying claims that this technology is performing well in the field and citing the experiences of farmers in the developing nation of Argentina as further proof of the potential benefits that are likely to be incurred by transgenic maize farmers in India (Brookes and Barfoot 2014; Kumar 2015, 138-139). For the purpose of this study, the central arguments used in support of this technology will be compared against the experiences of farmers in Argentina to discern whether they are empirically founded and to make inferences about the nature of the potential benefits that may also be experienced by maize farmers in Punjab.

A central question arises: how can inferences be made about the experience of farmers in India based on their counterparts in Argentina? First of all, maize production in these two countries is similar and has been fraught with success as well as failure. In addition to its status as one of the largest countries in South America, Argentina, like India, is one of the world's largest maize producers. As of 2011, it was ranked 4th in the world for maize production, accounting for 2.7 percent of the total share of global production (Hamel and Dorff 2015). As Brookes and Barfoot (2014) state, the greatest benefits from Bt maize technology will be experienced in areas with significant production like India and Argentina. Although the numbers are declining, Argentina is similar to India in relation to the importance of its agricultural sector, which continues to play a significant role in the economy by generating 7 percent of the total GDP and employing 12 percent of the workforce (Schnepf et al. 2001; Garbulsky and Deregibus 2006). Also, like India, maize production is particularly important in Argentina, serving as an important staple crop due to domestic consumption demands. Due to significant international demands however, Argentina has also become a major maize exporting country and in 2002 alone it exported a total of 11 million megatons (James 2003, 46). Thus, in addition to fulfilling an important role in the promotion of food security for the country, through the exportation of surplus to other developing nations, maize cultivation in Argentina fills an important role in the promotion of global food security. Argentina was not always a major exporter of maize however and in many ways the success of this sector is often attributed to the widespread implementation of transgenic Bt varieties that began in 1998.

The socio-economic condition of farmers in both of these nations is also similar, as many of them are impoverished, depending on agricultural production for their livelihood while facing stark food insecurities. As such, farmers in India and Argentina both experience narrow profit margins that can be adversely affected by widespread technological change. Likewise, as a result of the shift to neoliberalism that occurred throughout the 1990s, farmers in Argentina and India experience similar pressures to adopt foreign technologies owned by Monsanto, which uses its power and clout to infiltrate policy and decision making processes in both countries.

In 1992, after significant unrest and political turmoil caused by a deepening economic crisis and hyperinflation attributed to the state interventionist paradigm of the former President Raul Alfonsin (1983-1989), President Carlos Menem (1989-1999) began liberalizing the economy under the auspice of the United States in an attempt to "rebuild Argentina's economic force in the international community" (Harvey 2005, 104). Menem, in the spirit of the neoliberal era of the late 1980s and early 1990s, opened Argentina's markets to foreign trade and capital flows, selling off and privatizing a number of state-owned enterprises and assets (Harvey 2005, 104). As a result of the extensive liberalization of Argentinean markets, much like in India, foreign companies like Monsanto, peddling their own patented hybrid and transgenic maize varieties, were able to establish a stronghold in the country's seed market beginning in 1998. Argentina, along with China, the United States and Canada, cultivates 99 percent of all transgenic crops and agricultural biotechnology has come to dominate the maze sector of the country. In 2012, 87 percent of crop plantings were of the insect resistant, Bt variety that is owned and controlled by Monsanto (Brookes and Barfoot 2014, 56). As Bt maize has been cultivated in Argentina for nearly two decades, particularly in the province of Buenos Aires, it serves as an effective case study for examining the impacts of this technology for farmers in developing nations. An examination of the experiences of farmers in Argentina will help determine whether the major arguments used in support of the widespread adoption of this technology are empirically founded, particularly in developing nations, serving as an important consideration for policy makers in India that are pushing for the adoption of this new technology.

As discussed in great length in the first chapter, one of the strongest arguments in favour of the adoption of Bt maize is its ability to generate an increase in overall yields. As James and Brookes and Barfoot state, the main impact on farm level profits for maize cultivators in Argentina has been via an increase in overall yields and this is likely to be the case in India as well. According them, maize farmers in Argentina experienced average yield impacts of between 8 and 10 percent between 1998 and 2004 (2003, 87; 2014, 56). Although they declined slightly between 2004 and 2014, yield impacts were still significant, averaging around 5.5 percent (James 2003, 87). The question remains however, have yield impacts been as significant as supporters of this new technology claim?

Table 6 - Average Crop Yields of Maize in Buenos Aires, Argentina (1985-2015)			
Year	**Average Crop Yields (Kg/ha)**	**Year**	**Average Crop Yields (Kg/ha)**
1985	4.267	**2001**	6.454
1986	3.457	**2002**	6.988
1987	4.478	**2003**	7.569
1988	3.694	**2004**	8.236
1989	4.594	**2005**	7.154
1990	4.650	**2006**	8.604
1991	5.116	**2007**	7.552
1992	4.460	**2008**	5.017
1993	4.498	**2009**	8.755
1994	5.037	**2010**	7.058
1995	4.526	**2011**	6.337
1996	5.817	**2012**	8.010
1997	7.258	**2013**	6.954
1998	6.058	**2014**	7.983
1999	6.100	**2015**	N/A
20000	5.836		
Source: Integrated Agricultural Information System of Argentina n.d.			

As table 6 indicates, since the adoption of Bt maize in Argentina in 1998, average crop yields have experienced an overall increase. However, like the case of Bt maize cultivation in Ontario, Canada, the impacts of this new technology in relation to its ability to increase yields have been overstated by proponents. Maize yields in Buenos Aires have experienced significant fluctuations since 1985, a trend that has persisted in spite of claims that the implementation of this new technology would generate immediate yield gains for farmers, reducing production risks and improving grain quality (Brookes and Barfoot 2014, 109). While average crop yields increased slightly from 6.058 kg/ha to 6.100 kg/ha during the first year of widespread cultivation (1998-1999), they fell once again in 2000 to 5.836 kg/ha. Between 2000 and 2006, there was a dramatic increase from 5.836 kg/ha to 8.604 kg/ha. However, they fell significantly once again in 2007 to 7.552 kg/ha and then again in 2008 to 5.017 kg/ha, reaching a low that had not been experienced since 1994, four years before the arrival of Bt maize on the Argentinean seed market. While average crop yields improved significantly in 2009, reaching 8.755 kg/ha, they fell once again to 6.337 kg/ha in 2011, only to increase once again in 2012 to 8.010 kg/ha. This rise in average yields was short lived however, as they fell once again to 6.954 kg/ha in 2013. While average maize yields appear to be increasing as of 2014 at 7.983 kg/ha, these results are only slightly more than the 7.258 kg/ha achieved in 1997, a year before the widespread adoption of Bt maize. Upon careful examination of maize yields in Buenos Aires, Argentina, it becomes increasingly apparent that while the general trend has been an increase in overall yields, the increase has been significantly overstated by biotech proponents.

Another argument that is used in favour of the widespread adoption of this technology is its ability to dramatically decrease required input levels. Contrary to India, in Argentina insecticides are not heavily relied upon as a pest management strategy for maize cultivation. While the use of synthetic insecticides in Argentina is far less significant than it is in other developing nations, it is significant none the less, particularly in relation to arguments that claim an overall reduction in required inputs. In fact, current research indicates that farmers are increasingly turning to synthetic insecticides for pest management are not, as it is commonly assumed, reducing their consumption as a result of adopting Bt maize. According to Warren and Pisarenko's (2013) examination of government and pesticide industry data, while the adoption of GM technologies like Bt maize initially spurred a reduction in synthetic inputs, they have been steadily increasing from 34 million litres in 1990 to more than 317 million litres in 2013. Currently, it is estimated that farmers in Argentina, 96 thousand of which are maize cultivators, apply 4.3 pounds of agrochemical concentrate per acre, which is more than twice what farmers in the United States apply (Warren and Pisarenko 2013; James 2003, 48). While a significant amount of this increase in pesticide use is attributed to the cultivation of other GM crops like soybeans, Bt maize is also identified as a major culprit, indicating that the promises of a widespread reduction in required inputs may have been overstated.

The final argument that is used in support of the widespread implementation of this technology is its ability to generate greater farm level profits. While information regarding the yield impacts of Bt maize in Argentina is abundant, information on the specific economic impacts of this technology is scarce. This is due to the fact that the main impacts on farm profitability have been through the generation of increased yields. As Brookes and Barfoot state however, due to the increased productivity of Bt maize cultivation in Argentina, the net impact on farm level profit margins over recent years have been between (US)$ 3 and (US)$ 36 per hectare (2014, 57). They estimate that at the national level in 2012, positive impacts on productivity generated by the adoption of Bt maize spurred an increase in profitability of nearly (US)$ 115 million and cumulatively, since its arrival on the seed market in 1998, Bt maize adoption has generated an estimated farm level income gain of (US)$ 495.2 million (2014, 57).

However, as Brookes and Barfoot's report also indicates, farmers in Argentina experienced little savings in relation to the cost of production relative to conventional cultivars. Between 1998 and 2006, the cost of production increased significantly by an average of between (US)$ 20 and (US)$ 22 per hectare due to additional seed costs (2014, 56). While positive farm level benefits of adopting Bt maize are often stated as being cut and dry, the cost of accessing and adopting this technology cannot be overlooked, particularly for farmers in developing nations. Since agricultural production is highly volatile and susceptible to biotic and a-biotic stress, the propensity for poor growing conditions to generate higher costs of production compared to farm level economic returns is a significant threat for farmers in the developing world.

What can be inferred from the experiences of maize farmers in Buenos Aires, Argentina in relation to the experience of Indian maize farmers? In relation to yield impacts, Bt maize has resulted in a slight increase in average maize yields, as between 1985 and 1997 it was only 4.76 kg/ha compared to 7.10 kg/ha between 1998 and 2014. However, as a thorough analysis of the data indicates, while there has been a generally positive trend in relation to yield impacts in the province Buenos Aires, Argentina, these impacts have once again been overstated by proponents like James (2002) and Brookes and Barfoot (2006, 2014). While it is likely that farmers in India will experience an increase in overall yields, it is also likely that they will not be as significant as originally predicted. In relation to a reduction in required inputs, as Brookes and Barfoot (2014) and James (2003) state in their reports, the effect that Bt maize will have in relation to environmental and economic impacts will vary based on the average insecticide expenditure of farmers. In Argentina, expenditure devoted to external inputs including insecticides is comparatively low at an average of between (US)$ 1 and (US)$ 2 per hectare and of the 2.4 million hectares planted in 2002, only 1 million hectares were infested by corn borers and rootworms (Brookes and Barfoot 2014, 109). Conversely, in India in 2002, of the 6.2 million hectares planted, 3.7 million hectares, over half of the area of production, was infested by stem borers, generating an estimated damage cost of Rs 1.35 million for maize farmers (James 2003, 74; Joshi et. al 2005, 21-22). In India, yield losses as a result of stem borers can be significant, ranging anywhere between 20 and 87 percent (James 2003, 89). Crop losses as a result of stem borers are even more significant in non-traditional maize growing areas like Punjab, where Bt maize is set to be heavily cultivated (Joshi et. al 2005, 22). As a result of this high level of infestation, it is frequently argued that while information from initial field trials are unavailable, the estimated gains from the widespread adoption of maize in relation to required inputs is likely to be significant (James 2003, 89). In fact, according to estimates by James (2003), the largest gains from implementing this technology will be experienced in relation to an increase in yields in countries like India that have significant hectarage, high levels of production and are particularly susceptible to borer infestations. In India alone, James (2003) estimates that the widespread adoption of Bt maize will result in yield gains of at least 0.7 million megatons (155). The generosity of this estimate is attributed to the creation of stable yield conditions as well as a reduction in required input levels due to the high levels of infestation in tradition and non-traditional maize producing states.

While the experience of Argentinean maize farmers in relation to required inputs is not directly applicable to India, which in all likelihood will probably be more accurately represented by the experiences of farmers in Ontario, Canada and their reliance on synthetic inputs to combat frequent infestations, the increased cost of seed inputs is highly relevant. Maize farmers, particularly those in the developing world, are "very sensitive and responsive to price relationships between crops and inputs which govern profitability" (Schnepf et al. 2001, 29). As a result, an increase in the cost of this technology will inevitably affect the farm level income of farmers in developing nations like India where farmers experience narrow profit margins and a plethora of biotic and a-biotic stresses. In developing nations, these stresses can make or break maize farmers each growing season and an increase in seed costs could significantly affect the farm level income of farmers who choose to cultivate Bt maize over conventional cultivars. While the true economic impact of Bt maize technology in India remains to be seen as field trials have dwindled, recovering only recently, and their results have yet to be made public, it is likely that farmers in India will experience modest economic gains as a result of a reduction in required input levels. However, it is likely that these gains will be offset by an increase in the cost of GM seed inputs.

The most significant correlation that can be drawn between these two developing nations is their dependency on foreign technology. Like Argentina and other developing nations, agricultural in India has become highly dependent on western technology, investment and expertise. However, as Mallick et al. state, the transfer of biotechnology from industrial countries ultimately ignores the socio-economic specificities of developing countries (2011, 446). According to biotech proponents, India stands to gain proportionately more than other developing countries from reforming their agricultural sector and adopting new technologies (Anderson 2003, 6; Brookes and Barfoot 2006, 2014). A report by the Expert Group on Agricultural Indebtedness, appointed by the Ministry of Finance, claims that Indian agriculture is in a period of severe crisis that has assumed a level of seriousness not witnessed since the mid 1990s (2007, 13; Srinivasan 2007, 2). Much like the implementation of Green Revolution technologies, the implementation of agricultural biotechnology in India is driven by the overwhelming need to feed a growing population. As a result of ever increasing food production pressures and constraints, agricultural biotechnology is being touted as a potential solution. While the previous government suspended field trials of Bt products, due to the power and clout of transnational corporations like Monsanto, coupled with the severity of food security concerns, it is likely that the support needed to spur the widespread implementation of this new technology will be mobilized. As such, it is important that the experiences of farmers in the developed as well as the developing world be examined and compared in an attempt to discern if the major arguments that are used in support of this new technology are empirically founded and determine whether or not the widespread adoption of Bt maize in India serves as an appropriate and effective strategy for agricultural development.

As outlined in this chapter, agricultural production in India has undergone a stark transformation since the neoliberal shift in the early 1990s. As a result of the retrenchment of the state and the liberalization of markets, transnational corporations like Monsanto have permeated the agricultural sector in India, pushing agricultural biotechnology as a way to address ever increasing food production pressures. As a careful analysis of the experience of farmers in Punjab indicates, supported by the experiences of farmers in Buenos Aires, Argentina, while the major arguments used in support of the widespread implementation of Bt maize appear to have some empirical validity, the merits of this new technology are often overstated by proponents. The next chapter will compare and contrast the experiences of farmers cultivating Bt maize in Ontario, Canada and Punjab, India.

Chapter Five: A Comparison of Agricultural Biotechnology in Canada and India

As indicated in the previous chapter, which served as an overview of the experiences of farmers cultivating Bt maize in Punjab, India, while the major arguments used in favour of the widespread adoption of this technology have some degree of validity, they are often over stated by proponents. The central purpose of this chapter is to compare and contrast the experiences of farmers cultivating Bt maize in Canada and India and examine the impacts of this new technology in the developed and the developing world. It will begin with an examination of the main arguments used by biotech proponents and conclude with an overview of the role that socio-economic conditions play in the implementation and governance of this new technology.

Upon careful examination of the evidence presented in the previous chapter it becomes increasingly clear why debates surrounding the widespread implementation of agricultural biotechnology are so highly polarized. The case study of Bt maize in Ontario, Canada and Punjab, India, supported by evidence from the experiences of farmers in Buenos Aires, Argentina, has served as an effective examination of the impacts of this new agricultural biotechnology. However, a central question remains unanswered: are the major arguments used in favour of the widespread adoption of agricultural biotechnology empirically founded based on the experiences of farmers cultivating Bt maize in the developed and developing world? What becomes apparent almost immediately is the tendency for proponents to overstate the merits of this new technology. While it simply cannot be argued that maize farmers in both the developed and the developing world did not experience, at the very least, modest gains as a result of cultivating transgenic cultivars, many of the gains predicated by biotech supporters are far greater in theory than they are in praxis. While the overall merit of this new technology cannot be dismissed, countries and farmers alike should err on the side of caution when they are assessing the potential impacts of adopting Bt maize, as they are likely to be greater on paper than they are in the field.

In relation to the ability of Bt maize to generate an increase in overall yields, it would appear that in major maize producing areas in developed and developing nations, farmers have experienced, at the very least, a modest increase in overall yields. While opponents of this technology assert, often without the support of empirical evidence, that “yield losses not gains have been associated with transgenic crops compared to the best available conventionally bred cultivars” (Shiva and Jafri 10, 2003; Moore 2010, 390), the case study of Bt maize in Canada and India has illustrated the folly of this assessment. In Canada where Bt maize has been cultivated for well over a decade, evidence suggests that farmers have experienced an increase in average yields. Likewise, while the field trials of Bt maize in Punjab, India have not been released publically, the experiences of maize farmers in Argentina indicate that farmers in India will likely experience at least modest yield increases if they switch to the transgenic, Bt variety.

In relation to the ability of Bt maize to generate a reduction in required inputs, evidence suggests that the adoption of maize already containing the Bt gene has resulted in a reduction in the need to apply synthetic inputs like insecticides. While the experience of farmers in Argentina proved to be an outlier, considering that the use of insecticide does not play an integral role in farmer’s pest management strategies, the experience of Canadian maize farmers serves as proof of the validity of this argument. It is likely that farmers in India will experience a reduction in required inputs as well, as maize producing areas that are more prone to infestation will see the greatest merit in relation to a decrease in required inputs. In Canada alone, the adoption of Bt maize has helped generate a significant decrease in required inputs and it is estimated that the experience of maize farmers in India will be reminiscent of this. The evidence presented in the previous chapter would seem to suggest that the widespread implementation of Bt maize may have some merit in relation to the adoption of sustainable agricultural development strategies now and in the future.

Economic arguments that are often invoked in support of the widespread adoption of Bt technology, specifically the ability to generate an increase in farm level profits, are far more difficult to prove empirically. This is due to the fact that the returns that farmers receive from selling their products are highly dependent on a multitude of factors, including the strength of domestic and international markets, commodity prices and the quality of growing seasons; all of which determine the economic gains or losses experienced by farmers in a given season. As stated in the previous chapter, since the greatest economic gains are often associated with an increase in yields coupled with a decrease in costly input requirements, in major maize producing areas like Canada and India where crop losses as a result of pest damage are significant, it is likely that farmers will experience at least modest economic gains as a result. However, as the experience of maize farmers in Argentina illustrates, an increase in the cost of seed inputs could adversely affect the economic gains experienced by those who adopt Bt technology over traditional cultivars. This is particularly relevant for developing nations like India, where many farmers in traditional as well as non-traditional maize growing provinces are impoverished and hard-pressed to afford the extra costs associated with the transition to this new technology. If the supposed reduction in required input levels does not come to fruition, it is likely that the extra costs associated with Bt maize will serve as a deterrent for farmers who are considering the switch.

Overall, a thorough examination of the evidence presented in the previous chapter would seem to indicate that the major arguments used in support of the widespread implementation of Bt maize are empirically founded, although they are often over stated by proponents. As such, the ecologic and economic potential of this new technology simply cannot be dismissed, especially in light of ever increasing global food security concerns. However, by outlining the governance structure of agricultural biotechnology, this study has illustrated the folly of the current approach and illuminated the validity of the central hypothesis. One can clearly identify a modern form of technological hegemony or the “emergence of a certain form of social consensus on the use of a prominent set of technologies” (Gramsci 2012, 160-161, 176, 206-210 & 416-418) in which new technologies are owned and controlled by transnational corporations that are unconcerned about, and ill equipped to address, local and global food security concerns. Far from being an effective tool for promoting genuine food security, these new technologies actually serve to weaken states’ food security, eroding food sovereignty by placing it in the hands of a private sector that is far more concerned with generating profit than it is with feeding the global population.

A thorough examination of the experiences of Canadian and Indian maize farmers illustrates that the socio-economic conditions of a country significantly affect the implementation of agricultural biotechnology. While farmers in the developed world experience pressures from the state and other powerful actors to adopt this new technology, they are not nearly as stark or pressing as those experienced by farmers in the developing world where food security concerns are already highly prevalent. The process of neoliberal transformation that began in the late 1980s and early 1990s is far more pronounced in the developing world, where many farmers feel domestic and international pressures to reform their agricultural practises and adopt a more modern, technological approach. In the developed world in countries like Canada, farmers adopt this foreign technology under the assumption that they will receive at least modest economic gains as a result. While this is also an important consideration for farmers in developing nations like India, a far more pressing issue is the ability of new technology to spur agricultural production and ease food security concerns. As a result, farmers in developing nations may feel as though they have little choice but to adopt this technology in the hope of easing national food security concerns. This has only served to perpetuate the culture of dependency in the developing world, as farmers increasingly rely on foreign corporations and their crop technology to feed the growing population.

As opponents of agricultural biotechnology assert, the current governance structure surrounding this new technology ensures that the benefits incurred from widespread implementation are experienced first and foremost by the corporations who own and control it. As Shiva, Jalees and Moore state, "the reality of agricultural biotechnology is different from the corporate propaganda and promises offered by the World Bank and the WTO, as nearly three decades of experimentation with GMOs has succeeded in transferring wealth and power from farmers to big capital" (2006, 140; 2010, 390). In a context of technological hegemony in which non-state actors are pushing a top down agricultural restructuring or 'passive revolution', the technologies that are being implemented are seen as both neutral and necessarily progressive and to question their value becomes an act of transgression (Gramsci 2012, 160-161, 176, 206-210 & 416-418). As prominent Indian scholars Vandana Shiva and Kunwar Jalees state, farmers in developing nations are being pushed into “a dependency on the corporate monopoly of patented seeds” (2006, 25). Instead of providing assistance, these technologies have reinforced what McMichael refers to as a culture of third world dependency in which farmers in developing nations embrace the ‘anarcho-capitalism’ of patented seeds and agricultural technologies with the hopes of increasing yields and combating starvation (1997, 639; Herring 2007, 135). While the results of this study represent the experiences of farmers in distinct maize growing regions, they appear to be indicative of the broader experiences of farmers who have adopted agricultural biotechnology over the past two decades. The results of this study also illuminate the fact that, while the arguments that are often used in support of the widespread implementation of Bt technology are overstated but empirically founded, the current neoliberal development paradigm significantly erodes the possibility of effectively addressing local and global food security concerns.

As it currently stands, the governance of agricultural biotechnology makes it an ineffective strategy for achieving global food security, which is being steadily eroded. This is particularly true in developing nations where farmers adopt this new technology under the guise that it will ease existing food security concerns and improve their overall health and wellbeing. Unfortunately, due to pre-existing socio-economic conditions in developing nations, the widespread adoption of transgenic crop varieties serves as a hindrance for achieving genuine food security. As scholars like Scoones assert, far from addressing the food production needs of small-scale subsistence farmers in developing nations, agricultural biotechnology privileges large-scale farming practises, creating significant barriers for effective implementation, specifically in relation to access (2002, 117; Qaim 2009, 673; Ozor 2008, 327; Pinstrup-Andersen and Cohen 2000, 159; Altieri and Rosset 1999). The deleterious impacts of private ownership structures are the starkest in developing nations where barriers to effective access are highly prevalent. The most significant barriers for farmers in developing nations are in relation to access to technology, information, land, and food markets, all of which are being exacerbated by the widespread implementation of agricultural biotechnology.

As discussed in chapter four, significant barriers have been created that hinder farmers' access to technological inputs. As proponents like Brookes and Barfoot state, while additional seed costs are to be offset by a reduction in other costly inputs, additional costs are often incurred by farmers as a result of the transition to transgenic crop varieties. According to their study, additional seed costs increase the overall cost of production in developing nations like Argentina by between (US)$ 20 and (US)$ 22 per hectare (2014, 56; Qaim 2009, 684). As additional input costs are only offset during seasons in which pest generated crop losses are significant, an increase in seed costs can adversely affect the economic situation of farmers in developing nations. Unlike farmers in developed nations, small-scale subsistence farmers in the developing world do not have the resources or access to credit that is needed to cope with potential increases in external input costs. This restricts farmers' initial access to transgenic seed varieties and can significantly impact the economic stability of those who are already cultivating them (Altieri and Rosset 1999). As there is currently a lack of effective mechanisms to monitor and control the cost of corporate seed inputs, biotech corporations are able to ensure that they are maximizing profit first and foremost. As a result, additional input costs are exacerbating inequalities amongst agricultural communities, engendering a situation in which large-scale, affluent farmers are granted access to this new technology while small-scale subsistence farmers are being further marginalized.

There are also significant barriers in relation to access to information regarding agricultural biotechnology. Unlike farmers in the developed world, small-scale subsistence farmers in developing nations are restricted in their access to information which, under the prevailing development paradigm, is disseminated poorly by private sector biotech corporations (Ozor 2008, 328). Once there is a lucrative market established in which to sell their products, biotech corporations have little incentive to ensure that farmers are using this new technology to their optimal advantage. As the role of the state has been significantly diminished in many developing nations, the public sector has a limited capacity and cannot ensure that appropriate information reaches those who could significantly benefit from it. Unfortunately, as a result of poor information flows between the private sector and farmers in the developing world, many of them are adopting agricultural biotechnology without fully comprehending or understanding the potential risks and benefits of this technology. In many cases, farmers are adopting transgenic crop varieties in the absence of knowledge regarding effective production methods that could significantly increase the viability of this new technology.

The prevailing neoliberal development paradigm, centered on private ownership and control, also fails to address issues regarding access to land and access food markets, two issues that are already highly prevalent for farmers in developing nations. As a result of the extra costs associated with agricultural biotechnology, it privileges those who can afford access, solidifying the power and clout of affluent farmers and the large-scale agricultural practices of private firms. Through the unchecked technocratization of agricultural sectors in the developing world, land costs are rising and affordable, arable land is diminishing rapidly (Altieri and Rosset 1999). As a result, the productive capacity and livelihood of small-scale subsistence farmers in the developing world is being steadily eroded, exacerbating existing food security concerns. As scholars like Scoones assert, the realization of genuine food security requires a development strategy that addresses distributional issues in relation to agricultural products as well (2002, 118; McMichael 2004a, 147). While the widespread implementation of agricultural biotechnology may serve as an effective development strategy for addressing food security in relation to increasing production and agricultural efficiency, it does little to address the social, economic and political realities inherent in food distribution systems that significantly impact the availability and accessibility of agricultural products in developing nations (Pinstrup-Andersen and Cohen 2000, 166). While production is an important element in achieving global food security, producing more food will not ensure that everyone has equal access to the products they require.

As McMichael states, the widespread implementation of agricultural biotechnology is failing to effectively address global food security by exacerbating access related issues, perpetuating a culture of dependency on foreign technology under the guise that it will improve agricultural production and the wellbeing of farmers everywhere (1997, 639). The stakes of adoption are far greater for small-scale subsistence farmers in the developing world as they lack an effective resource base, causing many of these barriers to be insurmountable. Sadly, and rather ironically, by adopting agricultural biotechnology in its current context, farmers in developing nations are inadvertently exacerbating food security concerns by supporting an agricultural development paradigm that perpetuates inequality, specifically in relation to access. Upon careful examination it becomes increasingly clear that food security is a highly complex issue, one that is not as black and white as proponents often claim. Unfortunately, the current agricultural biotechnology development paradigm suffers from a restrictive neo-Malthusian focus on production alone, ignoring stark socio-economic realities and various access barriers that significantly impact agricultural production and food security.

Unfortunately, proponents often argue that the benefits of agricultural biotechnology are black and white, stating that any minor increase in production means that this new technology is inherently beneficial and able to fulfill its primary role of addressing food security concerns in developing nations. However, as the results of this study indicate, while the benefits of this technology are empirically founded and simply cannot be ignored, in many cases, they are significantly outweighed by the consequences of adoption. This is particularly true in developing nations. While farmers in developing nations have experienced at least modest benefits from the implementation of Bt maize in relation to yields, required inputs and farm level profit, the real benefits of this technology are experienced by the transnational biotech corporation Monsanto which, through the protection of IPR, controls this highly valuable genetic resource. Farmers in the developing world are becoming increasingly more dependent on foreign technology under the guise that it will improve their food security. However, far from ensuring that this is the case, the current governance framework surrounding this technology is actually eroding food sovereignty and food security by placing it in the hands of the private sector. While modest gains in production and farm level income and reductions in required inputs and their associated cost signify the potential of this new technology to address global food security issues, the true nature of private sector agricultural development is simply to create commercially viable products. As such, while this technology continues to be lucrative, it will be heavily marketed by Monsanto and sold to farmers in the developing world under the guise of improving agricultural production and promoting food security. If this or other GM crop technology no longer proves to be lucrative, there is nothing stopping Monsanto from abandoning it in favour of other, more commercially viable biotech ventures. As such, the claims that are often made by proponents in relation to an increase in yields, a reduction in required inputs and an increase in farm level profit do not automatically translate into genuine food security. To achieve genuine food security, the state itself must increase its role in the research and development as well as the regulation of agricultural biotechnology to ensure that valuable agricultural resources are being used for the benefit of citizens and not being exploited for the purpose of enhancing corporate profits. This notion will be examined in greater detail in the next chapter.

As this chapter has effectively outlined, the impacts of the widespread implementation of Bt maize technology have been similar for farmers in the developed and the developing world. The results of this study indicate that while the major arguments that are used in favour of this new technology are empirically founded, they have been significantly overstated in both regions. However, upon careful examination of the socio-economic conditions in Canada and India, it becomes increasingly clear that farmers in the developing world experience greater pressures to adopt this new technology as a result of pressing national food security concerns. The next chapter will conclude the study and reiterate its major findings, serving as a critique of the current governance structure surrounding agricultural biotechnology. It proposes the need to rethink the role of state governments in this sector to ensure that the new technologies that are being created are able to effectively address global food security concerns.

Chapter Six: Conclusion

As this study on the impacts of biotechnology in Canada and India has illustrated, while the major arguments used in support of the widespread adoption of agricultural biotechnology are empirically founded, it has ultimately failed to accomplish its supposedly benign mission of addressing global food security concerns. Still, in spite of mounting evidence to suggest that the genetic modification of living organisms, exemplified through the creation and proliferation of agricultural biotechnology, is more of a vice than it is a virtue, a number of scholars are still convinced that "outside of corporate profits, widely applied biotechnology is the way of the future" (Lorquin 2001, 122). Biotechnology is part of an engineering paradigm or ethos that applies technical fixes to highly complex problems, ultimately ignoring the socio-economic realities of the farmers who cultivate these new technologies. Through a careful dissection of the rise of agricultural biotechnology in countries in the developed and developing world, this study has shown that the true beneficiaries of these new technologies are the transnational corporations that control the rights over the genetic material that is used.

While agricultural biotechnology is a historically recent development, over the past three decades it has spread prolifically across the globe. As a result, its merit in addressing local and global food security concerns simply cannot be ignored. However, the current governance structure of this new technology makes it an ineffective strategy for addressing food security concerns. As Rao and Deshpande, and Pinstrup-Andersen and Hazell state, the strongest arguments against agricultural biotechnology are not a direct criticism of the technologies themselves, but instead of the form that the biotech development strategy took, particularly in developing nations. This is due to the fact that "the final outcome of technological change is influenced by the institutional and policy environments within which it is introduced" (1985, 106; 1985, 85). As a result of the follies of the private ownership of resources that were once considered, and arguably should remain as, a public resource, several scholars have called for the democratization of local agricultural production systems and the implementation of a broader vision of food security. This broader vision should ensure that new technologies are being developed and implemented for the sole purpose of securing abundant and sustainable local food supplies and not simply in the interest of generating revenue and pleasing stock holders (Mujumdar 2006, 31-32; Srinivasan 2007, 22). There is an overwhelming need to match new technologies with publically defined needs and goals, rather than a prospective market or technological pipe dream. For a variety of socio-economic reasons the effective implementation of agricultural biotechnology presents a far more complex challenge in the developing world and requires a "regime that defines it in a manner consistent with the contexts, needs and concerns of developing countries such as India" (Gupta 2002, 2762 & 2767; Mruthyunjaya et al. 2006, 111). Contrary to Anderson's questionable assumption that "it is in the interests of developing nations to be pressured from abroad even if it is politically painful", developing nations and their respective governments need more room to develop their own policies governing the implementation of agricultural biotechnology that "suit their levels of development and socio-economic conditions, as effective and sustainable development can only come from within" (2003, 8; Nayyar and Chang 2005, 7; Ocampo 2005, 25). This is the only way to ensure that technologies that are adopted as part of the new sustainable development paradigm are also socially sustainable.

There is a non-economic objective of agricultural policy that is often forgotten in the quest for corporate profit, as it serves a multitude of functions and is ultimately responsible for the promotion of the health and wellbeing of society (Mujumdar 2006, 32). As such, agricultural development strategies should be implemented for the sole purpose of improving the living conditions and general well being of citizens, as well as ensuring the provision of their basic necessities. Unfortunately however, "in the pursuit of wealth and economic concerns, this purpose is often forgotten or overlooked" (Nayyar and Chang 2005, 1). As Gupta states, the basic challenge is how to govern technological change in a way that can help to meet desired social goals as "even though the powerful potential of biotechnology for social benefit is acknowledged, the complex challenge is how to develop mechanisms that can allow both for public debate and for the equitable and sustainable use of new technologies" (2002, 2762 & 2767).

Current agricultural development strategies, particularly in light of mounting climate change pressures[19], should be a means of achieving the broader objective of food security by promoting public sector control and oversight regarding newly developed agricultural biotechnologies as a direct challenge to corporate control and ownership. Corporate ownership of agricultural biotechnology compromises food security through the appropriation of seed resources, the basic delivery input for realizing genuine food security. Through its promotion of monocultures, the current development paradigm promotes "single-track, market-based solutions in a world of cultural and ecologic

[19] While it is outside of the scope of this study, it is estimated that global climate change will have a profound impact on agricultural development globally, posing an unprecedented challenge for global food security. As such, publically funded research and development into more efficient and sustainable agricultural biotechnology is more important than ever, particularly in countries in the developing world where food security issues are already highly prevalent (FAO 2009, 54-55; Rozenweig and Hillel 2010, 9; Adams 2004, 6; Hatfield and Prueger 2011, 27; Martin and Sauerborn 2013, 320; Parry et al. 2004, 54; Antle 1995, 741-745).

diversity" (McMichael 2004a, 137-138; Altieri and Rosset 1999). This reduces biodiversity and ignores the potential of viable alternatives or existing conventional methods that may, if used in tandem with this new technology, significantly improve agricultural production and global food security (McMichael 2004a, 141 & 151). As transnational biotech corporations are able to skirt public scrutiny and oversight, there are few mechanisms in place to hold them accountable for their products. The private sector has no formal obligation to protect the wellbeing of its end users and as such, there is no way to guarantee that they are meeting their objective of addressing global food security. As the ultimate goal of the private sector is profit generation, if transgenic crop varieties are deemed as being no longer lucrative, it is likely they will be abandoned in favour of more commercially viable products. Biotech corporations often overlook the social benefits of subsistence crop varieties in favour of more economically beneficial products, regardless of their potential to address global food security concerns. As scholars like Gupta and Chandak state, achieving genuine food security requires permanent, lasting solutions, not the creation of short-term, economically viable 'goodies' (2004, 10). Under the prevailing development paradigm, biotech research is "profit driven as opposed to needs driven" (Altieri and Rosset 1999), which has only served to exacerbate farmers' dependencies on costly seed inputs designed to maximize private profits. As a result, while this study illustrates the productive potential of agricultural biotechnology, development strategies advocated by proponents of this new technology focus solely on production, ignoring the follies of private ownership and control. As a result, these strategies are unable to address the broader objective of achieving genuine food security.

The prevailing development paradigm has a neo-Malthusian focus that implies that improving production alone will achieve global food security. However, as the results of this study illustrate, there are a multitude of other factors that contribute to global food insecurities. As such, it is often argued that increasing state involvement in the research, development and regulation of agricultural biotechnology would help to protect farmers, particularly those in the developing world, against the potentially adverse effects of adopting transgenic crop varieties. A state centered approach to development would assist in addressing issues of access in the developing world by promoting an open access framework that would "effectively enable the people who have helped to build and preserve the wealth of genetic resources through decades of indigenous selection to benefit equally from the commercial returns of genetic exploits" (Ozor 2008, 327). Through the dissemination of important information, a state-based approach to agricultural development would also promote human capacity and efficacy building, improving the scientific literacy of farmers in developing nations. As scholars like Altieri and Rosset state, achieving genuine food security requires a people centered approach aimed at "strengthening farmers' technical competence to acquire, assimilate, further develop and effectively apply this new technology to enhance agricultural production" (1999). The state could help to ensure that relevant information regarding this new technology is disseminated effectively, improving the longevity and sustainability of agricultural development project and "ensuring the optimal utilization of locally available skills and resources" (Abah et al. 2010, 8899). A state centric approach to agricultural biotechnology would also promote initiatives to address issues of access in relation to the food that is being produced. Development strategies could incorporate a focus on distributional issues and the promotion of systems designed to ensure the availability and accessibility of food stuffs. It would also eliminate the propensity to pursue 'silver-bullet' solutions at the expense of other viable alternatives. Under the current neoliberal development paradigm, research and development is dominated by the private sector which ignores the social benefit of agricultural production and focuses exclusively on economic returns. Increasing state involvement in the research and development of agricultural biotechnology would highlight the importance of exploring the possibility of co-evolution with "local social and economic production systems and conventional development strategies that may be beneficial if used in tandem with new technologies" (Abah et al. 2010, 8899; Ozor 2008, 328).

As scholars like McMichael (2004a) assert, genuine food security requires the democratization of agricultural production systems. This can only be achieved through the promotion of a state centered approach to development that recognizes the social benefit of research and development efforts that can improve agricultural production as well as social welfare. This approach requires that end users are engaged in the policy making and the regulatory processes to ensure that they are "active participants, not simply passive recipients of this new technology" (Pinstrup-Andersen and Cohen 2000, 161). A fundamental aspect of the creation of a new agricultural development paradigm is a people centered approach, which emphasises the importance of greater democratic participation and public knowledge sharing and consultation (Shiva and Jalees 2006, 87; Mallick et al. 2011, 455; Scoones 2006, 353). Arguments in support of this new paradigm center on the notion that the consultation of end users in both the policy making and regulatory process will ensure that farmers and consumers alike have a direct voice when it comes to the development and implementation of technologies that affect their daily lives. Strategies with a focus on democratic participation and consultation will also help to promote human development in this burgeoning sector and ensure that this new technology is serving the needs of those for whom it was designed. These measures, coupled with technological training and capacity building projects, will increase the likelihood of the success of development schemes, as users are invested in the products that are being created. It will also help to ensure the optimal use of indigenous knowledge in the creation of new products and increase the potential to bridge modern agricultural development strategies with other conventional practises (Scoones 2002, 117; Kent 2009). The achievement of genuine food security requires that research and development efforts are needs oriented, which will spur the creation of expanded, enlightened and adaptive research, strengthening the success of future agricultural development strategies.

The transition towards a state centered approach to agricultural biotechnology would also improve transparency and accountability, as products created in the public sphere will be subject to public scrutiny. This will help to ensure that products designed to address global food security are meeting their objective. It will also assist farmers in coping with the various risks associated with the transition to transgenic crop varieties, including increased input costs, poor market integration, poorly functioning markets, climate fluctuations and rising land costs (Pinstrup-Andersen and Cohen 2000, 161). Not only that, an enhanced government role in this sector would also help to reduce policy inconsistencies that plague the widespread adoption of agricultural biotechnology under the prevailing development paradigm (Ozor 2008, 325). An effective state centered regulatory framework would help to manage and assess the potential risks and benefits of this new technology more effectively, while keeping the promotion of the health and wellbeing of famers as an important objective (Ozor 2008, 328).

However, the promotion of a state centered approach is subject to many criticisms from traditional biotech proponents. Sceptics of a state centered approach to agricultural development are critical of the propensity to foster and sustain this type of approach in the current neoliberal, global economy. Increasing the role of the state in this particular sector does not devalue the importance of the private sector. Instead, private sector research and development efforts would be expanded with the hopes of "converting private gains into the realization of increasing social benefits" (Pinstrup-Andersen and Cohen 2000, 165). Research and development in agricultural biotechnology is a costly and demanding venture, particularly for developing nations. On average, basic biotech research and development costs an average of (US)$ 1 million and takes between 3 and 6 years to produce a viable product (Ozor 2008, 323). As such, as scholars like Graff and his colleagues assert, state governments should foster new partnerships between public and private research and development companies, government institutions and transnational biotech corporations (2000, 148; Abah et al. 2010, 8899). Essentially, these PPPs would create strategic agreements and links through collaboration and joint ventures that would enhance the availability and accessibility of this new technology. As Qaim states, this strategy would exploit the comparative strength of both sectors, as the private sector has a significant resource base and the public sector has the wherewithal to navigate the bureaucracy (2009, 684; Kent 2009). The products created under this new system would be subject to state regulation, which could be maintained by strengthening agricultural ministries and their capacity to conduct and analyze studies that address the potential costs and benefits of transgenic crop varieties (Kent 2009). While scholars like Kent (2009) assert that a shift towards a state centered approach that focuses on promoting strategic alliances through PPPs creates “a welcoming policy environment for private sector investment that also protects the interests and overall wellbeing of farmers and society at large”, one should refrain from defining this strategy as a ‘win-win’. As was discussed in great detail in chapter two, governance through PPPs allows private interests to obtain a privileged and intimate role in policy decisions and the setting of regulatory frameworks (Harvey 2005, 76). As such, while it is a step in the right direction, it is important to remember that the power and clout of transnational biotech corporations will place them in a privileged position in PPP arrangements. As a result, other methods of enhancing state involvement in this sector must also be examined.

As scholars like Pinstrup-Andersen and Cohen (2000) examine, states could forge strategic alliances with the private sector by offering to purchase the rights to beneficial technology for a period of time. This serves as an incentive for private sector research and development efforts, as corporations bear fewer risks than they do in the open market system (165). Often, private research corporations will refrain from developing potentially beneficial technology if potential users cannot afford access or if there are no viable markets or channels through which to secure adequate economic returns (Graff et al. 2000, 148; Qaim 2009, 684; Kent 2009; Pinstrup-Andersen and Cohen 2000, 161). A state centered approach would help to combat this tendency by ensuring that transgenic crops that may be beneficial for addressing global food security are developed, even if they are not commercially viable in the eyes of the private sector. This approach would also significantly reduce access barriers experienced by farmers in developing nations in relation to costly inputs. By purchasing the rights over beneficial technology from biotech corporations, state governments can then ensure acceptable unit costs for farmers, either providing transgenic seed varieties for free or for a nominal fee. This will help to reduce the growing inequalities in the agricultural sectors of developing nations that is currently being exacerbated by the current neoliberal development paradigm.

The use of modern methods of agricultural production is conditioned by the institutional framework of a particular sector. As Ahuja states, “if the institutional setup is exploitive, it will ultimately discourage the effective and sustainable adoption of new technologies” (2006, 15). Agricultural production continues to be dominated by the private sector and transnational corporations that are able to utilize their power and clout to influence agricultural policies, particularly in developing nations. Contemporary agricultural development discourse, centered on neoliberal, laissez-faire policies, has proven to be highly detrimental to the protection of local and global food security as it lacks a national mandate; eroding nations’ food sovereignty and exacerbating food security concerns. As Eashvaraiah (2001) states, to achieve the important objective of local and global food security, the development of common property resources including seeds, transgenic or otherwise, should rest with the state and its various actors and should be used and improved for common benefit and not for the generation of higher corporate profits.

Even the most ardent proponents of agricultural biotechnology admit that, “regardless of ideology driven economic policies, many countries in the developed and the developing world have intervened, and continue to intervene, in the agricultural sector” (Srinivasan 2007, 5). Thus, it can be effectively argued that corporate control over valuable resources that should be publically owned and controlled is yet another reason to evoke the revitalization of government involvement and oversight in agricultural sectors. This is due to the fact that "if a significant portion of seed production is in foreign hands, foreign companies are in a position to wield disproportionate influence over a country's policies, particularly countries in the developing world like India" (Sahai 1996, 444). As a result, food sovereignty is eroded, as is the ability to achieve genuine food security. More importantly however, representative democracy becomes highly contentious as populations' ability to feed themselves is being placed in the hands of a private sector that is able to skirt public accountability and oversight while simultaneously achieving their primary goal; the generation of capital gains.

As scholars like Mahendra Dev state, there is a pressing need for public investment in agriculture, particularly in the areas of research and development and the establishment of an independent monitoring and evaluation agency (2003; Mather, Das and Sircar 2006, 5328-5331; Mujumdar 2006, 33; Rao 2001, 3457; Rao and Deshpande 1986, 40; Mallick et al. 2011, 455; Gupta and Chandak 2004, 2). While the private sector will continue to play a vital role in research and development and agricultural production, the state should assume a more active role to ensure that the products that are being created for the purpose of providing enhanced food security are doing exactly that. This is particularly true in developing nations like India, where Mathur, Das and Sircar suggest an increase in average growth of 10 to 15 percent per annum in government expenditure, as well as a stepping up of public investment and subsidies for usage inputs could significantly strengthen the nation's ability to address increasing food security concerns (2006, 5330-5331). While it is dangerous to view modern agricultural biotechnology as a ‘silver bullet’ for addressing and achieving food security, if used in conjunction with other strategies designed to promote a policy environment that is favourable for farmers adopting new technologies, they could serve as a powerful tool for addressing food security concerns now and in the future.

Works Cited

Abah, J., M. Ishaq and A. Wada. 2010. "The Role of Biotechnology in Ensuring Food Security and Sustainable Agriculture," *African Journal of Biotechnology* 9(52): 8896-8900.

Abergel, Elisabeth and Katherine Barrett. 2002. "Putting the Cart before the Horse: A Review of Biotechnology Policy in Canada," *Journal of Canadian Studies* 37(3): 135-161.

Adams, Richard. (2004). *Climate Change and Agriculture: Climate Change, Human Systems and Policy*. Developed Under the Auspices of UNESCO Oxford: Eolss Publishers.

Agriculture and Agri-Food Canada. 2013. Canada's Farm Income Forecast for 2012 and 2013. Accessed online on October 5th 2015 at http://www.agr.gc.ca/eng/about-us/publications/economic-publications/alphabetical-listing/canada-s-farm-income-forecast-for-2012-and-2013/?id=1361554073074.

Agriculture Canada. 1980. "Review of Western Grain Stabilization Program 1976-1978," *Agriculture Canada Publication 5125*. Available online at http://www.archive.org/details/reviewofwesterngOOcana.

Ahuja, Astha. (2006). *Agriculture and Rural Development in India: Post-liberalization Initiatives*. New Delhi: New Century Publications.

Aitken, Rob (2009). Global Political Economy. In Janine Brodie and Sandra Rein (eds.), *Critical Concepts* (317-328). Toronto: Pearson Publishing Inc.

Alam, Ghayur. (1994). OECD Development Center Technical Papers No. 103 Biotechnology and Sustainable Agriculture: Lessons from India. Paris: OECD Development Center.

Albo, Gregory. 2002. "Neoliberalism, the State, and the Left: a Canadian Perspective," *Monthly Review* 54(1): 46-55.

Altieri, Miguel. 1999. "Applying Agroecology to Enhance the Productivity of Peasant Farming Systems in Latin America," *Environment, Development and Sustainability* 1(3/4): 197–217.

Altieri, Miguel and Peter Rosset. 1999. "Ten Reasons Why Biotechnology Will Not Ensure Food Security, Protect the Environment, And Reduce Poverty in the Developing World," *AgBioForum* 2(3&4): 155-162.

Altieri, Miguel and Walter Pengue. 2006. “GM: Soybean Latin America’s new Colonizer,” *Seedling* January edition: 13-17.

Anderson, Kym. 2003. “Trade Liberalization, Agriculture, and Poverty in Low-income Countries,” *WIDER Discussion Papers No. 2003/25, ISBN 9291904333*. World Institute for Development Economics.

Ankli, Robert. 1982. “The Decline of the Winnipeg Futures Market,” *Agricultural History* 56(1): 272-286.

Antle, John. 1995. “Climate Change and Agriculture in Developing Countries,” *American Journal of Agricultural Economics* 77, 3: 741-746.

Atkins, Eric. July 21st 2015. “Corn Crash: Ontario Farmers Hit by Plummeting Prices,” *The Globe and Mail.* Retrieved from http://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/ontario-corn-farmers-hit-by-plummeting-prices/article19701695/.

Babinard, Julie and Timothy Josling. (2001). The Stakeholders and the Struggle for Public Opinion, Regulatory Control and Market Development. In G. Nelson (ed.), *Genetically Modified Organisms in Agriculture* (81-96). New York: Academic Press.

Bakker, Isabella and Katherine Scott. (1997). From the Postwar to the Post-Liberal Keynesian Welfare State. In Wallace Clement (eds.), *Understanding Canada: Building on the New Canadian Political Economy* (286-310). Kingston: McGill-Queen’s University Press.

Balakrishnan, Pulapre. 2000. “Agriculture and Economic Reforms: Growth and Welfare,” *Economic and Political Weekly* 35(12): 999-1004.

Banting, Keith. 2013. “Royal Commission on Economic Union and Development Prospects for Canada,” *Canadian Encyclopaedia*. Available online at http://www.thecanadianencyclopedia.ca/en/article/royal-commission-on-economic-union-and-development-prospects-for-canada/.

Beniston, M. 2009. “Food Security and Global Environmental Change: Emerging Challenges,” *Environmental Science and Policy* 12: 373-377.

Bernstein, H. 2006. “Is There an Agrarian Question in the 21st Century,” *Canadian Journal of Development Studies* 27(4): 449–60.

Bernstein, H. 2013. “Food Sovereignty: a Sceptical View,” *Paper presented at the Conference on Food Sovereignty: a Critical Dialogue.* Yale University, September 14–15th 2013.

Bernstein, H. 2014. “Food Sovereignty via the ‘Peasant Way’: a Sceptical View,” *Journal of Peasant Studies* 41(6): 1031-1063.

Beuzekom, Brigitte and Anthony Arundel. 2009. OECD Biotechnology Statistics 2009: OECD. Available online at www.oecd.org/sti/42833898.pdf.

Bhatia, Juhie, Sarah Grant and Douglas Powell. 2000. “Backgrounder: GE Bt-Containing Field Corn,” *Technical Report No. 12*. Available online at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.410.1047&rep=rep1&type=pdf.

Bhaumik, Sankar and Abdul Rashid. (2013). Production Performance of Indian Agriculture in the Era of Economic Reforms. In Sarmila Banerjee and Anjan Chakrabarti (eds.), *Development and Sustainability: India in a Global Perspective* (125-154). New Delhi: Springer.

Bierle, Thomas. 2002. “Agricultural Trade Liberalization: Uruguay, Doha and Beyond,” *Journal of World Trade* 36(6): 1089-1110.

Brass, Paul. (1994). *The Politics of India since Independence*. New York: Cambridge University Press.

Brinkman, George. 2002. “Report Card for Prairie Agriculture,” *Canadian Journal of Agricultural Economics* 50(4): 391-413.

Brookes, Graham and Peter Barfoot. (2006). *GM Crops: The First Ten Years – Global Socio-Economic and Environmental Impacts – ISAAA Brief 36*. New York: ISAAA.

Brookes, Graham and Peter Barfoot. (2014). *GM Crops: Global Socio-Economic and Environmental Impacts 1996-2012*. Dorchester, UK: PG Economics Ltd.

Bureau, Jean Christophe, Sebastien Jean and Alan Mathews. 2005. “The Consequences of Agricultural Trade Liberalization for Developing Countries: Distinguishing Between Genuine Benefits and False Hopes,” *CEPII Working Paper No. 2005-13.*

Callinicos, Alex. (2004). Marxism and Global Governance. In David Held and Anthony McGrew (eds.), *Governing Globalization: Power, Authority and Global Governance* (249-266). Massachusetts: Blackwell Publishing Inc.

Cameron, Duncan. (1993). Introduction. In Duncan Cameron and Mel Watkins (eds.), *Canada under Free Trade* (ix-xxiii). Toronto: James Lormier & Company.

Campbell, Bruce. (1993). Continental Corporate Economics. In Duncan Cameron and Mel Watkins (eds.), *Canada under Free Trade* (21-40). Toronto: James Lormier & Company.

Canadian Agriculture in the Seventies. 1970. *Report of the Federal Task Force on Agriculture December 1969*. Ottawa: Information Canada.

Carroll, William and Matthew Greeno. (2013). Neoliberal Hegemony and the Organization of Consent. In Rebecca Fisher (ed.), *Managing Democracy Managing Dissent* (121-135). London: Freedom Press.

Chandrashekhar, Vaishnavi. July 31st 2014. "India puts GM Crop Trials on Hold," *The Guardian.* Accessed online at http://www.theguardian.com/environment/blog/2014/jul/31/india-gm-crop-trials-bjp-rss.

Chomsky, Noam. (1999). *Profit Over People: Neoliberalism and Global Order*. London: Turnaround Publisher Service Ltd.

Chopra, R.N. (1988). *Food Policy in India: A Survey*. New Delhi: Intellectual Publishing House.

Clarke, Simon. (2005). The Neoliberal Theory of Society. In Deborah Johnson and Alfredo Saad-Filho (eds.), *Neoliberalism: a Critical Reader* (50-59). London: Pluto Press.

Clarkson, Stephen. (1993). Constitutionalizing the Canadian-American Relationship. In Duncan Cameron and Mel Watkins (eds.), *Canada under Free Trade* (3-20). Toronto: James Lormier & Company.

Clay, Edaward. 2002. "Food Security: Concepts and Measurement," *Paper for FAO Expert Consultation on Trade and Food Security: Conceptualizing the Linkages*. Rome July 2002.

Colas, Alejandro. (2005). Neoliberalism, Globalization and International Relations. In Deborah Johnson and Alfredo Saad-Filho (eds.), *Neoliberalism: a Critical Reader* (70-79). London: Pluto Press.

Coleman, William and Grace Skogstad. 2007. "Neo-liberalism, Policy Networks and Policy Change: Agricultural Policy Reform in Australia and Canada," *Australian Journal of Political Science* 30(2): 242-263.

Coleman, William, Grace Skogstad and Michael Atkinson. 1996. "Paradigm Shifts and Policy Networks: Cumulative Change in Agriculture," *Journal of Public Policy* 16(3): 273-301.

Conway, Gordon and Edward Barbier (2009). *After the Green Revolution*. London: Earthscan.

Correa, Carlos. (2000). *Intellectual Property Rights, the WTO and Developing Countries*. New York: Zed Books Ltd.

Dev, Mahendra S. (2003). World Trade Organization and Food Security. In S. Mahendra Dev, K.P. Kannan and Nira Ramachandran (eds.), *Towards a Food Secure India: Issues and Policies* (132-153). New Delhi: Institute for Human Development.

Downes, Gerard. 2004. "TRIPs and Food Security: Implications of the WTO's TRIPs Agreement for Food Security in the Developing World," *British Food Journal* 106(5): 366-379.

Drahos, Peter. 1995a. "Global Property Rights in Information: the Story of TRIPs at the GATT," *Prometheus* 13(1): 6-19.

Drahos, Peter. 1995b. "Information Feudalism in the Information Society," *The Information Society* 11: 202-222.

Dumenil, Gerard and Dominique Levy. (2005). The Neoliberal (Counter-) Revolution. In Deborah Johnson and Alfredo Saad-Filho (eds.), *Neoliberalism: a Critical Reader* (9-19). London: Pluto Press.

Eashvaraiah, P. 2001. "Liberalization, the State and Agriculture in India," *Journal of Contemporary Asia* 31(3): 331-345.

Eaton, Emily. (2013). *Growing Resistance: Canadian Farmers and the Politics of Genetically Modified Wheat*. Winnipeg: University of Manitoba Press.

Ericksen, Polly. 2008. "Conceptualizing Food Systems for Global Environmental Change Research," *Global Environmental Change* 18: 234-245.

Farm and Food Care Ontario. n.d. Agricultural Biotechnology Facts. Accessed online at http://www.farmfoodcare.org/pdfs/biotechnology/why-bt-corn.pdf.

Food and Agricultural Organization of the United Nations. (2000). *The State of Food and Agriculture 2000.* Rome: FAO.

Food and Agricultural Organization of the United Nations. 2004. The State of Food and Agriculture 2003-2004: Agricultural Biotechnology: Meeting the Needs of the Poor. Accessed on September 7th at http://www.fao.org/docrep/006/y5160e/y5160e00.htm.

Food and Agricultural Organization of the United Nations. (2009). *Coping with a Changing Climate: Considerations for Adaptation and Mitigation in Agriculture*. Rome: FAO.

Food and Agricultural Organization of the United Nations Statistics Division (FAO Stat). 2015. Accessed on August 20th 2015 at the Food and Agricultural Organization of the United Nations Statistics Division website. http://faostat3.fao.org/download/Q/QC/E.

Food and Agricultural Organization of the United Nations. 2015. The State of Food and Agriculture 1947-2013. Accessed on September 7th 2015 at the Food and Agricultural Organization of the United Nations website. http://www.fao.org/economic/es-home/sofa/en/#.VgwZ5fmznng.

Fowke, V. 1945. "Economic Effects of the War on the Prairie Economy," *The Canadian Journal of Economics and Political Science* 11(3): 373-387.

Fowke, V. (1957). *The National Policy and the Wheat Economy.* Toronto: University of Toronto Press. .

Friedman, Milton. (1962). *Capitalism and Freedom*. Chicago: University of Chicago Press.

Gallivan, G. (2011). *Survey of Pesticide Use and Evaluation of the Changes in Pesticide Risk on Agricultural Crops in Ontario*. Guelph: Ontario Ministry of Agriculture, Food and Rural Affairs.

Garbulsky, Martin and Alejandro Deregibus. 2006. FAO Country Pasture/Forage Resource Profiles: Argentina. Accessed on October 8th 2015 at http://www.fao.org/ag/agp/agpc/doc/counprof/argentina/argentina.htm.

Ghatak, Shambhu. 2010. "What Has the World Development Report 2008 to say about Indian Agriculture," *Development in Practice* 20(1): 131-137.

Gilbert, Lawrence. (1994). Howard A. Schneiderman. In *Biographical Memoirs National Academy of Sciences* (481-504). Washington DC: National Academy Press.

Global Yield Gap Atlas. n.d. Common Definitions of Terms Frequently Used. Accessed on September 8th 2015 at the Global Yield Gap Atlas website. http://www.yieldgap.org/glossary.

Glover, Dominic. (2008). *Made by Monsanto: the Corporate Shaping of GM Crops as a technology for the Poor STEPS Working Paper 11*. Brighton: STEPS.

Glover, Dominic. 2010. "The Corporate Shaping of GM Crops as a Technology for the Poor," *The Journal of Peasant Studies* 37(1): 67-90.

Government of India. 2011. Economic Survey 2010-2011 Statistical Appendix. Available online at indiabudget.nic.in/es2010-11/estat1.pdf.

Graff, Gregory, David Zilberman and Cherisa Yarkin (2000). The Roles of Economic Research in the Evolution of International Agricultural Biotechnology. In Matin Qaim, Anatole Krattinger and Joachim von Braun (eds.), *Agricultural Biotechnology in Developing Countries: Towards Optimizing the Benefits for the Poor* (125-154). The Netherlands: Springer Science + Business Media BV.

Gramsci, Antonio. (2012). *Selections from the Prison Notebooks of Antonio Gramsci 1971.* Quintin Hoare and Geoffrey Nowell Smith (eds.). New York: International Publishers.

Gupta, Anil. 2002. "Ensuring 'Safe Use' of Biotechnology: Key Challenges," *Economic and Political Weekly* 37(27): 2762-2769.

Gupta, Anil and Vikas and Chandak. 2004. "Agricultural Biotechnology in India: Ethics, Business and Politics," *Presented at the International Workshop on Agricultural biotechnology in the Developing World: Perceptions, Politics and Policies*. Zurich Switzerland March 12th 2004.

Harvey, David. (2003). *The New Imperialism.* New York: Oxford University Press.

Harvey, David. (2005). *A Brief History of Neoliberalism*. New York: Oxford University Press.

Harvey, Mark. (2004). "The Appearance and Disappearance of the GM Tomato: Innovation, Strategy, Market Formation and the Shaping of Demand," In Kees Jansen and Sietze Vellema (eds.), *Agribusiness and Society: Corporate Responses to Environmentalism, Market Opportunities and Public Regulation*. New York: Zed Books.

Hamel, Marie-Andree and Erik Dorff. 2015. Corn: Canada's Third Most Valuable Crop. Accessed on August 1st 2015 at the Statistics Canada website. http://www.statcan.gc.ca/pub/96-325-x/2014001/article/11913-eng.htm.

Hategekimana, Bernard and Martin Beaulieu. 2002. "Genetically Modified Crops: Steady Growth in Ontario and Quebec," *Vista on the Agri-Food Industry and the Farm Community*. Statistics Canada.

Hatfield, Jerry and John Prueger. (2011). Chapter Two: Agroecololgy: Implications for Plant Response to Climate Change. In Shyam Yadav, Robert Redden, Jerry Hatfield, Hermann Lotze-Campen and Anthony Hall. (eds.), *Crop Adaptation to Climate Change*. Oxford: Wiley-Blackwell.

Hayek, F. (1944). *The Road to Serfdom*. Chicago: University of Chicago Press.

Herdt, Robert. 2006. "Biotechnology in Agriculture," *Annual Review* 31: 265-295.

Herring, Ronald. 2007. "Stealth Seeds: Bioprosperity, Biosafety and Biopolitics," *Journal of Developmental Studies* 43(1): 130-157.

Hertel, Thomas, Kym Anderson, Joseph Francois and Will Martin. 2000. "Agriculture and Non-agricultural Liberalization in the Millennium Round," *GTAP Working Paper No. 8*. Retrieved from http://docs.lib.purdue.edu/gtapwp/8.

Hunter, Craig and Bill McGee. (1994). *Survey of Pesticide Use in Ontario 1993.* Toronto: OMAFRA.

Hunter, Craig and Bill McGee. (1999). *Survey of Pesticide Use in Ontario 1998*. Guelph: OMAFRA.

Imber, Mark. (2004). Functionalism. In David Held and Anthony McGrew (eds.), *Governing Globalization: Power, Authority and Global Governance* (290-304). Massachusetts: Blackwell Publishing Inc.

Ingco, Merlinda and Tonia Kandiero. (2003). Introduction. In Merlinda D. Ingco (ed.), *Agriculture, Trade, and the WTO in South Asia* (1-37). Washington DC: The World Bank.

Integrated Agricultural Information System of Argentina. n.d. Accessed online at http://www.siia.gov.ar/_apps/siia/estimaciones/estima2.php.

James, Clive (2003). *Global Review of Commercialized Transgenic Crops: 2002 ISAAA Brief No. 29*. New York: ISAAA.

James, Clive. (2011). *Global Status of Commercialized Biotech/GM Crops: 2011 – ISAAA Brief No. 43*. New York: ISAAA.

James, Clive. (2014). *Global Status of Commercialized Biotech/GM Crops: 2014 – ISAAA Brief No. 49.* New York: ISAAA.

Jansen, Kees. 2014. "Food Sovereignty: a Critical Dialogue," *The Journal of Peasant Studies* 42(1): 213-232.

Jansen, Kees and Aarti Gupta. 2009. "Anticipating the Future: Biotechnology for the Poor as an Unrealized Promise," *Futures* 41: 436-445.

Jessop, Bob. (2002). *The Future of the Capitalist State.* Cambridge: Polity Press.

Joseph, Jonathan. (2003). *Hegemony: A Realist Analysis*. New York: Routledge.

Joshi, P., N. Singh, N.P. Sing, R. Gerpacio and P. Pingali. (2005). *Maize in India.* Mexico: International Maize and Wheat Improvement Center.

Josling, Timothy, Stefan Tangermann and Thorald Warley. (1996). *Agriculture in the GATT*. London: Macmillan.

Kelves, Daniel. 1994. "Ananda Chakrabarty Wins a Patent: Biotechnology, Law, and Society, 1972-1980," *Historical Studies in the Physical and Biological Sciences* 25(1): 111-135.

Kent, Lawrence. 2004. "What's the Holdup? Addressing Constraints to the Use of Plant Biotechnology in Developing Countries," *AgBioForum* 7(1&2): 63-69.

Keynes, John Maynard. (1936). *The General Theory of Employment, Interest and Money*. London: Palgrave Macmillan.

Ki-Moon, Ban. 2011. "Foreword," *Third World Quarterly* 32(1): 1-2.

Knight, Henry. (1954). *Food Administration in India: 1939-47*. California: Stanford University Press.

Kumar, Sanjay. 2015. "India Eases Stance on GM Crop Trials," *Nature* 521: 138-139.

Lapavitsas, Costas. (2005). Mainstream Economics in the Neoliberal Era. In Deborah Johnson and Alfredo Saad-Filho (eds.), *Neoliberalism: a Critical Reader* (30-40). London: Pluto Press.

Larner, Wendy. 2000. "Neoliberalism: Policy, Ideology, Governmentality. *Studies in Political Economy* 63: 5-25.

Ledoux, L. and R. Huart. 1968. "Integration and Replication of DNA of *M. lysodeikticus* in DNA of Germinating Barley," *Nature* 218: 1256-1259.

Lee, Richard. 2007. "Food Security and Food Sovereignty," *Center for Rural Economy Discussion Paper Series No. 11*. University of Newcastle: 1-16.

Lorquin, Paul. (2001). *The Green Phoenix: A History of Genetically Modified Plants.* New York: Columbia University Press.

MacRae, Rod and Vijay Cuddeford. (1999). *A Sustainable Food & Agricultural Agenda for Ontario*. Toronto: Canadian Institute for Environmental Law and Policy.

Mallick, Sambit, Haribabu Ejnavarzala and Bhoopathi Reddy. 2011. "Industrialization of Seed Production: Implications for Agriculture in India," *Perspectives on Global Development and Technology* 10: 441-457.

Marchak, M. (1991). *The Integrated Circus: The New Right and the Restructuring of Global Markets*. Montreal: McGill-Queen's University Press.

Martin, K and J. Sauerborn. (2013) *Agroecology*. The Netherlands: Springer.

Mathur, Archana, Surajit Das and Sabhalakshmi Sircar. 2006. "Status of Agriculture in India: Trends and Prospects," *Economic and Political Weekly* 41(52): 5327-5336.

McBride, Stephen and Kathleen McNutt. 2007. "Devolution and Neoliberalism in the Canadian Welfare State," *Global Social Policy* 7(2): 177-201.

McCallum, John. (1980). *Agriculture and Economic Development in Quebec and Ontario until1870.* Toronto: University of Toronto Press.

McGee, Bill, Hugh Berges and Kristen Callow. (2004). *Survey of Pesticide Use in Ontario 2003*. Guelph: OMAF.

McGee, Bill, Hugh Berges and Denise Beaton. (2010). *Survey of Pesticide Use in Ontario 2008*. Toronto: OMAFRA.

McGloughlin, Martina. 1999. "Ten Reasons why Biotechnology will be Important to the Developing World," *AgBioForum* 2(3/4): 163-174.

McGuirk, Anya and Yair Mundlak. (1991). *International Food Policy Research Institute Research Report 87: Incentives and Constraints in the Transformation of Punjab Agriculture.* Washington, DC: International Food Policy Research Institute.

McMichael, Philip. 1997. "Rethinking Globalization: The Agrarian Question Revisited," *Review of International Political Economy* 4(4): 630-662.

McMichael, Philip. (2004a). Biotechnology and Food Security: Profiting on Insecurity. In L. Beneria and S. Bisnaith (eds.), *Global Tensions: Challenges and Opportunities in the World Economy* (137-153). New York: Routledge.

McMichael, Philip. 2004b. "Global Development and the Corporate Food Regime," *Paper Prepared for the Symposium on New Directions in the Sociology of Global Development, XI World Congress of Rural Sociology*. Trondheim, July 2004. 1-24.

Monsanto. (1984). *Annual Report*. St. Louis: Monsanto.

Monsanto. 2014. Our Commitments: Sustainable Agriculture. Accessed on August 1st 2015 at the Monsanto Corporation website. http://www.monsanto.ca/ourcommitments/Pages/SustainableAgriculture.aspx.

Mooij, Jos. 1998. "Food Policy and Politics: The Political Economy of the Public Distribution Systems in India," *Journal of Peasant Studies* 25(2): 77-101.

Moore, Jason. 2010. “The End of the Road? Agricultural Revolutions in the Capitalist World-Ecology, 1450-2010,” *Journal of Agrarian Change* 10(3): 389-413.

MOSST. 1980. “Biotechnology in Canada,” *MOSST Background Paper.* Ottawa*.*

Moxley, Jacqueline. (1989). *Survey of Pesticide Use in Ontario 1989*. Toronto: OMAF.

Mruthyunjaya, Suresh Pal, P.K. Joshi and Raka Saxena. (2006). Institutional Reforms for Agricultural Development under New Economic and Technological Environment. In N.A. Mujumdar and Uma Kapila (eds.), *Indian Agriculture in the New Millennium: Changing Perceptions and Development Policy Volume 2* (111-126). New Delhi: Academic Foundation.

Mudge, Stephanie. 2008. “What is Neoliberalism,” *Socio-Economic Review* 6: 703-731.

Mujumdar, N. 2006. “Centrality of Agriculture to India’s Economic Development,” *Economic and Political Weekly* 41(1): 31-34.

Munck, Ronaldo. (2005). Neoliberalism and Politics, and the Politics of Neoliberalism. In Deborah Johnson and Alfredo Saad-Filho (eds.), *Neoliberalism: a Critical Reader* (60-69). London: Pluto Press.

Murgai, Rinku, Mubarik Ali and Derek Byerlee. 2001. “Productivity Growth and Sustainability in Post-Green Revolution Agriculture: The Case of the Indian and Pakistan Punjabs,” *The World Bank Research Observer* 16(2): 199-218.

Nath, V. 1969. “The Growth of Indian Agriculture: A Regional Analysis,” *Geographical Review* 59(3): 348-372.

Nayyar, Deepak and Han-Joon Chang. (2005). Introduction: Towards a People-Centered Approach to Development. In Eric Hershberg and Christy Thornton (eds.), *The Development Imperative: Toward a People-Centered Approach* (1-9). New York: Social Science Research Council.

Ocampo, Jose Antonio. (2005). Globalization, Development and Democracy. In Eric Hershberg and Christy Thornton (eds.), *The Development Imperative: Toward a People-Centered Approach* (13-35). New York: Social Science Research Council.

Otero, Gerardo. (2014). The Neoliberal Food Regime and its Crisis: State, Agribusiness, Transnational Corporations, and Biotechnology. In Steven Wolf and Alessandro Bonanno (eds.), *The Neoliberal Regime in the Agri-Food Sector: Crisis, Resilience, and Restructuring* (225-244). New York: Routledge.

Oya, Carlos (2005). Sticks and Carrots for Farmers in Developing Countries: Agrarian Neoliberalism in Theory and Practice. In Deborah Johnson and Alfredo Saad-Filho (eds.), *Neoliberalism: a Critical Reader* (127-134). London: Pluto Press.

Ozor, Nicholas. 2008. "Challenges and Impacts of Agricultural Biotechnology on Developing Societies," *African Journal of Biotechnology* 7(4): 322-330.

Park, Julian, Ian McFarlane, Richard Phipps and Graziano Ceddia. 2011. "The Role of Transgenic Crops in Sustainable Development," *Plant Biotechnology Journal* 9: 2-21.

Palley, Thomas. (2005). From Keynesianism to Neoliberalism: Shifting Paradigms in Economics. In Deborah Johnson and Alfredo Saad-Filho (eds.), *Neoliberalism: a Critical Reader* (20-29). London: Pluto Press.

Parry, M., C. Rosenzweig, A. Inglesias, M. Livermore and G. Fischer. 2004. "Effects of Climate Change on Global Food Production under SRES Emissions and Socio-economic Scenarios," *Global Environmental Change* 14: 53-67.

Patnaik, Prabhath. (1998). *Impact of Globalization on Indian Agriculture*. Hyderabad: Uddaraju Raman Memorial Foundation.

Pentland, H. 1959. "The Development of Capitalist Labour Market in Canada," *The Canadian Journal of Economics and Political Science* 25(4): 297-310.

Perriere, Robert and Franck Seuret. (2000). *Brave New Seeds*. New York: Zed Books.

Petras, James and Henry Veltmeyer. (2011). *Beyond Neoliberalism: A World to Win*. Vermont: Ashgate Publishing Company.

Pinstrup-Andresen, Per. 2009. "Food Security: Definition and Measurement," *Food Security* 1: 5-7.

Pinstrup-Andersen, P. and M. Cohen. (2000). Modern Biotechnology for Food and Agriculture: Risks and Opportunities for the Poor. In G. Persley and M. Lantin (eds.), *Proceedings of an International Conference*. Washington DC: The World Bank

Pinstrup-Andersen, Per and Peter Hazell. 1985. "The Impact of the Green Revolution and Prospects for the Future," *Food Reviews International* 1(1): 1-25.

Plehwe, Dieter, Bernhard Walpen and Gisela Neunhoffer. (2006). *Neoliberal Hegemony: A Global Critique*. New York: Routledge.

Proulx, Stefanie. 2012. "The Rise and fall of the Canadian Wheat Board: A Historical Institutional Analysis," *Graduate School of Public and International Affairs*: 1-49.

Qaim, Matin. 2009. "The Economics of Genetically Modified Crops," *Annual Review of Economics* 1: 665-693.

Qaim, Matin. 2010. "Benefits of Genetically Modified Crops for the Poor: Household Income, Nutrition and Health," *New Biotechnology* 27(5): 552-557.

Qaim, Matin, Carl Pray and David Zilberman (2008). Economic and Social Considerations in the Adoption of GM Crops. In J. Romeis and A. Shelton (eds.), *Integration of Insect-Resistant Genetically Modified Crops within IPM Programs* (329-356). Netherlands: Springer Science and Business Media B.V.

Raney, Terri. 2006. "Economic Impact of Transgenic Crops in Developing Countries," *Current Opinion in Biotechnology* 17: 1-5.

Rao, C. 1998. "Agricultural Growth, Sustainability and Poverty Alleviation: Recent Trends and Major Issues of Reform," *Economic and Political Weekly* 33(29/30): 1943-1948.

Rao, C. 2001. "WTO and Viability of Indian Agriculture," *Economic and Political Weekly* 36(36): 3453-3457.

Rao, V. and R. Deshpande. 1986. "Agricultural Growth in India: A Review of Experiences and Prospects," *Economic and Political Weekly* 21(38/39): 101-112.

Reichman, J.H. 2000. "The TRIPS Agreement Comes of Age: Conflict or Cooperation with the Developing Countries," *Journal of International Law* 32: 441-470.

Road, Rajendra and Krishi Bhavan. (2011). *Indian Council of Agricultural Research: Vision 2030*. Indian Council of Agricultural Research: New Delhi.

Rozenweig, Cynthia and Daniel Hillel. (2010). "The Role of Soils in Climate Change," In Daniel Hillena and Cynthia Rozenweig (ed.). *Handbook of Climate Change and Agroecosystem* (9-20). London: Imperial College Press.

Ryan, Camille and Peter Phillips. 2004. "Knowledge Management in Advanced technology Industries: an Examination of International Agricultural Biotechnology Clusters," *Environment and Planning C: Government and Policy* 22: 217-232.

Sahai, Suman. 1996. "American Pressure to Open up Indian Agriculture," *Economic and Political Weekly* 31(8): 443-444.

Sarkar, A and G. VanLoon. 2015. "Modern Agriculture and Food and Nutrition Insecurity: Paradox in India," *Public Health* 30: 1-3.

Schanbacher, William. (2010). *The Politics of Food: The Global Conflict Between Food Security and Food Sovereignty*. Connecticut: Praeger Security International.

Schmitz, Andrew, Charles Moss, Troy Schmitz, Hartley Furtan and Helen Schmitz. (2010). *Agricultural Policy, Agribusiness, and Rent-Seeking Behaviour*. Toronto: University of Toronto Press.

Schneiderman, H. and W. Carpenter. 1990. "Planetary Patriotism: Sustainable Agriculture for the Future," *Environmental Science and Technology* 24 (4): 466-473.

Schnepf, Randall, Erik Dohlman and Christine Bolling. (2001). *Agriculture in Brazil and Argentina*. Washington DC: USDA.

Scoones, Ian. 2002. "Can Agricultural Biotechnology be Pro-Poor? A Sceptical Look at the Emerging Consensus," *IDS Bulletin* 33(4): 114-119.

Scoones, Ian. (2006). *Science, Agriculture and the Politics of Policy*. New Delhi: Orient Longman Private Limited.

Shapiro, Robert. 1999. "How Genetic Engineering will save our Planet," *The Futurist* 33(4): 28-29.

Shields, John and B. Mitchell Evans. (1998). *Shrinking the State.* Halifax: Fernwood Publishing.

Shiva, Vandana. (1997). *Biopiracy.* Massachusetts: South End Press

Shiva, Vandana. (2000). *Stolen Harvest*. Massachusetts: South End Press.

Shiva, Vandana and Afsar Jafri. 2003. "Bursting the GM Bubble: The Failure of GMOs in India," *The Ecologist Asia* 11(3): 6-14.

Shiva, Vandana and Kunwar Jalees. (2006). *Seeds of Suicide: The Ecological and Human Costs of Seed Monopolies and Globalization of Agriculture*. New Delhi: Navdanya.

Shrivastav, Snehlata. May 16th 2013. "Farmers Flock to GM Crops," *The Times of India*.

Skogstad, Grace. 2005. "The Dynamics of Institutional Transformation: the Case of the Canadian Wheat Board," *Canadian Journal of Political Science* 38(3): 529-548.

Skogstad, Grace. 2007. "The Two Faces of Canadian Agriculture in a Post-Staples Economy," *Canadian Political Science Review* 1(1): 26-41.

Skogstad, Grace. (2008). *Internationalization and Canadian Agriculture: Policy and Governing Paradigms*. Toronto: University of Toronto Press.

Smith, Adam. (1778). *The Wealth of Nations*. London: W. Strahan and T. Cadell.

Smith, M., J. Pointing and S. Maxwell. (1992). *Household Food Security, Concepts and Definitions: An Annotated Bibliography. Development Bibliography No 8*. Sussex: Institute of Development Studies Brighton University.

Srinivasan, T. 1979. "Trends in Agriculture in India, 1949-50 – 1977-78," *Economic and Political Weekly* 14(30/32): 1283-1294.

Srinivasan, T. 2007. "Development Strategy: The State and Agriculture Since Independence," *SCID Working Paper No. 363*. 1-47.

Statistics Canada. 2001. Census of Canadian Agriculture. Ottawa.

Statistics Canada. 2008. Net Farm Income. Accessed on September 18th 2015 at the Statistics Canada website. http://www.statcan.gc.ca/daily-quotidien/060526/dq060526a-eng.htm.

Statistics Canada. 2014. Net Farm Income of Ontario Farmers. Agricultural Economics Statistics Cat. 21-010-X. Available at http://www.statcan.gc.ca/pub/21-010-x/21-010-x2014002-eng.pdf.

Statistics Canada. 2015a. Estimated Areas, Yield, Production and Average Farm Price of Principal Field Crops. CANSIM Table 001-0010. Accessed on September 18th 2015 at the Statistics Canada website. http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=10010.

Statistics Canada. 2015b. Estimated Areas, Yield, Production of Corn for Grain and Soybeans Using GM Seeds. CANSIM Table 001-0072. Accessed on September 18th 2015 at the Statistics Canada website. http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0010072&& pattern =&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid=.

Statistics Canada. 2015c. Farm Cash Receipts by Province. CANSIM table 002-0001. Accessed on August 1st 2015 at the Statistics Canada website. http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/agri04a-eng.htm.

Steger, Manfred and Ravi Roy (2010). *Neoliberalism: A Very Short Introduction*. New York: Oxford University Press.

Stiglitz, Joseph. (2002). *Globalization and its Discontents*. New York: W.W. Norton & Co.

Storm, Servaas. 1997. "Agriculture under Trade Policy Reform: A Quantitative Assessment for India," *World Development* 25(3): 425-436.

Swain, Ashwini. June 1st 2014. "Can India Reform its Agriculture," *The Diplomat*.

Swaminathan, M.S. (1999). Genetic Engineering and Food Security: Ecological and Livelihood Issues. In G. Persley and M. Lantin (eds.), *Agricultural Biotechnology and the Rural Poor* (37-42). Washington DC: CGIAR.

Swaminathan, M.S. (2006). Science and Technology for Sustainable Food Security. In N.A. Mujumdar and Uma Kapila (eds.), *Indian Agriculture in the New Millennium: Changing Perceptions and Development Policy Volume 2* (169-191). New Delhi: Academic Foundation.

The Economist. June 27th 2015. "Farming in India: In a Time Warp," *The Economist*.

The Expert Group on Agricultural Indebtedness. (2007). *Report of the Expert Groups on Agricultural Indebtedness*. New Delhi: Ministry of Finance, Government of India.

The National Portal of India. 2015. Agriculture. Accessed on August 1st 2015. http://india.gov.in/topics/agriculture.

The Rockefeller Foundation. 2015. Agriculture in India. Accessed on August 1st 2015 at the Rockefeller Foundation website. http://rockefeller100.org/exhibits/show/agriculture/india.

Thompson, Jennifer. (2002). *Genes for Africa: Genetically Modified Crops in the Developing World*. Cape Town: UCT Publishing.

Thompson, Jennifer. (2007). *Seeds for the Future*. New York: Comstock Publishing Associates.

Thorsen, Dag and Amund Lie. 2008. "The Neoliberal Challenge: What is Neoliberalism," *Contemporary Readings in Law and Social Justice* 2(2): 188-214.

Topalova, Petia. (2007). Trade Liberalization, Poverty, and Inequality: Evidence from Indian Districts. In Ann Harrison (ed.), *Globalization and Poverty* (291-335). University of Chicago Press: Illinois.

Tripathi, Amarnath and A. Prasad. 2009. "Agricultural Development in India since Independence: A Study on Progress, Performance, and Determinants," *Journal of Emerging Knowledge on Emerging Markets* 1(1): 63-92.

United Nations Development Programme. (2001). *Making New Technologies Work for Human Development*. New York: Oxford University Press. Available at http://hdr.undp.org/reports/global/2001/en/pdf/completenew.pdf.

United Nations Development Programme. 2015. Human Development Reports. Accessed on September 08th 2015 at the United Nations website. http://hdr.undp.org/en/global-reports.

United Nations Millennium Project. 2006. What are the MDGs? Accessed on August 20th 2015 at http://www.unmillenniumproject.org/goals/.

US Department of State Office of the Historian. 2013. Milestones: 1961-1968. Accessed on the US Department of State website on August 1st 2015. https://history.state.gov/milestones/1961-1968/pl-480.

US Food and Drug Administration. 2014. Agency Summary Memorandum Re: Consultation with Calgene Inc. Concerning FlavrSavr Tomatoes. Accessed on May 20th 2015 at the US Food and Drug Administration website. http://www.fda.gov/Food/FoodScienceResearch/Biotechnology/Submissions/ucm225043.htm#out2.

Vandemoortele, Jan. 2011. "If not the Millennium Development Goals, then what?," *Third World Quarterly* 32(1): 9-25.

Varshney, Ashutosh. (1998). *Democracy, Development, and the Countryside: Urban-Rural Struggles in India*. New York: Cambridge University Press.

Via Campesina. 1996. "Food Sovereignty: a Future without Hunger," *International Conference of Via Campensina*. Available online at http://www.voiceoftheturtle.org/library/1996%20Declaration%20of%20Food%20Sovereignty.pdf.

Via Campesina. 2011. What is La Via Campesina. Accessed on September 7th 2015 at the Via Campesina website. http://viacampesina.org/en/index.php/organisation-mainmenu-44/what-is-la-via-campesina-mainmenu-45.

Vyas, Vijay. (2003). Economic Policies for Ensuring Food Security. In S. Mahendra Dev, K.P. Kannan and Nira Ramachandran (eds.), *Towards a Food Secure India: Issues and Policies* (105-112). New Delhi, India: Institute for Human Development.

Warren, Michael and Natacha Pisarenko. October 20th 2013. "As Argentina's Pesticide Use Increases, Many Worry about Growing Link to Health Problems," *The Huffington Post*.

Weasel, Lisa. (2009). *Food Fray: Inside the Controversy over Genetically Modified Food*. New York: American Management Association.

Wezel, A. and C. David. (2012). Agroecology and the Food System. In Lichtfouse (ed.). *Agroecology and Strategies for Climate Change: Sustainable Agriculture Reviews* (17-33). Paris: Springer.

Wittman, Hannah, Annette Desmarais and Nettie Weibe. (2010). *Food Sovereignty: Reconnecting Food, Nature and Community.* Halifax: Fernwood Publishing.

Windfuhr, M. and J. Jonsen. (2005). *Food Sovereignty: Towards Democracy in Localised Food Systems*. Bradford, UK: ITDG Publishing.

Witkowski, J., J. Wedberg, K. Steffey, P. Solderbeck, B. Siegfried, M. Rice, C. Pilcher, D. Onstad, C. Mason, L. Lewis, D. Landis, A. Keaster, F. Huang, R. Higgins, M. Haas, M. Gray, K. Giles, J. Foster, P. Davis, D. Calvin, L. Buschman, P. Bolin, B. Barry, D. Andow and D. Alstad. 2008. Corn Production: Bt Corn and European Corn Borer. Accessed on August 1st 2015 at the University of Minnesota website. http://www.extension.umn.edu/agriculture/corn/pest-management/bt-corn-and-european-corn-borer/#ch1.

Wolf, Steven and Alessandro Bonanno (2014). Introduction. In Steven Wolf and Alessandro Bonanno (eds.), *The Neoliberal Regime in the Agri-Food Sector: Crisis, Resilience, and Restructuring* (1-10). New York: Routledge.

World Bank. 2012a. India: Issues and Priorities for Agriculture. Accessed on August 1st 2015 at the World Bank website. https://www.worldbank.org/en/news/feature/2012/05/17/india-agriculture-issues-priorities.

World Bank. 2012b. "World Agriculture towards 2030/2050: the 2012 Revision," *Food and Agriculture Organization of the United Nations. Working Paper No. 12-03*. Retrieved from ww.fao.org/economic/esa.

World Intellectual Property Organization. n.d.a. Berne Convention for the Protection of Literary and Artistic Works. Accessed on September 8th 2015 at the WIPO website. http://www.wipo.int/treaties/en/ip/berne/.

World Intellectual Property Organization. n.d.b. Paris Convention for the Protection of Industrial Property. Accessed on September 8th 2015 at the WIPO website. http://www.wipo.int/treaties/en/ip/paris/.

World Trade Organization. 1994. "TRIPS: Agreement on Trade-Related Aspects of Intellectual Property Rights," *Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization established April 15th 1994*. Available online at https://www.wto.org/english/docs_e/legal_e/27-trips.pdf.

World Trade Organization. 2015a. Overview: the TRIPS Agreement. Accessed on September 20th 2015 at the World Trade Organization website. https://www.wto.org/english/tratop_e/trips_e/intel2_e.htm.

World Trade Organization. 2015b. The Uruguay Round. Accessed on September 20th at the World Trade Organization website. https://www.wto.org/english/thewto_e/whatis_e/tif_e/fact5_e.htm.

Wambugu, Florence. 1999. "Why Africa Needs Agricultural Biotech," *Nature* 400: 15-16.

Yadav, Priya. November 29th 2012. "Resistance Sprouts Against Bt Maize," *The Times of India.*

Yu, Peter. 2009. "The Objectives and Principles of the TRIPS Agreement," *Houston Law Review* 46: 797-1046.