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Climate-Resilient Crops and International Climate Change Adaptation Law

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Abstract

This article explores the role of international climate change adaptation law in promoting the use of genetically engineered crops as an adaptation strategy. The severity of climate change impacts and the realization that, by now, some adverse effects are inevitable, has intensified the urgency to devise effective adaptation strategies. Genetically engineered climate-resilient crops are presented as one possible means to adapt to the predicted adverse impacts of climate change on agriculture and crop yields. Despite increased attention on the research and development of climate-resilient crops, particularly by private sector seed corporations, there are many controversies surrounding this proposed adaptation strategy. The key contentions relate to apprehensions about genetically engineered crops more generally, the effectiveness of climate-resilient crops, and the involvement of the private sector in international climate change adaptation initiatives.

The main argument in this article is that the emerging field of international climate change adaptation law contributes to promoting genetically engineered climate-resilient crops as a possible means of adaptation. Moreover, international adaptation law creates an enabling environment for the active engagement of private sector corporations in devising adaptation strategies. Notwithstanding controversies over genetically engineered crops and the role of the private sector, there has been little consideration so far of the influence of the growing international legal regime on climate change on the types of adaptation strategies that are devised and promoted.

Key words

international climate change adaptation law; genetically engineered crops; climate-resilience; seed corporations

1. Introduction

In light of the predicted negative impacts of climate change on food production,[1] genetically engineered climate-resilient crops are increasingly being proposed as a possible adaptation strategy.[2] Climate-resilient crops are intended to increase crop yields, and thereby provide a means of adapting to diminishing crop yields in the face of droughts, higher average temperatures, and other climatic conditions associated with climate change. In December 2011, a genetically engineered drought-resistant type of maize, developed and patented by Monsanto, was approved for

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1 *Infra* notes 31–4.

2 *Infra* Section 3.1.

commercial use on the US market.[3] Although it has hardly received international media attention, this event provides the starting point for this article.

In discussions on climate change adaptation, some participants actively promote genetically engineered climate-resilient crops, whereas others are extremely critical.[4] Even though Monsanto's drought-resistant maize was approved for commercialization in the US, there is little evidence to-date that genetically engineered crops are more 'climate-resilient' than conventionally bred crops.[5] Discussions about climate-resilient crops take place in the context of larger debates about genetically engineered foods and the role of private seed corporations in developing adaptation strategies within the international climate change regime.

This article explores what international climate change adaptation law has to say about genetically engineered climate-resilient crops as a proposed adaptation strategy. Although there are many discussions about climate-resilient crops, there has been little attention to the role of international law.[6]

The article starts by setting out the increasing importance of climate change adaptation and sketching an understanding of international climate change adaptation law. The second section elaborates on the predicted impacts of climate change on agricultural crop yields and on climate-resilient crops as a possible adaptation strategy. The third section of the article explains some of the main controversies surrounding genetically engineered crops. The fourth section contains the main analysis of this article. The argument will be made that international climate change adaptation law – as it is framed and invoked – contributes to promoting genetically engineered climate-resilient crops as adaptation tools and, moreover, creates an enabling environment for the active engagement of the private sector in devising adaptation strategies.

2. Climate change adaptation and international law

Climate change is one of the biggest challenges of our time. The first World Climate Conference was held in Geneva in 1979. The intention behind this conference was to gather scientific evidence relating to climate change and global warming, and to develop policy accordingly. In 1988, the World Meteorological Organization and the United Nations Environment Programme set up the Intergovernmental Panel on Climate Change (IPCC). Its stated aim is 'to provide the governments of the

3 United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA, APHIS), 'Biotechnology: Determinations of Nonregulated Status', www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml. Monsanto's drought-tolerant corn (MON 87460) is listed under number 91 in the table.

4 Sections 3.1 and 3.2 of this article provide some examples of how genetically engineered climate-resilient crops are promoted – more or less explicitly – as a proposed adaptation strategy. Section 4 of this article gives an overview of some of the main controversies of this purported adaptation strategy.

5 *Infra* notes 91–5.

6 In the debates around genetically engineered climate-resilient crops, there is much emphasis on the growing number of patent applications by corporations, and the dominant role played by the private sector. See Section 3 of this article. There are few, if any, discussions of what the influence is of the climate change regime – and particularly international law that relates to adaptation – on creating a conducive context in which such adaptations can be promoted.

world with a clear scientific view of what is happening to the world's climate'.[7] The IPCC attempts to realize this aim in part through the publication of assessment reports, providing 'full scientific and technical assessment of climate change'. The first IPCC assessment report was published in 1990.[8] These reports are considered highly authoritative in the field of global climate change policy, and influence the policies devised to deal with the impacts of climate change.

An international legal framework on climate change was established soon after. During the second World Climate Conference in 1990, preparations were made for the creation of an international treaty on climate change. The United Nations Framework Convention on Climate Change (UNFCCC) came into being in 1992.[9] The aim of the UNFCCC is 'to cooperatively consider what [States Parties] could do to limit average global temperature increases and the resulting climate change, and to cope with whatever impacts were, by then, inevitable'.[10] Five years later, in 1997, the Kyoto Protocol was adopted.[11] It aims primarily at making States Parties commit to realizing emissions reductions to mitigate climate change. The UNFCCC and the Kyoto Protocol together constitute the international legal framework on climate change.[12] This international legal framework on climate change does not create clear obligations on states; however, it can be seen as a regulatory framework within which responses to climate change are negotiated.[13]

As the objectives of the UNFCCC indicate, climate change policy includes mitigation (limiting the impacts of climate change) and adaptation (adjusted to those impacts that are already occurring or inevitable). Early responses focused heavily on mitigating climate change. Emphasis on mitigation is reflected in earlier IPCC assessment reports, as well as in the texts of the UNFCCC and the Kyoto Protocol. The Convention's 'ultimate objective' is the stabilization of greenhouse gas concentrations, in other words, mitigation.[14] The Kyoto focuses on reducing carbon emissions

7 'Intergovernmental Panel on Climate Change (IPCC)', www.ipcc.ch.

8 'Intergovernmental Panel on Climate Change: Reports', www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml.

9 1992 United Nations Framework Convention on Climate Change (UNFCCC), 1771 U.N.T.S. 107 (1992).

10 See UNFCCC, 'Background on the UNFCCC: The International Response to Climate Change', unfccc.int/essential_background/items/6031.php.

11 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change, 37 I.L.M. 22 (1998). The 21st Conference of the Parties to the UNFCCC, taking place in Paris in November and December 2015, aims to create a new agreement to replace the Kyoto Protocol. There are strong calls for the creation of a legally binding and universal agreement. See for more information, S. Maljean-Dubois, M. Wemaere, and T.A. Spencer. 'A Comprehensive Assessment of Options for the Legal Form of the Paris Climate Agreement' (November 2014) *Institute for Sustainable Development and International Relations (IDDRI) Working Paper No.15/14*, Sciences Po.

12 There can be many discussions about whether there is international law on climate change, and, if so, what constitutes this law. Robert Keohane and David Victor have described the broad range of mechanisms developed to regulate climate change action as the 'regime complex for climate change'. One of these regimes is the 'UN Legal Regime', including the UNFCCC and the Kyoto Protocol. R.O. Keohane and D.G. Victor, 'The Regime Complex for Climate Change', The Harvard Project on International Climate Agreements, Discussion Paper 10-33, January 2010, at 5.

13 The UNFCCC has been called 'a system of negotiation through which it would be possible to speedily adopt amendments and updates arising from the continuous rounds of negotiations covering development protocols'. R. Giles-Carnero, 'Climate Change', Oxford Bibliographies, 25 June 2013, www.oxfordbibliographies.com/view/document/obo-9780199796953/obo-9780199796953-0080.xml.

14 UNFCCC, *supra* note 9, Art 2: 'The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of

and mitigating further climate change impacts. Despite accentuating mitigation, the legal framework on climate change also seeks to regulate 'State obligations to conduct adaptation measures and thus enhance adaptive capacity'.[15]

The urgency to focus on adaptation strategies to impacts that were already inevitable became particularly clear with the publication of the third IPCC assessment report in 2001, in which adaptation was addressed in a separate volume.[16] By this time, there was a general consensus that climate change could not be completely averted or sufficiently limited. The need to devise adaptation strategies became unavoidable. The fourth assessment report from 2007 stated that '[f]or impacts that already show or will show in the very near future, *adaptation is the only available and appropriate response*'.[17] The fifth and latest IPCC assessment report, published in 2014, likewise includes a separate volume on adaptation – namely the contribution of Working Group II.[18] The importance of adaptation is recognized also outside of the IPCC reports. A paper published by the Organisation for Economic Co-operation and Development (OECD) in 2011 stated that '[a]daptation to climate change is now widely recognised as an equally important and complementary response to greenhouse gas mitigation'.[19]

Climate change affects many sectors on different levels and in different ways. Adaptation to these various impacts therefore must necessarily encompass different types of measures.[20] In order to implement and enforce adaptation measures on a global scale, an international legal regime is needed.[21] Jan McDonald has stated clearly that '[l]egal institutions and instruments will play an important role in climate change adaptation' and '[l]aw can facilitate adaptation'.[22] The UNFCCC and the Kyoto Protocol have been identified as the international legal framework on climate change, including adaptation. There are, however, a few general references to adaptation in the texts of the UNFCCC and the Kyoto Protocol. Article 4(1)(b) UNFCCC and Article 10(b) Kyoto Protocol stipulate obligations for States Parties to '[f]ormulate,

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the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.'

15 R. Verheyen, 'Adaptation to the Impacts of Anthropogenic Climate Change: The International Legal Framework', (17 December 2002) *Review of European Community & International Environmental Law* 11, at 129. See also J. Verschuuren, 'Climate Change Adaptation under the United Nations Framework Convention on Climate Change and Related Documents', in J. Verschuuren (ed.) *Research Handbook on Climate Change Aaptation Law*, Research Handbooks in Environmental Law no. 16 (2013), 16–31.

16 J.J. McCarthy et al. (eds.), *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (2001).

17 M.L. Parry et al. (eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007), at 19 (emphasis added). See also Verschuuren, *supra* note 15, at 17.

18 C.B. Field et al. (eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*, Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (2013).

19 S. Agrawala et al., 'Private Sector Engagement in Adaptation to Climate Change: Approaches to Managing Climate Risks', (2011) *OECD Environment Working Papers Series No.39*, OECD Publishing, at 9.

20 See, for example, Verschuuren, *supra* note 15, at 3–4.

21 'Regime' is understood here in the sense in which Keohane and Victor described it, as a broad range of mechanisms to regulate climate change impacts. *Supra* note 12.

22 J. McDonald, 'The Role of Law in Adapting to Climate Change', (March/April 2011) *WIREs Climate Change* 2.

implement, publish and regularly update national and, where appropriate, regional programmes containing measures … to facilitate adequate adaptation to climate change'.[23] Article 4(1)(e) UNFCCC urges states parties to '[c]ooperate in preparing for adaptation to the impacts of climate change'.[24]

Even though the UNFCCC and the Kyoto Protocol constitute the international legal framework for climate change adaptation, the texts contained therein are very broad and open-ended. The texts oblige states to 'facilitate adequate adaptation', but do not specify what is meant by 'facilitate' and 'adequate'. The open-endedness of stipulations on adaptation can be attributed in part to the initial emphasis on mitigation, the uncertainties surrounding the course and consequences of future climate change, and the need to capture a wide range of adaptations across sectors and regions.

On account of the open-endedness of adaptation regulations in the UNFCCC and the Kyoto Protocol, and the diversity of climate change impacts and adaptation measures, many authors view international adaptation law more broadly. Jouni Paavola and W. Neil Adger refer to the 'climate change regime' as 'the collection of principles, norms, rules, and decision-making procedures around which actor expectations converge' in the field of climate change.[25] In a later article, J.B. Ruhl and James Salzman refer to international climate change adaptation law as 'a collection of fields independently adapting to climate change – rather than organically coalescing into a new and distinct field'.[26]

The texts of the UNFCCC and the Kyoto Protocol can be seen as the international legal framework on climate change adaptation. However, other 'principles, norms rules, and decision-making procedures' are involved in interpreting what 'facilitating adequate adaptation measures' means. In this article, 'international climate change adaptation law' is understood as a 'regime', including the framework convention and its additional protocol, as well as relevant reports, initiatives, discourse, institutions, and decision-making procedures that give meaning to the broad framework of 'adequate adaptation'. This article focuses on IPCC assessment reports, international adaptation initiatives, and special reports and papers commissioned by the UNFCCC and the IPCC.[27] The main international adaptation initiatives are the Cancun Adaptation Framework (CAF),[28] the Nairobi Work Programme on

23 UNFCCC, *supra* note 9; Kyoto Protocol, *supra* note 11.
24 UNFCCC, *supra* note 9.
25 J. Paavola and W.N. Adger, 'Fair Adaptation to Climate Change', (2006) 56 *Ecological Economics* 594, at 597–8.
26 J.B. Ruhl and J. Salzman, 'Climate Change Meets the Law of the Horse', (2013) 62 *Duke Law Journal* 975, at 976. Ruhl and Salzman liken climate change adaptation law to cyberspace law in the mid-1990s; a new issue that is regulated by a range of legal fields rather than one new legal regime.
27 The understanding of 'international climate change adaptation law' in this article is inspired by the 'regime complex' as described by Keohane and Victor, *supra* note 12. International climate change adaptation law is an emerging distinct field of international law, and its contours are being defined through expert assessments, discourse, and adaptation initiatives.
28 The CAF was adopted at the 2010 Climate Change Conference in Cancun. Its primary objective is 'to enhance action on adaptation, including through international cooperation and coherent consideration of matters relating to adaptation under the Convention'. United Nations Framework Convention on Climate Change, Decision 1/CP.16: The Cancun Agreements: Outcome of the Work of the Ad Hoc Working Group on Long-Term Cooperative Action, Section II Enhanced Action on Adaptation (2011), paras 11–35. See also 'Cancun Adaptation Framework', unfccc.int/adaptation/items/5852.php.

Impacts, Vulnerability and Adaptation to Climate Change (NWP),[29] and the National Adaptation Programmes of Action (NAPAs).[30]

This article explores the role that international climate change adaptation law – understood in this broad fashion – plays for drought- and other climate-resilient seeds and crops as one proposed adaptation strategy. The next section will elaborate on the predicted adverse impacts of climate change on agriculture, and introduce drought-resilient crops as an adaptation strategy.

3. Climate-resilient crops as an adaptation strategy to the adverse impacts of climate change on crop yields

Agriculture is one of the sectors predicted to be most severely affected by the impacts of climate change. The fifth and latest IPCC Assessment Report indicates that it is highly likely that the impacts of climate change – including higher average temperatures, more (severe) instances of drought, and higher levels of precipitation – will adversely affect food production.[31] The 2014 Climate Summit held in September at the UN Headquarters in New York gave particular attention to agriculture. Agriculture was one of the 'action areas' during this summit, and experts emphasized that 'the warming of the planet is already affecting yields of crucial crops'.[32] The website of this summit stated that '[f]ood production will need to increase by at least 60 per cent over the next 35 years to provide food security for the 9 billion people expected to be living on the planet by 2050'.[33] At least in part, losses of important crop yields are attributed to changing climatic conditions. These seem to be inevitable consequences of climate change that require adaptation strategies to cope.

The accent in discourse about climate change impacts on agriculture is on declining crop yields. The most obvious way to adapt is to find ways in which to maintain, or even to increase, crop yields. The UNFCCC, in Article 2, names as one of its objectives the adequate availability of food.[34] One adaptation strategy that has gained popularity in recent years is the development and use of seeds and crops that are resistant to certain climate-related stresses. These 'climate-resilient' or 'climate-ready'

29 The NWP was established at the 2005 Conference of the Parties (COP). It is a mechanism established under the UNFCCC and its aim is to 'facilitate and catalyze the development and dissemination of information and knowledge that would inform and support adaptation policies and practices'. 'Nairobi Work Programme on Impacts, Vulnerability and Adaptation to Climate Change (NWP)', www3.unfccc.int/pls/apex/f?p=333:1:5438959288838350.

30 NAPAs are part of a work programme for least developed countries, established at the 2001 meeting of the COP. The main aim of NAPAs is to 'provide a process for the LDCs to identify priority activities that respond to their urgent and immediate needs with regard to adaptation to climate change'. UNFCCC, 'Background Information on the NAPAs', unfccc.int/adaptation/workstreams/national_adaptation_programmes_of_action/items/7572.php.

31 J.R. Porter et al., 'Food Security and Food Production Systems', in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*, Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (2013).

32 UN Climate Summit 2014, 'Action Area: Agriculture', www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/07/Climate-Summit-Action-Areas_Agriculture1.pdf.

33 Ibid.

34 UNFCCC, Art. 2, *supra* note 14: The articulation of the 'ultimate objective' includes a reference a consideration 'to ensure that food production is not threatened'.

crops are intended to produce higher crop yields in the face of climatic conditions associated with climate change, and particularly drought.

3.1. Climate-resilient / Climate-ready crops

The call for developing crops to be resistant to abiotic stresses related to climate change comes from various actors. By far the most dominant players in the research and development of climate-ready crops are the biggest agricultural biotechnology corporations.[35] Their interest in developing climate-resilient crops is evident in part in the rising number of patent applications filed on such climate-related crop traits. In a 2009 report, the OECD stated that annual patent applications on adaptation-related biotechnology 'have increased from fewer than 10 in 1995 to almost 200 by 2007'.[36] This 'adaptation-related biotechnology' includes engineering seeds and crops for specific climate-resistant traits. Civil society organization ETC Group in a report from 2008 stated that large seed corporations had filed 532 patent applications on 'climate-ready' genes at patent offices around the world.[37] A later ETC Group report from 2010 notes that a further 1663 patent documents for abiotic stress tolerance in plants were filed between 2008 and 2010.[38] This organization has estimated that 90 per cent of patent applications on abiotic stress-resistant traits in seeds come from private corporations, and only 10 per cent from the public sector.[39]

While private sector corporations play a leading role, public sector international agricultural research institutions are collaborating with private corporations in developing climate-resilient seeds and crops. One example of such collaboration is a project called 'Water Efficient Maize for Africa' (WEMA) by the African Agricultural Technology Foundation. Monsanto is a partner institution in this project.[40] Another example is a project called 'Improved Maize for African Soils', led by the International Maize and Wheat Improvement Centre (CIMMYT) and in partnership with Pioneer Hi-Bred (DuPont).[41]

The CIMMYT is one of the research centres of the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is the largest conglomerate of international agricultural research, including 15 research centres. This consortium of (public) international agricultural research institutes also promotes the research and development of climate-resilient crops. In a press release from 2006, the CGIAR explicitly names 'climate-ready crops' as a possible adaptation strategy.[42] The news report states that the CGIAR is contributing to 'refining a

35 The largest corporations include Monsanto, Syngenta, Pioneer Hi-Bred, BASF, and Bayer.
36 S. Agrawala, 'Adaptation and Innovation: An Analysis of Crop Biotechnology Patent Data', (2012) *OECD Environment Working Papers No. 40*, OECD Publishing, at 3.
37 ETC Group, 'Patenting the "Climate Genes" … and Capturing the Climate Agenda', (2008). A list of these patent applications can be found in Appendix A of the report.
38 ETC Group, 'Capturing "Climate Genes": Gene Giants Stockpile Patents on "Climate-Ready" Crops in Bid to Become "Biomassters"', (2010), at 1.
39 Ibid., at 20.
40 For more information about WEMA, see wema.aatf-africa.org/about-us/partner-institutions.
41 For more information about CIMMYT, see: www.cimmyt.org.
42 'Intensified Research Effort Yields Climate-Resilient Agriculture to Blunt Impact of Global Warming, Prevent Widespread Hunger', Consultative Group on International Agricultural Research, www.cgiar.org/newsroom/releases/news.asp?idnews=521.

comprehensive climate change agenda that is already generating climate-resilient innovations, including crops bred to withstand heat, salt, submergence or waterlogging, and drought'.[43]

A multitude of reports and other literature is actively promoting the need for adaptation measures that will contribute to increasing food production in the face of adverse climatic conditions. The International Food Policy Research Institute (IFPRI), in a report on adaptation strategies for climate change impacts on agriculture, concludes with a recommendation that '[c]rop and livestock productivity-enhancing research, including biotechnology, will be essential to help overcome stresses due to climate change'.[44] An article that appeared in *The Economist* in 2006 focused on efforts to increase yields of rice in adverse climatic conditions using genetic modification by the International Rice Research Institute (IRRI).[45] This article iterates the predicted increase in droughts as a result of climate change, and the adverse effects it will have on rice yields in Asia. Scientists from the IRRI voice doubts that conventional breeding alone will be enough to sustain rice yields, and advocate the use of genetic engineering techniques to develop more drought-resistant rice.[46] A more recent article in *The Economist* argues that '[g]enetic research holds out the possibility of breakthroughs that could vastly increase the productivity' and that GM (genetically modified) crops 'are more resistant to the vagaries of climate change'.[47]

Academic authors, coming from different perspectives, also reinforce the necessity of climate-resilient crops. Robert Paarlberg makes a strong case for agricultural biotechnology in the fight against hunger, particularly in his book *Starved for Science*, in which he promotes the use of agricultural biotechnology in Africa. He argues that '[t]he science of genetic engineering has significant potential to help rural Africa, particularly since it can now speed the development of crop varieties better able to tolerate stress factors such as drought'.[48] In a book on fairness in climate change adaptation, one of the authors includes '[e]ngineering seeds to make them cope better with altered climates'[49] as one of a range of adaptation strategies.

This brief overview is by no means intended to paint a complete or detailed picture of the actors involved in the development and promotion of climate-resilient crops as a proposed adaptation strategy. The purpose is merely to illustrate that various actors promote climate-resilient seeds and crops as potential adaptation strategies. While the general discourse includes a variety of climate-resilient traits, recent attention has focused on drought-resistance.

43 Ibid.
44 G.C. Nelson et al., 'Climate Change: Impact on Agriculture and Costs of Adaptation' (2009) International Food Policy Research Institute, Washington D.C., at viii.
45 The Economist, 'Genetic Modification Filling Tomorrow's Rice Bowl: Genetic Engineers Are Applying Their Skills to Tropical Crops', (6 December 2006) *The Economist*, www.economist.com/node/8380318.
46 As mentioned in *The Economist* article, ibid.
47 The Economist, 'Fields of Beaten Gold', (7 December 2013) *The Economist*, www.economist.com/news/leaders/21591176-greens-say-climate-change-deniers-are-unscientific-and-dangerous-so-are-greens-who-oppose-gm.
48 R.L. Paarlberg, *Starved for Science: How Biotechnology Is Being Kept out of Africa* (2008), viii.
49 W.N. Adger et al. (eds.), *Fairness in Adaptation to Climate Change*, (2006), 46.

3.2. Drought-resistant crops and Monsanto's DroughtGard

One of the biggest challenges for agriculture in the context of climate change is the increasing incidence of droughts.[50] Water is one of the main limiting factors in food production, so a loss of water is potentially devastating for agricultural crops yields.[51] For this reason, corporations and agricultural research institutes are particularly interested in developing drought-resistant traits in crops.[52] Biotechnology corporations have presented themselves as some of the main providers of these seeds, investing vast amounts of funds into the research and development of crops that are able to grow with less water.[53]

Bill Niebur, vice president and general manager for DuPont Pioneer China, has been quoted as saying about the development of drought-resistant crops: 'Drought is a global problem and we recognize the threat that comes with climate change. We've got our top talent in our organization working on this.'[54] At the Food and Agriculture Organization's 'High-Level Conference on World Food Security: the Challenges of Climate Change and Bioenergy' in 2008, biotechnology corporations promoted their drought-resistant technologies.[55] Among those was Monsanto, who announced its commitment to contribute to increasing food production, for instance by developing drought-resistant seeds.[56]

Breeding crops to thrive in particular climatic conditions is not new. Farmers have since the beginning of agriculture chosen those crops most suitable to the environment.[57] What is different about today's drought-resistant crops is that some of these crops are developed using genetic engineering techniques. Genetic engineering allows single genetic traits to be extracted from the seed or plant, and inserted into another seed or plant. Until now, genetic engineering in agriculture has been used mostly to make crops resistant to herbicides and pesticides, often also developed

50 See, for example, K.E. Trenberth et al., 'Global Warming and Changes in Drought', (2014) 4 *Nature Climate Change* 17, and Parry et al., *supra* note 17.

51 See, for example, A. Dai, 'Increasing Drought under Global Warming in Observations and Models', (2013) 3 *Nature Climate Change* 52, and Trenberth et al., *supra* note 50.

52 This idea of finding and using 'drought-resistant' crops to adapt to periods of drought is not a new idea, as Richard Grove demonstrates in his book *Green Imperialism*. Grove cites examples of scientists during the British rule in India in the 1700s talking of 'deliberately cultivating and bringing drought-resistant crops together in one place, with the intention of distributing them to peasants living in drought-prone regions'. R.H. Grove, *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600-1860* (1995), 333.

53 Suggestions to use biotechnology to develop 'drought-resistant' crops are done often by or on behalf of the private sector. See for instance Agrawala et al., *supra* note 36; Agrawala et al., *supra* note 19; KPMG, 'Climate Change Adaptation in the Private Section: UNFCCC Private Sector Initiative', (30 March 2012), 28, unfccc.int/files/adaptation/nairobi_work_programme/private_sector_initiative/application/pdf/kpmg_psi_database_report.pdf; Pricewaterhousecoopers LLP, 'Business Leadership on Climate Change Adaptation: Encouraging Engagement and Action', (December 2010), PricewaterhouseCoopers, London, www.pwc.co.uk/sustainability-climate-change/publications/adapting-to-climate-change.jhtml.

54 C. Gillam, 'Biotech Companies Race for Drought-Tolerant Crops', *Thomson Reuters*, 14 January 2008, uk.reuters.com/article/2008/01/14/lifestyle-seeds-drought-dc-idUKN1149367520080114.

55 G. Lean, 'Biotech Giants Demand a High Price for Saving the Planet', *The Independent*, 8 June 2008, www.independent.co.uk/environment/climate-change/biotech-giants-demand-a-high-price-for-saving-the-planet-842480.html.

56 Ibid.

57 Grove, *supra* note 52.

by the same corporations.[58] While many drought- and other climate-resilient crops are developed using conventional breeding methods,[59] large corporations such as Monsanto are increasingly relying on genetic engineering techniques to develop drought-resistant crops.

Monsanto has been very active in the research and development of drought-resistant maize using genetic engineering techniques. One type of drought-resistant maize developed by Monsanto is called 'MON 87460' or 'DroughtGard'. Monsanto developed DroughtGard in the context of severe droughts in the United States. This variety of maize is promoted to adapt to drier conditions and sustain or even increase yields of maize. In December 2011, the United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) approved this first genetically engineered drought-resistant maize for commercial use on the US market [60]

Although DroughtGard was approved for commercialization in the US domestic market, it is nevertheless a landmark event for climate-ready crops as an international adaptation strategy. Monsanto and other large seed corporations are the main players in the research and development of climate-resilient crops as a proposed adaptation to adverse climatic conditions. The decision by APHIS is a great commercial success for Monsanto, and moreover reinforces the idea that drought-resilient crops are desirable and necessary in the struggle to adapt to the impacts of climate change.[61] Monsanto's success has, however, not abated fierce discussions over genetically engineered and climate-resilient crops.

4. Controversies over climate-resilient crops

Despite increasing attention for climate-resilient seeds and crops as a possible adaptation strategy,[62] and notwithstanding the recent commercial success of Monsanto's DroughtGard in a domestic context, there is a great deal of criticism surrounding climate-resilient crops. Three lines of contentions will be explored here. Namely, controversies over genetically engineered and patented crops, doubts about the effectiveness of climate-resilient crops and technological fixes more generally, and criticisms of the dominant role played by the private sector.

58 GMO Compass, 'Herbicide Resistant Crops', www.gmo-compass.org/eng/agri_biotechnology/breeding_aims/146.herbicide_resistant_crops.html.

59 Some evidence can be found that conventional breeding techniques are in fact outperforming genetic engineering in developing higher yielding drought-resistant crops. See, for instance, N. Gilbert, 'Cross-Bred Crops Get Fit Faster', (16 September 2014) *Nature* 513, at 16, www.nature.com/news/cross-bred-crops-get-fit-faster-1.15940;

60 USDA, APHIS, *supra* note 3.

61 One critic of DroughtGard has suggested that Monsanto might never succeed in developing effective genetically engineered drought-resistant crops, 'except in PR terms'. T. Philpott, 'USDA Greenlights Monsanto's Utterly Useless New GMO Corn', *Mother Jones*, 23 January 2012, www.motherjones.com/tom-philpott/2012/01/monsanto-gmo-drought-tolerant-corn. Succeeding in PR terms is not a small feat in complex debates about climate change adaptation and genetically engineered crops.

62 See discussion in Section 3.1 of this article.

4.1. Genetically engineering food: the big debate

Until now, the cultivation of genetically engineered crops is primarily taking place in five countries, which concentrate on four types of crops, and two main traits.[63] There is, however, evidence of increasing use of genetically engineered crops worldwide,[64] and this is coupled with a growing number of patent applications.[65] Notwithstanding this rise, there is a great deal of resistance against the use of genetically engineered crops. This resistance takes a number of angles, including ethical questions and food safety concerns. There is also particular opposition against corporate domination of genetically engineered seeds through patents. Arguments are often made that these seed corporations concentrate on commercially viable crops,[66] and not necessarily on those crops that are used by farmers in developing countries.[67] The scope of this article does allow for a detailed analysis of the debates surrounding genetically engineered food, but will instead highlight some of the key contentions.

Genetically engineered (or modified) foods are described by the World Health Organization as 'foods derived from organisms whose genetic material (DNA) has been modified in a way that does not occur naturally, e.g. through the introduction of a gene from a different organism'.[68] One line of criticism in relation to genetic engineering of living organisms – including food crops – is an ethical criticism. There are critics who argue that genetic engineering is 'playing God'.[69] Such arguments are often based on contentions that even though it may be technically possible to genetically engineer food, the wider consequences of modifying living things that have developed over thousands of years cannot be overseen.[70] The term 'Frankenfoods' is sometimes invoked to describe genetically engineered foods;[71] this

63 Nature, 'GM Crops: A Story in Numbers', in 'GM Crops: Promise and Reality' (2 May 2013) *Nature* 497, Special Edition, 22–3. Most genetically engineered crops are grown in the United States, Brazil, Argentina, Canada, and India. In 2012, nearly all genetically engineered crops were soya, maize cotton, and granola. The most popular genetically engineered traits are herbicide tolerance and insect resistance. See also: ISAAA, 'Global Status of Commercialized Biotech/GM Crops: 2014' Brief 49-2014: Executive Summary, www.isaaa.org/resources/publications/briefs/49/executivesummary/default.asp. Table 1 of this report shows the 'Global Area of Biotech Crops in 2014'. In addition to the five top countries, countries such as Bangladesh, Vietnam, and Indonesia are also starting to introduce genetically engineered crops.

64 ISAAA 2014, *supra* note 63.

65 For instance, about 2,000 patent applications were applied for in Europe on genetically engineered crops, mostly by the largest seed corporations. ASEED Europe, 'GMO Patents Held by Bayer and BASF', 21 October 2013, aseed.net/en/gmo-patents-held-by-bayer-and-basf. In China, patent applications on genetically engineered crops are also increasing. SciDev.Net, 'China's Agricultural Patents on the Rise', 2 March 2010, www.scidev.net/global/farming/news/china-s-agricultural-patents-on-the-rise.html.

66 Nature 2013, note 63 above: the four most grown genetically engineered crops are commercially viable.

67 Crops that are 'under-researched and underfunded due to their limited importance in the global market' are often referred to as 'orphan crops'. Despite their relative lack of commercial value, orphan crops can be extremely important in local food production, particularly in the face of climate change. See, for example, K. Assefa, 'The Dire Need to Support "Orphan Crop" Research' SciDev.Net, 27 January 2014, www.scidev.net/global/agriculture/opinion/the-dire-need-to-support-orphan-crop-research.html.

68 World Health Organization, 'Food, Genetically Modified', www.who.int/topics/food_genetically_modified/en/.

69 See for an overview of controversies related to genetically engineered food, P. Diehl, 'The Controversy of Genetically Modified Food', 24 November 2014, biotech.about.com/od/Genetically-Modified-Organisms/a/The-Controversy-Of-Genetically-Modified-Food.htm.

70 Ibid.

71 See, for example, T. Laskawy, 'Frankenfoods: Good for Big Business, Bad for the Rest of Us', *Grist*, 9 May 2013, grist.org/food/frankenfoods-good-for-big-business-bad-for-the-rest-of-us/; M. Schoffro Cook, '20 Frankfoods to Avoid', Care2, 12 September 2013, www.care2.com/greenliving/top-20-frankenfoods-to-avoid.html;

term refers to any food that is genetically engineered and alludes to its 'unnatural' origins.[72]

Another big issue related to genetically engineered food focuses on food safety concerns. These concerns are illustrated most clearly through consumer fears, especially evident in Europe. Consumer fears heightened particularly in the 1990s as a result of a number of food safety crises, including Bovine Spongiform Encephalopathy (BSE), more commonly known as Mad Cow Disease.[73] Although this was unrelated to genetically modified foods, such large-scale food safety crises seriously affected consumer attitudes towards genetically engineering foods. Safety concerns are often coupled with disagreement about the labelling of genetically engineered foods.[74] Some of these concerns are highlighted in current debates surrounding the Transatlantic Trade and Investment Partnership (TTIP) between the US and the EU. Groups within the EU express fears that the TTIP could open the door for genetically engineered foods in Europe.[75]

Another controversial issue relates to the application of patent rights on genetically engineered crops, as made possible especially by Article 27.3(b) of the Agreement on Trade-Related Aspects of Intellectual Property (TRIPS).[76] A particular concern is voiced by developing countries, whose territories contain most of the world's genetic resources. These countries consider it highly unfair that seed corporations supported by developed country governments are able to apply for exclusive patent rights on seeds and crops that have been genetically engineered using plant genetic resources as their raw material. Developing countries do not receive similar benefits from offering these genetic resources.[77]

'No patents on life!' and 'no patents on seeds!' are popular slogans that signal resistance to subjecting plants and living things to intellectual property protection.[78] The coalition of 'No Patents on Seeds!' has recently published an appeal to European

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C. Guthrie, 'Frankenfood = Genetically Modified Foods', Experience Life, June 2013, experiencelife.com/article/frankenfood-genetically-modified-foods/.

72 For a definition of Frankenfoods see dictionary.reference.com/browse/frankenfood.

73 European Food Safety Authority, 'Successful EU Response to BSE', 30 January 2012, www.efsa.europa.eu/en/press/news/120130f.

74 See, for example, GMO Compass, 'Labelling of GMO Products: Freedom of Choice for Consumers', www.gmo-compass.org/eng/regulation/labelling/; LabelGMOs website, focusing on the need to label genetically engineered foods, see www.labelgmos.org/the_science_genetically_modified_foods_gmo.

75 See, for instance, Corporate Europe Observatory, 'An Open Door for GMOs? – take action on the EU-US Free Trade Agreement', corporateeurope.org/trade/2013/05/open-door-gmos-take-action-eu-us-free-trade-agreement; F. Harvey, 'EU Under Pressure to Allow GM Food Imports from US and Canada', *The Guardian*, 5 September 2014, www.theguardian.com/environment/2014/sep/05/eu-gm-food-imports-us-canada.

76 Agreement on Trade-Related Aspects of Intellectual Property Rights, 15 April 1994, Marrakesh Agreement Establishing the World Trade Organization, Annex 1C, in *The Legal Texts: The Results of the Uruguay Round of Multilateral Trade Negotiations*, 1869 U.N.T.S. 299; 33 I.L.M. 1197, 1994.

77 See, for example, J. Linarelli, 'TRIPS, Biotechnology and the Public Domain: What Role will World Trade Law Play?' in M.N. Cardwell, M.R. Grossman, and C.P. Rodgers (eds.) *Agriculture and International Trade: Law, Policy, and the WTO* (2003), 197.

78 See, for example: R. Charnas, '"No Patents on Life" Working Group Update', www.councilforresponsiblegenetics.org/ViewPage.aspx?pageId=169; The International Coalition of 'No Patents on Seeds', 'Stop Patents on Plants and Animals!', no-patents-on-seeds.org/.

governments to stop the application of patent rights on genetically engineered food crops.[79] A spokesperson for the coalition has stated that:

> Farmers, food producers and consumers will be severely impacted by the negative consequences. Patents on plants and animals give corporations the power to decide what is grown in the fields and which price we all have to pay for it.[80]

The contemporary debate on the legal treatment of plant genetic resources has been referred to as 'Seed Wars'. This term was first used in a 1984 *Wall Street Journal* report. Keith Aoki and Jack Kloppenburg have written extensively about seed wars, articulating the controversies over intellectual property protection on seeds.[81] Vandana Shiva of Navdanya has argued that '[t]he only reason crops have been genetically engineered is to take patents on seeds, and collect royalties'.[82]

Many of the climate-resilient seeds developed by seed corporations are genetically engineered. Therefore, debates about climate-resilient seeds as possible adaptation measures should be viewed against the backdrop of larger discussions and controversies about genetically engineered foods. On top of questions about ethics, food safety, and patent rights more generally, there are also doubts about the effectiveness of genetically engineered climate-resilient crops.

4.2. Climate-resilient or not so climate-resilient?

When we accept that drought- and other climate-resilient crops are necessary adaptation measures in the face of adverse climatic conditions, and put aside the ethical concerns over genetically engineered foods, a more practical criticism is to question whether these crops in fact produce higher yields. The main concerns about climate change impacts on agriculture relate to significant loss in crop yields.[83] If climate-ready seeds are a proposed adaptation strategy, then logically their principal rationale must be to increase crop yields. Despite calls for the necessity of genetically engineered, climate-resilient crops, uncertainty remains about whether these crops actually produce more food. These doubts can be viewed in a broader context of scepticism about technological solutions.

The CGIAR has contributed to discourse promoting the use of climate-ready crops.[84] In the same press release that advocates climate-ready seeds, there is also the recognition that 'there are limits to the ability of new varieties to counteract the effects of heat, drought, and submergence'.[85] These limits become very clear

79 No Patents on Seeds!, 'Monsanto soon to receive 30 European patents on food plants: Coalition of No Patents on Seeds! publishes appeal to European governments', 21 May 2015, no-patents-on-seeds.org/en/information/news/monsanto-soon-receive-30-european-patents-food-plants.
80 Ibid.
81 See, especially: J. Kloppenburg Jr. and D.L. Kleinman, 'Seed Wars: Common Heritage, Private Property, and Political Strategy' (1987) *Socialist Review* 95, at 7–41; and K. Aoki, *Seed Wars: Controversies and Cases on Plant Genetic Resources and Intellectual Property* (2008).
82 V. Shiva, 'GMOs, Seed Wars, and Knowledge Wars', Navdanya, www.navdanya.org/news/282-gmos-seed-wars-and-knowledge-wars.
83 *Supra* notes 31–3.
84 CGIAR, *supra* note 42.
85 Ibid.

in two reports by the Union of Concerned Scientist (UCS).[86] In a report published in 2009, the UCS presents findings that genetically engineered crops have to date not produced higher yields than conventionally bred crops.[87] Following the general report on genetically engineered crops, the UCS published another report in 2012 – after DroughtGard was approved for commercialization on the US market – looking specifically at drought-resistant crops.[88] This report highlights the lack of success to date in terms of 'improved water use efficiency' of genetically engineered corn varieties.[89] Moreover, the limited drought-resistance is not deemed to hold up against the costs invested in their development. The number of field trials done with drought-resistant crops in the US, the UCS argues in this report, has not increased significantly over the years, casting doubts from the perspective of these scientists on whether drought-resistance is really a priority of biotechnology research.[90]

Part of the critique in the later report is based on Monsanto's and APHIS's own acknowledgements about the limitations of DroughtGard. APHIS in its final assessment report of this drought-resistant corn variety wrote that 'equally drought resistant corn varieties produced through conventional breeding techniques are readily available and may be cultivated in lieu of MON87460'[91] and that 'reduced yield-loss phenotype of MON87460 does not exceed the natural variation observed in currently-available corn varieties'.[92] This drought-resistant maize variety may not really be very drought-resistant at all, and in any case no more drought-resistant than non-GM varieties.[93]

GM Watch[94] wrote after the approval for commercialization of Monsanto's DroughtGard:

> Despite all the hyperbole about the promise of GM drought resistant crops, it took until December 2011 for the first GM drought resistant crop to be approved for marketing anywhere in the world. [...] By contrast, non-GM plant breeding has achieved success after success in producing a variety of drought resistant crops, including a whole series of drought resistant maize varieties, and these have been made available in many countries, including developing countries that are particularly vulnerable to drought.[95]

Scepticism about the effectiveness of genetically engineered, climate-resilient crops can be viewed within a broader context of apprehension towards

86 The Union of Concerned Scientists is an independent collaboration of scientists based in the US that critically addresses 'the planet's most pressing problems'. See www.ucsusa.org.
87 D. Gurian-Sherman, 'Failure to Yield: Evaluating the Performance of Genetically Engineered Crops', (2009) Union of Concerned Scientists, Cambridge, Massachusetts.
88 D. Gurian-Sherman, 'High and Dry: Why Genetic Engineering Is Not Solving Agriculture's Drought Problem in a Thirsty World', (2012) Union of Concerned Scientists, Cambridge, Massachusetts.
89 Ibid.
90 Ibid., at 4.
91 USDA/APHIS, 'Monsanto Company Petition (07-CR-191U) for Determination of Non-regulated Status of Event MON 87460' (November 2011), 33, www.aphis.usda.gov/brs/aphisdocs/09_05501p_fea.pdf.
92 Ibid., at 34.
93 Philpott, *supra* note 61.
94 GM Watch is a not-for-profit organization that seeks to counter what they see as 'propaganda' in the biotech industry. See www.gmwatch.org.
95 GM Watch, 'Non-GM Successes: Drought Tolerance', www.gmwatch.org/component/content/article/31-need-gm/12319-drought-resistance.

technologically-informed solutions.[96] In a commentary in *Nature*, Daniel Sarewitz and Richard Nelson caution against using technological fixes out of context. They argue that not all problems can be solved using technology, and perhaps more importantly, that technology by itself is not enough.[97] John Bellamy Foster echoes these criticisms specifically regarding technologies as used in climate change strategies. He writes that 'the dominant response [to climate change] is to avoid all questions about the nature of our society, and to turn to technological fixes or market mechanisms of one sort or another'.[98] Bellamy Foster argues that technology alone will not suffice in addressing the problems caused by climate change, but that a 'revolution of our social system'[99] is required, as well.

Jack Heinemann reinforces this view by writing that '[t]he current failures to feed the world are not due to limitations of technology, but to social choices'.[100] He underscores the findings by the Union of Concerned Scientists[101] in confirming that there are to date 'no commercially available GM plants with traits that reduce the effects of abiotic stress'.[102] There are serious questions, therefore, about the effectiveness of genetically engineered climate-resilient crops specifically and, more generally, about the potency of technology in adapting to the impacts of climate change.

4.3. Private sector monopoly of climate-ready crops: Gene Giants

Private sector seed corporations are the main players in the research and development of climate-resilient crops.[103] Leaving aside general controversies over genetically engineered foods and more specific doubts about the effectiveness of genetically engineered, climate-resilient crops, a third significant line of criticism is directed at private sector dominance. The principal concern is that private sector corporations are primarily interested in making profits. Consequently, they focus on research and development of commercially viable crops, which are not necessarily the crops grown and used in the developing world that suffers the most from climate change impacts.[104]

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96 David Harvey writes, for instance, about the 'fetish of technology', which 'arises because we endow technologies – mere things – with powers they do not have (e.g., the ability to solve social problems, to keep the economy vibrant, or to provide us with a superior life)'. D. Harvey, 'The Fetish of Technology: Causes and Consequences' (2003) 13 *Macalester International* 3, at 3.

97 D. Sarewitz and R. Nelson, 'Three Rules for Technological Fixes' (December 2008) *Nature* 456.

98 J. Bellamy Foster, 'Why Ecological Revolution?' (2010) 61 *Monthly Review*.

99 Ibid.

100 J.A. Heinemann, Ch.4 Commentary VI: 'Genetic Engineering and Biotechnology for Food Security and for Climate Change Mitigation and Adaptation: Potential and Risks' in *Trade and Environment Review* 2013: 'Wake Up Before It Is Too Late: Make Agriculture Truly Sustainable Now for Food Security in a Changing Climate' United Nations Conference on Trade and Development, at 203.

101 Gurian-Sherman 2009, *supra* note 87.

102 Heinemann, *supra* note 100, at 208.

103 See, for instance, reports by the ETC Group and the OECD, noting both the rapidly rising number of patent applications and the large proportion of those applications from a handful of seed corporations. *Supra* notes 37–8 (ETC Group), 19 and 36 (OECD).

104 See, for example, M.A. Altieri, 'Agroecology, Small Farms, and Food Sovereignty', (2009) 61 *Monthly Review*, in which the author argues that traditional crops grown by indigenous farmers often outweigh corporate monocrops in terms of productivity and resilience to adverse climatic conditions.

Henry Shue writes that '[i]f there were lots of profit to be made in solving the world's hunger problem, market forces would presumably have sent people rushing in to solve it long ago'.[105] This observation can be applied to private sector dominance in climate-resilient crops. This does not mean that private actors can have no contribution to addressing problems of crop losses in the face of climate change; the point is simply that this is not their primary goal. In an article about biotechnology and hunger that discusses the problem of private control over plant genetic resources, the journalist cites Ethiopian plant ecologist Tewolde Berhan Gebre Egziabher as saying the following:

> It's not the nature of genetic engineering itself that's the problem; it is the way genetic engineering has evolved. Early on, it came under the control of the private sector and is now being developed almost solely by that sector. By definition, the private sector's goal is to make money. It will not focus its attention on the needs of the poor, except as a way to sell its products.[106]

Additionally, there are concerns about the growing number of patent applications on climate-resilient crops that may obstruct access to these seeds to those who need them most. The ETC Group has been very vocal of what they perceive as a private sector monopoly over climate-resilient crops, referring to large seed corporations as 'Gene Giants'.[107] In a 2010 report about climate-ready seeds, they state their policy goals as follows:

> **There is no societal benefit when governments allow six corporations to monopolize food.** The pretext of indispensible [sic] so-called climate-ready genes will increase farmer dependence on GM crops, jeopardize biodiversity, and threaten global food sovereignty.[108]

These critical words make clear that there are doubts not only about the effectiveness of genetically engineered climate-resilient crops, but also serious concerns about the purported private sector monopoly through patent applications.

Onora O'Neill in an article on ending world hunger has written that '[t]echnological innovation, even if successful, may not benefit those who need it most'.[109] This observation can also apply to climate-resilient seeds and the private sector monopoly. As private corporations are focused on commercially viable crops and moreover increasingly applying for exclusive patent rights that may prevent poor farmers to purchase the seeds, there are concerns that climate-resilient crops will not benefit those who suffer most from the impacts of climate change on crop yields. London-based International Institute for Environment and Development (IIED) writes in this regard that 'farmers in developing countries are losing one of

105 H. Shue, 'Solidarity among Strangers and the Right to Food' in W. Aiken and H. LaFollette (eds.) *World Hunger and Morality* (1996), 128.
106 M. Berlin Snell, 'Against the Grain: Why Poor Nations Would Lose in a Biotech War on Hunger', (July/August 2013) *Sierra Magazine – Sierra Club.*
107 For instance, in the title of their 2010 report, *supra* note 38.
108 ETC Group 2010, *supra* note 38, at 2 (emphasis in original text).
109 O. O'Neill, 'Ending World Hunger' in W. Aiken and H. LaFollette (eds.) *World Hunger and Morality* (1996), 92.

their best hopes to limit the impacts of climate change because of growing corporate control of the seeds they plant'.[110]

A fundamental concern in terms of international law – and, in this case, particularly climate change adaptation law – is that it creates obligations for states, and not for private corporations. It may therefore be difficult to regulate climate-resilient crops as a global adaptation measure if they are almost exclusively in the hands of private sector seed corporations. The next part of this article returns to international climate change adaptation law, and explores how these key controversies and concerns related to climate-resilient crops are addressed in law.

5. International climate change adaptation law is conducive to climate-resilient crops as adaptation measures

Section 1 of this article discussed the growing awareness that some impacts of climate change are already inevitable, and therefore adaptation is now considered equally urgent as mitigation. It also outlined the international legal framework on climate change adaptation. Climate-resilient crops are often presented as a possible adaptation measure. The main argument of the article will be made in the following sections, to the effect that international climate change adaptation law creates an enabling environment for the private sector to develop genetically engineered climate-resilient crops as adaptation measures. In a subtle but powerful manner, international climate change adaptation law, in how it is framed and invoked, largely foregoes serious considerations of the controversies related climate-resilient crops. In making this argument, reference will be made to Articles in the UNFCCC and the Kyoto Protocol, as well as IPCC assessment reports, international adaptation initiatives, and special reports written under the auspices of the UNFCCC.

5.1. Climate-resilient crops as a necessary adaptation strategy

The texts of the UNFCCC and the Kyoto Protocol regarding adaptation – being very open-ended – could easily be interpreted to include genetically engineered climate-resilient crops as adaptation measures. Article 4(1)(e) of the UNFCCC stipulates that States Parties should 'cooperate in preparing for adaptation to the impacts of climate change' and specifically refers to areas 'affected by drought'.[111] Article 10(b)(i) of the Kyoto Protocol specifically names agriculture as one of the sectors that requires the formulation and implementation of national and regional programmes containing measures to adapt to climate change.[112] These references, in addition to the broader stipulations about adaptation, open the way for the development of adaptation measures that address the problems facing agriculture.

110 'Seed Industry Ignores Farmers' Rights to Adapt to Climate Change', International Institute for Environment and Development, 7 September 2009, www.iied.org/seed-industry-ignores-farmers-rights-adapt-climate-change.

111 UNFCCC, *supra* note 9 (emphases added).

112 Kyoto Protocol, *supra* note 11.

Article 4(5) of the UNFCCC creates an obligation for developed states parties to 'promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and knowhow to other Parties'. Although not mentioning any particular technologies, this reference indicates at least an acceptance that technologies can play a valuable role in adaptation.

The IPCC in its assessment reports identifies biotechnologies as a possible tool in adaptation. The fourth assessment report states that '[e]ffective planning and capacity building for adaptation to climate change could include: [. . .] *improved crop*, forage, livestock, forest and fisheries germplasm, including via *biotechnology* [. . .].'[113] The same assessment report makes an explicit reference to stress-resilient crops. Under the heading of sector-specific adaptation strategies in agriculture, the report mentions the '[d]evelopment of agricultural bio-technologies' and specifically the '[d]evelopment and distribution of more drought, disease, pest and salt-tolerant crop varieties'[114] as one way to adapt to predicted decrease in agricultural yields as a result of climate change. The synthesis report of the fifth and latest IPCC assessment report includes 'biotechnology and genetically modified crops' as possible adaptation options aiming to 'enhance drought-resistance' and 'enhance yields'.[115] These references in the authoritative assessment reports reinforce the idea that genetically engineered climate-resilient crops are valuable adaptation strategies.

Various international adaptation initiatives have also explicitly recognized the value of technologies. The Cancun Adaptation Framework states that all parties to the UNFCCC will 'research, develop, and diffuse technologies, practices and processes for adaptation'.[116] The adaptation advice and decisions by the Nairobi Work Programme must be taken based on a 'sound scientific, *technical* and socio-economic basis'.[117] These adaptation initiatives therefore link adaptation with technology. The CAF aims to support and enable least developed countries to develop national adaptation plans.[118] The National Adaptation Programmes of Action[119] provide information from these least developed countries on adaptation needs and proposals.[120]

The texts of the NAPAs submitted by least developed countries also include references to technologies. A browse through the texts of these country-specific reports on adaptation strategies reveals that 'technologies' are often cited.[121] There

113 Parry et al., *supra* note 17, at 296 (emphases added).
114 Ibid., Table 10.8 at 490.
115 R.K. Pachauri and L.A. Meyer et al. (eds.), *Climate Change 2014: Synthesis Report*, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (2014), Intergovernmental Panel on Climate Change, Table 4.3 at 98.
116 Verschuuren, *supra* note 15, at 22.
117 NWP, *supra* note 29.
118 UNFCCC, 'National Adaptation Plans', unfccc.int/adaptation/workstreams/national_adaptation_plans/items/6057.php.
119 NAPAs, *supra* note 30.
120 CAF, *supra* note 28.
121 To establish this, a search was done for the terms 'technology', 'technologies', and 'technological' in the 50 country reports. All of the NAPAs that are available include at least some references to these terms. Such a cursory search suggests merely that there is recognition of the value of technologies. What kinds of technologies, for what purposes, and with what intention they are used exactly cannot be recounted without

are general references to the use of technologies for adaptation, such as 'technology transfer for mitigation and adaptation',[122] 'use of the new technologies capable to guarantee adaptation to the era of climate change',[123] and a call on developed states to 'facilitate the transfer of needed technology and resources so that effective adaptation can continue to take place'.[124] In several NAPA reports, there are specific references to technologies for agriculture. These include: 'use of appropriate technologies to achieve higher farm productivity, food security and farm income',[125] 'improving crop production through the use of appropriate technologies',[126] and 'use of technologies for fertility improvement'.[127]

There are moreover some specific references to climate resilient crops in NAPAs, including: development of 'climate change resilient cropping systems',[128] 'introduction of new more productive agricultural varieties, with a wide spectrum of climate tolerance',[129] 'introduc[ing] and scal[ing] up existing innovative technologies to deal with flood, drought and salinity',[130] and applying 'genetic improvement programs through introduction of drought-, salinity-, heat-, disease- and pest resistant/tolerant varieties/crops'.[131] Although these adaptation initiatives are not strictly speaking 'law', they do contribute to a perception of what could be considered 'adequate adaptation'.

In the same vein, the information produced by the IPCC also contributes to filling in the gaps of what 'adequate adaptation' entails. In addition to assessment reports, the IPCC also publishes special reports. These special reports focus on specific issues in relation to climate change. In 2000, the IPCC published a special report on 'Methodological and Technological Issues in Technology Transfer'. This report was prepared by Working Group III, dealing with responses to climate change, 'in

a more detailed analysis of the reports. The main point to make here is that there is at least a superficial recognition that technologies are necessary for adaptation.

122 Ministry of Environment and Forests Government of the People's Republic of Bangladesh, 'National Adaptation Programme of Action', June 2009, unfccc.int/resource/docs/napa/ban02.pdf, at 1.

123 Republic of Sao Tome and Principe, 'National Adaptation Programmes of Action on Climate Change', December 2006, unfccc.int/resource/docs/napa/stp01.pdf, at 17.

124 State of Eritrea, Ministry of Land, Water and Environment, Department of Environment, 'National Adaptation Programme of Action', April 2007, unfccc.int/resource/docs/napa/eri01.pdf, Preface.

125 'Afghanistan: National Capacity Needs Self-Assessment for Global Environmental Management (NCSA) and National Adaptation Programme of Action for Climate Change (NAPA)', Final Joint Report, February 2009, unfccc.int/resource/docs/napa/afg01.pdf, at 34.

126 Republic of Malawi, 'Malawi's National Adaptation Programmes of Action', March 2006, unfccc.int/resource/docs/napa/mwi01.pdf, at 3. This is listed third on a list of 15 adaptation options, ranked in terms of priority.

127 Ministry of Tourism Environment and Natural Resources of the Republic of Zambia, 'Formulation of the National Adaptation Programme of Action on Climate Change', September 2007, unfccc.int/resource/docs/napa/zmb01.pdf, at 20.

128 Ibid.

129 Republic of Sao Tome and Principe, 'National Adaptation Programmes of Action on Climate Change', December 2006, unfccc.int/resource/docs/napa/stp01.pdf, at 17.

130 Ministry of Environment and Forests Government of the People's Republic of Bangladesh, 'National Adaptation Programme of Action', June 2009, unfccc.int/resource/docs/napa/ban02.pdf, at 29.

131 Republic of Yemen, Environment Protection Authority, 'National Adaptation Programme of Action', 2009, unfccc.int/resource/docs/napa/yem01.pdf, at 59.

response to a request by the Subsidiary Body for Scientific and Technological Advice (SBSTA) to the UNFCC'.[132]

Section 11.3.3 of this report is titled: 'Genetic Improvements Critical to Climate Adaptation'.[133] This section describes the need for genetic improvements in agriculture to increase production in the face of climate change. It presents agricultural biotechnologies as important means through which to increase production and notes that half of the increases in crop yields in recent years are attributable to 'genetic improvements in crop varieties'.[134] The report also states that: 'In the future, biotechnology may offer significant opportunities to address the need for crop adaptation to changing climate across all countries'.[135]

The special report expresses concern about the decline in public funding for agricultural biotechnologies research. Section 11.3.5 of the report discusses institutional barriers related to controversies over transgenic crops as major concerns with regard to climate change adaptation. The authors argue that such barriers should be removed to allow genetically engineered seeds and crops to be used as part of the adaptation strategies in all countries, and especially the most vulnerable developing regions likely to be most affected by climate change. The report states that '[d]eveloping countries will have to interact with an increasingly concentrated private agricultural (primarily seed) biotechnology industry'.[136]

Like the IPCC, the UNFCCC also publishes reports and papers that discuss specific issues related to climate change adaptation. These include technical papers, many of which focus on responses to climate change in the form of new technologies and transfer of technology. Technical papers are commissioned by the secretariat of the UNFCCC and prepared by a group of experts in the field.[137] Disclaimers to these papers state that their content 'does not necessarily reflect the views of the secretariat'. Despite this disclaimer, the fact that technical papers are commissioned and published by the UNFCCC suggests that the information contained in them is along the lines of the UNFCCC's climate change strategies.

The technical paper entitled 'Application of Environmentally Sound Technologies for Adaptation to Climate Change' published in 2006 provides an overview of available technologies that may be used in adapting to the present and future consequences of climate change.[138] The recommendations in this report can be seen as more detailed articulations of what 'adequate adaptation', as stipulated in the UNFCCC and Kyoto Protocol, may look like.

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132 Intergovernmental Panel on Climate Change, 'Methodological and Technological Issues in Technology Transfer – Special Report of Working Group III of the Intergovernmental Panel on Climate Change', in B. Metz et al. (eds.) *IPCC Reports* (2000) Cambridge, UK: IPCC, Foreword.

133 Ibid., section 11.3.3.

134 Ibid.

135 Ibid., section 11.3.3.

136 Ibid., section 11.3.5.

137 The list of technical papers published by the UNFCCC until now can be found here: unfccc.int/documentation/documents/advanced_search/items/3594.php?symbol=%22/TP%22#beg.

138 R.J.T. Klein et al., 'Application of Environmentally Sound Technologies for Adaptation to Climate Change, FCCC/TP/2006/2', in *FCCC Technical Papers* (10 May 2006).

This technical paper is based on, and builds upon, the IPCC special report from 2000.[139] An interesting preliminary observation to make on this paper is the authors' explicit recognition of the limitations of technologies. At paragraph 53, the paper states that '[t]he idea of using technology to solve or alleviate an adverse situation is deceptively appealing', and highlights that technology is only one part of the solution. This reflects recognition that technological fixes alone will not be enough to adapt to the impacts of climate change.[140] Notwithstanding this awareness of the limits of technology, the main argument of the paper is that 'many technologies exist to adapt to natural weather related hazards and that these technologies can also play an important part in reducing vulnerability to climate change'.[141] The essence of the paper's argument is that while the authors recognize and acknowledge the limitations of technologies, they nevertheless suggest that technologies play an important role in adapting to the impacts of climate change.

The advantage of employing biotechnologies in the quest to devise adaptation strategies to climate change impacts on agriculture has already been recognized in early climate change discourse. One of the first UNFCCC technical papers mentions biotechnology in relation to seed development as a possible adaptation option.[142] Referring back to the first IPCC assessment report of 1996, the 2006 technical paper states that '[t]he ability of world agriculture to meet the needs of an ever expanding population has been due to the development and adoption of new technologies, rather than to the expansion of cultivated land'.[143]

The 2006 UNFCCC technical paper explicitly names 'genetically modified organisms'[144] and 'drought-resistant seeds'[145] as options in a range of agricultural biotechnologies that can contribute to adaptation. Table 8 under paragraph 206 of the paper also lists the conducting of 'research to develop new crop varieties' as an example of 'adaptation opportunities vis-à-vis climate change impacts on agricultural systems'. Paragraphs 216 and 221 again mention biotechnology, and more specifically gene technologies. Paragraph 216 states that:

> [T]o address adverse effects of global warming it is necessary to have a new generation of varieties. Breeding will continue to be important, but gene technology will help to speed up the process.[146]

Moreover, this paragraph cites research that demonstrates the potential of genetic engineering in developing drought-resistant crop varieties.[147] The subsequent paragraphs go on to predict that genetic improvements to crops 'are likely to play an even greater role' in the future, and that biotechnology 'may offer important

139 IPCC, *supra* note 132.
140 Klein et al., *supra* note 138. See also Sarewitz and Nelson, *supra* note 97, and Bellamy Foster, *supra* note 98.
141 Ibid., in the Summary on the front page.
142 R.J.T. Klein and R.S.J. Tol, 'Adaptation to Climate Change: Options and Technologies: An Overview Paper, FCCC/TP/1997/3', in *FCCC Technical Papers* (9 October 1997), especially Box 3.2: 'Opportunities for biotechnology in seed development'.
143 Klein et al., *supra* note 138, para. 193.
144 Ibid., para. 58.
145 Ibid., para. 55.
146 Ibid., para. 216.
147 Ibid.

opportunities to address the need for crop adaptation to changing climate across all countries'.[148] The overall gist of the report seems to be that new genetic engineering technologies in agriculture are necessary adaptation tools.

The texts of the UNFCCC and the Kyoto Protocol contain few directions on what 'adequate adaptation' entails. International adaptation initiatives regulated by the UNFCCC and reports and papers commissioned by the IPCC and the UNFCCC explicitly name genetically engineered climate-resilient crops as a possible adaptation strategy. The argument here is that, even though there is no hard and clear international law on this matter, there is a tendency in those parts of the climate change regime that deal with adaptation, to promote the development and use of these crops.

5.2. Law's invitation to private sector engagement in adaptation

International law, including international climate change adaptation law, creates obligations for States Parties. In the words of Roda Verheyen, the UNFCCC and the Kyoto Protocol govern 'only public adaptation measures and [do] not prescribe any particular activities by private entities'.[149] The text of the UNFCCC does not once mention the word 'private'.[150] The Kyoto Protocol mentions the private sector in Article 10(c) where it states that parties shall co-operate in the 'creation of an *enabling environment for the private sector*, to promote and enhance the transfer of, and access to, environmentally sound technologies'.[151] This article refers specifically to the transfer of technologies, and does not say much about private sector involvement in adaptation in general.

Strictly speaking, therefore, international law on climate change adaptation does not create any obligations or restrictions for the private sector; it simply does not address the private sector. While the text of the UNFCCC makes no mention of the private sector, adaptation initiatives introduced under its umbrella create a welcoming and enabling environment for private sector engagement in adaptation. Some initiatives explicitly mention genetically engineered, climate-resilient crops as possible adaptation strategies.

Christiana Figueres, Executive Secretary of the UNFCCC, has stated that '[a]daptation to climate change is no longer the exclusive ambit of the public sector'.[152] Adaptation initiatives introduced at the international level reinforce this perspective. In Article 34, the Cancun Adaptation Framework explicitly invites a large number of stakeholders, including the private sector, to undertake and support action on climate change adaptation.[153] The Nairobi Work Programme has moreover launched the Private Sector Initiative (PSI) in 2011/2012, which:

148 Ibid., paras 217 and 218.
149 Verheyen, *supra* note 15, at 132.
150 Neither does it use the words 'business' or 'corporation'; private entities are excluded entirely from the text.
151 Kyoto Protocol, *supra* note 11 (emphasis added).
152 Pricewaterhousecoopers LLP, *supra* note 53.
153 Cancun Adaptation Framework 2010, Art. 34: '*Invites* relevant multilateral, international, regional and national organizations, the public and private sectors, civil society and other relevant stakeholders to undertake and support enhanced action on adaptation at all levels, including under the Cancun Adaptation Framework, as appropriate, in a coherent and integrated manner, building on synergies among activities and processes, and to make information available on the progress made.' *Supra* note 28.

> [A]ims to catalyze the involvement of the private sector in the wider adaptation community. The unique expertise of the private sector, its capacity to innovate and produce new technologies for adaptation, and its financial leverage can form an important part of the multi-sectoral partnership that is required between governmental, private and non-governmental actors.[154]

Private sector engagement is valued especially for its expertise and financing capacities, particularly with regard to research and development of new (agricultural bio-) technologies. The PSI invites private sector parties to submit case studies showcasing how they are engaging with, and adapting to, climate change. These case studies include examples of adaptation strategies for agricultural crops, submitted by some of the large agricultural biotechnology corporations. The following is an overview of the private adaptation initiatives included in the PSI database that involve genetically engineered crops.[155]

- BASF submitted an initiative with the title 'New technologies for climate change adaptation'. It is aimed at improving food security by providing an adaptation strategy for the agricultural sector. It mentions the development of stress-tolerant plants. (No date is specified for this initiative.)[156]
- Bayer submitted an initiative under the name 'Developing stress-tolerant plants'. The focus area of this initiative is Europe. In this submitted case study, Bayer highlights the growing demand for food and the strain on resources. It advertises Bayer's contribution to developing adaptation technologies for the agricultural sector. (No date is specified for this initiative.)[157]
- BASF, in collaboration with Monsanto, submitted an initiative named 'Help crops adapt to changing climates' in 2012. It focuses on research and development of drought-tolerant maize as an adaptation strategy to climate change.[158]
- Bayer submitted an adaptation initiative entitled 'Provide seed treatment for more efficient resources use' in 2012. It briefly describes two technologies that are in the pipeline, one of which is the development of stress-tolerant crops.[159]

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154 UNFCCC, 'Adaptation Private Sector Initiative', unfccc.int/adaptation/workstreams/nairobi_work_programme/items/4623.php.

155 See for the complete database so far UNFCCC, 'Private Sector Initiative – Database of Actions on Adaptation', unfccc.int/adaptation/workstreams/nairobi_work_programme/items/6547.php.

156 UNFCCC Private Sector Initiative – Actions on Adaptation: BASF, 'New Technologies for Climate Change Adaptation', unfccc.int/files/adaptation/nairobi_work_programme/private_sector_initiative/application/pdf/basf.pdf.

157 UNFCCC Private Sector Initiative - Actions on Adaptation: Bayer, 'Developing Stress-Tolerant Plants', unfccc.int/files/adaptation/nairobi_work_programme/private_sector_initiative/application/pdf/bayer.pdf.

158 UNFCCC Private Sector Initiative – Actions on Adaptation: BASF, 'Help Crops Adapt to Changing Climates', 19 December 2012, unfccc.int/files/adaptation/nairobi_work_programme/private_sector_initiative/application/pdf/basf.wbcsd.pdf.

159 UNFCCC Private Sector Initiative – Actions on Adaptation: Bayer, 'Provide Seed Treatment for More Efficient Resources Use', 19 December 2012, unfccc.int/files/adaptation/nairobi_work_programme/private_sector_initiative/application/pdf/bayer_cropscience.wbcsd.pdf.

- In 2013, Syngenta submitted an initiative called 'Boosting crop yield for every drop of water'. The description includes the slogan 'grow more from less' and highlights the company's efforts in developing drought-tolerant crops.[160]

Although the Nairobi Work Programme does not create obligations for the private sector nor does it judge on the value of the private sector initiatives in the database, it does create a platform for corporations to showcase their proposed adaptations. It is important to underscore here that the intention is not to judge the effectiveness or the value of these adaptation initiatives proposed by seed corporations; such an endeavour goes beyond the scope of this article. Rather, the objective is to demonstrate that the UNFCCC, through its PSI, provides a podium for corporations to promote their proposed adaptation initiatives, and that corporations make use of the podium.

A browse through the National Adaptation Programmes of Action received by the UNFCCC is also illustrative of the invitation extended to the private sector by individual countries. Many NAPAs name the private sector as an important stakeholder, and some reports present the lack of private sector involvement in adaptation as problematic. For instance, the following references are made in NAPAs: 'private sector development' is one way in which to create an 'enabling framework for successful implementation of NAPA projects',[161] 'government, non-government and private institutions that should contribute to the implementation of the NAPA project',[162] part of the implementation strategy of the NAPA is for 'government to encourage and promote the involvement of the private sector',[163] and 'the NAPA team comprised of experts from various government institutions … and private institutions and NGOs'.[164] Angola's NAPA mentions the 'lack of involvement by the private sector in questions related to climate change' as a 'potential barrier to implementation' of adaptation policy.[165] While the text of the UNFCCC makes no mention of the private sector, adaptation initiatives introduced under its umbrella create a welcoming and enabling environment for private sector engagement in adaptation.

In addition to adaptation initiatives, the IPCC special report and the UNFCCC technical paper, discussed in relation to adaptation technologies in the previous section, also allude to private sector engagement. In paragraphs 69 and 436, the special report mentions the need to 'stimulate private sector investment' in various adaptation options.[166] Paragraph 130 states that the private sector can extend its role

160 UNFCCC Private Sector Initiative – Actions on Adaptation: Syngenta, 'Boosting Crop Yield for Every Drop of Water', 5 February 2013, unfccc.int/files/adaptation/nairobi_work_programme/private_sector_initiative/application/pdf/syngenta.wbcsd.pdf.

161 Lesotho Ministry of Natural Resources and Lesotho Meteorological Services, 'Lesotho's National Adaptation Programme of Action', June 2007, unfccc.int/resource/docs/napa/lso01.pdf, Section 6.3.

162 Republic of Cape Verde, Ministry of Environment and Agriculture, 'National Adaptation Programme of Action on Climate Change', November 2007, unfccc.int/resource/docs/napa/cpv01.pdf, at 17.

163 Government of Sierra Leone, Ministry of Transport and Aviation, 'National Adaptation Programme of Action (NAPA)', December 2007, unfccc.int/resource/docs/napa/sle01.pdf, 52.

164 United Republic of Tanzania, 'National Adaptation Programme of Action (NAPA), January 2007, unfccc.int/resource/docs/napa/tza01.pdf, at 3.

165 Angola, 'National Adaptation Programme of Action', 2011, unfccc.int/resource/docs/napa/ago01.pdf, at 65.

166 IPCC, *supra* note 132.

in adaptation 'when provided with the right incentives'.[167] Paragraphs 230 and 231 subsequently address the inadequacy of intellectual property protection for plants as barriers to incentivizing private sector investments.[168] Finally, paragraph 317 states that '[i]ncorporation of the private sector, identified as an important source of funding, should be a major focus of efforts aimed at the transfer of technologies'.[169] The UNFCCC technical paper underscores some of the same points. Namely, section 11.3.4 of this paper names the lack of intellectual property protection for plants as a limitation to private sector investments. The paper also predicts that '[I]n the future, biotechnology may offer significant opportunities to address the need for crop adaptation to changing climate across all countries'.[170]

The main argument here is that, even though international climate change adaptation law is not directed at the private sector and does not create obligations for the private sector, the private sector has almost unnoticeably become part of adaptation policy. Adaptation initiatives, reports, and papers published with the backing of the UNFCCC and the IPCC in a subtle but indisputable way incorporate the private sector into the adaptation regime. International climate change adaptation law contributes to creating an enabling environment for the engagement of the private sector and for promotion of genetically engineered climate-resilient crops as adaptation tools.

6. Conclusion

It is increasingly acknowledged that at least some climate change impacts are by now inevitable, and that international co-operation is needed to devise effective adaptation measures. The predicted climatic changes are already having and will continue to have adverse effects on agriculture and food production in some regions of the world. One proposed adaptation strategy that is being promoted is the development and use of crops that are genetically engineered for resistance to certain climatic stresses, notably drought.

With increased attention for climate-resilient crops as climate adaptation tools, comes a great deal of criticism. Controversies relate to more general debates about genetically engineered food and the application of patent rights, as well as specific concerns about the effectiveness of climate-resilient crops. A genetically engineered drought-resistant type of maize, developed by Monsanto, was the first such crop approved for commercialization on the US market in late 2011.[171] This development, in combination with the growing sense of urgency to devise adaptation strategies and the emergence of a distinct legal regime on climate change adaptation, spurred this exploration. The intention in this article was to explore the role that international climate change adaptation law may have in stimulating or opposing genetically engineered climate-resilient crops.

167 Ibid.
168 Ibid.
169 Ibid.
170 Ibid., Section 11.3.3.
171 USDA, APHIS, *supra* note 60.

A distinct area of international law that governs climate change adaptation does not yet exist. However, there is increasing attention in legal discourse for adaptation. 'International climate change adaptation law' as understood in this article includes the international legal regime on climate adaptation (mainly the UNFCCC and Kyoto Protocol), as well as reports, discourse, and initiatives taken within the broader climate change regime. This emerging area of international law creates an enabling environment for private sector seed corporations to be actively engaged in the development of genetically engineered climate-resilient crops. Therefore, notwithstanding the criticisms of this proposed adaptation strategy, the way in which international adaptation law is developing seems to promote climate-resilient crops.

The intention in this article was not to say that genetic engineering is not potentially of great value; it was not to say that climate-resilient crops are not a potentially effective and necessary adaptation strategy; and it was not to say that the private sector cannot play an important role in developing adaptation strategies. The point here is to highlight that despite significant controversies related to the development and use of genetically engineered climate-resilient crops as adaptation, international climate change adaptation law in a subtle manner creates a conducive context in which to promote both genetically engineered climate-resilient crops and private sector engagement. Actors in the discussions, by invoking international climate change adaptation law, perhaps unintentionally, reinforce the value of climate-resilient crops and the position of the private sector in adaptation.