

Protest in Córdoba, Argentina, against Monsanto and the spraying of pesticides.  
Photo: Romina Martino, 2012



food  
sovereignty

# A Wolf in Sheep's Clothing?

An analysis of the 'sustainable  
intensification' of agriculture

October 2012



**Friends of  
the Earth  
International**



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An analysis of the 'sustainable intensification' of agriculture

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Part of the Friends of the Earth International 'Who Benefits' series investigating the winners and losers of industrial agriculture models.

**friends of the earth international** is an international federation of diverse grassroots-based environmental organizations with over 2 million members and supporters around the world. We challenge the current model of economic and corporate globalization, and promote solutions that will help to create environmentally sustainable and socially just societies.

**our vision** is of a peaceful and sustainable world based on societies living in harmony with nature. We envision a society of interdependent people living in dignity, wholeness and fulfilment in which equity and human and peoples' rights are realized.

This will be a society built upon peoples' sovereignty and participation. It will be founded on social, economic, gender and environmental justice and free from all forms of domination and exploitation, such as neoliberalism, corporate globalization, neo-colonialism and militarism.

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## one: Introduction

### Introduction

This report examines what governments and international donor organizations mean when they refer to the so-called sustainable intensification of agriculture, and whether it represents a change in direction for agriculture.

There is growing evidence of the global harm being caused by intensive, high input agricultural production, globalised trade in industrial food and overconsumption of food in some populations. Agriculture (including fishing) is the single largest cause of global biodiversity loss.<sup>1</sup> Nitrogen pollution from agriculture is now four times greater than the ability of planetary eco-systems to absorb it.<sup>2</sup>

Agriculture accounts for 60 per cent of global methane emissions and 70 per cent of freshwater withdrawals from the world's rivers.<sup>3</sup> Unsustainable agriculture is destroying future ability to produce food; the United Nations Environment Programme (UNEP) has estimated that unsustainable farming leads to reductions of global agricultural productivity of around 0.2 per cent a year.<sup>4</sup> As a recent report by the European Commission stated: 'we can expect ecosystem services and entire ecosystems ... to collapse by 2050 if production systems and consumption patterns do not change'.<sup>5</sup>

Globalization of agriculture has led to food chains that reach around the world, while trade agreements such as the World Trade Organization Agreement on Agriculture have exposed small farmers to the volatility of international markets, as well as competition from large scale, chemical-intensive and subsidised agriculture.<sup>6</sup> In the United States, commercial family farms have an average income from farming of \$78,466, although this average hides huge differences between different sized farms.<sup>7</sup> At the other end of the scale, nearly three quarters of those who survive on less than \$2 per day are food producers.<sup>8</sup> In terms of calories, enough food is produced globally to feed the world's population, but almost half the world's cereal crop is used as animal feed and the amount of food wasted in 2010 was equivalent to the other half of the world cereal crop.<sup>9</sup> The food that isn't diverted or wasted is so unevenly distributed that 900 million people are undernourished, while more than 500 million are obese<sup>10</sup>. The world food system as it stands today is harming the environment, wasting food, and failing to feed large numbers of people adequately. As Professor Robert Watson, Director of the International Assessment of Agricultural

Knowledge Science and Technology for Development, has said: 'business as usual is not an option'.<sup>11</sup>

The need for dramatic change in the food system is increasingly evident and various options to solve the broken food system have been put forward by experts and decision makers. In recent years, a new concept has started to gain popularity with high-level funders and international agencies involved in agricultural development and research. In 2009, the UK's Royal Society argued for the 'pressing need for the "sustainable intensification" of global agriculture'.<sup>12</sup> In 2010, the United Nations (UN) Food and Agriculture Organization (FAO) made 'the sustainable intensification of crop production' its Priority Objective A. In 2011, the UK Government's Foresight Panel, mandated to look into the future of food and farming, on the future of global food and farming concluded that 'sustainable intensification is a necessity'.<sup>13</sup> The Consultative Group on International Agricultural Research (CGIAR) has adopted sustainable intensification as policy, as has the US Government's \$3.5 billion 'Feed the Future' programme.

Section II of this report explores the origins and history of sustainable intensification. Section III looks at how sustainable intensification is applied in practice, with a special emphasis on the UK Government's support for the concept, as well as the support provided by a number of significant donor organizations. Section IV consists of a case study that examines one particular sustainable intensification technology: genetically modified crops (GM crops). Section V offers conclusions and recommendations.

## two: Background to sustainable intensification

### Background to sustainable intensification

In June 2008, at the height of the global food price crisis, the UN hosted a High Level Conference on world food security, attended by 181 countries. At the meeting, the then Director-General of the FAO, Jacques Diouf, said that 'global food production must be doubled to feed a world population currently standing at 6 billion and expected to rise to 9 billion by 2050'.<sup>14</sup> Against a backdrop of high commodity prices, food riots in some countries and export bans of rice and wheat by India and Russia, the FAO's statement raised the spectre of a hungry world. In 2009, the UK's Chief Scientist described the issues of food, water, energy and climate as a 'perfect storm' facing the world.<sup>15</sup> The FAO has since changed its position on the need to double food production, clarifying that we have the resources to guarantee food security for all, today and in four decades from now; and the importance of guaranteeing food security without needing to increase agricultural output by 60 per cent.<sup>16</sup>

Nevertheless, many governments and international agencies have accepted the need to double food supplies by 2050. Agribusiness companies were also quick to support the idea that agricultural production must be increased; in 2010, at the World Economic Forum in Davos, 27 multinational agribusiness companies launched A New Vision for Agriculture, '[i]n order to feed a population of 9 billion in 2050'.<sup>17</sup> Questions have been raised about the FAO's calculations. It has been pointed out that the study on which they were based only considered animal feed demand in terms of edible crops, ignoring the potential of pastures and fodder crops, so it over-estimated what will be needed.<sup>18</sup> The UN Committee on Food Security has stated that hunger now, and in the future, is as much about accessible and adequate food, as it is about the availability of food.<sup>19</sup> The FAO figures on global food production also show that we produce about 2000 calories per day more per capita than needed to feed our current population.<sup>20</sup> Nevertheless, the idea that food production must be doubled by 2050 has taken hold, and is regularly repeated.

So-called sustainable intensification has been framed as the direct answer to meeting this challenge. In its 2009 report, the Royal Society<sup>21</sup> defined sustainable intensification as a process whereby 'yields are increased without adverse environmental impact and without the cultivation of more land'.<sup>22</sup> Sustainable intensification is presented as a step change in agricultural science and development; the marriage

of sustainable agriculture and intensive farming to create an environmentally benign agriculture that also improves yields. It has been heavily promoted as a solution for small farmers in developing countries, and as a successor to the Green Revolution.

The Royal Society defined the sustainability part of sustainable intensification by including reducing inputs and greenhouse gas emissions, and using some agro-ecological farming methods.<sup>23</sup> The UK Government's Foresight Panel went further, saying that issues such as global meat consumption by industrial nations, gender inequalities and food waste should also be tackled. Despite this, one key phrase from the Royal Society's *Reaping the Benefits* report—'no techniques or technologies should be left out'—has come to define sustainable intensification.<sup>24</sup> It opens the door for any technology—including those that are specifically adapted to work in large scale commercial, intensive agriculture—to be defined as 'sustainable'.

For example, the US Government's 'Feed the Future' programme defines sustainable intensification as 'research (such as technologies and best management practices) and non-research inputs (such as fertilizer, quality seed, water, energy, market information, and others) come together with improved access to markets to increase productivity, enhance environmental sustainability, reduce risk, and encourage producers to increase investments to agricultural production'.<sup>25</sup> Aside from 'environmental sustainability', this could be a definition of commercial, intensive agriculture. Similarly, the European Union (EU) Agriculture, Food Security and Climate Change Joint Programming Initiative (FACCE JPI) has 'environmentally sustainable growth and intensification of agriculture' as one of its five core themes, but the long-term aim is to develop 'genomic selection, ecological engineering, precision farming, ecotechnologies and biotechnologies'.<sup>26</sup>

Because nothing is excluded, organizations representing global agribusiness have been able to use sustainable intensification to promote their own technologies. In 2011, the Agricultural Biotechnology Council, which represents BASF, Bayer CropScience, Dow AgroSciences, Monsanto, Pioneer (DuPont) and Syngenta, stated that 'Biotechnology is one of the tools which farmers can use to achieve sustainable intensification'.<sup>27</sup> The International Fertiliser Industry

## two: Background to sustainable intensification

Association also supports sustainable intensification, defining it as including 'fertilizer best management practices'.<sup>28</sup> The chief executive of Croplife Australia, which represents the Australian agro-biotechnology and pesticides industry, has said that 'to sustainably intensify food production ... [farmers] need a range of tools ... including GM crops.'<sup>29</sup>

### 'Land sparing': an unproven premise of sustainable intensification

Part of the rationale of sustainable intensification is that increasing crop yields on existing agricultural land will protect the world's remaining natural habitats, by stopping further agricultural expansion.<sup>30</sup> This is often referred to as 'land sparing', however there is actually little evidence to support this idea. Between 1965 and 2000 crop yields increased by 140 per cent, but one model suggested that the gains in crop yields up to 2000 had only slowed global agricultural expansion by 1 to 2 per cent.<sup>31</sup> In developed countries, increased yields of staple crops were not found to have caused any reduction in cropping area. Instead, agricultural intensification has led to major losses of farmland biodiversity, such as the decline of farmland bird species across the EU.<sup>32</sup>

Intensifying agriculture can lead indirectly to habitat loss. Intensive farming can simply replace more extensive farming, such as animal herding, and the people who lose out in this process may end up moving into natural habitats to carry on their farming.<sup>33</sup> Studies in Tanzania and Brazil have found that increasing farmers' yields encouraged them to take more land into production, not less.<sup>34</sup> Improving the profitability of commercial crops may be particularly harmful. According to the CGIAR, 'research that improves the profitability of specific crops grown in regions with large areas of remaining forests may promote greater deforestation'.<sup>35</sup> Protection of natural habitats is vital, but there is not enough evidence this can be achieved by agricultural intensification.

### Spreading influence

The FAO, like the governments of the USA and the UK, the EU and agribusinesses organizations, also uses the concept of sustainable intensification. In fact the FAO has

been using the term for more than a decade but in 2010 it made 'sustainable intensification of crop production' its 'Priority Objective A', and is now promoting the concept to policy-makers in developing countries through its 'Save and Grow' programme.<sup>36</sup> The FAO's definition of sustainable intensification specifically mentions conservation agriculture as a means of achieving it.<sup>37</sup> The FAO has been promoting conservation agriculture for years, so its use of sustainable intensification appears to endorse its existing policy.

Where sustainable intensification has not been directly adopted, its influence is clear. There is widespread adoption of its endorsement of our ability to continue with an industrial food system and manage environmental risks. For example, the Bill and Melinda Gates Foundation's agricultural strategy states that '[w]e are focused on helping farm families increase their yields while preserving and enhancing natural resources'. However, the strategy, which is based on increasing productivity and getting farmers to sell more to markets, fails to mention the overwhelming evidence that simply increasing productivity is highly unlikely to increase food security, or that promoting farmers selling to international markets may undermine their food security.<sup>38</sup>

The objective of the World Economic Forum's New Vision for Agriculture is to 'advance economic growth, global food security and environmental sustainability through market-based approaches', while its strategy is to increase yields.<sup>39</sup> Sustainable intensification also goes hand in hand with so-called climate smart agriculture, which is defined by the FAO as 'agriculture that sustainably increases productivity, resilience, reduces or removes greenhouse gases (GHGs), and enhances achievement of national food security and development goals'. It gives support to some ecological farming techniques but a closer look at climate smart agriculture shows how sustainable intensification has enabled industries that are responsible for the climate crisis in the first place to label themselves as climate smart. This includes the world's largest fertilizer company, the Norwegian company Yara International, which is a sponsor of climate smart agriculture.<sup>40</sup>

While industrial livestock farming is one of the biggest contributors to climate emissions, food insecurity, loss of biodiversity and pollution globally, climate smart agriculture promotes sustainable intensification of livestock—that is,

further increasing yields and intensity of livestock systems to reduce emissions per unit of meat produced. This is despite vast amounts of evidence on the urgent need to reduce intensive livestock production and consumption globally. The World Bank has adopted climate smart agriculture as policy. In the run up to the 2011 international climate talks in Durban it organized a scientific conference on climate smart agriculture in the Netherlands, and it also sponsored a conference of African government ministers on the same subject. Both conferences went on to make statements calling for 'climate smart' agricultural practices to be considered for inclusion in carbon trading initiatives.<sup>41</sup> Carbon market mechanisms actually finance the emissions reduction commitments of developed countries through offsetting emissions in developing countries. This not only increases the threat of climate change by allowing developed countries to continue rather than change their unsustainable production and consumption patterns, but also forces emissions

reduction responsibilities onto peasants and small producers in developing countries.

As a concept, sustainable intensification has become very influential very quickly. However, by excluding nothing the concept has become a catch-all, and is used to endorse existing policies. It has been adopted by organizations representing the biotechnology, pesticide and fertilizer industries. And by focussing on increasing yield, sustainable intensification fails to address the political and economic issues that prevent millions of people from having access to safe and nutritious food. From this perspective, sustainable intensification seems more like business as usual than a radical change in direction. Nevertheless, definitions of sustainable intensification do include agro-ecological approaches. So, what is being funded by the organizations that have adopted sustainable intensification and its allied concepts?



Isabele Portillo and her son Diego live in the hamlet of Colonia Yerrú, Canindeyú department, Paraguay. Isabele's husband Ruben died in January 2011 of acute poisoning doctors suspect was caused by prolonged exposure to the pesticides used in the soy plantations in their area. Isabele says she will have to abandon her smallholding because she fears for her son Diego's health. Friends of the Earth EWN, 2012

## three: Sustainable intensification in practice

### Sustainable intensification in practice

To understand what sustainable intensification means in practice, we need to look beyond policies, to the agricultural research and development projects being funded by the organizations using sustainable intensification and its related concepts.

#### UK Government

The UK was one of the first countries to start using sustainable intensification in public policy, as demonstrated by the Royal Society's 2009 *Reaping the Benefits* report. The report's first recommendation was for the UK Government's research councils to develop a 'grand challenge' on scientific research for global food crop security, in order to secure 'at least' £2 billion in funding.<sup>42</sup> The second recommendation was increased support for crop breeding and genomics, while another was for the UK Government to support 'long-term high-risk approaches' for the genetic improvement of crops. Only one of the twelve recommendations mentioned ecosystem approaches to agriculture.

The Royal Society's report was followed by the Foresight Panel report on the future of global food and farming. The Panel's conclusions covered a wider range of issues, including more research into agro-ecological techniques but they still called for 'new science and technology to raise the limits of sustainable production and address new threats' and for an emphasis on sustainable intensification and genetic modification and cloning.<sup>43</sup> Therefore the Foresight Panel's report sticks to the position that sustainable intensification should not exclude any technology. The report also agreed with the recommendations of the Royal Society. In 2011, the UK farming minister pledged that the UK would 'lead the way on promoting sustainable intensification'.<sup>44</sup> So how has sustainable intensification affected the UK's funding of agricultural research and development?

In 2010, the UK research councils followed the Royal Society's recommendation and set up a new research programme on global food security.<sup>45</sup> The UK Government has also set out a new food research strategy including, amongst other things, a £75 million fund for 'technological research and development' in UK food systems.<sup>46</sup> Since 2010, the fund has channelled £41 million into projects to increase competitiveness and reduce food waste in the UK's food industry; create new food products; increase the

domestic supply of animal feed; increase the efficiency of feed conversion by livestock; and develop new technologies to protect crops from pests and diseases.<sup>47</sup> In 2011, a £20 million 'Green Farm Project' was announced, providing grants to rural businesses for environmental and 'profit-boosting' projects.<sup>48</sup> The recent announcements make little mention of ecological farming methods, although the UK Department of the Environment (DEFRA) does support some research projects on organic farming, amounting to £400,000.<sup>49</sup>

What is really noticeable is the increase in public funding into UK agricultural science institutions. The UK's Biotechnology and Biological Sciences Research Council (BBSRC) directs money to British universities and scientific organizations. In 2009 it invested around £78 million in UK plant and crop science research, and by 2011 it had an annual budget of £104 million for its 'global food security' programme.<sup>50</sup> In 2012, the UK Government announced £250 million of investment in bioscience projects, including projects on genome analysis, wheat breeding, industrial and pharmaceutical properties of crop plants, identification of new herbicides and biological control agents, and support for long term trials of different farming systems.<sup>51</sup> The Royal Society's GM research, self defined as 'long-term high-risk' research, is also being funded; the BBSRC recently awarded £8 million for research to 'enhance photosynthesis' using biotechnology.<sup>52</sup>

The UK Government also doubled funding by the Department for International Development (DFID) into agricultural research, in part to 'provide farmers in developing countries with access to technologies'. One of DFID's largest agricultural grants is £188 million to support the Consultative Group on International Agricultural Research, a global network of agricultural research centres with influence and presence at global decision-making forums on food issues, which also focuses on technological solutions.. Apart from this, its largest agricultural research project is the £70 million Strategic Collaboration Portfolio for Sustainable Intensification of Agriculture, which is jointly funded by the Gates Foundation. Launched in 2010, the Portfolio is paying for research into virus resistant wheat; the development of genetically modified C4 rice; new maize varieties suited to African soils; and improved yield and stress tolerance of legume crops, including using genetic modification.<sup>53</sup>

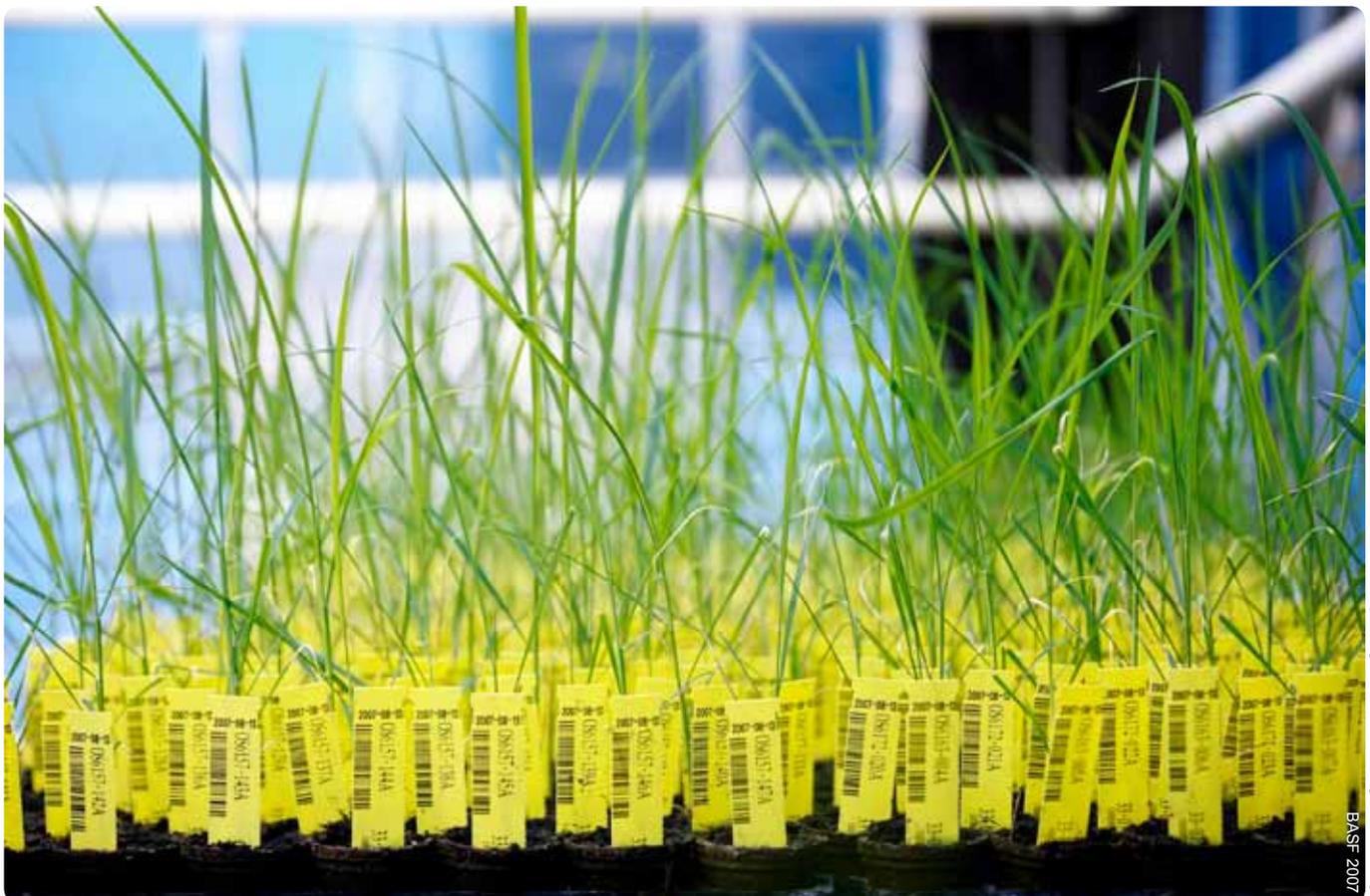
Other current grants include £10 million to the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), which conducts crop breeding and biotechnology research. In a recent review, DFID noted that ASARECA could not show whether its projects benefited small farmers.<sup>54</sup> DFID also granted £7.5 million to the African Agricultural Technology Association, which promotes private-public partnerships 'for the access and delivery of appropriate proprietary agricultural technologies' to small farmers.<sup>55</sup> One example is a project with BASF to develop herbicide (imazapyr) resistant maize.<sup>56</sup>

Much of DFID's agricultural research funding goes to scientific institutions working on technology-led solutions for agriculture. Interestingly, DFID is also funding a research project that aims to 'shed light on the question of why the

economic and environmental benefits of new agricultural technology often appear to bypass poorer farmers, even when they are the "target" group'.<sup>57</sup> The UK Government has not waited for the results of this research before making its funding decisions.

### The Bill and Melinda Gates Foundation

The UK Government provides a striking example of this technological approach, but it is not the only one. The Gates Foundation is also focussed on technological solutions for agriculture, and is particularly supportive of biotechnology. A recent analysis of its grants database found that between 2005 and 2011 the Gates Foundation spent US\$162 million on projects that included genetic modification (GM) technologies, such as drought tolerant maize, maize with improved nitrogen efficiency, crops with increased levels



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of specific nutrients, disease resistant cassava and wheat, and rice with altered photosynthesis.<sup>58</sup> In 2010, the Gates Foundation donated £71 million to the CGIAR, becoming the largest individual donor after the US Government. All of the Gates Foundation funding is 'restricted' to specific projects—presumably those that match the Foundation's own objectives.

### ***The Consultative Group on International Agricultural Research***

The CGIAR is a major beneficiary of sustainable intensification. One of its strategic objectives is to '[c]reate and accelerate sustainable increases in the productivity and production of healthy food by and for the poor',

and it specifically promotes this version of sustainable intensification within several of its programs. From the Royal Society's Reaping the Benefits report onwards, the concept of sustainable intensification has included calls for more agricultural research. As a result, the CGIAR has seen a leap in its funding. In 2005 it received US\$465 million from international donors; by 2010 this had jumped to US\$696 million, and the organization's aim is to triple its budget to \$1.6 billion by 2025.<sup>60</sup> The CGIAR's Funders Forum considers and endorses its strategy and programs. In 2010, the top five donors to the CGIAR were the US Government (\$86 million), the Gates Foundation (\$71 million), the World Bank (\$50 million), the UK Government (\$49 million) and the European

### **THE GATES FOUNDATION: PROMOTING BUSINESS INTERESTS IN THE NAME OF SUSTAINABLE INTENSIFICATION**

The Bill and Melinda Gates Foundation was set up 1994 and 'works to help all people lead healthy, productive lives'. It supports work in developing countries, and has a particular focus on agricultural projects in Africa. Its grant-making strategy is driven by the Foundation's co-chairs, Bill and Melinda Gates, with trustee and donor Warren Buffett.

In January 2007, an investigation by the *Los Angeles Times* found that the Foundation had invested a significant proportion of its funds in corporations responsible for the problems they aimed to solve and that this behaviour could be explained by the tax exemptions that the foundation was benefiting as a result of its grants. The investigation found the Gates Foundation endowment had major holdings in companies ranked among the worst US and Canadian polluters, including ConocoPhillips and Dow Chemical.

In 2010, the Bill and Melinda Gates Trust, which manages the Foundation's endowments, purchased half a million shares in biotech giant Monsanto worth US\$23 million. The Gates Foundation has also formed an US\$8 million partnership with the US commodity giant Cargill to introduce soya to African smallholder farmers. The project aims to introduce so-called 'modern' technology and increase farmer productivity and market access for 37 000 small-scale farmers. Partners include the Coca-Cola Company, General Mills, Goldman Sachs, J. P. Morgan, Nestlé–Nespresso, Olam International, Peet's Coffee and Tea, and Unilever.

Critics point to the potential consequences of the close connections between AGRA's donors (the Gates Foundation) and GM giant Monsanto and they are worried that AGRA is developing seeds that remain privately owned, with potential harmful impacts on food security.

On 23 February 2012, the International Fund for Agricultural Development (IFAD) and the Gates Foundation announced a new joint partnership to support the 'generation of new technologies to create the possibility of sustainable intensification of agriculture.'

IFAD, the Gates Foundation and other partners have granted approximately US\$200 million in projects to promote biotechnology and the interests of agribusiness corporations. These include the Water Efficient Maize for Africa project; a partnership with DuPont Crop Genetics Research on the Africa Biofortified Sorghum; and research with the International Food Policy Research Institute (IFPRI), a research institute promoting the development of GM crops involved in projects with the Syngenta Foundation, the International Life Science Institute (ILSI), Veolia and Croplife International.<sup>59</sup>

Commission (\$43 million), all of which have declared their support for sustainable intensification or allied concepts.<sup>61</sup>

The CGIAR has recently been going through a reform process, and has developed a new strategy. It now has programs including initiatives on agro-forestry, climate change adaptation and ecosystems services, but it has still kept its technological focus. Three research programmes on rice, maize and wheat take one-third of the CGIAR's budget, and a significant proportion of funds go to developing new varieties.<sup>62</sup> For example, one-third of funding in the maize programme is for developing stress tolerant, yield doubling or bio-fortified varieties, all of which make reference to some level of transgenic technology.<sup>63</sup> Similarly, developing new varieties is the largest individual funding stream within the rice programme and the major focus of the wheat programme.<sup>64</sup> Enormous claims are made for the potential value of this type of crop research, for example that it will have impacts on hundreds of millions of people.<sup>65</sup> But the CGIAR is often its own judge when assessing the value of its work, and its documents admit that assessments have tended to measure economic returns, not the real impacts on people.<sup>66</sup> The CGIAR should aim to help small farmers, reduce poverty and improve the sustainability of agriculture, but its Standing Panel on Impact Assessment has commented that there have been 'few rigorous studies on the poverty impacts of agricultural research to date', and that 'relatively little effort has been made to measure the impacts of CGIAR research on the environment'.<sup>67</sup>

### **The US Government's Feed the Future Programme**

In 2009, the US Government launched a new \$3.5 billion agricultural development programme called Feed the Future, which is led by the US Agency for International Development (USAID). Its research strategy is 'underpinned by the philosophy of sustainable intensification', which it defines as being close to conventional intensive agriculture.<sup>68</sup> In 2011, USAID undertook a consultation on the Feed the Future research strategy, including a research forum in Washington. Participants at the forum mostly came from US universities and international agencies, as well as some non-governmental organizations (NGOs) and agribusiness delegates; organizations representing smallholder farmers were not included.<sup>69</sup> Despite this, the forum's report strongly urged Feed the Future to develop an agenda of 'problems

that must be addressed, rather than pre-determined solutions that must be pursued.'<sup>70</sup> It appears this call was not heeded, because the Feed the Future research strategy contains a range of pre-determined solutions including: developing drought and stress tolerant crops; developing disease and pest resistant crops; developing crops with improved nitrogen use efficiency and yield improvements. According to the strategy 'the emphasis will be on genetic enhancement to overcome such constraints.'<sup>71</sup>

Feed the Future has been true to its strategy. In 2011, when USAID staff gave an outline of funding priorities, they revealed that 28 per cent of research funding would be directed to 'climate resistant cereals'.<sup>72</sup> In the Ethiopia country plan, there is a \$7 million project aimed at capacity building for Ethiopian civil servants, including developing public-private partnerships and 'biotechnology options to support agricultural development'.<sup>73</sup> In Zambia, Feed the Future will 'support reform on biotechnology'.<sup>74</sup> Feed the Future promotes biotechnology through other programmes as well.

When describing what farming practices would be promoted for sustainable intensification in Feed the Future target countries, a USAID official was reported as 'basically talking about conservation agriculture'.<sup>75</sup> Conservation agriculture is farming that eliminates tilling (turning the soil over) in order to prevent soil erosion, as well as maintaining organic cover on the soil and (in some cases) increasing the range of crops grown. No-till farming systems often come along with the industrialization of agriculture with high inputs of agrochemicals, although it can be conducted with organic systems. It is often used to promote the GM crop model that doesn't require tilling for weed control. However there are also questions about whether GM no-till farming can reduce climate emissions or promote yields.<sup>76</sup>

### **Endorsing free trade and corporate agriculture**

Sustainable intensification prioritizes market development as crucial to improving the situation of small farmers. For example, the FAO defines sustainable intensification as 'progressing from subsistence farming to market-oriented agriculture', while Feed the Future includes 'improved access to markets'.<sup>82</sup> But will small farmers really be the beneficiaries of this commercialization? In February 2012, USAID held a 'Private-partnership Technical Forum' for the Feed the

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Future programme. It invited multinational agribusiness corporations including Monsanto, Bunge and Nestle, as well as organizations such as CropLife, which represents the pesticides and biotech industry. The participants at the meeting noted that Feed the Future offered 'a number of clear benefits to public-private partnerships, such as expanding access to critical contacts ... and lowering the barriers for entry into new markets.'<sup>83</sup> Biotech companies Dupont and Syngenta are aiming to grow their business in Africa to \$1 billion in the next decade.<sup>84</sup>

The World Economic Forum's New Vision for Agriculture aims to 'leverage public and private-sector investment and strengthen markets ... including opportunities for small scale farmers.'<sup>85</sup> The Southern Agricultural Corridor of Tanzania (SAGCOT) is an example of the type of project New Vision

for Agriculture is involved with. SAGCOT is a \$3 billion public-private project in Tanzania focussing on a corridor of agricultural land bordering transport routes through the country.<sup>86</sup> The project was launched at the World Economic Forum in Africa in 2010, and is supported by New Vision for Agriculture participant corporations including Unilever, DuPont, Syngenta and Monsanto, as well as the FAO and the World Economic Forum itself. Feed the Future is directing 80 per cent of its funding for Tanzania into the SAGCOT area.<sup>87</sup>

The core objective of SAGCOT is to 'foster inclusive, commercially successful agribusinesses'. The aim is to bring 350,000 hectares into 'profitable production', much of it into irrigated crop production. The investment documents refer to the large areas of potential arable land not currently in production, with a clear implication that increased agricultural

A seed producer in Kinoo, Kenya attending to a plot of KD-1, a drought tolerant (DT) seed maize variety developed with the Kenya Agricultural Research Institute (KARI) as part of CIMMYT's Drought Tolerant Maize for Africa (DTMA) project.



### USAID MODEL FOR CONSERVATION AGRICULTURE CONTINUES HERBICIDE USE

USAID is working on a joint project in Mozambique, with CGIAR's International Maize and Wheat Improvement Center (CIMMYT), to promote conservation agriculture and GM drought-tolerant varieties.<sup>77</sup> CIMMYT already leads a project in the region, called Sustainable Intensification of Maize-Legume Systems for Food Security in Eastern and Southern Africa (SIMLESA). Farmers are 'encouraged to adopt, experiment with, and adapt the [conservation agriculture]-oriented technologies'.<sup>78</sup> But from the reports provided about farmers involved in the SIMLESA trials, it appears that the type of conservation agriculture being promoted involves the use of herbicides for weed control.

A farmer from Mozambique was quoted as saying 'If this product [Roundup] were available in the shops, we would buy it and use it elsewhere on the farm'.<sup>79</sup> But a researcher who recently visited conservation agriculture trials in Mozambique noted that 'few if any farmers appear to be adopting CA on their own fields', because of the cost and difficulty of buying herbicides, fertilizers and the specialist tools used in the trials.<sup>80</sup> Similarly, a review in 2008 found that conservation agriculture has had very low rates of adoption in many areas of sub-Saharan Africa, because it requires the use of inputs and tools that small farmers can't afford.<sup>81</sup>

production will be achieved by bringing this land into use. Documents also state that at later stages 'SAGCOT will explore the opportunities for greenfield site development'.<sup>88</sup> However, many areas of land considered 'marginal' and suitable for development are actually used by local people, especially for herding and pastoral uses as well as medicines and foraging, and are vital for woman and indigenous people.<sup>89</sup> In addition, while smallholders are said to be the core growers of all this increased crop production, 'early win projects' promoted to investors include several farms of more than 3,000 hectares and a 40,000-hectare government ranch.<sup>90</sup> Concerns have been raised about whether commercial farms rather than small holders will benefit; the transparency of investments; and whether the project will lead to land grabbing.<sup>91</sup> Further, although agro-ecological farming is talked about, one of the first major investments, a \$20 million new fertiliser terminal at Dar es Salaam, has come from global fertilizer giant Yara International.

SAGCOT is just one example of this new approach of concentrated agricultural development; similar areas are being developed in Burkino Faso, Kenya, Rwanda and Mozambique.<sup>92</sup>

In fact, nearly all the proponents of sustainable intensification also heavily promote liberalised trade, opening up markets of smallholder farmers and export agriculture. The model suggests that increased production from sustainable intensification will go to those that need it via trade, and farmers can increase yields to sell onto international markets

in order to be able to buy food with the income earned. However, several experts—including the UN High Level Panel on Food Security and Nutrition, the UN Special Rapporteur on the Right to Food, and the International Assessment of Agricultural Science and Technology for Development—have raised concerns that export agriculture and current trade terms are contributing to food insecurity for the world's small farmers and those most hungry and vulnerable.<sup>93</sup> This is because liberalised trade increases price volatility, and diverts global food supplies to those that are wealthy enough to buy them rather than providing good food for local populations. During the recent food crises in 2008 many poor farmers and poor countries were hit hard by rising prices precisely because they were depending on food imports rather than local markets for food. In a time of rising competition for grain from intensive livestock systems and biofuel production, small farmers are simply unable to access food on markets even with more cash.<sup>94</sup>

### Power and participation in science and research

Various sustainable intensification reports and initiatives talk about the needs and participation of small farmers. The UK Government's Foresight Panel report stated that 'it is important to incorporate possible beneficiaries in decision-making at all stages of the development process'.<sup>95</sup> However, the Foresight Panel only included one smallholder farming organization in its 'expert' and 'high level stakeholder' groups, while there were many more representatives from powerful organizations such as the Organisation for Economic Co-

## three: Sustainable intensification in practice

operation and Development (OECD) and WTO, and the agribusiness sector, including Cargill and Unilever.<sup>96</sup> The Gates Foundation claims to 'listen to farmers to understand the realities they face in their local areas' but strategy development and review appears to be contained within the organization and the Foundation doesn't have any offices in Africa. Similarly, when developing the Feed the Future research strategy, USAID's research forum did not include any organizations representing small farmers in developing countries, and only a scattering of developing country NGOs.<sup>97</sup>

The CGIAR does use farmer participation in developing some of its project-level research, but strategic decisions still seem to be made primarily by scientists and donors. In the period 2009–2011, the CGIAR developed a new organizational strategy, setting the future direction of research across all its institutions. The strategy process used scenario modelling, surveys of scientists, consultations with agricultural research institutions and discussion with 'well-known visionary thinkers'.<sup>98</sup> No mention was made of consulting with small or peasant farmers (or even with groups who represent them). The CGIAR then invited its donors to a Funders Forum, where they considered and endorsed the strategy framework. In March 2012, the CGIAR Fund Council even held one of its meetings at the Gates Foundation, where Bill Gates gave a speech that touched on the importance of agricultural biotechnology.<sup>99</sup>

In 2010, the Global Conference on Agricultural Research for Development (GCARD) highlighted that 'urgent changes [are] required in AR4D [agricultural research for development] systems globally' to tackle issues such as food security, environmental sustainability and raising the rural poor from poverty. The hundreds of delegates from around the world agreed that business as usual could not continue, and set out some key changes that needed to occur, including that 'the millions of resource-poor small farmers in diverse environments ... form part of innovation processes from the outset'.<sup>100</sup> The conference highlighted the lack of any voice for farmers when research agendas are being decided.

In the light of this, how do the research priorities set by sustainable intensification align with those of small farmers? In 2010, small-scale farmers and food processors (men and women) from Benin, Mali, Burkino Faso and Senegal

were involved in 6 day-long citizen juries on agricultural development and research, after which they made their recommendations for research priorities.<sup>101</sup> Table 1 compares some of these with the practice of the organizations promoting the concept of sustainable intensification and its allied terms.

When small farmers in African countries are asked what their priorities are, they do not fit with the sustainable intensification agenda as it is being promoted by various organizations. For decades, agricultural research and development has been dominated by top-down, expert-led approaches, whether in the public or private sector. Farmers have often been presented with new policies and technologies that don't meet their needs, which led to farmers rejecting them.<sup>102</sup> Sustainable intensification risks making the same mistakes, rather than learning from them.

**Table 1.** Comparison between recommendations by West African small farmers' citizen juries and the practices of organizations promoting sustainable intensification

<b>Citizen juries composed of West African small farmers and processors</b>	<b>Organizations promoting sustainable intensification and allied concepts</b>
Involve farmers in every stage of creating and selecting crop varieties.	Strategic direction for creating crop varieties set by scientists, industry and funders.
Involve producers, users and consumers (both women and men) in controlling, designing, conducting and monitoring research activities.	Mainly involve scientists, experts and funders in controlling, designing and monitoring research.
Focus on improving the productivity of local varieties, e.g. through growing practices, land use and soil fertility management.	Focus on developing new crop varieties.
Promote the use, exchange, and storage of local seeds. Avoid hybrid seeds and genetically modified organisms.	Promote improved varieties, hybrid seeds and genetically modified organisms.
Use natural mineral resources and compost; integrated pest management; and mixed cropping.	Some agencies are promoting this approach (FAO, some CGIAR projects). Others are encouraging use of artificial fertilisers and pesticides (e.g. Feed the Future, New Vision for Agriculture, some conservation agriculture projects).
Develop mechanisms to help protect the local market and local produce from unfair competition from imported products.	Increase involvement of small farmers in global supply chains and markets (New Vision for Agriculture; USAID; Gates Foundation).
Build on and disseminate farmers' agro-ecological knowledge and innovations.	Promote and disseminate agency or funder's preferred agricultural system or technology. (FAO; some CGIAR projects; New Vision for Agriculture; USAID). Some projects do use participatory approaches to build on farmer knowledge.

Source: Pimbert, M., 'Putting farmers first: reshaping agricultural research in West Africa', International Institute for Environment and Development Briefing (2012).

## four: A closer look at sustainable intensification technologies

### A closer look at sustainable intensification technologies

#### The case of genetically modified crops (GM crops)

Sustainable intensification specifically includes genetic modification as a solution to the problem of food security in the future. However, if the issue is to grow more food to feed people, the contribution of current GM crops and genetically modified crops (GM crops) is questionable. These have been developed by biotech corporations such as Monsanto, Bayer and Syngenta, all of which have concentrated their efforts on soybeans, maize, cotton and oilseed rape. These four crops made up 99.6 per cent of global GM crop production in 2011.<sup>103</sup> In the case of soybeans, up to 75 per cent of the crop's value is for animal feed.<sup>104</sup> Maize is also becoming an industrial crop: only 20 per cent of US maize production is now used for food, with the rest split between animal feed (which is diverting grain from hungry people to animals to feed rich people) and biofuels.<sup>105</sup> Cotton is a cash crop, and while oilseed rape is processed for edible oil, the fastest growing demand for this oil is biodiesel.<sup>106</sup>

#### Have GM crops delivered higher yields?

The GM crops currently being grown were not developed to increase yield but rather were aimed at reducing the costs of production by simplifying pest or weed control. Overwhelmingly, only two traits—herbicide tolerance and insect resistance—are currently used in commercial GM crop production, with many GM crops frequently having both traits 'stacked' in them.<sup>107</sup> Most yield improvements in GM varieties continue to be developed primarily through conventional breeding, with the GM traits inserted into these new varieties.<sup>108</sup> A 2009 International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) report concluded that evidence of yield gains from GM crops was anecdotal and variable, with yield gains in some locations, and yield losses in others.<sup>109</sup>

An analysis of the yields of GM crops in the USA found that genetic modification only accounted for 14 per cent of the yield increases of GM insect resistant (Bt) maize. Conventional plant breeding and other factors accounted for the rest.<sup>110</sup> The yields of GM herbicide tolerant maize and soybean did not increase any more than those of non-GM varieties grown with herbicides. In other words, GM crops yielded the same as non-GM varieties grown in equivalently intensive cropping systems. Similarly, an analysis of soybean

yields in Brazil and Argentina found that Monsanto's glyphosate-tolerant soybeans had the same yields as conventional varieties, and that any differences 'are usually related to the genetic background of the GM varieties'.<sup>111</sup> A recent study from Ohio State University, which examined long-term yield trends before and after the introduction of GM crops in the USA, found there was an extra increase in yield trends for maize, soybean and cotton after 1996, of 1 per cent for maize, 1.4 per cent for soybeans and 7.9 per cent for cotton.<sup>112</sup> However, the study also found similar extra yield increases for peanuts, potatoes, rice, wheat and barley, all of which are non-GM crops in the USA.

In India, cotton productivity has leapt in the last decade. It is claimed this is because Indian farmers adopted Bt cotton.<sup>113</sup> But a recent analysis by the International Food Policy Research Institute (IFPRI) found that while some Indian states had large increases in cotton productivity since 2002, other states had no significant improvement, and in Madhya Pradesh (which has seen widespread adoption of GM cotton) yields per hectare actually declined after 2002.<sup>114</sup> The study also found that major gains in many areas occurred before 2005, when adoption of Bt cotton by farmers was still at low levels. IFPRI concluded that much of the increase in Indian cotton productivity was down to factors other than Bt cotton, including the use of hybrid seeds and more irrigation. Bt cotton accounted for an 'average 0.29 per cent [of yield increase] per percentage adoption in each State'.<sup>115</sup>

The results for small Indian farmers of growing Bt cotton have been highly variable, and disastrous for some. For example, in 2010, Bt cotton farmers in Gujarat reported high yields, which they attributed to good rainfall, but Bt cotton farmers from the Punjab reported variable and inconsistent yields, and farmers from Andhra Pradesh reported only minor yield improvements.<sup>116</sup> In Maharashtra, reports that only wealthy farmers who could afford irrigation saw good yields from Bt cotton were supported by state cotton production data.<sup>117</sup> The variability may be explained by evidence that Bt cotton hybrids are susceptible to sudden wilting (para-wilt) when grown in un-irrigated fields, which can lead to major reductions in yield or crop failure.<sup>118</sup>

### **Will GM crops increase yields in the future?**

Sustainable intensification promotes the idea that new types of GM crops will increase yields, especially for resource-poor farmers in areas such as sub-Saharan Africa.<sup>119</sup> Modifications being discussed in this way include drought tolerant crops, apomixis (plants producing seed without sexual reproduction), crops with altered photosynthesis, GM nitrogen fixing crops, salt tolerant crops and more efficient use of nitrogen by crop plants. Millions of dollars of research funding is being put into these areas of GM plant development, in both the public and private sector, but the outcomes remain uncertain.

For example, one proposal is to genetically modify non-legume crops to convert nitrogen from the atmosphere into a form usable by plants for fertilizer. This is to be done by using genes from blue-green algae, nitrogen-fixing bacteria or legume crops. Discussing these different options, the Royal Society commented that all these approaches are 'long-term' and that recent advances in genetic research had only led to the prospect of nitrogen-fixing GM crops becoming 'less fanciful'.<sup>120</sup> The fact is that after more than twenty-five years of research into GM technologies and many years of promises about these second-generation GM crops, none till date have been developed for the market.

### **Climate-resistant GM crops**

Climate change is predicted to have major impacts on agricultural production around the world. One response is the push to develop crops genetically modified to be 'climate-ready' or 'climate-resistant'. It is claimed such crops will be better able to stand abiotic stresses such as drought, high or low temperatures, floods or saline soil. Between June 2008 and June 2010 more than 1600 patent documents were published relating to 'climate ready' genetically modified plants—Monsanto, BASF and Dupont account for two thirds of these patents.<sup>121</sup> This is seen as the next big market for biotech crops; the global market for drought-tolerant maize alone has been estimated at \$2.7 billion.<sup>122</sup>

However, on closer inspection much of this is uncertain. In the case of drought tolerance, the strategies used by plants to deal with dry conditions (e.g. slow growth) are often unsuitable for crop plants, because they cause yield reductions in normal conditions.<sup>123</sup> To complicate matters

further, drought comes in different intensities and different cycles, and can vary from year to year, or alternate with wet conditions. It is also likely that climate change will bring more variable, not just drier weather. Although large numbers of potential modifications for drought tolerance have been identified, most are at a very early stage in the laboratory.<sup>124</sup> Some GM drought-tolerant crops have been tested in outdoor trials, but modifications that worked in the lab don't always worked in real world conditions, because plants' water use involves complex sets of genes interacting with the environment.<sup>125</sup>

It has been claimed that the yield of maize could be increased threefold but drought tolerance via biotechnology has yet to show anything so spectacular.<sup>126</sup> In December 2011, the US Department of Agriculture (USDA) approved a GM 'drought-tolerant' maize produced by Monsanto (MON87460). The USDA's report stated that the GM maize only maintained yield under 'moderate' water stress (up to 20 per cent less water than normal), reducing yield loss by 6 per cent in these conditions.<sup>127</sup> However, in drier conditions the GM maize was just as sensitive to drought as conventional varieties. In fact, the USDA stated the drought tolerance of the GM maize 'does not exceed the natural variation observed in regionally-adapted varieties of conventional corn'.<sup>128</sup> In other words, the GM maize is no better at coping with drought than existing varieties of maize grown in drier parts of the USA.

One flagship project on GM drought tolerance is Water Efficient Maize for Africa (WEMA), a collaboration between Monsanto, BASF and the African Agricultural Technology Foundation (AATF), funded by the Gates Foundation. Monsanto and BASF are donating up to four licenses for GM drought tolerance maize lines to AATF. These will be bred into African varieties and then sub-licensed, royalty-free, to seed companies.<sup>129</sup> So far, Monsanto has donated the same genetic trait used in its recently approved MON 87460 maize, raising the question of whether it will perform any better than locally-adapted African maize varieties.<sup>130</sup> The agreement between Monsanto, BASF and the AATF emphasizes the use of formal seed networks to distribute the seed. 'Stewardship' and quality control terms will be included in sub-licenses, and the seeds will be hybrids, and therefore not suitable for seed saving.<sup>131</sup> In Kenya, one of the project countries, 80 per cent of farmers save their own seeds or obtain them from

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community seed banks, and in 2012 certified maize seed could only be afforded by 1 per cent of farmers.<sup>132</sup>

In the future, the climate may change rapidly. Researchers in Mexico have pointed out that instead of encouraging small farmers to use GM crops, a better strategy would be to help them select and improve their own traditional varieties as conditions change, making use of the genetic diversity found in these varieties.<sup>133</sup> Other alternatives would also be less risky for small farmers than buying GM seeds (see section V). The Rodale Institute in the USA has been running side-by-side field trials of organic and conventional crop production since 1981. They found that the organically managed plots had much higher organic matter content in the soil, and that soil water volumes were 15 to 20 per cent higher than in conventional plots.<sup>134</sup> In drought years, the crops grown in the organic plots had a 31 per cent yield advantage over the same variety grown in conventionally managed soils. This is much more than the 6 per cent managed by Monsanto's GM drought-tolerant maize. Organic soil-management emphasises well-established practices of soil conservation and improvement, which can be used by farmers without the need for added inputs.

### **Genetically modifying photosynthesis**

Different plant species use different biological pathways during photosynthesis, called C3 and C4 photosynthesis. Many important crop plants—including wheat, rice, rye, oats, barley, soybean and potato—use C3 photosynthesis, which is less efficient and uses more water than C4 photosynthesis. It has been suggested that genetic modification of such crops to C4 photosynthesis would increase yields, because they would make more efficient use of water and sunlight. For example, the International Rice Research Institute (IRRI) is leading a worldwide project to try and develop C4 rice, with the stated goal of increasing rice yields by 50 per cent. At an initial cost of \$3.5 million per year, the project is being funded by the Gates Foundation and is expected to run for 25 years.<sup>135</sup> Supporters of this approach argue that, because C4 photosynthesis evolved naturally from the C3 form, it should be possible to replicate this through genetic modification. However, many crop plants have evolutionary histories unconnected with C4 plants, so they may have a genetic makeup incompatible with C4 photosynthesis.<sup>136</sup> In addition, the genetic regulation of C4 photosynthesis is poorly

understood, and the number of genes involved is large, with some estimates at thousands of genes.<sup>137</sup> As two researchers in the field recently commented: 'Existing methods of genetic engineering are probably insufficient for [C4] installation, and the genetic engineering challenge will increase as we identify more genes essential to C4'.<sup>138</sup>

### **When will these GM technologies become available?**

These 'long-term, high-risk' GM crops are still decades away, if they are achieved at all. A paper in *Science*, published in 2010, estimated that GM disease-resistant wheat, insect-resistant rice and drought-tolerant crops might be developed within 5 to 10 years. Within 10 to 20 years, salt-tolerant and high-temperature-tolerant plants might be developed, while GM traits such as nitrogen fixation, altered photosynthesis and apomixis were considered to be more than 20 years away.<sup>139</sup> These estimates may be optimistic. The UK Government's Foresight Panel stated that the more 'revolutionary' approaches were 'unlikely to contribute significantly to raising agricultural productivity until at least the latter end of the 40-year period considered by this Report'.<sup>140</sup> In other words, not before 2050.

### **Is GM an affordable technology?**

While sustainable intensification promotes GM crops as a solution for the world's poorest farmers, GM seeds are also a product, and the corporations who develop them—as well as the seed companies selling them—are looking to make a profit. In countries where GM seeds have already been adopted, the biotechnology companies have been aggressive in their takeovers of seed companies. Further, through the use of technology agreements, farmers have been prohibited from saving seed themselves, which ties them into buying new seed each year. In the US farm belt, Monsanto has reportedly taken over 24 independent seed companies, and it has been estimated that Monsanto now has a 98 per cent share of the US soybean seed market, a 79 per cent share of the US maize seed market, and 60 per cent control of all licensed soy and maize germplasm.<sup>141</sup> In Brazil, Monsanto had 80 per cent of the market share of soybeans in 2011, while in India it has licensed Bt cotton to 44 Indian seed companies, 10 of whom now dominate the market.<sup>142</sup> In South Africa, Dupont is attempting to acquire Pannar Seeds,

which would effectively divide the South African seed market between Dupont and Monsanto.<sup>143</sup>

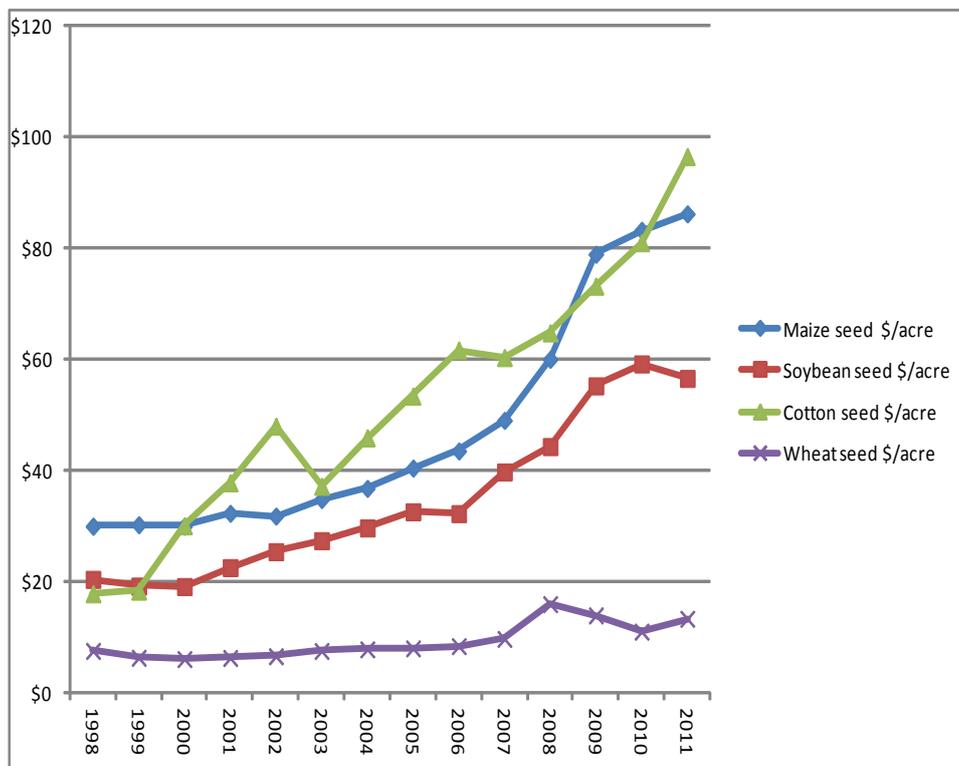
Since the introduction of GM crops in the USA, the price of maize seed has more than doubled, the price of soybean seeds has almost tripled, and the price of cotton seeds has quadrupled (see figure 1). In comparison, the price of seed wheat, which is not genetically modified, remained largely stable until the recent rise in global wheat prices. Even then, seed wheat prices remained low when compared to the GM dominated crops.

One of the few options available to American farmers who wish to reduce the price of GM seeds is to enter into

Monsanto's Roundup Reward programme, through which they receive discounts. However, this agreement requires them to use Monsanto's branded herbicides and secures for Monsanto another part of farmers' spending.<sup>144</sup>

GM seeds aren't just expensive in the USA. In India, the price of Bt cotton seeds can be up to 950 rupees per packet, compared to between 350 and 500 rupees for a packet of non-GM seeds. According to the director of one Indian seed company 'much of this price of cotton seed goes towards paying royalty to Monsanto'.<sup>145</sup> State governments have attempted to set a cap on the price of Bt cotton seeds but such moves have been challenged by seed companies.<sup>146</sup>

**Figure 1.** Price of seed in the United States



Source: |United States Department of Agriculture, Economic Research Service, 'Commodity costs and returns: data', <<http://www.ers.usda.gov/Data/CostsAndReturns/testpick.htm>>. Seed prices are taken from historical data sets for corn, soybeans, cotton and wheat.

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Similar price rises are occurring in South Africa where between 2010 and 2011 the price of Monsanto's GM seeds increased by up to 8 per cent, the price of Pioneer (Dupont) GM maize seeds increased by up to 14 per cent, and GM soya seeds went up by almost 10 per cent.<sup>147</sup>

In Brazil, the Mato Grosso Institute of Agricultural Economics recently calculated that non-GM soybeans are 14.6 per cent cheaper to grow than Roundup Ready soybeans, the difference being due to higher seed costs, paying the technology fee, and higher chemical costs.<sup>148</sup> In 2012, the Brazilian state agricultural body Embrapa stated that, based on a 1,000 hectare soybean crop, non-GM soybeans would save \$R110,000 (approximately US\$54,200) over GM beans, solely on the basis of not paying the technology fee.<sup>149</sup> However, if GM soybeans contaminate a non-GM crop

at levels above 0.1 per cent the farmer risks having to pay the technology fee anyway, or else face legal action. The biotechnology companies see many African countries as new markets for their GM seeds. The royalty-free agreements on some GM crops appear to be strictly limited. After that, will small farmers face the same upward spiral of seed prices as suffered by farmers in the USA, Brazil, South Africa and India?

### ***Is GM good for the environment?***

Global GM crop production is dominated by herbicide tolerance, whether in maize, soybean, cotton or oilseed rape. The main herbicide used is glyphosate, which was developed and often marketed by Monsanto as Roundup, although it is also marketed under other names. Glyphosate is a broad-



Container of Monsanto's Roundup Pesticide

spectrum herbicide, meaning that it should kill every plant in the field except the GM crop. Adoption rates have been high in the USA, Canada, Brazil, Argentina and Australia, with global consumption of glyphosate rising 27 per cent per year between 2004 and 2008.<sup>150</sup> Because glyphosate tolerant crops are easy to use, many American farmers started to use glyphosate continually in the same fields, year after year.<sup>151</sup> Monsanto's own adverts stated that weed resistance would not occur if they did this.<sup>152</sup> Nevertheless, weed resistance to glyphosate has evolved rapidly, with 23 species reported globally by 2012.<sup>153</sup>

Resistant weeds are becoming a serious problem for farmers in the USA, affecting 12 million acres.<sup>154</sup> The University of Tennessee has estimated that glyphosate-resistant weeds are costing farmers \$200 million per year in Tennessee alone.<sup>155</sup> A 2012 survey of US farmers found that more than one-third of those growing herbicide-tolerant crops were planning to use multiple herbicides to tackle glyphosate-resistant weeds.<sup>156</sup> In some cases farmers are resorting to hand weeding to deal with herbicide-resistant weeds.<sup>157</sup> The head of a USDA task force on dealing with herbicide tolerant weeds said recently that 'we don't have that next technology [to eliminate them]. We will have to get back to the fundamentals.'<sup>158</sup>

A study analysing pesticide use on GM and non-GM equivalent crops between 1996 and 2011 in the USA found that herbicide-tolerant (HT) crops have increased herbicide use by a total of 527 million pounds (239 million kilograms).<sup>159</sup>

The problems with herbicide-tolerant crops in the USA have been repeated in other countries. A study of the main soybean growing area in Argentina found that more herbicide was applied to Roundup-ready soybeans than conventionally grown beans, and the environmental impact of the sprays used on GM crops was higher than those for conventional crops.<sup>160</sup> In Brazil, farmers interviewed in Rio Grande de Sul confirmed that they were having to increase their doses of glyphosate, while a study in the Cascavel soy producing region of Brazil found that sales of other herbicides had dramatically increased since the introduction of GM soy, with sales of paraquat-related products increasing by more than 400 per cent between 2004 and 2008.<sup>161</sup>

In response to the development of herbicide-resistant weeds, the biotechnology corporations have now started making

GM crops resistant to other herbicides; often older, more toxic chemicals. Alarm has been raised in the USA about the approval of 2,4-D resistant maize, due to the high toxicity of this herbicide and the fact that it easily evaporates into the air, so drifting onto other crops and surrounding non-crop areas.<sup>162</sup> The company producing it, Dow Agrosiences, intends to extend 2,4-D resistance into GM soybeans and cotton, estimating the market value of its 'weed control system' to be \$1 billion.<sup>163</sup> In the USA, recent applications and approvals of GM crops show the range of herbicide resistance is being increased (see table 2). These GM crops have the potential to reverse reductions in use of older, more toxic herbicides.

Biotechnology corporations are showing little innovation in dealing with the problem they have created. It seems likely that weeds will develop resistance to these other herbicides; there are already 16 weed species resistant to 2,4-D and 6 species resistant to Dicamba, as well as 2 species resistant to both herbicides.<sup>164</sup> When it comes to GM crops tolerant of ALS inhibitors (Imidazolinone), there are already 123 species resistant to these herbicides.<sup>165</sup> What is happening in the USA shows that GM herbicide-tolerant crops are not a good option for the intensification of agriculture, and are definitely not sustainable.

**Table 2.** Recent applications to the USDA for deregulation of new GM herbicide-tolerant crops

Company	GM crop	Tolerant to herbicide(s)
Dow	soybean	2,4-D, Glyphosate and Glufosinate
Monsanto	soybean	Dicamba
Dow	corn	2,4-D
BASF	soybean	Imidazolinone
Pioneer	corn	Glyphosate and Imidazolinone
Pioneer	soybean	Glyphosate and acetolactate synthase (ALS)

Source: APHIS, 'Petitions for Non-regulated Status, granted or pending', <[http://www.aphis.usda.gov/biotechnology/not\\_reg.html](http://www.aphis.usda.gov/biotechnology/not_reg.html)>.

## five: Conclusions

### Conclusions

#### Small holders can reclaim sustainable agriculture

While the challenges facing agriculture are clearly urgent, sustainable intensification is not the answer. Sustainable intensification claims to include agro-ecological farming practices but in practice seems to focus primarily on technology-based approaches. It aims to help small farmers but is driven by the agendas of corporations, the science establishment and international donors. It talks about participation but generates its strategies far away from small farmers.

Yet it is small farmers who feed the majority of the world. In Africa, peasant farmers grow almost all domestically consumed food. In Latin America, 60 per cent of agricultural production (including meat) comes from family farms.<sup>166</sup> In Asia, almost all rice is grown on farms of less than 2 hectares.<sup>167</sup> In fact, most of the world's food is grown by small farmers, without the use of industrial inputs, and using traditional seed varieties.<sup>168</sup>

Sustainable intensification characterises small farmers as having low yields, and being in need of new technologies, such as high yielding varieties. However, if small holders are feeding much of the world, how unproductive are they? In fact, if total output is measured, rather than just the yield of one crop, small farmers can be more productive than commercial operations. For example, a study in Mexico found that 1.73 hectares of mono-cropped maize was required to produce the same food output (in terms of calories) as 1 hectare of the traditional maize, beans and squash system.<sup>169</sup> The traditional system also produced twice as much residue for incorporation back into the soil.

Small farmers can produce grains, fruit, vegetables, animal fodder, animal products and fuel, all at the same time. Further, because they eat the food they produce they are discerning consumers just as much as producers. Approximately 70 per cent of the world's poorest people live in rural areas, and the people feeding them are more likely to be peasant farmers than large-scale commercial farmers.<sup>170</sup> Despite this, the voices of small farmers are hardly ever heard in discussions about sustainable intensification.

When small farmers *are* asked, they are clear about what they want, including:

- sustainable agriculture that builds on farmers' own expertise and knowledge, rather than seeking to replace it;
- clear land rights, and rights for women, including agrarian reforms;
- agricultural research that starts by asking farmers what they need;
- knowledge and technologies that are based on agro-ecological principles, including compost, integrated pest management and mixed cropping;
- seed development based on traditional varieties; and
- mechanisms to protect them from unfair competition from imported products.<sup>171</sup>

The UN Special Rapporteur on the Right to Food has also proposed using agro-ecological practices, which he says have the potential to double small farmers' food production in 10 years.<sup>172</sup> An agro-ecological approach would build on farmers' own knowledge, rather than imposing new technologies, because traditional agriculture often includes agro-ecological practices such as high levels of biodiversity; complex landscape-management; resilient agro-ecosystems (e.g. using a wide range of crops to spread risk); innovations developed by farmers; and agricultural management that is also part of the culture (e.g. sharing rights to the use of common resources).<sup>173</sup>

Supporters of sustainable intensification have made statements along the lines of conventional agriculture being the 'greenest', and that organic agriculture is a luxury for the rich because it cannot 'feed the world'.<sup>174</sup> In fact, organic and near-organic agriculture is particularly well suited to helping small farmers.

In 2008, the UN Conference on Trade and Development (UNCTAD) and the UN Environment Programme (UNEP) published a report examining organic agriculture and food security in Africa.<sup>175</sup> The study found average yield increases of 116 per cent, as well as increased access to food and reduced financial risk. A range of environmental benefits included carbon sequestration in soil organic matter, and improved soil condition leading to better crop yields over time.

Social benefits included the building up of skills, improved access to markets and, for farmers growing for export, higher profitability than comparable conventional farms. There are barriers for entry into certified organic markets, such as the cost of certification, but the UNEP/UNCTAD report concluded that organic and near-organic agriculture would be particularly suited to many poor, marginalised farmers in Africa, because it doesn't require the buying of inputs, uses locally derived inputs and creates a more resilient and lower financial risk system of farming.

Sustainable intensification has attempted to claim the moral high ground by talking about the needs of small farmers, and the spectre of future famines. Friends of the Earth International believes that small farmers should be able to have good lives, and live without fear of hunger or financial ruin. Increasing yields is part of this; but yields of which crops, and under whose control?

La Via Campesina, which represents about 200 million peasant farmers worldwide, has coined the term 'food sovereignty'. Food sovereignty is the right of all peoples to produce and consume healthy and culturally appropriate food that has been produced through ecologically sound and sustainable methods. It enshrines people's right to define, and own, their own food and agriculture systems and demands that those who produce, distribute and consume food be at the heart of food systems and policies, rather than markets or corporations.

Food sovereignty is an idea that comes from small farmers themselves. In contrast, sustainable intensification is an ideology that adheres to a productivist view of feeding the world. It fails to take into account power, profit, politics and participation in the food system. As this report has shown, in practise it can mean business-as-usual intensive farming with slight modifications to try and tackle the growing environmental crises caused by industrial agriculture.

Sustainable intensification's philosophy of including all possible solutions and technologies can provide a cover for environmentally destructive practices as well as corporate concentration of food production, inputs and distribution. Therefore the term must be used with caution.

### Building on the recommendations of the IAASTD report

Before the Royal Society report made the term 'sustainable intensification' fashionable, the International Assessment of Agricultural Science and Technology for Development (IAASTD) report had already provided a coherent and inclusive roadmap for solving global hunger. The IAASTD report was a multi-year, multi-stakeholder initiative involving hundreds of scientists from many disciplines, civil society, companies, several UN institutions and the World Bank. The IAASTD called for greater recognition of the role of smallholder farming in feeding the world. It recognised the importance of participatory public research that genuinely works for peasant farmers and of far greater funding and support for agro-ecological farming methods. It provided decision makers with authoritative and evidence based findings on which to base further science and research as well as policy solutions to tackle hunger.

In addition to the recommendations of IAASTD, several measures can be taken now that will significantly lessen pressure on land and resources from food production. These measures will also ensure more equitable distribution of resources, food and land among the global community. They include:

- Stopping the large amounts of crops and land diverted from food to agofuels production;
- Introducing measures to reduce high levels of consumption of livestock products in the West that are sucking up global grain supplies;
- Reducing high levels of retail and household waste in the West and post-harvest loss in the developing world.
- Providing access to land, water and other resources is vital for communities to be able to feed themselves.
- Stopping land grabbing and instead implementing genuine agrarian reform programmes—in particular, the actions agreed at the 2006 International Conference on Agrarian Reform and Rural Development.<sup>177</sup>

## five: Conclusions

### IAASTD RECOMMENDATIONS/FINDINGS<sup>176</sup>

1. **PRODUCTION INCREASES:** Agricultural Knowledge, Science and Technology (AKST) has contributed to substantial increases in agricultural production over time, contributing to food security.
2. **UNEVEN BENEFITS:** People have benefited unevenly from these yield increases.
3. **NEGATIVE CONSEQUENCES:** Emphasis on increasing yields and productivity has in some cases had negative consequences on environmental sustainability.
4. **ENVIRONMENTAL DEGRADATION:** The environmental shortcomings of agricultural practice [are] increasing deforestation and overall degradation.
5. **INCREASED DEMAND EXPECTED:** Global cereal demand is projected to increase by 75 per cent between 2000 and 2050 and global meat demand is expected to double.
6. **MULTIFUNCTIONALITY OF AGRICULTURE:** Agriculture operates within complex systems and is multifunctional in its nature.
7. **STRENGTHEN AGROECOLOGICAL SCIENCES:** An increase and strengthening of AKST towards agro-ecological sciences will contribute to addressing environmental issues while maintaining and increasing productivity.
8. **REDIRECT AKST:** Strengthening and redirecting the generation and delivery of AKST will contribute to addressing a range of persistent socioeconomic inequities.
9. **INVOLVE WOMEN:** Greater and more effective involvement of women and use of their knowledge, skills and experience will advance progress towards sustainability and development goals: a strengthening and redirection of AKST to address gender issues will help achieve this.
10. **BUILD ON EXISTING KNOWLEDGE:** [using] more innovative and integrated applications of existing knowledge, science and technology (formal, traditional and community-based).
11. **USE NEW AKST APPROPRIATELY:** Some challenges will be resolved primarily by development and appropriate application of new and emerging AKST.
12. **RESEARCH FOCUS ON SMALL-SCALE:** Targeting small-scale agricultural systems helps realize existing opportunities.
13. **CREATE OPPORTUNITIES FOR POOR FARMERS:** Significant pro-poor progress requires creating opportunities for innovation and entrepreneurship that explicitly target resource-poor farmers and rural labourers.
14. **DIFFICULT POLICY CHOICES:** Decisions around small-scale farm sustainability pose difficult policy choices.
15. **PUBLIC POLICY AND REGULATION CRITICAL:** Public policy, regulatory frameworks and international agreements are critical to implementing more sustainable agricultural practices.
16. **NEW INSTITUTIONAL ARRANGEMENTS REQUIRED:** Innovative institutional arrangements are essential to the successful design and adoption of ecologically and socially sustainable agricultural systems.
17. **NEGATIVE IMPACT OF INTERNATIONAL TRADE:** Opening national agricultural markets to international competition can lead to long-term negative effects on poverty alleviation, food security and the environment.
18. **EXPORT AGRICULTURE UNSUSTAINABLE:** Intensive export-oriented agriculture has adverse consequences such as exportation of soil nutrients and water, unsustainable soil or water management, or exploitative labour conditions, in some cases.
19. **CRUCIAL CHOICES:** The choice of relevant approaches to adoption and implementation of agricultural innovation is crucial for achieving development and sustainability goals.
20. **MORE INVESTMENT IN MULTIFUNCTIONALITY:** More and better-targeted AKST investments, explicitly taking into account the multifunctionality of agriculture.
21. **CODES OF CONDUCT NEEDED:** Codes of conduct by universities and research institutes can help avoid conflicts of interest and maintain focus when private funding complements public sector funds.
22. **MULTIDISCIPLINARY APPROACHES REQUIRED:** Diverse voices and perspectives and a multiplicity of scientifically well-founded options.

## six: References

# References

- 1 European Commission, *Sustainable food consumption and production in a resource-constrained world*, 3rd SCAR Foresight Exercise (2011).
- 2 Rockström, J. et al., 'A safe operating space for humanity', *Nature*, v. 461 (2009), pp. 472–475.
- 3 McIntyre, B. D. et al. (eds), *Agriculture at a Crossroads: International Assessment of Agricultural Knowledge Science and Technology for Development: Global Report* (2009).
- 4 Nellemann, C. et al. (eds), *The Environmental Food Crisis: the Environment's Role in Averting Future Food Crises—A UNEP Rapid Response Assessment* (United Nations Environment Programme and GRID-Arendal, 2009).
- 5 European Commission (note 1), p. 10.
- 6 McIntyre et al. (note 3).
- 7 US Department of Agriculture, *Farm Household Economics and Well-Being: Farm Household Income*, Economic Research Service briefing, <<http://www.ers.usda.gov/Briefing/WellBeing/farmhouseincome.htm>>.
- 8 World Bank, *World Development Report: Agriculture for Development* (2008).
- 9 McIntyre et al. (note 3); De Schutter, O., 'Report to the 16th session of the UN General Assembly Human Rights Council', A/HRC/16/49, 20 Dec. 2010; and UN Food and Agriculture Organization (FAO), *Global Food Losses and Food Waste* (FAO, 2011), study conducted for the International Congress SAVE FOOD! (Interpack2011, Düsseldorf, Germany).
- 10 UN Food and Agriculture Organization (FAO), *Statistical Yearbook* (FAO, 2012); World Health Organization, Global Health Observatory, 'Risk factors: overweight', <<http://www.who.int/gho/en/>>; and World Health Organization, 'Obesity and overweight', <<http://www.who.int/mediacentre/factsheets/fs311/en/>>.
- 11 International Assessment of Agricultural Knowledge Science and Technology for Development (IAASTD), 'Major agriculture report: "business as usual is not an option"', Press release, Date 2008, <[http://www.agassessment.org/docs/nae\\_press\\_release\\_final.doc](http://www.agassessment.org/docs/nae_press_release_final.doc)>.
- 12 Royal Society, *Reaping the Benefits: Science and the sustainable intensification of global agriculture*, Policy document 11/09 (Royal Society: London, 2009).
- 13 Foresight Panel, *The Future of Food and Farming: Final Project Report* (Government Office for Science: London, 2011), p. 31.
- 14 UN Food and Agriculture Organization (FAO), *Report Of The High-Level Conference On World Food Security: the Challenges Of Climate Change And Bioenergy*, Rome, 3–5 June 2008, HLC/08/REP.
- 15 Beddington, J., *Food, Energy, Water And The Climate: A Perfect Storm Of Global Events?*, (Government Office for Science: London, 2009).
- 16 Graziano da Silva, J., Keynote address at the Economist Conference, 'Feeding the World in 2050', Geneva, Switzerland, 8 Feb. 2012, <[http://www.fao.org/fileadmin/user\\_upload/FAODG/docs/2012-02-08-DG\\_Economist\\_Conference-FINAL.pdf](http://www.fao.org/fileadmin/user_upload/FAODG/docs/2012-02-08-DG_Economist_Conference-FINAL.pdf)>.
- 17 World Economic Forum, 'Agriculture and food security', <<http://www.weforum.org/issues/agriculture-and-food-security>>.
- 18 Wierseniens, S., Azar, C. and Berndes, G., 'How much land is needed for global food production under scenarios of dietary changes and livestock productivity increases in 2030?', *Agricultural Systems*, vol. 103 (2010), pp. 621–638.
- 19 Committee on Food Security, *Global Strategic Framework for Food Security and Nutrition*, First draft, Sep. 2012, <<http://www.fao.org/docrep/meeting/026/ME498E.pdf>>.
- 20 Committee on Food Security, 'Feeding the world', <<http://www.fao.org/docrep/015/i2490e/i2490e03a.pdf>>.
- 21 Based in the UK, the Royal Society is a self-governing fellowship of scientists from across the world. It publishes journals, provides funds and is linked in with other scientific bodies around the world. In 2009 it published 'Reaping the Benefits' a study examining the contribution of the biological sciences to food crop production, which was highly influential in furthering the international recognition of the term sustainable intensification. The Royal Society study was criticized by civil society groups as replicating the International Assessment of Agricultural Science and Technology for Development UN-backed study which found a minimal role for GM crops in feeding the world.
- 22 Royal Society (note 12), p. ix.
- 23 Royal Society (note 12), p. 7.
- 24 Royal Society (note 12), p. ix.
- 25 US Government, *Feed the Future: Global Food Security Research Strategy* (2011), <<http://www.feedthefuture.gov>>, p. 20.
- 26 European Union, Scientific Advisory Board of the Agriculture, Food Security and Climate Change Joint Programming Initiative (FACCE JPI), *Scientific Research Agenda: Scope, Common Vision And Priority Actions*, Dec. 2010, p. 11.
- 27 Agricultural Biotechnology Council, Written evidence to the Environment Audit Committee Session 2010–11: Sustainable Food, <<http://www.publications.parliament.uk/pa/cm201011/cmselect/cmenvaud/written/food/m15.htm>>.
- 28 International Fertilizer Industry Association, 'Green economy', <<http://www.fertilizer.org/ifa/HomePage/SUSTAINABILITY/Green-Economy>>.
- 29 Croplife Australia, 'Stark warning on future food security', Press release, 25 Jan. 2011.
- 30 See e.g. Royal Society (note 12).
- 31 Consultative Group on International Agricultural Research (CGIAR), Independent Science and Partnership Council Standing Panel on Impact Assessment, 'Does crop improvement reduce agricultural expansion?', Brief no. 40, Jan. 2012.
- 32 Ewers, R. M. et al., 'Do increases in agricultural yield spare land for nature?' *Global Change Biology*, vol. 15, no. 7 (July 2009); and Donald, P. F., Green, R. E. and Heath, M. F., 'Agricultural intensification and the collapse of Europe's farmland bird populations', *Proceedings of the Royal Society of London: Biological Sciences*, vol. 268 (2001), pp. 25–29.
- 33 Matson, P. A. and Vitousek, P. M., 'Agricultural intensification: will land spared from farming be land spared for nature?', *Conservation Biology*, vol. 20 (2006), pp. 709–710.
- 34 Angelsen, A., Shitindi, E. F. K. and Aarrestad, J. 'Why do farmers expand their land into forests? Theories and evidence from Tanzania', *Environment and Development Economics*, vol. 4 (1999), pp. 313–331; and Vosti, S. A., Carpentier, C. L., Witcover, J. and Valentim, J. F. 'Intensified small-scale livestock systems in the western Brazilian Amazon', eds A. Angelsen and D. Kaimowitz, *Agricultural Technologies and Tropical Deforestation* (CABI: New York, 2001), pp. 113–133.
- 35 Consultative Group on International Agricultural Research (note 30).
- 36 UN Food and Agriculture Organization (FAO), 'Save and grow: A policymaker's guide to the sustainable intensification of smallholder crop production', <[http://www.fao.org/ag/save-and-grow/index\\_en.html](http://www.fao.org/ag/save-and-grow/index_en.html)>.
- 37 UN Food and Agriculture Organization (FAO), 'Sustainable Crop Production Intensification (SCP) in FAO', <<http://www.fao.org/agriculture/crops/core-themes/theme/spi/scpi-home/framework/sustainable-intensification-in-fao/en/>>.
- 38 Bill and Melinda Gates Foundation, *Agricultural Development: Strategy Overview* (2011), p. 5, <<http://www.gatesfoundation.org/agriculturaldevelopment/Documents/agricultural-development-strategy-overview.pdf>>.
- 39 World Economic Forum, *Putting the New Vision for Agriculture into Action: A Transformation Is Happening* (World Economic Forum: Davos, 2012).
- 40 Fertilisers are a major contributor to climate change through N2O emissions and the decomposition of soil organic matter.
- 41 Global Science Conference on Climate-Smart Agriculture, Wageningen, Oct. 2011, <<http://www.gscsa2011.org/>>; and African Ministerial Conference on Climate-Smart Agriculture, Johannesburg, Sep. 2011, <<http://www.nda.agric.za/index2011ClimateChange.htm>>.
- 42 Royal Society (note 12), Recommendations.
- 43 Foresight Panel (note 13), section 3.2.
- 44 'UK "will lead way on sustainable intensification"', *Farmers Guardian*, 3 Nov. 2011.
- 45 See Global Food Security, <<http://www.foodsecurity.ac.uk/>>.
- 46 UK Government, Office for Science, *UK Cross-Government Strategy for Food Research and Innovation* (2010).
- 47 Technology Strategy Board, 'New £15 million programme to stimulate food industry sector growth', Press release, 14 March 2012; Technology Strategy Board, 'New research will help make foods healthier, safer and more nutritious', Press release, 11 Oct. 2011; Technology Strategy Board, 'New research and development will help secure future supply of meat, fish and animal feed', Press release, 23 Sep. 2011; and Technology Strategy Board, 'Innovative crop protection R&D may help farmers cope with new EU regulations', Press release, 1 July 2012.
- 48 'UK "will lead way on sustainable intensification"' (note 43); and UK Department of the Environment (DEFRA), '£20 million for farming and forestry businesses', Press release, 10 Nov. 2011.
- 49 Specific projects include 'Reduced tillage and green manures for sustainable organic cropping' (Project OF0392); 'Promoting good health and welfare in European organic laying hens' (Project OF0394); and 'Improved contribution of local feed to support 100 per cent organic feed supply to pigs and poultry' (Project OF0395: CORE 2). DEFRA projects database, <<http://randd.defra.gov.uk>>.
- 50 UK Biotechnology and Biological Sciences Research Council (BBSRC), 'New publication highlights role of plant science in delivering food security', Press release, 2 Mar. 2009; and UK Biotechnology and Biological Sciences Research Council (BBSRC), 'Delivery plan 2011–2015', <[http://www.bbsrc.ac.uk/web/FILES/Publications/delivery\\_plan\\_2011\\_2015.pdf](http://www.bbsrc.ac.uk/web/FILES/Publications/delivery_plan_2011_2015.pdf)>.
- 51 UK Biotechnology and Biological Sciences Research Council (BBSRC), 'Minister announces £250M strategic investment in UK bioscience', Press release, 24 May 2012.
- 52 UK Biotechnology and Biological Sciences Research Council (BBSRC), 'Increasing food and fuel production—thinking outside the box', Press release, 27 Sep. 2011.
- 53 UK Department for International Development (DFID), <<http://www.dfid.gov.uk/r4d/Project/60792/Default.aspx>>.
- 54 UK Department for International Development (DFID), 'Annual review of Project Association for Strengthening Agriculture and Research in Eastern and Central Africa (ASARECA)', Mar. 2012, <<http://projects.dfid.gov.uk/project.aspx?Project=114115>>.
- 55 UK Department for International Development (DFID), 'Ending Striga's reign with IR maize', <<http://www.dfid.gov.uk/R4D/Output/186218/Default.aspx>>; and UK Department for International Development (DFID), 'African Agricultural Technology Foundation

## six: References

- (AATF)—Phase 2', <<http://www.dfid.gov.uk/R4D/Project/60707/Default.aspx>>. See also African Agricultural Technology Foundation, <<http://www.aatf-africa.org/en/>>.
- 56 African Agricultural Technology Foundation, 'Project 1: Striga control in maize—managing a cereal killer', <<http://www.aatf-africa.org/striga/>>.
  - 57 The Institute for Development Studies, Sussex leads the project. UK Department for International Development (DFID), 'Under what circumstances and conditions does adoption of technology result in increased agricultural productivity?', <<http://www.dfid.gov.uk/r4d/Project/60857/Default.aspx>>.
  - 58 GM Freeze, 'The Bill and Melinda Gates Foundation, biotechnology and intensive farming', Oct. 2011, <[http://www.gmfreeze.org/site\\_media/uploads/publications/Gates\\_summary\\_final.pdf](http://www.gmfreeze.org/site_media/uploads/publications/Gates_summary_final.pdf)>.
  - 59 See also Friends of the Earth International (FoEI), 2012, *Reclaim the UN from corporate capture*, pp. 16–18, <<http://www.foei.org/en/resources/publications/pdfs/2012/reclaim-the-un-from-corporate-capture/view>>.
  - 60 Consultative Group on International Agricultural Research (CGIAR) annual reports can be found online: <<http://www.cgiar.org/publications/finrep/index.html>>. See also *A Strategy and Results Framework for the CGIAR*, submission to the CGIAR Funders Forum, 7 June 2010, <[http://www.cgiarfund.org/sites/cgiarfund.org/files/Documents/PDF/CGIAR\\_SRF\\_june7\\_2010.pdf](http://www.cgiarfund.org/sites/cgiarfund.org/files/Documents/PDF/CGIAR_SRF_june7_2010.pdf)>.
  - 61 Consultative Group on International Agricultural Research (CGIAR), *Financial Report 2010* (CGIAR, 2011).
  - 62 CRPs 3.1, 3.2 and 3.3 account for \$1058.9 million of a total budget of \$3219 million over 3 years. Consultative Group on International Agricultural Research (CGIAR), 'Fund update, March 2012', <[http://www.cgiarfund.org/news.cgiarfundupdate\\_march2012](http://www.cgiarfund.org/news.cgiarfundupdate_march2012)>.
  - 63 International Maize and Wheat Improvement Center (CIMMYT) and partner organizations, 'CRP 3.2 MAIZE Proposal', 1 June 2011, <[http://www.cgiarfund.org/cgiarfund/crp\\_maize](http://www.cgiarfund.org/cgiarfund/crp_maize)>.
  - 64 CGIAR, 'Thematic Area 3—sustainable crop productivity increase for global food security: proposal for a CGIAR Research Program on Rice-Based Production Systems', Sep. 2010; and 'WHEAT-Global Alliance for Improving Food Security and the Livelihoods of the Resource-poor in the Developing World', Proposal submitted by CIMMYT and ICARDA to the CGIAR Consortium Board 30 Aug. 2011.
  - 65 CGIAR, *A Strategy and Results Framework for the CGIAR* (note 59), p. 80.
  - 66 CGIAR Standing Panel on Impact Assessment, 'Assessing the impacts of research-led agricultural technologies on poverty and hunger: plans for a major new initiative by the CGIAR Standing Panel on Impact Assessment (SPIA)', Briefing Note, 3 May 2010.
  - 67 CGIAR, 'Improved food security', <<http://www.impact.cgiar.org/improved-food-security>>; and CGIAR Independent Science And Partnership Council, Standing Panel on Impact Assessment, 'Ex-post environmental impact assessment: lessons from four CGIAR case studies', Briefing no. 39 (2012).
  - 68 US Government, *Feed the Future* (note 24), p. 16.
  - 69 Nicholson, S. (2011), *Feeding 10 Billion: a Dialogue Between Feed the Future and the International Research Community*, Appendix: list of participants, <<http://www.aplu.org/document.doc?id=3664>>.
  - 70 Nicholson (note 67), p. 55.
  - 71 US Government, *Feed the Future* (note 24), p. 21.
  - 72 Board for International Food and Agricultural Development (BIFAD), 'Minutes from the public meeting on "The next generation: global food security through human and institutional capacity building"', 11 Oct. 2011, Des Moines, Iowa, <<http://www.aplu.org/document.doc?id=3597>>.
  - 73 US Government, *Feed the Future*, 'Ethiopia multi-year strategy (2011–2015)', (2011), p. 33.
  - 74 US Government, *Feed the Future*, 'Zambia multi-year strategy (2011–2015)', (2011).
  - 75 BIFAD (note 71).
  - 76 Gattinger, G., Jawtusich, J., Muller, A. and Mäder, P., 'No-till agriculture: a climate smart solution?', German Catholic Bishops' Organisation for Development Cooperation (MISEREOR), Nov. 2011, <[http://www.misereor.org/fileadmin/redaktion/MISEREOR\\_no%20till.pdf](http://www.misereor.org/fileadmin/redaktion/MISEREOR_no%20till.pdf)>; and Friends of the Earth International, 'Who benefits from GM crops: the climate change swindle', <<http://www.foei.org/en/resources/publications/pdfs/2010/who-benefits-from-gm-crops-2010/view>>.
  - 77 'Drought tolerance, conservation agriculture, and double-cropping: a recipe for success in Mozambique', International Maize and Wheat Improvement Center (CIMMYT) blog, 29 Feb. 2012, <<http://blog.cimmyt.org/?p=7761>>.
  - 78 CIMMYT, Sustainable Intensification of Maize-Legume Systems for Food Security in Eastern and Southern Africa (SIMLESA), 'About the program: objectives and outputs', <<http://simlesa.cimmyt.org/index.php/about-the-program/objectives-and-outputs/8-objective-2-outputs>>.
  - 79 CIMMYT, Sustainable Intensification of Maize-Legume Systems for Food Security in Eastern and Southern Africa (SIMLESA), 'SIMLESA stories: SIMLESA in Mozambique', <<http://simlesa.cimmyt.org/index.php/newsroom/stories/48-simlesa-in-mozambique>>.
  - 80 Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program, *Trip Report: Mozambique* (2012), <<http://www.oired.vt.edu/sanremcrsp/public/official-reports/trip-reports/2012/>>.
  - 81 Giller, K. E. et al., 'Conservation agriculture and smallholder farming in Africa: the heretics' view', *Field Crops Research*, vol. 114 (2008), pp. 23–34.
  - 82 UN Food and Agriculture Organization (note 36).
  - 83 US Government, *Feed the Future*, 'Public-Private Partnership Technical Forum, final report', 22 Feb. 2012, p. 2.
  - 84 'U.S. agriculture companies set millions for Africa', *Reuters*, 18 May 2012.
  - 85 World Economic Forum, *A New Vision for Agriculture: Deepening public-private collaboration to accelerate growth in sustainable agriculture*, <[http://www3.weforum.org/docs/WEF\\_CO\\_AFB\\_IndustryProjectOverview.pdf](http://www3.weforum.org/docs/WEF_CO_AFB_IndustryProjectOverview.pdf)>.
  - 86 Southern Agricultural Growth Corridor of Tanzania (SAGCOT), *Investment Blueprint*, Jan. 2011, <<http://www.sagcot.com/home>>.
  - 87 *Feed the Future*, 'Southern Agricultural Growth Corridor of Tanzania (SAGCOT)', <<http://www.feedthefuture.gov/model/southern-agricultural-growth-corridor-tanzania-sagcot>>.
  - 88 Southern Agricultural Growth Corridor of Tanzania (SAGCOT), 'Appendix III: Land Development', <[http://www.sagcot.com/uploads/media/Appendix\\_III\\_Land\\_Development\\_04.pdf](http://www.sagcot.com/uploads/media/Appendix_III_Land_Development_04.pdf)>.
  - 89 Gaia Foundation et al., *Agrofuels and the Myth of the Marginal Lands* (2008), <<http://www.cbd.int/doc/biofuel/Econexus%20Briefing%20AgrofuelsMarginalMyth.pdf>>.
  - 90 SAGCOT (note 84), pp. 58–59.
  - 91 Kolbe, J. and Severino, J. M., Transformational Partnerships in Food Security in Africa: A Transatlantic Experts Group Final Report (German Marshall Fund of the United States: Washington, DC, 2012).
  - 92 Grow Africa, 'Initiatives', <<http://www.growafrica.com/initiatives>>.
  - 93 See e.g. High Level Panel of Experts on Food Security and Nutrition, 'Price volatility and food security' (2011), <[http://www.fao.org/fileadmin/user\\_upload/hlpe/hlpe\\_documents/HLPE-price-volatility-and-food-security-report-July-2011.pdf](http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE-price-volatility-and-food-security-report-July-2011.pdf)>.
  - 94 Olivier De Schutter, UN Special Rapporteur on the right to food, Briefing note: "The World Trade Organization and the Post-Global Food Crisis Agenda: Putting Food Security First in the International Food System" (2009)
  - 95 Foresight Panel (note 13), p. 11.
  - 96 The 'expert group' was made up of academics from UK universities, while the high-level stakeholder group included staff from UK Government departments, representatives of UN agencies and the OECD, international and national agricultural research agencies, developed country NGOs (e.g. OXFAM), and industry representatives.
  - 97 Nicholson (note 68), Appendix IV: list of research forum registrants.
  - 98 CGIAR, *A Strategy and Results Framework for the CGIAR* (note 62).
  - 99 CGIAR, 'CGIAR Fund Council holds meeting at Gates Foundation', 29 Mar. 2012, <<http://www.cgiarfund.org/cgiarfund/node/335>>.
  - 100 Global Conference on Agricultural Research for Development (GCARD) 2010, *The GCARD Road Map: Transforming Agricultural Research for Development (AR4D) Systems for Global Impact*, CGIAR/GFAR, pp. 1–3.
  - 101 Pimbert, M., 'Putting farmers first: reshaping agricultural research in West Africa', International Institute for Environment and Development Briefing (2012).
  - 102 Pimbert (note 100); and Scoones, I. and Thompson, J. (eds), *Farmer First Revisited* (Practical Action Publishing: Warwickshire, 2009).
  - 103 ISAAA, *Global Status of Commercialized Biotech/GM Crops*, Brief no. 43-2011, Executive Summary.
  - 104 US Department of Agriculture (USDA), Economic Research Service, *Soybeans and Oil Crops: Background*, <<http://www.ers.usda.gov/Briefing/SoybeansOilcrops/background.htm>>.
  - 105 'The US now uses more corn for fuel than for feed', *Scientific American*, 7 Oct. 2011.
  - 106 Rosillo-Calle, F., Pelkmans, L. and Walter, A., *A Global Overview Of Vegetable Oils, With Reference To Biodiesel*, A Report for the IEA Bioenergy Task 40 (2009).
  - 107 ISAAA (note 102).
  - 108 Fernandez-Cornejo, J. and Caswell, M., *The First Generation of Genetically Engineered Crops in the United States*, Economic Information Bulletin 11, USDA Economic Research Service (2006).
  - 109 IAASTD, *Agriculture at a Crossroads—Synthesis Report* (2009), pp. 8, 40.
  - 110 Gurian-Sherman, D., *Failure to Yield: Evaluating the performance of genetically engineered crops* (Union of Concerned Scientists: Cambridge, MA, 2009).
  - 111 Bindraban, P. S. et al., *GM-related sustainability: agro-ecological impacts, risks and opportunities of soy production in Argentina and Brazil*, Plant Research International, Wageningen University Report no. 259 (2009).
  - 112 Zulauf, C. and Hertzog, E., *Biotechnology and US Crop Yield Trends* (Ohio State University Department of Agricultural, Environmental and Development Economics, 2011), <<http://aede.osu.edu/biotechnology-and-us-crop-yield-trends>>.
  - 113 ISAAA (note 102).
  - 114 Gruere, G. P. and Sun, Y., *Measuring the Contribution of Bt Cotton Adoption to India's Cotton Yields Leap*, International Food Policy Research Institute Discussion Paper 01170 (2012).
  - 115 Gruere and Sun (note 111), p. 12.
  - 116 'Cotton fields back home', *Telheka Magazine*, vol. 7, no. 9 (6 Mar. 2010), <<http://www>>.

- tehelka.com/story\_main44.asp?filename=Ne060310coverstory.asp&id=5>.
- 117 Gruere and Sun (note 113).
  - 118 Hebbbar, K. B. and Mayee, C. D., 'Parawilt/sudden wilt of cotton—a perspective on the cause and its management under field conditions', *Current Science*, vol. 100 (2011), pp. 1654–1662.
  - 119 See e.g. Royal Society, *Reaping the Benefits* (note 12).
  - 120 Royal Society (note 12), p. 34.
  - 121 ETC Group, 'Capturing "climate genes"', 22 Oct. 2010, <<http://www.etcgroup.org/content/gene-giants-stockpile-patents-%E2%80%9Cclimate-ready%E2%80%9D-crops-bid-become-biomassters-0>>.
  - 122 'Monsanto, DuPont fight on parched Kansas battlefield', *Bloomberg News*, 21 Apr. 2010.
  - 123 Lopes, M. S., Araus, J. L., van Heerden, P. D. R. and Foyer, C. H., 'Enhancing drought tolerance in C4 crops', *Journal of Experimental Botany*, vol. 62, no. 9 (2011), pp. 3135–3153.
  - 124 Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), 'First GM tropical maize in Africa: how far, how soon?', 9 Mar. 2012, <<http://www.asareca.org/content/first-gm-tropical-maize-africa-how-far-how-soon>>; and Deikman, J., Petracek, M. and Heard, J. E., 'Drought tolerance through biotechnology: improving translation from the laboratory to farmers fields', *Current Opinion in Biotechnology*, vol. 23 (2012), pp. 243–50.
  - 125 See e.g. Oh, S. J. et al., 'Over-expression of the transcription factor AP37 in rice improves grain yield under drought conditions', *Plant Physiology*, vol. 150 (2009), pp. 1368–1379.
  - 126 Deikman, Petracek and Heard (note 123).
  - 127 US Department of Agriculture (USDA), Animal and Plant Health Inspection Service Biotechnology Regulatory Services, 'National Environmental Policy Act decision and finding of no significant impact: Monsanto Company Event Mon 87460 Corn' (2011).
  - 128 US Department of Agriculture (USDA), Animal and Plant Health Inspection Services, *Monsanto Company Petition (07-CR-191U) for Determination of Non-regulated Status of Event MON 87460 Draft Environmental Assessment*, BRS document 09-055-01p pea (2011).
  - 129 African Agricultural Technology Foundation (AATF), *Water Efficient Maize for Africa (WEMA) Project Collaboration, Intellectual Property and Licensing Background*, [n/d], <<http://www.aatf-africa.org/userfiles/Wema-Summary-Collaboration.pdf>>.
  - 130 African Agricultural Technology Foundation (AATF), *Water Efficient Maize for Africa (WEMA) Progress Report 2008–2011*, <[http://www.aatf-africa.org/userfiles/WEMA-Progress-Report\\_2008-2011.pdf](http://www.aatf-africa.org/userfiles/WEMA-Progress-Report_2008-2011.pdf)>.
  - 131 AATF (note 128).
  - 132 'KENYA: Maize farmers have rain but lack seeds', IRIN Africa News, 15 May 2012, <<http://www.irinnews.org/Report/95452/KENYA-Maize-farmers-have-rain-but-lack-seeds>>.
  - 133 Mercer, K. L., Perales, H. R. and Wainwright, J. D., 'Climate change and the transgenic adaptation strategy: smallholder livelihoods, climate justice, and maize landraces in Mexico', *Global Environmental Change*, vol. 22 (2012), pp. 495–504.
  - 134 Rodale Institute, *The Farming Systems Trial: Celebrating 30 Years* (Rodale Institute: Kutztown, PA, 2011).
  - 135 International Rice Research Institute (IRRI), AfricaRice and International Centre for Tropical Agriculture (CIAT), 'CGIAR Thematic Area 3: sustainable crop productivity increase for global food security', Proposal for a CGIAR Research Program on Rice-Based Production Systems (2010); and 'Researchers aim to flick the high-carbon switch on rice', *The Guardian*, 24 Jan. 2012.
  - 136 Covshoff, S. and Hibberd, J., 'Integrating C4 photosynthesis into C3 crops to increase yield potential', *Current Opinion in Biotechnology*, vol. 23, no. 2 (2012), pp. 209–214.
  - 137 Gowik, U. et al., 'Evolution of C4 photosynthesis in the genus *Flaveria*: how many and which genes does it take to make C4?', *Plant Cell*, vol. 23 (2011), pp. 2087–2015.
  - 138 Covshoff and Hibberd (note 135).
  - 139 Godfray, H. C. J. et al., 'Food security: the challenge of feeding 9 billion people', *Science*, vol. 327 (2010), pp. 812–818.
  - 140 Foresight Panel (note 13), p. 18.
  - 141 'Monsanto strong arms seed industry', CBS News, 4 Jan. 2011; and 'DuPont urges U.S. to curb Monsanto seed monopoly', Reuters, 8 Jan. 2010.
  - 142 'Monsanto sees Brazil soy seed share exceeding 80 per cent on new strain', *Bloomberg News*, 18 Feb. 2011; and 'Seed companies reap rich harvest on Bt cotton wave', *Business Standard*, 23 Feb. 2012.
  - 143 'DuPont to appeal competition tribunal's Pannar decision', allAfrica.com, 8 May 2012, <<http://www.allafrica.com/stories/201205080754.html>>.
  - 144 See e.g. <<http://www.roundupreadyplus.com/Soybean/Rewards-program/Pages/SoybeanIncentives.aspx>>.
  - 145 'Seed companies reap rich harvest on Bt cotton wave' (note 139).
  - 146 'Government raises Bt cotton prices', *Times of India*, 24 May 2011; and 'Gujarat bats for Bt cotton seed price regulation', *Times of India*, 8 Mar. 2012.
  - 147 www.senwes.co.za/files/main\_articles/2011/10/7/mielie\_mosanto.jpg accessed 16 May 2012; www.senwes.co.za/files/main\_articles/2011/10/7/mielie\_pioneer.jpg
  - 148 'Conventional soybeans (non-GM) promoted by Embrapa', *Soybean and Corn Advisor*, 24 May 2011, <[http://www.soybeansandcorn.com/news/May24\\_11-Conventional-Soybeans-non-GMO-Promoted-by-Embrapa](http://www.soybeansandcorn.com/news/May24_11-Conventional-Soybeans-non-GMO-Promoted-by-Embrapa)>.
  - 149 'Brazil farmers encouraged to plant non-GMO soybeans', *Soybean and Corn Advisor*, 20 Jan. 2012, <[http://www.soybeansandcorn.com/news/Jan20\\_12-Brazil-Farmers-Encouraged-to-Plant-non-GMO-Soybeans](http://www.soybeansandcorn.com/news/Jan20_12-Brazil-Farmers-Encouraged-to-Plant-non-GMO-Soybeans)>.
  - 150 Yin, G., 'Glyphosate: there is no substitute', *Farm Chemicals International*, Mar. 2011, <<http://www.farmchemicalsinternational.com/cropprotection/productfocus/?storyid=2997>>.
  - 151 US National Research Council, Committee on the Impact of Biotechnology on Farm Level Economics and Sustainability, *The Impact of Genetically Engineered Crops on Farm Sustainability in the United States* (National Academies Press, 2010).
  - 152 Iowa State University, 'Weed science online', 17 Dec. 2004, <<http://www.weeds.iastate.edu/mgmt/2004/twoforone.shtml>>.
  - 153 See International Survey of Herbicide Resistant Weeds, <<http://www.weedscience.org>>.
  - 154 'Super weeds no easy fix for US agriculture—experts', *Reuters*, 10 May 2010.
  - 155 'Herbicide resistant weeds cost farmers millions in lost yield, increased expense', Delta Farm Press, 25 Feb. 2011, <<http://deltafarmpress.com/soybeans/herbicide-resistant-weeds-costing-farmers-millions-lost-yield-increased-expense>>.
  - 156 BASF, 'Farmers plan to update weed control management in 2012', Press release, 24 Apr. 2012, <<http://www.basf.com/group/corporate/en/news-and-media-relations/news-releases/news-releases-usa/P-12-087>>.
  - 157 Hart, M. and Speller, P., 'GM crops farmer to farmer', YouTube, 14 June 2011, <<http://www.youtube.com/watch?v=jEX654gN3c4>>.
  - 158 'Super weeds no easy fix for US agriculture—experts' (note 153).
  - 159 Benbrook, C., 'Impacts of genetically engineered crops on pesticide use in the U.S.—the first sixteen years', *Environmental Sciences Europe*, vol. 24, no. 24 (2012).
  - 160 Bindraban et al. (note 110).
  - 161 Meyer, D. E. and Cederberg, C., 'Pesticide use and glyphosate-resistant weeds: a case study of Brazilian soybean production', SIK-Rapport no. 809 (2010), Appendix 1; and Riesenberg, A. and Silva, M., *Nota Técnica: Reflexos Associados ao Cultivo de Plantas Transgênicas no Estado do Paraná*, Department of Agriculture and Supply in Paraná (SEAB, 2009).
  - 162 Save Our Crops Coalition, 'Petition to the USDA', 18 Apr. 2012, <<http://www.saveourcrops.org/wp-content/uploads/2012/04/FINAL-Petition-to-APHIS-041812-Electronic.pdf>>.
  - 163 'Dow AgroSciences execs: "extremely high" interest in new 2,4-D cropping system', *Farm Chemicals International*, 3 Apr. 2012, <<http://www.farmchemicalsinternational.com/article/28470/dow-agrosciences-execs-extremely-high-interest-in-new-2-4-d-cropping-system>>.
  - 164 Mortensen, D. A. et al., 'Navigating a critical juncture for sustainable weed management', *Bioscience*, vol. 62 (2012), pp. 75–84.
  - 165 International Survey of Herbicide Resistant Weeds (note 152).
  - 166 UN Food and Agriculture Organization (FAO), 'Boletín de Agricultura Familiar en América Latina y el Caribe, Julio–Septiembre', Observatorio de la Agricultura Familiar (2012), <[http://www.ritc.fao.org/uploads/media/baf\\_201209.pdf](http://www.ritc.fao.org/uploads/media/baf_201209.pdf)>.
  - 167 ETC Group, 'Who will feed us? Questions for the food and climate crises', 1 Nov. 2009, <<http://www.etcgroup.org/content/who-will-feed-us>>.
  - 168 Altieri, M. A., Funes-Monzote, F. R. and Petersen, P., 'Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty' *Agronomy for Sustainable Development* (2011).
  - 169 Gliessman, S. R., *Agroecology: ecological process in sustainable agriculture* (Ann Arbor Press: Michigan, 1998).
  - 170 ETC group (note 166).
  - 171 See Pimbert (note 100).
  - 172 De Schutter (note 9).
  - 173 Altieri et al. (note 167).
  - 174 See e.g. 'Intensive farming can be greenest—Foresight scientist', *Farmers Guardian*, 9 Mar. 2011; and 'The 9 billion-people question', *The Economist*, 24 Feb. 2011, <<http://www.economist.com/node/18200618>>.
  - 175 UN Conference on Trade and Development (UNCTAD) and UN Environment Programme (UNEP), *Organic Agriculture and Food Security in Africa* (United Nations: New York/Geneva, 2008).
  - 176 UK food Group, 'The 22 findings of IAASTD at a glance' <<http://www.ukfg.org.uk/docs/IAASTDFEC%2B22FindingsAtaGlance.pdf>> (2008).
  - 177 International Conference on Agrarian Reform and Rural Development, 'Final declaration', Porto Alegre, 7–10 Mar. 2006, <[http://www.icarrd.org/news\\_down/C2006\\_Decl\\_en.doc](http://www.icarrd.org/news_down/C2006_Decl_en.doc)>.

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