Biotechnology and food security in developing countries

The case for strengthening international environmental regimes

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'*Whoever controls the seed today could rule over nations tomorrow*'.
Mary C. Carras

This article discusses and evaluates the potential impact of the modern biotechnological revolution (genetic engineering) on food security in developing countries. It finds that within the present framework, where innovations are driven by profit rather than by need-oriented research and development, the biotechnological revolution can have an adverse effect on small farms and exacerbate social, economic and environmental problems. Given that the current debate on biotechnology entered a period of intensified conflict over questions of ownership and control over biological materials, the role of patenting and Intellectual Property Rights (IPRs) is specifically highlighted. In conclusion, much emphasis is given to the international attempts at control of biotechnology within the UN system with particular regard to the Cartagena Protocol on Biosafety and the FAO International Treaty on Plant Genetic Resources for Food and Agriculture and their attempts to set guidelines governing trade in genetically modified organisms and to strengthen the concept of 'farmer's rights'.

The new technologies associated with genetic engineering and commonly referred to as biotechnology are increasingly perceived by their promoters and critics as so ground-breaking that their impact on farming, agriculture and food systems will far surpass that of the twentieth century industrial revolution. Consequently, many authors dealing with the issue of biotechnology and development point to the lessons learned from the 'Green Revolution' when the western industrial model of agriculture was exported to the developing world, producing mixed results [1,2,14,15,18]. In this article, first these lessons are reviewed and the current genetic revolution in developing countries is outlined. Subsequently, food security is redefined and agro-industry myths are debunked. The article continues with a discussion of intellectual prop-

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erty rights applied to biotechnology. Finally, international environmental regimes that aim to defend biodiversity and farmer's rights are reviewed.

Lessons from the Green Revolution and the current pace of the genetic revolution in developing countries

Though it is true that the Green Revolution was highly successful in initially increasing crop yields and aggregate food supplies, it has also been responsible for causing many environmental and socio-economic problems. By its promotion of the industrial farming model, favouring mostly export cash crops producing farms that have enough resources to purchase expensive chemical and mechanic inputs, the Green Revolution has failed to address the issue of food access and contributed to the erosion of genetic varieties in the food systems [1,2,10,18]. The technological change introduced by the Green Revolution has discriminated against small, sustenance-level production, contributing to the loss of food self-sufficiency and agro-biodiversity at the local level among many areas of Asia, Latin America and Africa [21]. In addition, the reliance on chemical fertilisers has not only led to a major environmental crisis by leading to new 'ecological diseases' [22] but has also made developing countries' food production dependent on expensive imports of agro-chemicals and machinery [1]. Essentially, although the Green Revolution contributed to the overall global food security in an aggregate sense, it has failed to address specific food security needs at household, intra-household and community levels and failed to deliver its promise of ending world hunger with today more than 850 million people being undernourished [23]. At the same time the Green Revolution is partially responsible for entrenching an unsustainable food production system favouring monocultures and exacerbating both environmental degradation and an unequal distribution of resources.

It is within this context that ironically virtually the same few firms that have profited the most from agro-chemical sales to developing countries are today's leaders of biotechnological research and development (R&D), marketing their new products as a solution to hunger that will turn farming into an environmentally friendly process with increased yields and profitability. 'According to FAO (Food and Agriculture Organisation of the United Nations), the five largest plant biotechnology companies are all large multinational corporations with important interests in agro-chemical sales: DuPont, ICI, Monsanto, Sandoz and Ciba-Geigy' [12]. The majority of biotechnological R&D takes place within the rich OECD countries, 'where most expenditures are directly accounted for by private-sector firms with much public-sector R&D undertaken for the indirect benefit of private firms' [3]. Overall, 70 percent of agricultural biotechnology investments are by private sector research and only four firms – DuPont, Monsanto, Syngenta and Bayer – control nearly 100 percent of the market in genetically modified (GM) products for agriculture. Only a handful of advanced developing countries have their own biotechnological programmes, among them being Argentina, India, Mexico, Brazil and China. By 2001, over 75% of GM crops have been planted in industrialised countries and substantial planting concerns only four crops – soybean, maize, cotton and canola – while there are no serious investments in most important crops for the semi-arid tropics. Additionally, given that increasing market share and control has become the guiding principle of the present-day biotechnological revolution in agriculture, the two greatest advances and most common traits of genetic modification are insect resistance and herbicide tolerance [9,12].

Concentration of research in biotechnology in the private domain, controlled by a few multinational companies of the North, and coupled with development of an international patenting regime, are the most crucial factors in shaping the socio-economic, environmental and the food-security consequences of biotechnological innovations for the developing countries.

Biotechnology via 'genetic engineering' involves 'the excision of individual genes or sections of chromosomes from a particular genome and their transfer into a different cell and, thus, a different genomic background' [13]. This extraction and replacement of genes allows for overcoming the species' biological and chemical barriers as well as for rapid movement of genetic material to create new micro-organisms, plants, and animals. Given that genetic material can now be exchanged among all living organisms within a short time combined with the new developments in patenting rights has put biotechnological R&D largely outside of the public domain's regulations. 'Companies are striving to develop novel biotechnology products as quickly as possible, while simultaneously lobbying to reduce as much as possible the public regulatory processes' [15]. In fact, companies are massively deploying genetically engineered plants around the world, usually without proper short and long term testing of their impact on health and environment. The rate of growth in the cultivation of genetically modified organisms (GMOs) during the past 5 years has been truly striking: in 2003 over 67 million hectares were cultivated with GMO crops as compared with only 11 million hectares in 1998 [24]. This rapid release of GMOs into environment has brought with it the consequences of genetic contamination of traditional varieties due to effects of cross-pollination, mixing with batches of GM seeds or illegal introduction of seeds without the explicit consent of a particular developing country. The location of transgenic maize crops in Mexican fields in 2001 [25], despite the Mexican moratorium on GMO crops established in 1998, is particularly disturbing as it serves to demonstrate the ease with which the GMO crops have contaminated other non-GMO varieties at the centres of origin of the crop's biodiversity [26].

The FAO [48] lists two levels of potential risks posed by genetic engineering: its effects on human and animal health as well as its effects on the environment. Among the risks to human and animal health is the potentiality of transfer of toxins from one life form to another, including substances responsible for allergic reactions. Risks to the environment are many, including the loss of biodiversity in favour of fewer new GMO crops and associated problems related to upsetting balance of the ecosystem. Some examples are the risk of contamination of the world's genetic resources and the risk of development of new more aggressive weeds with resistance to diseases and pesticides [27].

The present structure of the 'gene revolution' based on profit rather than need-motivated deployment of seed products coupled with enforcement of IPRs and absence of a fully implemented regulatory and biosafety framework, could have a disastrous effect on the developing countries' food security. This is why it is necessary to conduct research that addresses particular countries' environmental and socio-economic circumstances as well as the needs of the smallholder farmers. Furthermore, independent risk assessment of GMOs needs to be strengthened and national and international guidelines must be developed and supported on biosafety and preservation of biodiversity. All this is necessary to assure that the new technologies will not have a negative effect on global food security.

Redefining food security and debunking agro-industry myths

The concept of 'food security' has been undergoing many changes during the last 50 years and today it is widely acknowledged to mean much more than physical availability of food on the market in proportion to population. Although Malthusian anticipation over two centuries ago that food production would not keep up with population growth has never materialised in view of the fact that the world produces more food per inhabitant today then ever before, somehow the myth that hunger is rooted in the gap between food production and human population density and growth rate seems to persist in the mainstream view. The aftermath of the Green Revolution as well as ground-breaking studies of the roots of famines by Noble price winning economist Amartya Sen and others have moved the focus from aggregate production to the role of economic access and distribution. Sen has repeatedly shown that famines occur even without any decline in food production or availability (e.g., the Bangladesh famine of 1974 during the country's peak level of food production) and FAO's statistics demonstrate that on the global scale the food production rate, despite sometimes serious regional variations, is going upwards and in tune with population growth [17].

FAO defines food security as existing when 'all people at all times have access to safe nutritious food to maintain a healthy and active life'. There are three dimensions of food security according to FAO: availability, access and utilisation [28]. Each of these components needs to be considered at the level of individuals, households, nations and international relations. Additionally, the UN Conference on Environment and Development (1992) and the World Conference on Women (1995) have highlighted the principle of social access to food of women (the feminisation of agriculture and poverty, distribution within households) and the role of environmental factors in food security. In particular, sustainability of agricultural practices and the role of other environmental aspects, such as clean drinking water, have come into the forefront in the assessment and accounting for today's food security.

It is within this context that M. S. Swaminathan has proposed a comprehensive definition of food security in preparation for the 1996 World Food Summit:

> Policies and technologies for sustainable food security should ensure:
> That every individual has the physical, economic, social and environmental access to a balanced diet that includes the necessary macro- and micro-nutrients, safe drinking water, sanitation, environmental hygiene, primary health care, and education so as to lead a healthy and productive life.
> That food originates from efficient and environmentally benign production technologies that conserve and enhance the natural resource base of crops, animal husbandry, forestry, inland and marine fisheries [19].

Swaminathan's definition captures both the complexity and the multi-dimen sionality of food security with particular regard to environmental constraints and preservation of ecosystems. Keeping in mind that the majority of developing countries rely on smallholder farms and that hunger is caused by poverty, inequality and lack of access to food and to land, allows us to scrutinise the promises of agro-chemical industries.

Today, the main products of biotechnology revolve around patent-protected crops that are either herbicide resistant (e.g., Monsanto's 'Roundup Ready' soybean seeds that are tolerant to Monsanto's herbicide Roudup) or Bt (*Bacillus thuringensis*) crops engineered to produce their own insecticide. The logic behind herbicide resistance crops is the hope for the increased sales of herbicides from the same company. In the case of Bt crops, the expectation is to boost sales of patented crops while damaging the use of pest-management products used by most organic farmers instead of insecticides (the *Bacillus thuringiensis* is a bacterium that normally lives in the soil and produces toxins which kill the larvae of moths and almost nothing else). In fact, over one third of all biotechnological research on biological control agents focuses on transfer of the Bt gene into major crops [2,12]. According to entomologist Fred Gould, 'if pesticidal plants are developed and used in a way that leads to rapid pest adaptation, the efficacy of these plants will be lost and agriculture will be pushed back to reliance on conventional pesticides with their inherent problems' [12]. Since the expensive products of biotechnology require further input dependence from resource-poor farmers and lead to a probable damage to the environment, the result will be a higher risk to food security.

Another use of biotechnology to the potential detriment of developing farmers' interests is in industrial bio-processing and tissue culture. Present technology allows for the development of industrial substitutes for plant-derived products, which can be produced in factories of developed countries. Such production of many typical Third World exports such as spices, fragrances and sweeteners is already well entrenched in the modern agro-industry. For example, the High Fructose Corn Syrope (HFCS) is presently being produced by converting corn into a sweetener and has already gained wide use in such products as soft drinks. When HFCS attained widespread use, the world demand for sugar went down, threatening the livelihoods of an estimated eight to ten million people in the South and a total collapse of entire economies in the Caribbean and of sugar-producing regions in the Philippines [15,12]. The trend for development of sugar substitution products in the West is on the rise with aspartame being already consumed in large quantities. Among other modern R&D advances that have an adverse impact on major Third World products is cocoa and vanilla in-vitro production. The possibility that protein engineering techniques will be applied to conversion of low price oils (e.g., olive, sunflower and palm oil) into cocoa butter or utilising cell culture for the 'biosynthesis' of cocoa butter in a factory is also on the horizon [3]. According to Buttel [3], the impacts of such developments on developing countries will depend on the importance that a given raw material has as a source of export revenues. Therefore, for example countries such as Ghana and Cameroon, who earn most of their foreign exchange from cocoa, will be most dramatically affected and risk high levels of poverty and unemployment in areas where the crop has been cultivated. Other major cocoa suppliers, such as Brazil and Malaysia, having more diversified exports and production systems dominated by large-scale plantations, will probably be less affected in comparison to small producers in Africa. Keeping in mind that promotion of single export crops for raising export revenues has been heavily promoted in Africa by multilateral financial organisations, the countries' risk to food security due to bio-processing could be paramount. 'Biotechnology thus raises the possibility of a significant restructuring of the world food economy caused by the possible industrialisation of food production, and the relegation of agriculture to production of biotechnology feedstocks' [3].

A major argument used by biotechnology industries is that transgenic crops will significantly increase crop yields. Even putting aside the fact that increased yields alone might lead to increased development of monocultures and do not address developing countries' food security dilemma, studies conducted by the US Department of Agriculture (USDA) Economic Research Service and University of Nebraska shed doubt on the increased yields hypothesis. USDA analysed data collected in 1997 and 1998 from different region/crop combinations of Bt corn and cotton, herbicide tolerant corn, cotton and soybeans, and their non-engineered counterparts. No conclusive difference was found between GMO and non-GMO crops yield increases [29]. Additionally, the University of Nebraska Institute of Agriculture and Natural Resources grew five different Monsanto soybean varieties and their closest non-engineered relatives and found that, on average, the genetically engineered crops produced six percent less than their conventional relatives and eleven percent less then the highest yielding conventional crops [2].

Altieri in his comprehensive study of biotechnological industry products points out that, in terms of increased yields, land reforms produce best results: 'While industry proponents will often forecast 15, 20 or even 30 percent yield gains from biotechnology, smaller farms today produce from 200-1,000 percent more per unit area than larger farms world wide' [2].

When the multi-dimensional aspects of food security are acknowledged, it becomes clear that as long as biotechnological companies operate under the premise that hunger and poverty can be fixed by increased production and that the only way to do so is by genetic engineering of crops – without due regard for ecosystems, farmers control and access to crops and biodiversity –, the future food security of the developing world is most definitely not going to improve.

The patently problematic biotechnology

Perhaps the most voiced and contested aspect of biotechnology involves questions of patenting and expansion of Intellectual Property Rights (IPRs) within the realm of international and national laws. From the perspective of developing countries, patents can be seen as both obstacles to the transfer of available technologies – keeping poor farmers from affordably obtaining currently expensive seeds – as well as a new form of control over biological material and 'traditional knowledge'.

According to Fowler and Shiva, the developing countries' criticism of patents has a long history and patents are often perceived as an extension of colonial control over Third World natural resources. From this perspective 'patents may be seen by some as a civil right, but it would be more appropriate to view them as a legal mechanism of control in the marketplace' [8].

The consolidation and industrialisation of the seed industry with the growing importance of plant-breeding methods gave rise to the modern patent system related to the creation of new life forms. The Union for Protection of New Varieties of Plants was established in 1961 in order to promote 'plant breeders rights' (PBRs). The PBRs still provided for 'research' and 'farmers' exemptions, meaning that the farmers were allowed to save seeds for replanting. For developing country's farmers consolidation of plant breeders rights meant that the reinterpretation of invention to include discovery had begun. Nevertheless, the direct patenting of life forms remained very problematic for long, with the European Patent Convention expressively prohibiting patenting of plant varieties and with conflicts of interest over international patent reform at the World Intellectual Property Organisation. Already back in the 1960s developing countries have been firm in voicing their opposition to patenting rights via the United Nations

Conference on Trade and Development. According to Fowler, such developing countries' opposition to patents has led the United States to push for change of the arena for discussion of international enforcement of IPRs. It is not a coincidence that IPRs gained a new level of significance at the GATT (General Agreement on Tariffs and Trade), known today as the World Trade Organisation (WTO) [8,51].

Undoubtedly the advent of the biotechnological revolution has been one of the driving forces behind the US's and other developed countries' insistence on the importance of IPRs. The scope of coverage of patents given in the US and Europe have begun to include genes and variety characteristics by treating the new genetically modified product as an invention. The landmark event for patenting of plants has been the 1985 judgement in the United States in which molecular genetic scientist Kenneth Hibberd was granted patents on the tissue culture and the seed and whole plant of maize line selected from the tissue culture. This application included 260 separate claims giving him the right to exclude others from the use of any of the 260 aspects [18]. For the developing country farmer it meant that she could no longer save and replant such a protected seed without violating a law. In fact one of the greatest controversies surrounding the present day patents protecting genetically modified seeds deals with the prerequisite that a farmer purchases the GMO seed from a company each year without resorting to the age-old tradition of saving seeds for the next year's cultivation.

Another major conflict in the IPR domain is the patenting of products and processes derived from plants on the basis of indigenous knowledge. There are many examples of plant and micro-organism varieties that have been granted a patent in the West in ignorance of the fact that the patented subject has been used for centuries in some ethnic community. The examples range from the patent applications on the traditional African plant Eddod to kill Zebra mussels [30] to the biopesticidal properties of the Indian plant Neem known as Azarichdita Indica [31]. In both cases knowledge of the properties of these plants existed and was applied in the respective communities since centuries. Although the patent system is often defended by its promoters as a human right that rewards creativity of an inventor, in the cases mentioned above the real inventors, that is the developing countries' farmers, are not expected to see any benefits while at the same time the concept of common heritage on which development of indigenous knowledge depends is being eroded. Although the value of the patent is dependent on its source from nature's diversity, it is what Shiva defines as 'tinkering' that becomes the source of creation. 'The issue of IPRs is closely related to the issue of value. If all value is seen as being associated with capital, tinkering becomes necessary to add value. Simultaneously, value is taken away from the source (biological resources as well as indigenous knowledge), which is reduced to raw material' [18]. In effect, the rich resources of indigenous knowledge due to their communal ownership, uncertain date of creation and unwritten form do not fit the requirements of the western system of IPRs. This helps to explain why although a vast majority of Western patents issued on derived properties originates from the developing countries' biodiversity, less than 5 percent of the patents granted in developing countries are used there in production processes while fewer than 1 percent of the patents issued in developing countries go to developing countries' nationals. Additionally, inventors in poor countries would find it hard to patent their discoveries in the West given the high costs associated with securing a patent (at least $ 4,000 in the US) [32] not to mention the legal costs associated with defending it. An insight to the functioning of IPRs in the American system is illustrated by the fact that Genetech, a major US biotech company, has four times as many lawsuits to protect its patents as it has products [8].

Since the 1990s the push towards internationally recognised patents has gained momentum under the World Trade Organisation's TRIPS (Trade Related Aspects of Intellectual Property Rights) [50], which set standards for the legal protection of intellectual property. The world's poorest countries were given until 2006 to comply in full with the requirements of the TRIPS treaty [33]. The TRIPS lay the ground rules describing the IPR protections that each member country must provide, or to put it in other words, the absence of intellectual property rights protection constitutes an unfair trade barrier under WTO. Although the TRIPS Article 27.3 excludes from patentability 'plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animal other than non-biological and microbiological processes' (emphasis added), this wording creates specific constraints for developing countries' own research and development in the area of bio-engineering, given the patent walls constructed around these 'non-biological' processes [34]. Moreover, the patent protections of biotech companies put public independent research on risk assessment of their products at the mercy of the corporate willingness to release their seeds for testing [4].

So how can the IPR system work to benefit the world's poor countries? The United Kingdom's Department for International Development (DFID) has set up a Commission on Intellectual Property Rights which has produced a report published in September 2002 affirming that developing countries should take their time to committing themselves to the Western system of IPR protection unless such systems are beneficial to their needs and that the West should not push for stronger requirements than those already contained in the TRIPS. The Commission in its Report entitled 'Integrating Intellectual Property Rights and Development Policy' recognises that IPRs have done little to recognise the services of farmers in selection, development and conservation of their traditional varieties on the basis of which modern breeding techniques have been built. The Report distinguishes between the needs of poor developing countries and of those with a solid base for conducting their own R&D in agricultural biotechnology. Consequently the Commission recommends that:

> Developing countries should generally not provide patent protection for plants and animals, as is allowed under Article 27.3(b) of TRIPS, because of the restrictions patents may place on use of seed by farmers and researchers. Rather they should consider different forms of sui generis systems for plant varieties.
> Those developing countries with limited technological capacity should restrict the application of patenting in agricultural biotechnology consistent with TRIPS, and they should adopt a restrictive definition of the term 'micro-organ-ism'. [35]

Furthermore, the Commission recommends that the TRIPS that are undergoing review of its provisions in the TRIPS Council should preserve the right of countries not to grant patents for plants and animals, including genes and genetically modified plants and animals. More so, it lists the ways in which developing countries can meet TRIPS obligations by adopting alternative modes of protections such as Plant Variety Protections (UPOV) style legislation based on the 1978 or 1991 Convention (although they may now only join the 1991 Convention), another form of sui generis system including landraces or patents on plant varieties. In terms of the Low Income Developing Countries, the Report advocates that they should be granted an extended transition period for implementation of TRIPS until at least 2016. In addition, the Commission wishes to see more funding for public directed research in agricultural R&D and for preservation of the world's 'gene banks'.

Most importantly, the Report strongly encourages all countries to ratify multilateral treaties strengthening the concept of 'farmer's rights', aiming at the protection of biodiversity and enforcement of biosafety such as the FAO's International Treaty on Plant Genetic Resources for Food and Agriculture [49] and the Cartagena Protocol on Biosafety [46].

International environmental regimes in defence of biodiversity and farmer's rights

Both the developing and the developed world are seeking viable solutions to preserve the delicate balance between gaining maximal societal rewards from newly available technologies while at the same time assuring preservation of the world's rich resources, including biodiversity and indigenous knowledge. Humanity's food security depends on the judicious utilisation of the latter resources. As with all technologies, biotechnology offers both great promises and many risks. Minimising those risks requires international co-operation and strengthening of the multilateral initiatives in environmental regulatory regimes. The UN Conference on Environment and Development held in Rio de Janeiro [36] has led to adoption of the Convention on Biological Diversity [47] which in turn led to the breakthrough in the work of FAO addressing issues of protection of biodiversity and farmer's rights as well as to the adoption of the Cartagena Protocol on Biosafety in 2000.

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)

The foundation for international action to ensure conservation, use and availability of plant genetic resources was the FAO Undertaking on Plant Genetic Resources agreed in 1983. In 1989 the Undertaking has incorporated Farmers' Rights 'arising from the past, present and future contributions of farmers in conserving, improving, and making available plant genetic resources, particularly those in the centers of origin/diversity' [37].

The breakthrough came with the adoption of the Convention on Biological Diversity of 1992 which has allowed to transform the Undertaking into the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) that came into force on 29 June 2004 [38]. The Treaty has the specific objective of facilitating access to plant genetic resources held by contracting parties, and those in international collections, for the common good, recognising that these are an indispensable raw material for crop genetic improvement and that many countries depend on genetic resources which have originated elsewhere. The ITPGRFA also recognises the contribution of farmers in conserving, improving and making available these resources, and that this contribution is the basis of Farmers' Rights. It does not limit in any form the rights that farmers may enjoy under national law to save, use, exchange and sell farm-saved seed. Nevertheless, the Treaty's provisions leave it entirely up to national governments to implement Farmer's Rights which on one hand gives countries autonomy in developing such legal protections while on the other does not protect countries that do not devise their own national mechanisms [39].

The rationale for Farmers' Rights combines arguments about equity and economics. Plant breeders and the world at large benefit from conservation and development of plant genetic resources undertaken by farmers, but farmers are not recompensed for the economic value they have contributed. The Commission on Intellectual Property states that 'Farmers' Rights may be seen as a means of providing incentives for farmers to continue to provide services of conservation and maintenance of biodiversity' [40]. Moreover, by adopting the ITPGRFA, countries have a guarantee that possible extension of intellectual property protection does not carry risks of restricting farmers' rights to reuse, exchange and sell seed, the very practices which form the basis of their traditional role in conservation and development of plant genetic resources.

Provisions of ITPGRFA have also developed a 'Multilateral System' through which signatories agree to provide access to plant genetic resources from an agreed on list of crops that are deemed as important to food security. Signatories are also to encourage other institutions to become part of the 'Multilateral System' such as Consultative Group on International Agricultural Research (CGIAR) and other national and private collections of genetic material.

The Treaty has established an important principle by which any user of germoplasm material should sign a standard Material Transfer Agreement (MTA) [41], which will incorporate the conditions for access agreed in the Treaty (paragraph 12.3) and provide for benefit sharing of proceeds from any commercialisation arising from the material through a Fund established under the Treaty.

Notably, the Treaty provides for the establishment of a financing mechanism, funded by contributions and a share of the proceeds from commercialisation of regulated seeds. It is hoped that the financing mechanism will enable implementation of agreed plans for farmers 'who conserve and sustainably utilise plant genetic resources for food and agriculture' [42] and lead to innovative methods of managing traditional knowledge of plant genetic resources. Inclusion of such a funding mechanism has proved to be the single most important ingredient in assuring the success and compliance in the past environmental agreements such as the Montreal Protocol on Substances that Deplete the Ozone Layer [16].

Ironically, due to the fast-track ratification of the Treaty its entry into force in June 2004 has taken place before many of its aspects have been defined, including financial regulations and application criteria of the Multilateral Transfer Agreement. The Commission for Genetic Resources for Food and Agriculture (CGRFA) continued to act as the Interim Committee for the Treaty's implementation during the CGRFA's last meeting in November 2004 which has laid the groundwork for the first meeting of its Governing Body scheduled for 2006 [43]. Yet, the second meeting of the Commission acting as Interim Committee of the Treaty has postponed discussions on the definition of relations between the Treaty, NGOs and Inter-Governmental Organisations with respect to the Treaty's financing mechanisms. The November 2004 meeting, however, has been successful in developing the terms of reference for the creation of a group of experts who will work on the terms of the standard Multilateral Transfer Agreement (MTA) and in providing for a meeting of legal experts assigned the task of evaluating the procedures and operating mechanisms of the Governing Body. Currently, the provision of the necessary financial resources for the management and administrative tools is still not sufficiently addressed in order to make the Treaty a vital mechanism for the governance of plant genetic material and its uses [44].

The investment of western countries in ITPGRFA is consistent with their goal of assuring that biotechnology tools will not threaten conservation of biodiversity while creating an incentive for developing countries to support actions aimed at protecting biodiversity and indigenous knowledge.

The Cartagena Protocol on Biosafety

According to the provisions of the Convention on Biological Diversity (Article 19.1), the work on a separate protocol on biosafety has begun through the establishment of the Working Group on Biosafety which met between 1996 and 1999 with the aim to finalise the text of the Cartagena Protocol on Biosafety at the meeting in Cartagena, Colombia in February 1999. Nevertheless, due to the widespread differences on the contentious issues of trade in genetically modified organisms such as the definition of LMOs (Living Modified Organisms) and the scope of the LMOs covered by the Protocol, the final document was adopted at the subsequent meeting in Montreal in January 2000 [11].

The goal of the protocol is to protect biological diversity from potential risks posed by introduction of LMOs, which is the Protocol's way of deferring to GMOs, resulting from modern biotechnology. The backbone of the Protocol consists of the so-called Advanced Informed Agreement procedure for ensuring that countries are agreeing to the import of such organisms into their territory. The party of export is obliged to notify in writing the party of import of any given type of LMO covered by the Protocol. Then the importing party has 90 days to acknowledge receipt of the notification and to either proceed with the Protocol's decision procedure [45], or according to its domestic regulatory framework. The Protocol also establishes an Internet-based Biosafety Clearing House, to which all decisions must be relayed. There are, however, five types of LMOs that due to the compromise between negotiating parties were kept outside of the Advanced Informed Agreement Procedure. These include most pharmaceuticals, LMOs in transit to a third Party, LMOs destined for contained use, LMO-FFPs (intended for direct use as food or feed or for processing) and LMOs declared as safe by the Parties of the Protocol. In essence, it means that only LMOs destined for direct introduction to environment such as seeds and micro-organisms are covered by the Advanced Informed Agreement [46]. Still, other LMOs such as LMO-FFPs are subject to a less restrictive procedure (Article 11) in which parties making domestic decisions about the use of LMOs must still notify the Biosafety Clearing House and the importing party is responsible to develop and announce its own regulations with respect to LMOs. This means that the burden of proof and the development of the regulatory system in relation to LMOs not covered by the Advanced Informed Agreement lies with the importing party. The Protocol also requires that shipments of commodities that contain or may contain LMO-FFPs must be identified in their accompanying documentation, hence allowing countries to enforce their own labelling schemes for genetically modified products. According to Gupta, stating the exclusion for non Advanced Informed Agreement covered LMOs leaves open the possibility that in the future provisions of liability can also be applied to cover all LMOs [11].

Of the most breakthrough importance in international environmental law is that the Cartagena Protocol contains a strong reference to the precautionary principle. The precautionary principle holds that when a new technology may cause suspected harm, scientific uncertainty should not be used as the basis to prevent precautionary action [47]. The final text of the Protocol not only retains the reference to the principle in its objectives but also gives the right to the parties to take import-restrictive actions in operating articles dealing with the decision-making on commodities and LMOs for planting. The Article 1 states that the objective of the Protocol is to be pursued 'in accordance with the precautionary approach contained in Principle 15 of the Rio Declaration on Environment and Development'. The Article 10 then states that 'lack of scientific certainty…shall not prevent a party from taking a decision, as appropriate, with regard to the import of the living modified organism in question (…)' [48].

Given the strong incorporation of the precautionary principle into the text, the relationship of the Protocol to the WTO remains a highly contested issue. Although the text states that 'this Protocol shall not be interpreted as implying a change in the rights and obligations of a Party under any existing international agreement' another paragraph states that 'the above recital is not intended to subordinate this Protocol to other international agreements' [49]. The analysis of the International Institute on Sustainable Development suggests that the wording means that in case of a conflict both the Protocol and the WTO rules will have to be read as mutually supportive or, in other words, will be interpreted to suit different needs of the parties. At the moment the Protocol still lacks a dispute settlement mechanism and the issue of liability has been postponed giving the parties of the protocol 5 years for the completion of the drafting of the rules and procedures on this matter. Yet, the Cartagena Protocol has been a great success so far in allowing for a compromise between different interests of negotiating parties and the fact that liability issues have been given more time to be addressed only strengthens its possibility of becoming a viable Treaty by allowing time and flexibility to address this issue, especially taking into consideration that it took as much as 10 years to draft an agreement on liability in the highly successful Basel Convention [11].

Many policy analysts hailed the Cartagena Protocol to be the best example so far of a workable structure in the body of international law that allows for reconciliation of trade and environmental objectives. It is also very specific in addressing both developed and developing countries' concerns relating to the introduction of GMOs, hence ensuring that food security of all, specifically in terms of the environmental and health risks, can be sufficiently protected.

Conclusions

Although this article's assessment of the impact of the biotechnological revolution on developing countries' food systems began from a discussion on lessons learned from the Green Revolution, the present-day revolutionary force is different in one main respect: the biotechnological revolution in the food systems is being largely driven by private entities whereas the Green Revolution was supported by the publicly funded network of research institutes. Many policy advisors and institutes recommend that this imbalance between the private and public access to biotechnology should be addressed by increased funding towards public research institutes, hence assuring independent risk assessment and democratic control over the fruits of biotechnological research. Yet, beyond the well-acknowledged need for expensive research funding, governments should demonstrate their commitment to food security by strengthening and implementing existing environmental legal mechanisms. As stipulated in the previous sections, the developing countries' food security can suffer negative consequences not only in terms of the potential of environmental risks but also in terms of the risk of allowing the technological advancements to bypass the needs and interests of developing countries, with potentially disastrous consequences for their economies and ecosystems. Given today's context of globalisation, the protection and enhancement of developing countries' food security necessitates actions on global forums such as that provided by the FAO's instruments and by the new body of environmental law enshrined in the painstakingly negotiated Cartagena Protocol on

Biosafety and the International Treaty on Plant Genetic Resources for Food and Agriculture. Furthermore, urgent implementation and more widespread ratification of these instruments, which have operationalised the compromise needed in order to minimise the risks and maximise the benefits of the new technologies, are not only in interest of the developing countries but in interest of any developed country government paying lip service to food security and environmental concerns. Preservation of biodiversity and farmer's rights – coupled with research and development directed towards addressing the needs of developing countries – is the only strategy through which food security not only of the developing countries but of humanity at large can be improved and assured for the future generations. It is high time to press the world's governments for further ratification and the provision of sufficient financial commitments towards full implementation of these Treaties.

Notes

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21. For the discussion of the impact of technological changes on displacement of small farming units and subsequent concentration of food production and processing among few private companies see an excellent article by William D. Heffernan, Concentration of ownership and control in agriculture, in Fred Magdoff, John Bellamy Foster and Frederick H. Buttel (Eds.), Hungry for Profit: The Agribusiness Threat to Farmers, Food and the Environment, Monthly Review Press, New York, 2000, pp. 61-75. Heffernan points out how food processing has also led to displacement of small-farm production in the developed countries, particularly in the United States where the majority of the main food production is controlled by oligopolies of few companies.
22. Altieri (2000) lists two levels of environmental problems inherent in the modern agro-industrial system of food production based on favoring monocultures. 'A number of what might be called 'ecological diseases' have been associated with the intensification of food production and can be grouped into two categories. There are problems directly associated with the basic resources of soil and water, which include soil erosion, loss of inherent soil productivity and depletion of nutrient reserves, salinisation, and alkalisation (especially in arid and semi arid regions), pollution of surface and groundwater, and loss of croplands to urban development. Problems directly related to crops, animals, and pests include loss of crop, wild plant, and animal genetic resources, elimination of natural enemies of pests, resurgence and genetic resistance to pesticides, chemical contamination, and destruction of natural control mechanisms. Each 'ecological disease' is usually viewed as an independent problem, rather than what it really is – symptom of a poorly designed and poorly functioning system'.
23. See [7]. FAO estimates that 852 million people worldwide were undernourished in 2000-2002. This figure includes 815 million in developing countries.
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26. See FAO Statement on Biotechnology, published on the occasion of the Codex Alimentarius Ad Hoc Intergovernmental Task Force on Foods Derived from Biotechnology meeting in Japan, March 2000. (http://www.fao.org/ biotech/stat.asp).
27. For the definition of 'food security' see [6].
28. The study was published in the US Department of Agriculture (USDA) Economic Research Service Report (1999) and cited in [2].
29. Endnod, also known as African soapberry plant has been selected and cultivated for centuries by indigenous people in several parts of Africa where it was used as a soap and for its fish-killing properties. The US scientists have found that it is also effective in killing Zebra mussels disturbing water flows in Northern American pipe system. US scientists applied for a patent of Endod based on their 'discovery' of its Zebra mussels killing properties. See [12, p. 231].
30. Azarichdita indica or Neem, is widely known for its antibacterial and pesticidal properties in India since centuries. In the face of Western opposition to chemical pesticides Neem was 'discovered' by US and Japanese scientists and since 1985 over dozens of patents have been granted to Neem-based solutions and emulsions. For a detailed discussion see [18, pp. 73-75].
31. TRIPS, Part 2- Standards concerning the availability, scope and use of Intellectual Property Rights, Section 5 and 6. For the full text see [50].
32. See [5, p. 75].
33. See [16, p. 25] and [47].
34. IUPGR Resolution 5/89. (http://www.mtnforum.org/resources/library/ iupgr91a.htm).
35. For the text of the International Treaty on Plant Genetic Resources see [49].
36. See [5, pp. 75-78] and [33].
37. See [5, p. 77].
38. ITPGRFA, Article 18.5. See [33].
39. See Commission on Plant Genetic Resources for Food and Agriculture, 2nd Meeting of the Commission as Interim Com on the Treaty on Plant Genetic Resources for Food and Agriculture. (http://www.fao.org/ag/cgrfa/ docsic2.htm).
40. See http://www.iisd.ca/biodiv/itpgr2.
41. The decision procedure works as follows: 'A risk assessment must be carried out for all decisions made. Within 90 days of notification, the Party of import must inform that either it will have to wait for written consent or that if may proceed with the import without written consent. If the verdict is to wait for written consent, the Party of import has 270 days from the date of notification to decide either to: approve the import, adding conditions as appropriate, including conditions for future imports of the same LMO, prohibit the import, request additional information, extend the deadline for response by a defined period.' See: Aaron Cosbey and Stas Burgiel, The Cartagena Protocol on Biosafety: An Analysis of Results, IISD (International Institute For Sustainable Development) Briefing Note, 2000. (http//iisd.ca/trade).
42. See [46].
43. The precautionary principle is widely used in international environmental law and is even contended by some as the principle of customary international law. The text of the Cartagena Protocol uses a

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44. See [46].
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46. Cartagena Protocol on Biosafety: http://www.biodiv.org/biosafety.
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49. International Treaty on Plant Genetic Resources: http://www.fao.org/ag/ cgrfa/IU.htm.
50. Trade Related Aspects of Intellectual Property Rights (TRIPS): http://www.wto.org/english/docs_e/legal_e/27-trips_ 04c_e.htm#5.
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