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Linking access and benefit-sharing for crop genetic resources to climate change adaptation

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Abstract

This article links the concept of access and benefit-sharing as it pertains to crop genetic resources to climate change adaptation and argues that systems for access and benefit-sharing can, and should, be designed to contribute to climate change adaptation for agriculture. The access and benefit-sharing provisions of the two international agreements that together provide the international legal framework for access and benefit-sharing – the Convention on Biological Diversity (with its Nagoya Protocol) and the International Treaty on Plant Genetic Resources for Food and Agriculture – are presented and analysed. How these agreements are implemented is central to adaptation, as the effects of climate change threaten crop genetic resources and future adaptive capacity, and, if properly maintained and utilized, crop genetic resources will be essential to climate change adaptation across the globe. This article, therefore, argues that an important adaptation strategy linked to such implementation is to direct benefit-sharing for crop genetic resources towards adaptation efforts and to ensure facilitated and efficient access to crop genetic resources for adaptation purposes. Some options for how this can be pursued at both the international and national level are offered.

Keywords: access; adaptation; benefit-sharing; climate change; conservation; Convention on Biological Diversity; crop genetic resources; implementation; International Treaty on Plant Genetic Resources for Food and Agriculture (Plant Treaty); Nagoya Protocol; utilization

Introduction

A major challenge for present and future generations is to adapt food production to a changing climate. The effects of climate change on crop production are already being felt in several world regions; negative impacts dominate over positive ones for agriculture, and adaptation is urgently needed (IPCC, 2014). Crop genetic resources and diversity are, and will continue to be, essential to such adaptation. As they constitute the basis for food production and food security, crop genetic resources must be protected from the adverse effects of climate change and also utilized in adaptation efforts. It is therefore essential that the international agreements providing the international legal framework for the conservation and use of these resources are implemented in a way that facilitates both conservation and utilization for adaptation.

The most important international agreements related to the conservation and use of crop genetic resources are the International Treaty on Plant Genetic Resources for Food and Agriculture (the Plant Treaty) of 3 November 2001 and the Convention on Biological Diversity (CBD) of 22 May 1992 with its Nagoya Protocol of 29 October 2010. In these agreements, access to and the fair and equitable sharing of the benefits arising from the

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utilization of genetic resources are the central components. Agricultural adaptation must be based on access to and use of crop genetic resources. Therefore, in this article, it is argued that implementation of these agreements' provisions on access to crop genetic resources and benefit-sharing from their utilization should be seen in connection with and linked to climate change adaptation for agriculture. Based on a review of the relationship between climate change and crop genetic resources, as well as a presentation and analysis of the international legal framework, this article offers specific suggestions for how this can be done both nationally and internationally.

Crop genetic resources and climate change

To explore the implications for access and benefit-sharing of the climate change generated needs related to conservation and utilization of crop genetic resources, it is necessary to understand how climate change is affecting these resources, in what ways they are central to adaptation and to what extent interventions are necessary.

Of the observed shifts in climate properties, the increase in temperature is perhaps the one most often associated with ongoing climate changes. As summarized by the Intergovernmental Panel on Climate Change, 'the temperature increase is widespread over the globe and is greater at higher northern latitudes' (IPCC, 2007, p. 30); further, 'each of the past three decades has been successively warmer at the Earth's surface than all the previous decades in the instrumental record' (IPCC, 2013, p. 161).

However, other long-term changes are also evident. Some areas have been experiencing precipitation increases, while the opposite is happening in other regions. In addition, changes have been observed with regard to extreme weather events in terms of frequency and intensity, with heat waves, drought events and heavy precipitation events becoming more frequent in a great many areas (IPCC, 2007; Turner and Meyer, 2011).

These changes – temperature increases, precipitation changes and more extreme weather events – are affecting and will continue to affect crop genetic resources and crop genetic diversity (Turner and Meyer, 2011). In addition, the speed and complexity of the ongoing climate changes make adaptation more challenging compared with the changes that have faced agriculture previously (Ramirez-Villegas *et al*., 2013).

Some research, such as the field studies conducted by Mercer and Perales (2010) on maize (*Zea mays*), has indicated that high-elevation crop genetic resources are more vulnerable to the effects of climate change than those at lower elevations. Indeed, plant species are already migrating to both higher elevations and latitudes as their climatic optimums are shifting (Jump and Peñuelas, 2005). This is a sign that maintenance and breeding efforts are already urgently needed.

Landraces, which often contain considerable phenotypic variability, still dominate agriculture in many areas. The tolerances many have developed to biotic and abiotic stresses may prove essential to climate change adaptation. According to Mercer and Perales (2010), three factors will be particularly relevant for landraces in the context of climate change: phenotypic plasticity; evolution; and gene flow.

Phenotypic plasticity allows plants to adapt their phenotype to changing conditions without any change in gene frequencies (Mercer and Perales, 2010). However, the existence and extent of plasticity for a specific trait are genetically controlled and vary between plants, traits and populations (Jump and Peñuelas, 2005). Climate change may cause changes in, for example, the physical form and external structure of a crop plant, or the timing of its periodic life cycle events, but a change occurring in response to one type of environmental change might not be a beneficial response to another change occurring simultaneously (Mercer and Perales, 2010). That said, breeding for increased plasticity is one way to increase the adaptive capacity of crops (Haussmann *et al*., 2012), particularly for meeting the challenges of unpredictable extreme weather conditions and inter-annual variation.

Multiple new conditions also make it more difficult for crops to survive climate change through selection. There might be correlations between the traits needed that serve as constraints to their simultaneous development (Jump and Peñuelas, 2005). Selection is dependent on genetic variation, and landraces tend to be more diverse than 'improved' varieties, but it is still not given that they will be able to meet several environmental changes at the same time and quickly enough. In this context, it is essential to ensure that human-mediated selection does not work against beneficial natural selection (Mercer and Perales, 2010).

Variability as to climate change-relevant traits constitutes an advantage for populations that must adapt to rapid climate change, but as the response will be the emergence of a higher proportion of individuals that are adapted to the new environment, adaptation actually has the potential to reduce future variation (Jump *et al*., 2008). Reduced variation may affect a population's ability to survive pests, diseases and extreme weather events (Jump and Peñuelas, 2005), all of which are predicted to become increasingly prevalent with rising temperatures (Turner and Meyer, 2011). Climate change might in this way set in motion a downward diversity and adaptation spiral that it will be up to human conservation efforts to hinder.

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Gene flow, taking place through pollen or seed movement for example, can introduce new and potentially adaptive genetic variation into a population upon which selection can act. In this way, adaptive capacity may spread. However, pollen-mediated gene flow depends on overlapping flowering times – and if these change in response to climate change, gene flow patterns could also be affected (Mercer and Perales, 2010). In such circumstances, human-induced gene flow becomes even more important, through, for example, seed sharing.

If adaptation cannot keep up with climate change in a way that maintains productivity, the likely outcome is extinction. A landrace that no longer fulfils farmers' utility criteria will usually be replaced by another. Climate change may in this way cause genetic erosion, which will hamper adaptability both in the short and long term through the disappearance of potentially useful crop genetic diversity (Mercer and Perales, 2010). Interventions might therefore be necessary to ensure that such genetic diversity, including potentially climate-relevant traits, found among landraces and other locally adapted varieties, is conserved.

Whether they are found in gene banks or *in situ*, landrace collections represent a source of genetic variability that can be used for improving stress tolerance (Trethowan *et al*., 2010). One way to utilize, for example, drought and heat tolerance is to combine these traits, through modern plant-breeding, with the high-yielding traits of what are known as 'modern varieties' (Lane and Jarvis, 2007). Both wheat (*Triticum*) landraces and the wild relatives of wheat can, for example, constitute the new sources of genetic variation that Ortiz *et al.* (2008) argue is needed, along with efficient breeding and selection, for wheat yields to keep up with demand, to avoid food insecurity and increased poverty. Indeed, the genetic variability needed for adaptation is probably available in many crop species and must be exploited (Turner and Meyer, 2011).

Also crop wild relatives, like crop ancestors and other related species, are threatened by climate change (Jarvis *et al*., 2008). Even when the level of genetic variation is quite high, the predicted rapid increased in temperature will for many wild species outstrip their adaptive capacity (Jump and Peñuelas, 2005). Particularly at risk will be species with low migrational capacities (Jarvis *et al*., 2008; Padulosi *et al*., 2011). Furthermore, habitat fragmentation could push some species further towards extinction by hampering migration and decreasing gene flow (Jump and Peñuelas, 2005). Human agency, such as *ex situ* and *in situ* conservation efforts, may save diversity from becoming lost.

Indeed, crop wild relatives represent an important source of useful traits. According to Jump *et al.* (2008), crop wild relatives have an 'option value' for agriculture – meaning that even if their economic value is unquantified and little recognized today, there is a substantial potential for future exploitation. As crop wild relatives tend to be more genetically diverse than their domesticated relatives, which went through a genetic bottleneck in connection with domestication (Jarvis *et al*., 2008), they have been important for crop improvement for more than a century (Lane and Jarvis, 2007). So far, crop wild relatives have mainly been used to breed for improved resistance to biotic stresses, and there is an untapped potential to use these resources in breeding for climate-relevant traits, such as drought and heat tolerance (Lane and Jarvis, 2007). As the effects of climate change are increasingly felt, conservation of and access to these resources will become even more crucial to food security.

Many underutilized species, species whose food security potential is presently not being realized, should also be seen as possible contributors to agricultural adaptation (Sthapit *et al*., 2009; Padulosi *et al*., 2011). For instance, drought-tolerant species that are well adapted to marginal soils and harsh climates, but which also have some less desirable traits, such as bambara groundnut (*Vigna subterranea*) (Padulosi *et al*., 2011), could be subjected to modern breeding programmes aimed at reducing the prevalence of the unwanted traits and promoting the desirable ones.

To promote yield stability and food security as the climate becomes more variable and potentially more unpredictable, diverse varieties can also be important tools in themselves. According to Snook *et al.* (2011), breeders should focus on resilience and variation to a greater extent, rather than uniformity. Extreme events may prove more disruptive to agriculture than the steady temperature increases (Turner and Meyer, 2011), and increased variation represents one way to meet this challenge. Diversity for adaptation traits, also called population buffering, may, for example, contribute towards yield stability in variable environments (Haussmann *et al*., 2012). Past breeding successes have depended on access to and use of diverse crop genetic resources, and the formal breeding efforts required for adaptation to climate change will also need to rely on the crop genetic diversity developed through centuries (Burke *et al*., 2009).

As climate conditions change, some crops will experience an increase in suitable growing area. However, if these gains occur in regions where the crops in question are not an established, integral part of the food system, as noted by Lane and Jarvis (2007), international exchange and sharing of crop genetic resources will be needed in order to take advantage of the increases.

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Interdependence with regard to crop genetic resources is already a central part of agriculture, as all countries rely on resources that originate partly or wholly from outside their own borders (Ramirez *et al.*, 2013). Through migrating societies, botanical expeditions and the Colombian Exchange, as well as earlier and later exchanges of plants, crops have continuously been introduced to new areas, where natural and human selection have combined to create new varieties (Gepts, 2006). With continuing climate change, the widespread interdependency created by such crop introductions, exchanges and development seems set to increase.

According to Ramirez-Villegas *et al.* (2013), at least 30% of countries stand to benefit more from crop genetic resources from other countries than from those found within their own borders regarding adaptation to climate change. In addition, their results indicate that for more than half of all countries, climate change will lead to increased interdependence regarding 70% of the 17 analysed major staple food and cash crops.

Indeed, as the climate in various locations changes, new crop climates will fall in one of two categories. Some will be analogues to current climates in other areas, while others will be new crop climates different from all currently existing ones (Snook *et al.*, 2011). Burke *et al.* (2009) uses the term 'self-overlap' to characterize the degree to which crop–climate analogues for a country's future crop climates can be found within its own borders. The degree of such overlap varies between countries and from crop to crop. For many countries, most analogues to their future crop climates are to be found abroad (Burke *et al.*, 2009).

The identification and distribution of useful seed from climate analogues can serve as a way to expand the traditional systems for seed exchange between farmers, so that farmers in one community can access crop genetic resources from communities in other countries and regions (Snook *et al.*, 2011). Utilization of such material could be a very time-efficient adaptation strategy as extensive breeding, depending on the soil type and photoperiod, will not be needed, but farmers and scientists will need facilitated and efficient access to useful germplasm.

As this review has shown, the threats facing crop genetic resources as a result of climate change means that there is a greater need for conservation and maintenance, made even more crucial by the vital role that crop genetic diversity will need to play to ensure food security. Adaptation will depend not only on conservation, including further collecting and characterization efforts, but also on broad utilization and exchange of crop genetic resources. Because climate change is making countries more interdependent, the importance of international exchange of crop genetic resources is increasing and such exchange must therefore be incorporated in agricultural adaptation strategies. These factors all point to a growing role for the CBD, with its Nagoya Protocol, and for the Plant Treaty.

The international legal framework for access to crop genetic resources and fair and equitable benefit-sharing

The CBD

The CBD underlines that states have sovereign rights over their natural resources, and Article 15 specifies that it is national governments that have the authority to determine access to genetic resources. The Convention envisions a system whereby one Contracting Party (or a stakeholder from a Contracting Party) – the user – seeks to obtain access to the genetic resources of another Contracting Party – the provider. In Articles 15.4 and 15.5, it is established that access, when granted, should be on mutually agreed terms and subject to the prior informed consent of the Contracting Party in question. Article 15 also stipulates that the Contracting Parties must 'endeavour to create conditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties' and that restrictions running counter to the Convention's objectives are not to be imposed.

'The fair and equitable sharing of the benefits arising out of the utilization of genetic resources' (Article 1) is one of the three stated objectives of the CBD. This gives benefit-sharing the same importance as the conservation of biological diversity and the sustainable use of its components, the two other main objectives of the Convention. Further, 'by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding' (Article 1) is included in fair and equitable sharing of benefits. Access to and sharing of genetic resources and technologies are also referred to in the Preamble as being 'essential' with regard to meeting the 'food, health and other needs of the growing world population' (Preambular paragraph 20). Access to genetic resources and the fair and equitable sharing of benefits arising from their utilization are usually referred to as 'access and benefit-sharing'.

'Genetic resources' are in the CBD defined as 'genetic material of actual or potential value' (Article 2). Since the Convention covers all biological diversity, this also includes crop genetic resources. 'Genetic material' is defined as 'any material of plant, animal, microbial or other origin containing functional units of heredity'

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(Article 2). The emphasis on 'material' suggests that the resources in question are tangible, although, as Marrero-Girona and Vogel (2012) have pointed out, it would make more sense scientifically to acknowledge their immaterial and intangible nature by using the term 'information'.

The concept of country of origin is central, as it is specified that for the purpose of Convention, 'the genetic resources being provided by a Contracting Party (…) are only those that are provided by Contracting Parties that are countries of origin of such resources or by the Parties that have acquired the genetic resources in accordance with this Convention' (Article 15.3). The 'country of origin of genetic resources' is defined in Article 2 as 'the country which possesses those genetic resources in *in-situ* conditions'. *In situ* conditions are further defined as 'conditions where genetic resources exist within ecosystems and natural habitats, and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties' (Article 2).

The definition of domesticated or cultivated species, 'species in which the evolutionary process has been influenced by humans to meet their needs' (Article 2), is fairly broad, and crop species easily fall within it. However, especially with regard to crop genetic resources, the concept of country of origin, its definition and the related definitions are not, as pointed out by Fowler (2001), particularly well-suited. As Fowler (2001) emphasizes, a crop species or a farmers' variety may contain many different properties and therefore also have many countries of origin. In addition, also a specific trait may have more than one country of origin (Fowler, 2001). Many of the most-used modern crop varieties consist of genes from hundreds of varieties from different countries and regions (Snook *et al*., 2011). Identifying one particular country of origin for a crop variety, a seed sample or the genetic information contained within will therefore be complicated, and often impossible.

The Plant Treaty

The objectives of the Plant Treaty are 'the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of benefits arising out of their use, in harmony with the CBD, for sustainable agriculture and food security' (Article 1). They are based on the objectives of and 'in harmony with' the CBD, but with some minor differences, such as the reference to food security and sustainable agriculture. Most importantly, unlike the CBD, the Plant Treaty does not cover biological diversity in general, but only plant genetic resources for food and agriculture (here the term 'crop genetic resources' is used).

These resources are defined as 'any genetic material of plant origin of actual or potential value for food and agriculture' (Article 2), and 'genetic material' is defined as 'any material of plant origin, including reproductive and vegetative propagating material, containing functional units of heredity' (Article 2). Again, it is clear that the language of the CBD has been taken as the point of departure. However, in the Plant Treaty, it is specified that the definitions 'are not intended to cover trade in commodities' (Article 2), whereas no such clarification is offered directly in the CBD. Such a specification is required due to the focus on 'material', rather than 'information', and the reference to 'propagating material' perhaps makes it even more necessary to draw up the distinction to trade in the context of the Plant Treaty, because seed and other propagating material are regularly traded as commodities.

A main component of the Plant Treaty is its Multilateral System for Access and Benefit Sharing (the 'Multilateral System' for short). This system is to be 'efficient, effective and transparent' (Article 10.2) and was set up to facilitate access to crop genetic resources and enable the benefits arising from their utilization to be shared, fairly and equitably. Whereas the Plant Treaty itself covers all crop genetic resources, the Multilateral System covers only a subset of these resources: those listed in Annex 1 to the Treaty and 'under the management and control of the Contracting Parties and in the public domain' (Article 11.2).

As specified in Article 11.1 of the Plant Treaty, food security and interdependence were set as the criteria to be used for deciding which crops to include on the list. However, as discussed in the section 'How can access regimes contribute to climate change adaptation?', the selection process was quite political and important crops were left out. The end result was a list of 35 food crops, including barley (*Hordeum*), cassava (*Manihot esculenta* only), maize (*Zea*, excluding *Zea perennis*, *Zea diploperennis* and *Zea luxurians*), oats (*Avena*), potato (*Solanum*, including section tuberosa, except *Solanum phureja*), rice (*Oryza*), sorghum (*Sorghum*), sweet potato (*Ipomoea*), wheat (*Triticum et al*., including *Agropyron*, *Elymus* and *Secale*) and yams (*Dioscorea*), and 29 forage crops.

In addition to the mandatory inclusion of resources that are under the management and control of the Parties and in the public domain, the Plant Treaty encourages voluntary contributions from 'all other holders' (Article 11.2) of crop genetic resources listed in its Annex 1. Contracting Parties also agree to take 'appropriate measures' (Article 11.3) to encourage natural and legal persons holding Annex 1 resources to include these in the Multilateral System.

The Multilateral System provides facilitated access to the included crop genetic resources through a Standard

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Material Transfer Agreement adopted by the Governing Body (Article 12.4). According to the Plant Treaty, facilitated access is to be provided solely for 'utilization and conservation for research, breeding and training for food and agriculture, provided that such purpose does not include chemical, pharmaceutical and/or other non-food/feed industrial uses' (Article 12.3a). It is also specified that access should be given expeditiously, that a fee should only be charged to cover the minimal costs involved, and that available plant passport data, and 'subject to applicable law, any other associated available non-confidential descriptive information' (Article 12.3c), shall also be made available.

Recipients cannot claim intellectual property rights to the crop genetic resources, their genetic parts or components in the form received by the Multilateral System. Any subsequent transfers of crop genetic resources accessed through the Multilateral System are also to be done based on the provisions of the Standard Material Transfer Agreement. In addition, crop genetic resources accessed under the Multilateral System and conserved 'shall continue to be made available to the Multilateral System by the recipients' (Article 12.3g). Contracting Parties are obligated to provide access both to other Contracting Parties and to natural and legal persons under the jurisdiction of other Contracting Parties. However, the Governing Body has the power to strip legal and natural persons that have not included crop genetic resources in the Multilateral System of this privilege (Article 11.4). At the fifth meeting of the Governing Body in September 2013, the lack of inclusions by such entities was discussed, but no strong measures were agreed upon.

The Plant Treaty recognizes facilitated access itself as one of the benefits of the Multilateral System. In line with the CBD, benefits accruing from such access are to be 'shared fairly and equitably' (Article 13.1). The Treaty lists the following mechanisms for sharing of benefits arising from the use of crop genetic resources accessed through the Multilateral System: exchange of information, access to and transfer of technology, capacity building and sharing of monetary and other benefits of commercialization. As to the sharing of monetary benefits arising from commercialization of crop genetic resources from the Multilateral System, the Treaty (and the Standard Material Transfer Agreement) distinguishes between mandatory benefit-sharing, when the commercialized product is *not* available without restriction to others for further research and breeding; and voluntary benefit-sharing, when the commercialized product *is* available without restriction to others for future research and breeding. However, the Treaty provides the Governing Body with the opportunity to extend mandatory payment also to the latter cases.

In line with Article 13.2d and Article 19.3f of the Plant Treaty, a fund that could receive such payments, generally referred to as the Benefit-sharing Fund of the Plant Treaty, was established by the Governing Body at its first session.

According to Article 13.3 of the Plant Treaty, the benefits arising from the use of crop genetic resources in the Multilateral System 'should flow primarily, directly and indirectly, to farmers in all countries, especially in developing countries, and countries with economies in transition, who conserve and sustainably utilize' such resources.

Benefit-sharing is also mentioned in Article 9 on Farmers' Rights, where the right to participate equitably in the sharing of benefits arising from the utilization of crop genetic resources is listed among the elements that Contracting Parties should take measures to protect and promote as part of the realization of these rights.

Climate change is not specifically mentioned in either the CBD or the Plant Treaty, but in the Plant Treaty, the subject of climate change adaptation is addressed indirectly in its Preamble, paragraph 6: crop genetic resources are acknowledged as 'essential in adapting to unpredictable environmental changes and future human needs'. As the section 'Linking access and fair and equitable benefit-sharing to climate change adaptation' will show, climate change has increasingly been accorded greater prominence in the implementation of the Plant Treaty since it was adopted in 2001.

The Nagoya Protocol

The importance placed on access and benefit-sharing by the parties to the CBD has, following its entry into force, been underscored by the negotiation and adoption of the Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization. This Protocol provides further details as to how the Contracting Parties should go about fulfilling their access and benefit-sharing commitments.

The Nagoya Protocol was negotiated after the entry into force of the Plant Treaty, with its Multilateral System, and recognizes the 'special nature of agricultural biodiversity' as well as 'its distinctive features and problems needing distinctive solutions' (Preambular paragraph 15). The 'interdependence of all countries' (Preambular paragraph 16) with regard to crop genetic resources is also recognized, and explicit reference is made to the Multilateral System of the Plant Treaty.

In Article 4, on the Nagoya Protocol's relationship with other international agreements and instruments, the term 'specialized international access and benefit-sharing instrument' (Article 4.4) is introduced. It is specified

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that the Nagoya Protocol does not apply 'for the Party or Parties to the specialized instrument in respect of the specific genetic resource covered by and for the purpose of the specialized instrument' (Article 4.4) when the instrument is consistent with and does not run counter to the objectives of the CBD and the Protocol. For the Parties to the Plant Treaty, it is therefore the Treaty, and not the Nagoya Protocol, that applies for crop genetic resources in the Multilateral System. It is further specified that implementation of the Protocol is to take place 'in a mutually supportive manner with other international instruments' (Article 4.3).

The importance of crop genetic resources is also addressed under Article 8 on special considerations, where Parties are encouraged to consider their importance and 'special role for food security' (Article 8c) when developing and implementing national access and benefit-sharing legislation. National legislation will be central to implementation of the Nagoya Protocol, and it outlines some elements that Parties can consider. Among these are model contractual clauses for mutually agreed terms, codes of conduct, guidelines and best practices and standards. Further, the Annex to the Protocol lists examples of monetary and non-monetary benefits. Among the monetary benefits listed are access fees, up-front payments, milestone payments, royalties, license fees, research funding and special fees to trust funds for conservation and use. Non-monetary benefits listed include sharing of research results, research collaboration, product development participation, technology transfer, institutional capacity building and research directed towards priority needs.

As noted in the section on the CBD, identifying one sole country of origin is difficult in the case of most crop genetic resources. This makes the Nagoya Protocol's provisions on transboundary situations and cooperation particularly relevant for such resources. Directly relevant in this regard are Articles 10 and 11, but the issue of transboundary situations is mentioned already in the Preamble: 'an innovative solution is required to address the fair and equitable sharing of benefits derived from the utilization of genetic resources and traditional knowledge associated with genetic resources that occur in transboundary situations or for which it is not possible to grant or obtain prior informed consent' (Preambular paragraph 13).

Such an 'innovative solution' is then presented in the form of a global multilateral benefit-sharing mechanism in Article 10. This article calls for Contracting Parties to 'consider the need for and modalities of' such a mechanism for benefit-sharing related to this type of genetic resources and associated traditional knowledge. It is specified that the benefits shared through such a mechanism should be 'used to support the conservation of biological diversity and the sustainable use of its components globally', but otherwise no details are provided. In addition, although the phrasing 'shall consider the need for' implies that the Parties must consider this issue, they are free to conclude, after consideration, that there is no such need. The scope of such a global multilateral benefit-sharing mechanism would depend on how transboundary situations are defined, for example whether a genetic resource found in more than one country constitutes such a situation (see UNEP, 2013).

In case such a global mechanism is not developed, or before it is, Parties are still obliged to 'endeavour to cooperate, as appropriate' when 'the same genetic resources are found *in situ* within the territory of more than one Party' (Article 11) and when associated traditional knowledge is shared by one or more indigenous or local communities in more than one Party. However, if a global mechanism covering the instances mentioned in Article 11 is created under Article 12, the transboundary cooperation provided for in Article 11 will presumably be subsumed by the mechanism.

Whereas climate change is not referred to in the CBD, the Nagoya Protocol, negotiated at a time when the existence and consequences of climate change were increasingly being recognized, twice mentions climate change in its Preamble. The first time, the importance of genetic resources to the mitigation of, and adaptation to, climate change is recognized, along with their importance for food security, public health and biodiversity conservation. The second reference concerns crop genetic resources specifically; moreover, in addition to recognizing that all countries are interdependent with regard to these resources, 'their special nature and importance for achieving food security worldwide and for sustainable development of agriculture in the context of poverty alleviation and climate change' is recognized (Preambular paragraph 16). The same paragraph also goes on to acknowledge 'the fundamental role' of the Plant Treaty and the FAO Commission on Genetic Resources for Food and Agriculture.

These references to climate change in the Preamble are not followed by further direct mention in the Articles themselves. All the same, they can provide a foundation for finding ways to approach access to and fair and equitable benefit-sharing from the use of crop genetic resources that also take into account the needs of agriculture to adapt to climate change.

Linking access and fair and equitable benefit-sharing to climate change adaptation

As has been shown in the previous sections, the Multilateral System under the Plant Treaty provides for facilitated access to a subset of crop genetic resources

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under standardized terms, whereas the terms of and degree of access to the crop genetic resources covered by the CBD and its Nagoya Protocol will vary, depending on the legislation and institutions established as part of national implementation. These two approaches may create opportunities for as well as barriers to adaptation. How can the implementation and further development of these regimes incorporate adaptation concerns and contribute positively to climate change adaptation for agriculture? Two points are particularly relevant in this context: how can benefit-sharing contribute to climate change adaptation for crops, and how can access regimes contribute to such adaptation?

How can benefit-sharing contribute to climate change adaptation?

Adaptation measures for crops, such as breeding efforts, will require substantial investments from various actors and will have to compete with other initiatives and concerns for funding (Lobell *et al.*, 2008). Benefit-sharing could play an important role by channelling resources to the maintenance and utilization of crop genetic resources for adaptation purposes. The two following sections examine how benefit-sharing can be developed and implemented in ways that contribute to adaptation. Then, some potential priorities for such benefit-sharing, regardless of the agreement under which it takes place, are presented in the third section.

Under the CBD and the Nagoya Protocol

Because the provisions on benefit-sharing in the CBD and its Nagoya Protocol leave the specifics to national implementation in the various Contracting Parties, it is mainly up to national legislation to connect benefit-sharing to adaptation if the first is to contribute to the latter. This could be done by, for example, specifying – in national access and benefit-sharing legislation and regulations, standard agreements and model contractual clauses – that, for crop genetic resources, certain types of benefits or a set proportion of benefits must target adaptation.

For monetary benefits, such provisions might specify that a certain percentage of access fees, up-front payments, milestone payments, royalties and license fees be channelled to adaptation. The more adverse and urgent the effects that climate change is predicted to have on domestic agriculture, the higher the percentage set aside for adaptation work should be. Additionally, any research funding should be directed towards adapting national crop production to climate change. Another promising approach could be to establish national trust funds for adaptation and food security, funded through special fees provided for in access agreements.

In many countries, it would be useful if benefits were channelled to national efforts aimed at collecting, characterizing and maintaining crop genetic diversity currently not represented in or available from gene banks. This would be one way for benefit-sharing to contribute to the conservation of and improved access to a broader scope of material and traits, which again would benefit adaptation.

Adaptation requirements could also be envisioned for non-monetary benefit-sharing, with national legislation and other implementation tools, perhaps establishing that all research results of relevance to national adaptation must be shared. It would also be natural for many countries to declare adaptation a priority need related to food security, as a follow-up to the potential benefits listed in the Annex to the Nagoya Protocol, and to include adaptation research as a preferred benefit in transfer agreements. For countries with weak or struggling plant-breeding sectors, institutional capacity building will also be fundamental to sustainable and successful national adaptation efforts.

Countries that already have legislation and regulations in place covering access and benefit-sharing should consider whether amending these instruments is needed to take climate change adaptation into account, whereas countries that have not yet developed any such instruments should ensure that benefit-sharing from the utilization of crop genetic resources is linked to adaptation. One such country is Ethiopia, which has introduced legislation dealing specifically with access and benefit-sharing. Ethiopia has chosen an approach where the type and amount of benefit-sharing is to be decided on a case-by-case basis for each of the access agreements negotiated by the responsible national institution (Andersen and Winge, 2012). A first step towards channelling benefits to adaptation would therefore be to change institutional practice, but amendment might also be needed to specify that monetary benefits may be used for adaptation. In addition, the regulation on access to genetic resources and community knowledge, which establishes an access fund for all monetary benefits received (Andersen and Winge, 2012), could be amended to declare climate change adaptation one of the fund's explicit goals.

In addition to measures such as these taken at the national level, efforts can also be made to link benefit-sharing under the CBD, and its Nagoya Protocol, to adaptation at the international level. It would be advantageous if the Conference of the Parties to the Convention, as well as national governments, encouraged stakeholders to include provisions on contribution to adaptation in industry guidelines, standards or codes of conduct.

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Additionally, in connection with discussions on the need for and modalities of the global multilateral benefit-sharing mechanism of Article 10 in the Nagoya Protocol, the Contracting Parties should take adaptation to climate change into consideration. The Contracting Parties might wish to consider whether the effects of climate change affect the need for such a mechanism, and whether channelling a specified proportion of the benefits to adaptation should be part of the modalities if a mechanism is established. Based on the recommendation of the third meeting of the Intergovernmental Committee for the Nagoya Protocol, it can be expected that the first Conference of the Parties serving as the meeting of the Parties to the Protocol will invite Parties and others to submit views on 'situations that may support the need for' a mechanism, its possible modalities and 'areas requiring further consideration' (IISD Reporting Services, 2014, p. 5). In preparation of later submitting their views, countries that have ratified the Protocol and countries expecting to do so could initiate national processes that take climate change and adaptation into account.

Under the Plant Treaty

Whereas the potential to create room for adaptation has remained unrealized under the CBD and the Nagoya Protocol, adaptation to climate change has already received attention under the Plant Treaty, in particular with regard to the Benefit-sharing Fund. As of October 2014, funds from the Benefit-sharing Fund had been distributed through two rounds of benefit-sharing.

In line with the initial priority areas outlined in Annex 1 of the Funding Strategy for the implementation of the Plant Treaty, the three priorities of the first call for proposals, whose total portfolio amounted to only USD 543 004, were information exchange, technology transfer and capacity building; managing and conserving crop genetic resources on farm; and the sustainable use of crop genetic resources (FAO, 2013a). There was little direct focus on adaptation to climate change. However, the funding strategy mentions that increased sustainability of agricultural production through diversification, genetic enhancement and broadening of the genetic base of crops will 'respond to the challenges of climate change' (FAO, 2013c, p. 11).

Despite this indirect and not overly prominent focus on climate change adaptation in the first call, five of the eleven small-scale projects that were approved for funding by the Bureau of the Governing Body in May 2009 have been noted as having 'a strong focus on helping farmers adapt to climate change' (FAO, 2013a, p. 12). These projects were implemented in Costa Rica, India, Peru, Tanzania and Uruguay and focused, *inter alia*, on selection and breeding of varieties with high resistance levels to various biotic and abiotic stresses (like heat, drought and cold), as well as making them available to farmers, and training farmers in plant selection techniques and other adaptation strategies. Traditional and local crops were often taken as the point of departure for identifying such varieties. Collecting, evaluating and characterizing crop genetic resources, also from crop wild relatives, are also among the project activities with a potential to contribute to adaptation.

The focus on climate change adaptation under the Benefit-sharing Fund was considerably strengthened in connection with the second call for proposals in 2010, when the thematic focus chosen for the call was helping ensure sustainable security 'by assisting farmers adapt to climate change' (FAO, 2013c, p. 3). This choice was based on the expert advice of Hawtin *et al.* (2010), requested by the Bureau (FAO, 2013d). That study argued that the use of funds under the Benefit-sharing Fund needed to be highly thematically focused to achieve real impact and secure further funding and proposed that conservation and use of crop genetic resources for the purpose of ensuring food security in the face of climate change should be the thematic focus for at least the following two calls of the Benefit-sharing Fund.

For the second round, increased voluntary contributions allowed the selection of altogether 19 large-scale projects to receive funding from a total amount of USD 5,497,773. The projects were approved by the Bureau in August 2011 (FAO, 2013b). In addition, three projects nested within the United Nation Development Programmes (UNDP) are receiving support after joint resource mobilization with UNDP (FAO, 2013e). However, even with increased funding, the need for financing, highlighted by the more than 440 pre-proposals (Plant Treaty, 2013), was considerably higher than the ability of the fund to support projects.

In March 2014, a new call for proposals under the Benefit-sharing Fund was announced, after the Governing Body decided at its fifth session, in September 2013, that a third call should be launched. Continuing the round-wise increase of funds, the call indicates that more than USD 10 million will be available (Plant Treaty, 2014b). The link to climate change adaptation is further strengthened as the thematic focus on helping farmers adapt to climate change through conservation and sustainable use of crop genetic resources has been kept (FAO, 2012a,b; Plant Treaty, 2014b).

It can be expected that the Benefit-sharing Fund will continue to focus on climate change adaptation also after the third round of benefit-sharing has been conducted as the same thematic focus is outlined for the period 2015–2020 in the Draft Elements for the Mid-Term

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Plan for the Benefit-Sharing Fund that was presented at the fifth session of the Governing Body (FAO, 2013d).

As the Benefit-sharing Fund already has an explicit focus on climate change, one factor that will decide how much it will actually contribute to adaptation is the resources available. Thus far, the Benefit-sharing Fund has received only voluntary contributions, and, given the long time it takes for a new plant variety to be developed, several more years are likely to pass before the mandatory mechanism provides any payments (Noriega *et al.*, 2013). As adaptation efforts are already needed and the extent of future mandatory contributions is hard to predict, it is worth asking whether anything can be done to secure and increase the flow of resources.

Because voluntary contributions have proven central, one strategy for ensuring a steady flow of such contributions would be to increase the number and type of contributors. So far, such contributions have come only from a handful of Contracting Parties and the UNDP. The seed industry contains other important contributors, and the introduction of guidelines by the industry itself could be a promising approach to secure contributions from this sector. Such non-binding guidelines established by the seed industry could, as mentioned by Halewood *et al.* (2013), suggest that donations from seed companies to the Benefit-sharing Fund be calculated on the basis of seed sales or other metrics. As noted by Halewood *et al.* (2013), the Governing Body could then express appreciation for the initiative and encourage the sector to follow the guidelines. The stability of the fund would also improve if more Contracting Parties contributed to it and if contributions could be secured from private philanthropic foundations, international governmental organizations and non-governmental organizations. Further strengthening of, and emphasis on, the adaptation focus could contribute to securing such resources.

Multiple approaches can also be envisioned to ensure the sustainability of mandatory contributions. The Plant Treaty does provide its Governing Body with the opportunity to extend mandatory payment also to cases where the products are available without restriction for further research and breeding. The Governing Body might decide that plant variety protection also triggers mandatory payments. At the fifth meeting of the Governing Body of the Treaty, civil society representatives argued for a change in this direction, but no decision was made. However, an *Ad Hoc* Open-ended Working Group to Enhance the Functioning of the Multilateral System of Access and Benefit-sharing was established, tasked *inter alia* with developing a range of measures to increase user-based payments and contributions to the Benefit-sharing Fund (see Resolution 2/2013).

The extent of mandatory payments also depends on the amount of material from the Multilateral System used by the seed sector, and, as long as no new triggers are introduced, the sector's use of patents. Stannard *et al.* (2013) argue that the flow of benefits will be influenced by whether and when Contracting Parties make their Multilateral System material available through notifications, whether and when potential members join the Plant Treaty and whether the Governing Body decide to expand the list of crops in Annex 1. Availability, new members and new crops are seen as factors that will increase the flow of funds. With current availability and Plant Treaty membership, it is estimated that it will take as many as 38 years before the fund-raising target is reached, even under favourable assumptions regarding matters like voluntary payments and avoidance by breeders (Stannard *et al.*, 2013). For the sake of climate change adaptation, that timeframe will need to be shortened.

Although equitable benefit-sharing is the focus of the Benefit-sharing Fund, it also has the potential to contribute to improving access to crop genetic resources through the work of the projects funded. In addition, the accessions collected, evaluated, characterized and/or developed through funded projects from Annex 1 crops are to be included in the Multilateral System, as decided by the Governing Body in its Resolution 3/2011 para 12.

The realization of Farmers' Rights, in line with Article 9 in the Plant Treaty, is also linked to benefit-sharing. Much of the progress that has been achieved with regard to implementation of this Article has related to exchange of information, technology transfer and capacity building, in the form of participatory plant breeding, value adding, seed fairs, infrastructure and re-introduction of varieties (Andersen and Winge, 2013).

Because farmers in centres of diversity often rely on their own seed networks (Mercer and Perales, 2010), systems for seed exchange that facilitate access across borders for farmers, as well as distribution of new varieties, are needed as climate change increases interdependence. The realization of Farmers' Rights through benefit-sharing can help to create such systems: and here the point of departure should be the needs and priorities of the farmers and communities themselves.

Potential priorities for adaptation-focused benefit-sharing

The previous sections have argued that maintenance and utilization of crop genetic resources are central to adaptation, postulated that benefit-sharing should, at least partly, be devoted to helping crop production adapt to climate change and outlined some strategies for linking adaptation to benefit-sharing under the CBD, the Nagoya

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Protocol and the Plant Treaty. But where should such benefit-sharing be directed, more specifically?

Adaptation will require breeding of varieties with improved resistance to stresses, particularly abiotic stresses (Lane and Jarvis, 2007). Targeted benefit-sharing could help to shift the breeding focus in this direction. Additionally, incentives in the form of benefit-sharing can contribute to a broadening of the genetic base of important crops, for which the utilization of crop wild relatives (Jarvis *et al*., 2008) and landraces (Trethowan *et al*., 2010) will be particularly important. However, one of the adaptation challenges for agriculture is that, whereas food security is threatened by climate change in the relatively near term, with serious effects predicted by as early as 2030 (Lobell *et al*., 2008), it takes many years to breed a new variety (for cereals ten or more), and usually even longer, perhaps another 7–8 years, for a variety to be adopted by farmers (Lane and Jarvis, 2007).

Participatory plant breeding is an approach with the potential to speed up this process. Through farmer participation in testing and selection, the participating farmers themselves as well as their friends and family become familiar with the varieties in question, their properties and potential, so that breeding and adoption are combined to a greater extent. Knowledge about and trust in a new variety are important for adoption rates, particularly in marginal environments (Abay *et al*., 2013; Ceccarelli *et al*., 2013). Importantly, participatory plant breeding can also ensure that farmers' needs and knowledge are taken into account. Crop and variety selection should, as noted by Lane and Jarvis (2007), be guided by local knowledge to ensure that agriculture is adapted to local conditions (see also Snook *et al*., 2011).

The characteristics and results of participatory plant breeding make it stand out as one of the most promising adaptation approaches for agriculture and a considerable portion of benefit-sharing funding should therefore be channelled towards participatory plant-breeding projects focused on adaptation. Through sharing of technology and knowledge, participatory plant breeding is also an important tool for non-monetary benefit-sharing and can contribute to the maintenance of crop genetic resources and diversity. To ensure that such projects also lead to improved and continued access, provisions for ensuring the access conditions for resulting material could be given along with the funding. One example is the previously mentioned requirement of the Benefit-sharing Fund to include resulting accessions in the Multilateral System.

Funding for participatory plant breeding could, for example, target areas that currently have the highest average growing-season temperatures. As there will be few if any crop climate analogues for these climates (Burke *et al*., 2009) that better adapted varieties can be accessed from, breeding based on currently grown varieties is urgently needed.

The usefulness of participatory plant breeding has already been recognized under the Plant Treaty, with the Secretariat of the Plant Treaty, when summarizing the lessons learned from the first round of benefit-sharing under the Plant Treaty's Benefit-sharing Fund, recommending participatory approaches and underlining that beneficiaries should be involved during as many stages as possible, including planning (FAO, 2013a). However, further progress is still needed, and the approach should also be recognized as an efficient way to promote utilization, maintenance and adaptation in connection with national implementation of the CBD and the Nagoya Protocol.

Adaptation-related plant breeding will be needed everywhere and for practically all crops, but which areas and crops should be receiving the limited resources of benefit-sharing? Breeding priorities could be based on predicted climate impact on crop productivity, number of people dependent on the crop and how poor or affluent they are, as well as what can be achieved with breeding (Lane and Jarvis, 2007). Focusing on area–crop combinations for which negative impacts from climate change are very likely (including wheat (*Triticum*) in South Asia, rice (*Oryza*) in Southeast Asia and maize (*Zea*) in Southern Africa), or for which the probability is lower but the potential consequences worse (as for sorghum (*Sorghum*) in the Sahel and maize (*Zea*) in Southern Africa (Lobell *et al*., 2008)) could be another way to determine priorities for adaptation-focused benefit-sharing. In addition, regions likely to be most affected by reduction of suitable crop areas, such as sub-Saharan Africa and the Caribbean, and regions already struggling with food insecurity and where funds and capacity for plant breeding are lacking (Lane and Jarvis, 2007) could be prioritized.

Social capital, social networks and institutions are essential when it comes to vulnerability and adaptation (Turner and Meyer, 2011), and for plant production, this includes systems for selling, exchanging and sharing seed. In many countries, the informal market is an important source of seed, and more information is needed on how climate change affects local access to seed, including seed networks and markets (Padulosi *et al*., 2011). The hypothesis that communities with strong seed networks are better able to adapt to climate change (Sthapit *et al*., 2009) indicates that one priority for benefit-sharing could be research on and efforts to strengthen such networks. Evaluations of existing national legislation might be necessary in this context, as the degree of legal space for seed exchange affects utilization (Winge and Groome, 2013). As many com-

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munities will need genetic material from outside their own area and their own country (Burke *et al.*, 2009), such projects should also focus on linking local communities with gene banks.

The urgent need for collection, characterization and conservation of crop genetic diversity makes such efforts another natural target for adaptation-focused benefit-sharing. This could include initiatives targeting countries which have current crop climates that are analogues to the future climates likely in many other countries, such as Tanzania, Cameroon, Nigeria and Sudan (Burke *et al.*, 2009), and further research to match such source environments with areas in need of their crop genetic resources (Ramirez-Villegas *et al.*, 2013). Screening collections for drought and heat tolerance through the use of geographic information system tools based on information regarding original location and its environment (Trethowan *et al.*, 2010) might be useful in this connection. Addressing under-representation of certain types of crop genetic resources in international gene banks, such as that of many landraces (Trethowan *et al.*, 2010), crop genetic diversity from sub-Saharan Africa (Burke *et al.*, 2009) and crops that are more important locally and regionally than globally (Snook *et al.*, 2011), including neglected and underutilized species (Padulosi *et al.*, 2011), could also be central to such efforts. In all cases, ensuring that the resulting information is made freely available would be important for the adaptation-impact of such projects.

How can access regimes contribute to climate change adaptation?

As shown in the section 'Crop genetic resources and climate change', interdependence among countries with regard to crop genetic resources is increasing as a result of climate change. This, as Burke *et al.* (2009) argue, also implies an increased need for international cooperation as to conservation and use. Specifically, as Snook *et al.* (2011, p. 503) phrases it, 'international exchange of genetic resources will be crucial for adaptation to climate change'. How can this exchange best be facilitated? More specifically, how should the systems for access created under the CBD and the Plant Treaty be developed and implemented to provide the best possible framework for adaptation?

Under the CBD and the Nagoya Protocol

According to Article 15(2) of the CBD, Contracting Parties must 'endeavour to create conditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties', and adaptation efforts fall within this category of use.

One point of departure for implementation of the Convention and its Nagoya Protocol in a way that can facilitate adaptation can be found in the Protocol's Article 8 on special considerations. As previously mentioned, this Article outlines some considerations to be taken by the Contracting Parties when developing and implementing national access and benefit-sharing legislation. The first part of this Article concerns research and the possibility of including simplified measures for non-commercial research purposes; in a climate-change context, Contracting Parties could use it, together with the mention of the special role of crop genetic resources for food security, as a point of departure for providing simplified access for research on climate change, perhaps in particular for plant breeding for adaptation.

As with benefit-sharing, it is mainly up to national implementation to ensure that systems for access facilitate adaptation. Further, it is important that all countries have some sort of national implementation that clarifies how access can be obtained and that this information is easily accessible for all potential users. Again, national legislation and regulations, standard agreements and model contractual clauses will be central – for example, they may specify that facilitated or simplified access should be provided to crop genetic resources for adaptation purposes.

One approach could be to create a separate access category with separate conditions and requirements, and a related standard agreement, for material to be used for adaptation, possibly with various sub-categories for different users, such as non-profit and commercial initiatives. Countries might also want to consider introducing a separate user category for climate analogues: countries that will have future crop climates similar to the ones currently existing in the provider country. As explained in the section 'Crop genetic resources and climate change', easy access to pre-adapted varieties will be crucial to timely and resource-efficient adaptation. It is therefore particularly important for national implementation to ensure quick, smooth and inexpensive sharing of crop genetic resources between such analogues.

Standardized access could make time- and resource-consuming negotiations unnecessary. Access to the end-product could be taken into account when creating such standard agreements, for example, through preferential access requirements and conditions for users willing to commit themselves to not taking out intellectual property rights, in any form, on the resulting technologies and products.

Speedy processing of applications for adaptation access could be promoted by introducing measures like priority processing, time guarantees for final responses

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and deliveries and standard online click-wrap access agreements. For this access category, any access fees charged should be kept to a minimum, and upfront payments avoided, with the standard agreements focusing instead on royalties from and milestone payments tied to any resulting commercial success, as well as non-monetary benefit-sharing.

Systems for simplified access should also create the needed legal space for collecting expeditions. Collection of crop genetic resources and other under-represented crop genetic resources will be necessary to provide farmers and breeders with access to as much potentially climate change-relevant diversity as possible. While it is important that national institutions and experts are involved in such collecting efforts, also international and foreign institutions may be central. National access legislation should facilitate such projects and provide clear and simple access procedures, preferably standardized, to be followed.

Adaptation access can also be promoted at the international level. It would be useful if the Conference of the Parties to the CBD discussed the relationship between agricultural adaptation and access to crop genetic resources and also took concrete measures, like a decision specifically mentioning the possibility of providing for simplified access for adaptation efforts in national access legislation.

Under the Plant Treaty

Although the Multilateral System under the Plant Treaty could have been both simpler and more efficient (Stannard, 2013), it has the potential to contribute positively to climate change adaptation through its system for facilitated access. However, as it covers only a subset of crop genetic material, it is natural to ask whether Annex 1 should be expanded to meet the increased interdependence entailed by climate change.

When the Plant Treaty was negotiated, one of the difficult issues was agreeing on the list of crops to be included in the Multilateral System (Esquinas-Alcázar *et al.*, 2013). Agreement on this rather controversial subject was achieved only during the finalization of remaining issues during the 21st session of the FAO Council in 2001, just in time for the Treaty to be adopted on 3 November 2001 at the 31st session of the FAO Conference. As previously touched upon, food security and interdependence were the agreed criteria for including crops on the list, but as the lengthy process and disagreements indicate, the selection process proved highly political.

Two of the notable crops not on the list of 35 food crops and 29 forages are soy beans (*Glycine max*) and tomatoes (*Solanum lycopersicum*), both among the world's ten most important food commodities (FAOSTAT, 2013). Tomatoes and soybeans, as well as many other important crops, were included in a draft version of the list from August 2000, but had been removed when consensus was finally reached on a list of 30 food crops in April 2001 (five crops were later added) (Visser, 2013).

Visser (2013) argues that crops such as soybeans, groundnuts (*Arachis hypogaea*), sugar cane (*Saccharum officinarum*) and oil palm (*Elaeis guineensis*) were removed from the draft list because the objecting countries or regions saw their genetic resources as economic assets, not because they were seen as unimportant for food security. According to Ramirez *et al.* (2013), there are strong scientific arguments for including cacao (*Theobroma cacao*), groundnuts and other crops of worldwide importance in the Multilateral System. Further, Ramirez-Villegas *et al.* (2013) argue that a substantial number of farmers depend on the major staples, forage species, crop wild relatives, minor and underutilized crops not included in Annex 1 and that adaptation will require facilitated exchange also of these resources. Both science and the history of Annex 1 therefore seem to indicate that the list should be expanded to cover all food crops of actual importance for food security. The effects of climate change underline the need for such expansion, as they affect food security (IPCC, 2014) and increase interdependence.

It can also be argued that the food security and interdependence criteria should be interpreted quite broadly to promote access to and exchange of crop genetic resources of underutilized and neglected species as well. Sthapit *et al.* (2009) and Padulosi *et al.* (2011) argue that Annex 1 should be expanded to include underutilized species, in order to improve access to and exchange of the genetic resources of such species, thereby promoting crop diversification as an adaptation strategy.

Expanding the list in Annex 1 would also make it easier for countries to receive funding for conservation and sustainable-use efforts related to adaptation through the Benefit-sharing Fund. Annex 1 crops are prioritized, and the second window in the mid-term plan, farmer impact projects, will mainly fund projects on Annex 1 crops (FAO, 2013d). As the Global Crop Diversity Trust, which supports *ex situ* conservation, only funds collections whose crop genetic resources can be accessed 'under the internationally agreed terms of access and benefit-sharing provided for in the Multilateral System' (Global Crop Diversity Trust, 2013, p. 6), expansion of the list in Annex 1 would also enable the added crops to receive adaptation relevant funding from there.

However, access in general, and expansion of Annex 1 in particular, is, as inextricably tied to successful benefit-sharing. An expanded list would have the potential to increase benefit-sharing, but evidence of successful benefit-sharing is also needed if Contracting Parties are

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to reach consensus on expanding the list. According to Visser (2013), any perceived negative effects of intellectual property rights – in addition to how implementation of the Plant Treaty in general, and its benefit-sharing and funding strategy provisions in particular, will fare – affect the willingness of Parties to re-negotiate the list. In Visser's opinion, the effects of climate change on interdependence might induce the Parties to expand the list, but only after the various countries have analysed how climate change is affecting their national agriculture and come to realize that they are becoming even more dependent on crop genetic resources from other countries.

Judging by the statements made at the fifth meeting of the Governing Body of the Plant Treaty in 2013, consensus on the need to expand Annex 1 is still some years away. The African group, for example, underlined that they were not ready to discuss such an expansion. This position was supported by representatives of the civil society organizations present, who in a joint statement underlined that benefit-sharing under the Multilateral System must be proven effective before Annex 1 is re-opened (Author's personal notes from the meeting).

Although all crop genetic resources listed in Annex 1 of the Plant Treaty and under the management and control of the Contracting Parties and in the public domain are *per se* in the Multilateral System, actual access to these resources under the terms of the Treaty depends, among other things, on accessible knowledge about which resources can be accessed from where. According to Moeller and Stannard (2013), the fact that many Contracting Parties have not yet made available any or all of their crop genetic resources belonging to the Multilateral System is holding back utilization of the System by crop improvement programmes. Indeed, only 37 Contracting Parties have so far sent in notifications to the Secretariat regarding their national Annex 1 resources that are in the Multilateral System (Plant Treaty, 2014a). As international exchange of crop genetic resources is essential to climate change adaptation, this lack of what Moeller and Stannard (2013) call 'effective access to resources held by Contracting Parties' can be seen as an impediment to adaptation. To achieve a functioning system that facilitates adaptation, all Contracting Parties must provide information about their mandatory inclusions. Ideally, this information should also be systematized in the Global Information System envisioned in Article 17 of the Treaty.

Another factor that influences the Multilateral System's potential to contribute to adaptation is the inclusion of material by natural and legal persons. Progress thus far has been rather weak: only six notifications (Plant Treaty, 2014a) from natural and legal persons. As the usefulness of the System for adaptation purposes will increase along with the amount of potentially useful material in it, improving this situation is important. Some dissatisfaction with the current situation could be heard at the fifth meeting of the Governing Body in September 2013, where civil society representatives argued that inclusion of Annex 1 material should be mandatory also for natural and legal persons (Author's personal notes from the meeting). However, a more realistic approach to increase the contributions of natural and legal persons to the System might be for the Governing Body to exercise its mandate to withdraw access to the Multilateral System for legal and natural persons that fail to contribute to it. This is discussed by Halewood *et al*. (2013) as one approach for defining, monitoring and enforcing the boundaries and reciprocal obligations of the Multilateral System more clearly and effectively.

If the Multilateral System is to contribute to adaptation, its system for facilitated access must also function as smoothly as possible. According to Bjørnstad *et al.* (2013), some challenges still remain for plant breeders wanting to access material under the Multilateral System. Their requests for material sent out to 121 Contracting Parties resulted in what they call an 'alarming number of non-respondents' (Bjørnstad *et al.*, 2013, p. 1964), and the countries that actually provided seed were unevenly distributed geographically. Practices with regard to use of the Standard Material Transfer Agreement were found to vary greatly, and achieving access proved quite time-consuming. Noting that some countries seem to be struggling with harmonizing their national laws and regulations with their Plant Treaty obligations, Bjørnstad *et al.* (2013) conclude that access under the Plant Treaty has so far not reached the stage where it is generally straightforward. This indicates that the routines and logistics of Contracting Parties must be improved if the adaptation potential is to be fully realized and that capacity building might be needed in some cases.

Conclusions

The threats to crop genetic resources, and the vital contributions that such resources can make to climate change adaptation, should give the maintenance and utilization of crop genetic resources a prominent place on the agenda of decision-makers in all countries and on the international stage when adaptation strategies are developed.

As access is a precondition for utilization, and utilization is linked to maintenance, the international agreements dealing with access to crop genetic resources, and the access systems created as part of national implementation, are of crucial importance to adaptation. Adaptation strat-

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egies for crop production and food security need to take this into account. Due to the increased interdependence brought about by climate change, international exchange of crop genetic resources is growing in importance, and this should have implications for how access is viewed and regulated.

Here, some initial suggestions have therefore been offered for how access under the CBD and its Nagoya Protocol, as well as under the Plant Treaty, can be developed and implemented to assist adaptation. Possible strategies include expanding the Multilateral System of the Plant Treaty and introducing separate standard agreements for adaptation access as part of national implementation of the CBD and the Nagoya Protocol. Facilitated and efficient access for adaptation purposes must be part of the strategy if agricultural adaptation is to keep pace with climate change.

Access to genetic resources is usually linked, conceptually and practically, to the fair and equitable sharing of benefits resulting from their utilization. In the case of crop genetic resources, such benefit-sharing has the potential to contribute substantially to agricultural adaptation, especially in a context where funding for various adaptation initiatives remains limited. Benefit-sharing under the Multilateral System of the Plant Treaty is already focusing on adaptation to climate change, but also under the CBD and the Nagoya Protocol, benefits resulting from the utilization of crop genetic resources could be channelled towards adaptation work.

This article has outlined some strategies for improving the impact of benefit-sharing on adaptation under these agreements – from national implementation that specifically connects monetary as well as non-monetary benefits to adaptation to increasing the flow of benefits to the Benefit-sharing Fund of the Plant Treaty. Potential priorities for such adaptation-focused benefit-sharing abound: important candidates include participatory plant breeding, for example focusing on improved tolerance to abiotic stresses and greater resilience and variation; research on crop climate analogues; and the collection, characterization, conservation and increased use of crop genetic diversity, including crop wild relatives, landraces and underutilized species.

A key lesson from the examination and analysis presented here is that linking the regimes for access and benefit-sharing to adaptation has the potential to become a crucial strategy for creating climate-resilient pathways for crop production.

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