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Governing crop genetics in post-Soviet countries: Lessons from the biodiversity hotspot Armenia

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Abstract

Armenia is amongst the world's richest agrobiodiversity hotspots, but rapid genetic erosion is threatening these vital resources of food security. The objective of this study is to investigate how legislation and policies affect the conservation and sustainable use of plant genetic resources for food and agriculture (PGRFA) in Armenia. National gene banks are central actors in this regard. Relevant legislation and policies within the context of international commitments and the institutional structures of Armenia are analysed, as well as their impact on the gene banks' ability to provide access to PGRFA for farmers. Official documents, legislation and interviews with key stakeholders in Armenia are the primary sources of information. Despite Armenia's post-Soviet trajectory of institutional collapse, war and lack of political support, national gene banks have managed to store much of Armenia's plant heritage *ex situ*, even though under modest conditions. Armenian legislation provides barriers to the marketing and exchange of seeds from most traditional varieties. Nevertheless, informal exchange still continues amongst farmers to some extent. The legislation is a serious obstacle to conservation and sustainable use of PGRFA and thus to the compliance with relevant international agreements that Armenia is party to. As a comprehensive strategy and action plan on PGRFA conservation and sustainable use is still lacking, the gene banks' promotion of on-farm conservation and sustainable use of PGRFA can be attributed to committed individuals taking responsibility for the country's international obligations. Political attention and policy coherence are required, as are well-targeted long-term commitments from development agencies.

Keywords

Plant genetic resources for food and agriculture; gene banks; seed legislation; intellectual property rights; Armenia; International Treaty on Plant Genetic Resources for Food and Agriculture.

Introduction

As a centre of origin of cultivated plants (Vavilov 1992), Armenia, as part of the Caucasus region, is amongst the world's agrobiodiversity hotspots (McGuire 2009; CBD 2014). However, genetic erosion is occurring at a rapid pace. Halting this erosion is of great importance to maintaining agriculture's ability to respond to climate change and other environmental challenges as well as future nutrition needs and food preferences. The objective of this study is to investigate how legislation and policies affect the conservation and sustainable use of plant genetic resources for food and agriculture (PGRFA) [1] in Armenia. As Armenia is a case in point for discussing characteristics of post-Soviet agrobiodiversity hotspots, specific features of post-Soviet countries in this regard and the conditions

[1] Plant genetic resources for food and agriculture (PGRFA) means any genetic material of plant origin of actual or potential value for food and agriculture, according to the International Treaty on Plant Genetic Resources for Food and Agriculture (Article 2). The term encompasses cultivated plants as well as crop wild relatives and wild edible plants.

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upon which the findings from Armenia may have relevance for other countries in the region are also identified.

Crop varieties and fodder plants, their wild relatives and wild edible plants constitute the foundation of all food and agriculture. These plant genetic resources for food and agriculture (PGRFA) provide the essential pool from which plant traits can be found that meet the challenges of climate change, crop pests and diseases, marginal soils and other environmental factors (Esquinas Alcázar 2005; Andersen 2008; Fujisaka et al. 2009; United Nations 2009; FAO 2010; Kell et al. 2017; IPCC 2019) as well as nutritional needs and other consumer preferences. As for cultivated plants, the diversity of PGRFA is indispensable for plant breeding. For small-scale farmers in many countries, it is central for food security as an effective means of spreading the risks of crop failure and for selecting and enhancing varieties that can adapt to changing environmental conditions and nutritional needs (IAASTD 2009; IPES-Food 2016; Lin 2017; IPBES 2019).

Nevertheless, genetic erosion in PGRFA has been massive over the past 100 years and constitutes a major threat to food security (FAO 1998; IAASTD 2009; IPES-Food 2016). The main cause of genetic erosion in crops is the replacement of local varieties by improved or exotic varieties and species (FAO 2019). It is difficult to quantify the losses, as baseline data are missing, and the situations differ from locality to locality. However, there is consensus amongst scientists that the genetic erosion in crops and varieties is comprehensive and that it is a result of the shift of vast agricultural areas around the world from traditional production systems depending on farmers' varieties to modern production systems depending on released varieties (FAO 2019). Generally, current locally diverse food production systems are under threat and, with them, the accompanying local knowledge, culture and skills of the food producers.

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), adopted in 2001, in force since 2004 and with 148 contracting parties (states) as of November 2020, provides the international legally binding framework for ensuring the conservation and sustainable use of PGRFA and the equitable sharing of benefits arising out of their use. However, implementation is slow, *inter alia,* due to limited policy support and capacity, as well as limited access to plant genetic material and associated information (Kell et al. 2017) and, to different degrees, detrimental incentive structures and legislation (Andersen 2013, 2016). It is of great importance to get a better grasp of the various country-specific reasons for the slow progress in this regard and to identify possible avenues for improvement.

Armenia is a particularly significant case in this regard. As one of the world's great hot spots of crop genetic diversity, the country has 252 wild relative species of cultivated plants and is regarded as a global conservation centre of wild wheat, rye, barley and Aegilops (CBD 2014). Three out of four species of wild wheat known in the world grow in Armenia: *Triticum boeoticum, Triticum urartu* and *Triticum araraticum* (CBD 2014). The rich Armenian diversity also includes numerous wild species of cultivated leguminous plants as well as wild relatives of vegetables, oil-bearing and medicinal plants and spicy herbs (CBD 2014). Amongst fruit and berry species in Armenia, there are numerous wild relatives of apple, pear, rowan, hawthorn, plum, cherry, pistachio, pomegranate, almond, grape, raspberry, currant and other species (CBD 2014). The country has traditionally had a rich diversity of landraces and farmers' varieties of crops, some of which have been collected and conserved at Armenia's different national gene banks. The rich diversity of plant genetic resources in Armenia and the Caucasus region made the Russian botanist, geneticist and agronomist Nikolai Ivanovich Vavilov

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declare the Caucasus as a centre of origin of a number of cultivated plants, in particular various cereals (Vavilov 1992). Armenia also has a rich diversity of crops that do not originate from the region, such as tomato.

State of research

While there are country reports on the state of PGRFA, including crop wild relatives (CWRs) in Armenia, these are few and most are fairly old (Gabrielian and Zohary 2004; Avagyan 2007; Republic of Armenia Ministry of Agriculture 2008; Avagyan 2014). To the best of our knowledge, there are no published peer-reviewed journal articles related specifically to the management of PGRFA in Armenia, although case studies on the management of specific varieties exist (e.g. Avagyan et al. 2020). Various other relevant aspects of Armenia's environmental management are covered to a larger extent, documenting, for instance, forest policies (Sayadyan and Moreno-Sanchez 2006), citizens' participation in environmental decision-making and environmentalism (Ishkanian 2016; Skedsmo 2019), global environmental governance in Armenia (Skedsmo 2019) and Armenia's vulnerability to climate change as Armenia's agricultural sector is amongst the most vulnerable to climate change in the region (Ahouissoussi et al. 2014). In general, the literature on post-Soviet countries' PGRFA management is scarce.[2] Thus, this article is breaking new ground.

Research questions and analytical framework

Based on the above, our research question guiding this study is: How do legislation and policies affect the management of PGRFA generally in Armenia, and more specifically the national gene banks' capacity to provide access to PGRFA and thereby contribute to conservation and sustainable use of these resources?

To answer the research question, this study first describes the situation and challenges in Armenia with regard to conservation and sustainable use of PGRFA in general and features of the seed systems in particular, focusing on access to PGRFA. On this background, the overall institutional and policy framework is described, before relevant legislation and policies in Armenia is analysed, as well as how these affect the work of the national gene banks in providing access to PGRFA to farmers and breeders. This study situates Armenian legislation within the larger framework of relevant international regimes, in particular, the ITPGRFA, the Convention on Biological Diversity (CBD), the Union for the Protection of New Varieties of Plants (UPOV), the Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPs) of the World Trade Organization (WTO) and the Patent Cooperation Treaty (PCT). In particular, the study will assess the Armenian compliance with the ITPGRFA, and discuss the state of Armenian PGRFA governance and management in light of this (FAO 2010; Andersen 2016; Kell et al. 2017). In this context, the aim is to analyse national gene banks of Armenia and their role in conserving and making PGRFA available. The role of civil society organisations in interacting with public gene banks with regard to making crop genetic diversity available and contributing to conservation and sustainable use of PGRFA will also be assessed. Based on this analysis, the empirical findings explanatory approaches will be summarised and discussed.

One way of understanding the various 'bottlenecks' (Kell et al. 2017) of PGRFA use, constraints and needs is to delineate amongst (i) limitations regarding supporting policy, (ii) need for capacity building and (iii) access to plant genetic and associated material (Kell et al. 2017). Potential explanations will be explored with a view to Armenia's specific political trajectory, where Armenia's PGRFA management can be understood in light of the broader political shifts within the country. As a

[2] In Georgia, the loss of agrobiodiversity has been analysed by Akhalkatsi and Ekhvaia (2012).

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post-Soviet state in transition, Armenia has, in political and economic terms, over the course of the last 35 years, gone through three distinctive phases: (1) the period of *perestroika* starting in 1985 and continuing until the disintegration of the Soviet Union (approximately 1985–1991); (2) the first years of independence, war, crisis and transition (1991–1999); and (3) the ensuing period of consolidation and economic growth (from around 2000 onwards) (de Waal 2004, 2010, Mirzoyan 2010, Payaslian 2007, Skedsmo 2019). Viewed thus, the ups and downs of Armenia's PGRFA management may be interpreted as effects of broader political shifts and economic transitions in Armenia, such as de-collectivisation, land reform and economic crisis as well as the recovery that Armenia has experienced. Post-independence, Armenia has become a major development aid recipient per capita (Skedsmo 2019), which may also have repercussions for Armenia's PGRFA management. As a lower middle-income country, Armenia received USD 142 in official development aid (ODA) per capita in 2019. This is substantially more than most other ODA recipients (World Bank 2021). Environmental governance is among the sectors that are heavily influenced by, and dependent on foreign funding (Skedsmo 2019). Generally, the sheer volume of western development interventions in Armenia has to some extent turned democracy into projects and civil society into NGOs (Ishkanian 2008). This study will examine whether and how legacies of state socialism (Chari and Verdery 2009) and Armenia's aid dependency are factors that may explain the status of PGRFA management in Armenia today.

Research design and method

This exploratory study started with a desk study of relevant reports documenting the state of PGRFA conservation and use in Armenia which, to a certain extent, describe the public institutions involved. These reports provide valuable, reliable information about the state of PGRFA in Armenia, as they are written by renowned experts. Yet, as noted above, little information is available about gene bank management, cooperation with farmers and the seed system as such in Armenia. Our primary source of information is interviews carried out with gene bank managers representing the four most important gene banks in Armenia, farmers and non-governmental organisations (NGOs) involved in cooperation with gene banks, government officials from relevant departments and ministries, representatives of international organisations with offices in Armenia and agrobiodiversity experts in Armenia. The interviews were carried out in accordance with the *ethnographic* or *interpretivist* methodological tradition (Spradley 1979), and 20 meetings with a total of 25 interviewees were held in which qualitative, semi-structured interviews were conducted. All interviewees were informed of the project objectives in advance. The data gathered through interviews are contextualised in light of findings from extant reports on PGRFA in Armenia, but also analysed in light of Armenia's historical and political context.

Armenia: the context

Armenia is located at the geographical and political edges of Europe. The Republic of Armenia gained its independence on 21 September 1991, after some 70 years of Soviet rule, which obviously left its mark politically, economically, structurally, socially and culturally on the country (Skedsmo 2019). Armenia is a mountainous, landlocked republic located in the South Caucasus with 2.95 million inhabitants (World Bank 2018). Together with Georgia and Kyrgyzstan, Armenia is amongst the most aid-dependent post-Soviet republics (World Bank 2021, Skedsmo 2019). Armenia's main strategic ally is the Russian Federation, while its alliance with the EU is strengthened through the Eastern Partnership (EaP) initiative. Armenia is part of the Eurasian Customs Union, which means that control of goods imported from other members of the customs union, such as Belarus, Kazakhstan and

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Russia, is lenient. This also has consequences for the import of seeds, where Russia is the main source of imported cereal seeds.

Landlocked Armenia covers approximately 30,000 km^2 and has a continental highland climate with harsh, cold winters and hot summers (Skedsmo 2019). During Soviet times, grand modernisation schemes affected the agricultural sector; in addition to collectivisation, Soviet authorities initiated large-scale irrigation projects in several regions, such as constructing a channel to direct water from Lake Sevan into the Hrazdan River (Sayadyan and Moreno-Sanchez 2006). This channel project not only failed to achieve its ambitions, it was damaging to the biodiversity of Lake Sevan and to the farms around the lake (Skedsmo 2019). Moreover, the ultimate disintegration of the Soviet Union meant that 869 former large collective and state farms were privatised in the 1990s, with 147,000 separate parcels of land being allocated to 338,000 farmers and rural households. The rapidity with which this occurred and the conflict over property and water rights led to widespread dissatisfaction. Unlike in the Russian Federation, Armenian farms are mainly 'small farms with emerging concentration in corporate farms', where state influence is low (Spoor 2012). The reallocation of land initially provided a 'cushion' against rural poverty (Spoor 2012). Currently, the average farm size is 1.37 ha, and 88% of these are smaller than 2 ha. About one-third of the farmers do not cultivate their land, whereas 15% cultivate leased land (Millns 2013). More than 150,000 ha of arable land and 50% of pastureland are unused, and valuable plants of pastures and grasslands suffer from this, while aggressive weeds severely affect 33% (approximately 150,000 ha) of arable lands, which further threatens cultivated fields (Avagyan 2014).

Challenges related to crop genetic resources

Over approximately the last 70 years, and increasingly over the past 25–30 years, there has been a significant loss of crop genetic diversity in this global biodiversity hotspot, along with land degradation such as soil erosion, secondary salinisation and degradation of natural ecosystems (Avagyan 2014; World Bank 2012). The rapid replacement of traditional varieties by hybrids and modern varieties has resulted in genetic erosion. While this is documented in various assessment reports (e.g. Republic of Armenia Ministry of Agriculture 2008; Avagyan 2014), it is also a perception that was widely shared with us in nearly all the interviews conducted. The accepted view is that this is the case for all agricultural plants and that the rapid erosion in vegetables is the most recent phenomenon. Simply put, most of our informants argued that the supply of local varieties, especially vegetables such as cucumbers, tomatoes and peppers, has been significantly reduced over the past 10–20 years. One example that was mentioned particularly often was the virtual disappearance in local food markets of a local tomato variety called *Anahit,* which was known for its high content of dry matter, rich taste and thin skin. One interviewee said: 'We have gotten Dutch tomatoes that all look alike, have less taste, and you can throw them against the wall, and they will bounce back to you'. The Anahit is but one example of a variety that, for Armenians, denotes 'household names and tastes' as compared with the 'rubbery, tasteless supermarket varieties' (Aistara 2014). Seen this way, much like Aistara's compelling argument regarding vanishing and, in turn, illegal tomato varieties in Latvia, such locally produced and consumed varieties were part of a social fabric of 'different times, tastes and social relations' (Aistara 2014) that gradually has been lost or at least is now less accessible. It was a prevalent notion that, although the traditional varieties are hard to get in the marketplace, most thought that farmers still grew them for their own consumption. This implies perhaps that the level of genetic erosion is less than in the worst-case scenarios described by some.

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There is no statistical data on the prevalence of farmers' varieties, but estimation experts and informants provided us with the following picture. Prior to 1950, more than 20 local varieties of wheat were cultivated in Armenia. At present, only two or three local varieties of wheat are still being cultivated, and to a very limited extent. As for other cereals, the 'Nutans' farmer's variety of barley and old traditional landraces (populations) of emmer wheat are still cultivated due to their advantageous drought resistance. Actually, more than half of the areas cultivated with barley and emmer are cultivated with traditional varieties, according to the estimation of Armenian experts. Amongst perennial forage crops, some varieties are still widely cultivated, namely '*Aparani* local' of alfalfa, '*Sisiani* local' of sainfoin and '*Stepanavani* local' of clover.

A limited number of farmers' varieties of cucumber, pepper, sweet pepper, eggplant, tomato, okra, carrot, asparagus, onion and melon are cultivated, according to experts interviewed in this study. However, the majority of the cultivated spicy and leafy vegetable varieties are traditional farmers' varieties. Local varieties of beans are widely used, making up 85–90% of the area cultivated for beans.

Farmers' varieties of apple, pear, peach, plum and cherry are gradually being cultivated less because of low yields as compared with modern varieties, according to the experts consulted. But almost all apricot varieties cultivated in Armenia are endemic, and the variety '*Yerevani*' is by far the most popular. Armenia, as an ancient centre of viticulture, is also known for its traditional grape varieties. At present, out of about 40 widely cultivated grape varieties, 15 are traditional.

There is a considerable decrease in natural populations of CWRs and wild edible plants in Armenia. This is first and foremost due to direct human interventions, such as mining, road construction, other changes in land use and untimely harvesting. Another serious challenge is that Armenia has mounting backlogs for regeneration of its gene bank collections, as reported by the Food and Agriculture Organization of the United Nations (FAO) (2010, p. 77) and confirmed by our interviewees in 2019.

Several fragile states around the world are characterised by high endemism of plant diversity and by being centres of origin or diversity of certain plant species. Armenia is no exception to this, and particularly adding to the county's fragility is its vulnerability to climate change, risk of renewed violent conflict with Azerbaijan (with recent clashes and warfare in 2016 and 2020) and continuing challenges in recovering after the collapse of the Soviet Union. According to a study by the World Bank of the countries in the Caucasus and Central Asia, Armenia is the country most vulnerable to climate change (Ahouissoussi et al. 2014). In summer, the predicted rise in temperature is 1.6 degrees and up to 1.3 degrees annually in Ararat Valley 2011–2040, the agricultural powerhouse in Armenia (Melkonyan 2015). While a decrease in precipitation is predicted to take place in Ararat valley, relatively wet northern regions are predicted to become even wetter during the next three decades (Melkonyan 2015). Although this will affect the agricultural sector in different ways, climate change is thus likely to increase the risk of droughts, frost, and floods, in terms of frequency as well as magnitude (Ahouissoussi et al. 2014). Areas under desertification in Armenia have increased from 14 × 103 ha (2005) to about 17 × 103 ha (2011), and the area under erosion increased from 500 ha to 6000 ha. The risks posed by predicted less precipitation in the Ararat valley due to climate change is exacerbated by the fact that groundwater consumption already exceeds the security level by 1.5 times (Melkonyan 2015). The dissolution of the Soviet Union, the earthquake in Spitak (1988) and the

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war over Nagorno Karabakh severely affected Armenia's capacity for *ex situ* and *in situ* conservation of PGRFA, as elaborated below.

Features of the seed systems in Armenia since the Soviet era

According to data gathered through our interviews in Armenia – which the following observations are based upon – the Soviet Republic of Armenia relied largely on its own genetic resources for breeding and had a highly developed system for plant breeding for its time which included internationally known plant breeders. Seeds from the Soviet Republic of Armenia were also transferred to other Soviet republics through the Soviet barter economy. Many of the varieties now considered traditional around the former Soviet Union probably originated in other parts of the former Soviet Union due to the active distribution of seeds within the former Soviet Union (Aistara 2014).

The agricultural collectives established in Armenia under the Soviet Union also meant an interruption of the customary practices of farmers related to seeds. Aside from the fields administrated by the collectives, farmers were allowed to keep small private plots. Cereals and other field crops were grown by the collectives, but local varieties of these were largely neglected. Local varieties of vegetables, fruits, berries, nuts and herbs were maintained on the small plots. Thus, farmers largely lost access to local varieties of cereals and other field crops.

After the collapse of the Soviet Union, there was a period of great chaos in field crops. All domestic seed production stopped in 1991 and only slowly resumed from 1994 onwards (Melikyan 2020). During the first years after the collapse of the Soviet Union, farmers had to largely rely on their own seed production, but they had difficulties in selecting and separating seeds. As a result, there was a substantial drop in the productivity of field crops. Also, when lands from the former collectives were redistributed, many unemployed people without farming experience took this opportunity to try to make a living from farming. Without knowledge and know-how, many of them faced great difficulties. Nevertheless, vegetables, fruits, berries, nuts and herbs were maintained, as traditional knowledge about these crops was still available, as were, most importantly, their seeds.

When public plant breeding in Armenia recovered along with the development of some private plant breeding initiatives, breeding methods had changed. It was no longer sufficient to have access to local varieties with some documentation and to select quite randomly: the methods had become more precise and required material that had been evaluated, at best with molecular markers. As the local material had not previously been evaluated to any extent, this information did not exist for that material, and there was no equipment in the country at the time to evaluate the material and thus meet the information needs. Also, local varieties are genetically heterogenous, and thus require much more breeding work. It was easier to breed from breeding lines that had been evaluated and were rather stable. Thus, imported material was increasingly used, especially for field crops that were dominated by imported seed and domestic seed bred from – to a great degree – foreign genetic material. Armenian genetic resources were marginalised. Many farmers switched to high yielding improved varieties, but they continued growing local varieties of some vegetables, herbs, fruits, berries and nuts for home consumption. Today, some 80–85% of cereal and other field crop seeds are imported, mainly from Russia (Melikyan 2020). According to our informants, very few farmers are interested in local varieties of these crops. Despite Armenia being a world cradle for wheat, today, wheat seeds are mostly imported into the country.

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The demand for local varieties is rising, particularly in vegetables, herbs, berries and fruit, as people long for the varieties they consider Armenian, and still remember, for instance, the Armenian tomatoes that were sold in the markets less than 10 years ago. Generally, consumers would like to have more local food, but the farmers want to have stable crops with high yields, and this is also largely what is offered in terms of seed. However, demand for local varieties is also experienced by the gene banks, as this demand is rapidly increasing and by far exceeds the gene banks' capacity for distribution.

Currently, the formal and informal seed systems exist side by side in Armenia, and farmers tend to use both. According to some informants, the informal seed system is quite comprehensive. Farmers multiply seeds and exchange them with their neighbours. In general, farmers re-sow seeds from season to season, as seeds distributed in Armenia are 'often not tailored to the specific climate and soil conditions of their region' (Ahouissoussi et al. 2014). For high-yielding improved varieties, the process of cleaning and re-sowing will decrease genetic purity over the years, and yields will be reduced. It is claimed that, to a limited extent, Armenian farmers are aware of this (Ahouissoussi et al. 2014). This pertains to, for example, cereals imported from Russia and multiplied by farmers in Armenia. For local varieties with a broader genetic base and heterogeneity, the situation is different, and proper local management and seed selection will maintain or even increase yields.

Lack of statistical data makes it difficult to provide exact information on how large the informal seed system is when compared with the formal one and how they interact. These are questions that require data that are not currently available. Thus, we are left with the more general picture described above, which is derived from the interviews with central stakeholders in Armenia. We will now turn to identifying the institutional, policy and legislative framework of PGRFA management in Armenia.

Institutional and policy framework

Until 2019, the Ministry of Agriculture had been the primary ministry responsible for the management of crop genetic resources. But after the peaceful demonstrations of 2018 that led to the resignation of Prime Minister Serzh Sargysan and a new government under Prime Minister Nikol Pashinyan, the government began a reorganisation of several of the ministries involved in PGRFA management in Armenia. Almost the entire portfolio under the Ministry of Agriculture was merged with the Ministry of Economy, except for forest management, which was delegated to the Ministry of Environment (previously Ministry of Nature Protection). This reorganisation has meant that most government institutions involved in the management of PGRFA are now under the auspices of the Ministry of Economy. The most notable exception is the management of state reserves and national parks (*zapovedniki)* important for *in situ* preservation of CWRs, which is now the responsibility of the Ministry of the Environment.

One result of the reorganisation and the fact that many long-term staffers have left, is that at present, responsibilities are unclear, and it is difficult for organisations and outsiders to identify contact persons within the government, according to several of the interviewees in this study. The Ministry of Economy does not at present have any plans to maintain PGRFA, and no strategy has

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been adopted.[3] There is also a lack of policies to halt genetic erosion. Currently, no strategy and action plan for PGRFA conservation and sustainable use has been adopted by the Armenian government, although several international organisations and Armenian state institutions have worked together to develop and also submit a draft of such a strategy for consideration by the Parliament. Armenia is thus amongst several countries lacking strategies and plans for PGRFA use and conservation.[4] While developing national PGRFA strategies with action plans assigning responsibilities is urgent (Mba et al. 2012), simply having a policy in place will not suffice either (Kell et al. 2017).

With the introduction of the new institutional framework described here, the formal links between the relevant national authorities and the national gene banks have deteriorated, leaving the national gene banks in a kind of limbo in terms of political attention as well as policies and access to financial support. Similarly, it is also observed that the legislative and institutional frameworks for the management of PGRFA are somewhat disjoint.

Legislative framework for the management of PGRFA

The Armenian Constitution, as amended in November 2015, provides for the preservation of the environment and sustainable development (National Assembly of Armenia 2015). It establishes that the State shall promote the preservation, improvement and restoration of the environment and the reasonable utilisation of natural resources, guided by the principle of sustainable development and taking into account the responsibility for future generations. It also provides that everyone is obliged to take care of the preservation of the environment. Our analysis of the Armenian legislation shows that CWRs and wild edible food plants have quite a comprehensive legislative protection, whereas the legislation is detrimental to the conservation and sustainable use of cultivated crops, as explained below. Below, the legislation in the context of Armenia's commitments to international agreements and processes will be presented.

Environmental legislation relevant for CWRs and wild edible plants

As CWRs and wild edible plants are found in the wild and depend on natural wild habitats, the CBD is an international agreement of central relevance. Armenia has been a party to the CBD since its entry into force in 1993. It became a party to the Cartagena Protocol on Biosafety under the CBD in 2004, but has so far decided not to become a party to the Nagoya Protocol on Access and Benefit-sharing under the CBD.

The Armenian legislation for environmental protection is comprehensive. The most relevant environmental laws with regard to our topic are the Law of the Republic of Armenia on Flora of 1999 (amended in 2002 and 2008) (Ecolex 2008), which regulates the protection and use of flora in

[3] Interview with government representative, Ministry of Economy.

[4] As part of its commitment to the CBD, Armenia adopted a comprehensive Strategy (Government of the Republic of Armenia 2015a) and a National Action Plan of the Republic of Armenia on Conservation, Protection, Reproduction and Use of Biological Diversity for 2016–2020 (Government of the Republic of Armenia, 2015b). The strategy provides a brief description of CWRs, but provides no direction for the management of PGRFA. Only one activity of the action plan is devoted to PGRFA as such: an action plan which is to be developed and implemented on restoration and conservation of old traditional varieties of cultivated plants, in particular those which are out of cultivation and those of their gene pool (Activity 3.6). Thus, the action plan set out a specific action plan to be developed for this purpose by the end of 2020. This did not happen.

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Armenia; the Forest Code of the Republic of Armenia of 2005 (Ecolex 2005), which regulates the protection and sustainable management, guarding, rehabilitation, afforestation and use of forests of the Republic of Armenia, in addition to the monitoring and control of Armenian forests. Also included are the Law of the Republic of Armenia on Specially Protected Natural Areas, 2006 (Ecolex 2006), which regulates the conservation of biological and landscape diversity, natural monuments, the sustainability of natural ecosystems and their ecological balance; restoration of natural ecosystems of local, regional and international importance and sustainable development; management of biodiversity and ecological balance, prevention or mitigation of anthropogenic influence on the sustainable development of ecosystems, relevant scientific research, sustainable use, promotion of ecological education and training activities and regulation of public relations related to the conservation and use of specially protected natural areas; and the Law of the Republic of Armenia on Lake Sevan, 2001 (amended in 2002 and 2012) (CA Water-Info 2012), which regulates the protection, restoration, reproduction and use of natural systems for Lake Sevan, and its catchment basin and areas beyond Lake Sevan catchment basin within a 30 km distance of the water divide inside the borders of the Republic of Armenia.

The environmental legislation provides for detailed regulation *inter alia* for the conservation, management and sustainable use of CWRs and wild edible plants, their habitats and ecosystems. Furthermore, there are provisions for payments for the use of natural resources for certain stakeholders, but no benefit-sharing regime as envisaged under the CBD.

Legislation relevant for domesticated plants

Armenia became a party to the ITPGRFA in 2007 and is one of 148 parties, as of November 2020. Armenia is also a member of the Commission on Genetic Resources for Food and Agriculture under the FAO, which in 2010 adopted the Second Global Plan of Action (GPA) for PGRFA, which is currently guiding its 178 member countries that are members of the commission in their management of PGRFA. As emphasised in the preamble and text of the ITPGRFA, the GPA is an important tool for the implementation of the ITPGRFA, which is aimed at the conservation and sustainable use of PGRFA and the fair and equitable sharing of benefits arising out of their use.

The most relevant law for the management of PGRFA is the Law of the Republic of Armenia on Seeds, 2005 (amended in 2008), as it regulates to what extent and how the different stakeholders in agriculture, including farmers and gardeners, may save, use, exchange and sell seed and propagating material of the diversity at hand in Armenia. The Law of the Republic of Armenia on Seeds[5] regulates the registration of crop varieties permitted for use, including their seed and propagating material. It covers domestic as well as imported seed, except for genetically modified organisms. Seed is defined as covering both seed and propagating material of plants (Article 4, para. 1).

Article 5 regulates how the official list of plant varieties permitted for use in Armenia is to be set up. Importantly, Article 5 regulates that only the plant varieties that have passed an assessment of their economic benefits carried out by a competent authority and are registered on the official list can be used and reproduced in the territory of Armenia. According to the definitions of key terms in Article 2, an assessment of economic benefits refers to an assessment that determines the economic

[5] We are grateful to Gor Movsisyan, PhD, from the Environmental Law Resource Centre at the Faculty of Law at Yerevan State University translating from Armenian the Law of the Republic of Armenia on Seeds.

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usefulness and efficiency of a variety, its distinct characteristics, uniformity and stability as well as its adaptation to climatic conditions as compared with popular varieties.

This means that local varieties that do not fulfil the requirements for registration and are not registered for this or other reasons are not permitted for use in Armenia. As local varieties and landraces are normally genetically heterogenous and thus cannot fulfil the criteria of genetic distinctness, uniformity and stability (DUS-criteria), as set out in the Armenian legislation, they cannot be admitted on the official list. For varieties that would meet the requirements, registration depends on maintainers, normally small-scale farmers, who are willing to and have the capacity and financial means to apply for registration. According to a leading researcher at one of the Armenian gene banks, plant breeders in Armenia apply for registration of their new varieties under the seed law; it is possible for farmers to apply for registration of varieties as well, but there are very few cases of that.

In Article 8, the Seed Law prescribes how the seeds will be certified. Importantly, it provides that original, basic and reproduced seeds are subject to mandatory certification. Requirements are documentation of the varietal identity, purity and qualitative characteristics of the seeds, in compliance with the technical regulations, and standards and other normative documents in the field of seed production as set out by the competent authority (see also definition in Article 4, para. 10). The certification procedures include field testing and laboratory research. A special provision (Article 8, para. 6) addresses seeds produced or used for individual needs. These may not have to pass certification as such, but documentation confirming varietal identity, purity and quality characteristics is required.

The Armenian legislation on seed resembles that of many other countries, particularly those in the Global North, but is amongst the strictest.[6] It may well provide for quality seed and plant health but does not promote the conservation and sustainable use of PGRFA: the rich diversity of Armenian heritage crop varieties is not permitted for use. It is *de facto* illegal to maintain this diversity in farmers' fields. As such, the seed legislation indirectly conflicts with the provisions concerning on-farm conservation and sustainable use in the ITPGRFA. Even though some indication were received that farmers are not aware of the legislation and may not comply, the legislation as such is undermining the promotion of on-farm conservation and sustainable use of PGRFA, thus the implementation of the ITPGRFA in Armenia.

Legislation on intellectual property rights

Intellectual property rights represent another set of legislation that may affect the management of PGRFA (e.g. Dutfield 2000; Andersen 2008; United Nations 2009): whereas it is intended at covering costs and providing incentives for innovation, it may limit or prohibit practices of saving, using, exchanging and selling seed from varieties protected by such rights among farmers, and it may enable the appropriation of genetic resources from local and traditional varieties for varieties to be protected by intellectual property rights, thus further contributing to the enclosure of these commons. Whether and how legislation on intellectual property rights have such effects depend on the ways in which it is formulated.

[6] For example, as compared with the EU legislation, see e.g. Winge 2015.

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Armenia has been a party to the WTO since 2003 and is thus also a party to the TRIPs. In 2013, Armenia became a party to the Patent Law Treaty (PLT) under the World Intellectual Property Organisation (WIPO).[7] The country has been a contracting state to the PCT since 1991 and so is a member of the PCT Union.[8] The PCT assists applicants in seeking patent protection internationally for their inventions, helps patent offices with their patent granting decisions and facilitates public access to technical information relating to those inventions. By filing one international patent application under the PCT, applicants can simultaneously seek protection for an invention in all the other contracting states: as of March 2020, 153 countries. The PCT is part of The International Patent System under the WIPO.[9] Armenia became a WIPO member in 1993. In 1994, Armenia provided a declaration of continuation to the Director General of WIPO, with the result being that the PCT could be applied in Armenia. This means that nationals and residents of Armenia from that point in time could file international applications (EPO 1994).

In 1995, Armenia ratified the Eurasian Patent Convention (EAPC) together with eight other countries from the former Soviet Union, and the EAPC entered into force that same year.[10] The EAPC established the Eurasian Patent Organisation (EPO), which is aimed at providing legal protection for inventions in the contracting states on the basis of single Eurasian patents. The EAPC/EPO have many similarities with the European Patent Convention and the European Patent Office, and there is close collaboration between the two organisations.

The legislation on intellectual property rights related to PGRFA comprise the Law of the Republic of Armenia on Inventions, Utility Models and Industrial Designs, 2008, and the Law of the Republic of Armenia on the Protection of Plant Varieties, 2017.

In 2008, a patent law, The Law of the Republic of Armenia on Inventions, Utility Models and Industrial Designs, was adopted in Armenia (Ministry of Economy Republic of Armenia 2008). The law entered into force in 2009 and regulates intellectual property rights in the form of patents. In Article 10 (para. 4) of this patent law, inventions are described that are not patentable, i.e. plant varieties and animal breeds as well as, in principle, the biological methods of their derivation. The law specifies that the method of obtaining plants or animals is essentially biological if it is entirely composed of natural phenomena such as crossbreeding or selection. Article 17 describes acts not recognised as infringements on the exclusive right conferred by the patent under the law and states that the patent holder may grant farmers the right to use the results of their harvests for reproduction or multiplication purposes. In practice, this means that farmers are not allowed to save, use, exchange or sell farm-saved seeds from varieties affected by patents without the permission of

[7] The PLT was adopted in 2000 with the aim of harmonising and streamlining formal procedures with respect to national and regional patent applications, and it entered into force in 2005. See World Intellectual Property Organization: WIPO administered treaties – Contracting Parties of the Patent Law Treaty at https://www.wipo.int/treaties/en/ShowResults.jsp?lang=en&treaty_id=4.
[8] The PCT was adopted in 1970 and established the PCT Union. See https://www.wipo.int/pct/en/
[9] The WIPO was established in 1967 as an agency of the United Nations and serves as a global forum for intellectual property services, policy information and cooperation; it had 193 member states as of March 2020. See https://www.wipo.int/portal/en/
[10] In addition to Armenia: Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkmenistan and Moldova. Moldova withdrew its ratification in 2012. Georgia and Ukraine signed the treaty in 1994, but never ratified. Thus, there are 8 parties to the EAPC as of 2020. See: https://www.eapo.org/en/

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the patent holder. Normally, patent holders will either not allow that or set certain conditions, such as the payment of fees.

The Armenian patent law is largely equivalent to patent laws in Europe with regard to provisions related to plants. The European Patent Office is also developing closer collaboration with several countries on the geographical edges of Europe, such as Georgia.[11]

All in all, the Armenian patent law enables the patenting of plants, including their seeds and propagating material, as long as the objects of the patents are not described as plant varieties. The international commitments of Armenia relating to patents show that the country has taken steps to streamline its patent system and make it compatible with regional and international systems. Whereas such streamlining is important to make patents effective and thus protect innovations that stimulate development, it may work counterproductively regarding innovations in plants, as patented material is not available for further plant breeding. That is why a particular set of intellectual property rights for plants has been developed internationally: plant variety protection.

Armenia is not a member of the UPOV, even though there have been attempts to join the union for almost 20 years. This process is indicative of how the seed sector is changing in Armenia. UPOV is aimed at providing and promoting an effective system of plant variety protection, thereby encouraging the development of new varieties of plants. The UPOV Convention was adopted in Paris in 1961 and revised in 1972, 1978 and 1991. Each time, it was further specified, and plant breeders' rights were strengthened. The UPOV Convention of 1978, to which a number of countries are still bound, was closed for new accessions in 1998. Thus, Armenia could only become a member of UPOV based on the UPOV Convention of 1991. As of February 2020, the UPOV had 76 member states.

The Law of the Republic of Armenia on the Protection of Plant Varieties regulates the development, use and protection of plant varieties through plant breeder's rights (Republic of Armenia 2017: Article 1).[12] A variety to be protected has to be new, distinct, uniform and stable (i.e. the N-DUS criteria) set out in the UPOV Convention, which are further defined in the law. The breeders' rights will be granted on a temporary basis when the breeder has submitted the application (Article 12). This far exceeds what is provided in the UPOV Convention, where only certain measures are foreseen to ensure that a breeder is compensated if the variety for which an application has been filed comes into use before the right is granted (provisional protection, Article 13 of the UPOV Convention). The rights are granted for 20 years, except in cases of fruit tree and grape varieties, where they are granted for 25 years (Article 18), which is in line with the UPOV Convention.

The breeders' rights cover the production or reproduction (multiplication) of the protected variety, conditioning for the purpose of propagation, offering for sale, selling or other forms of marketing, exporting, importing and stocking for any of the purposes mentioned here (Article 13). This is also in line with the UPOV Convention.

The rights explained here extend to varieties that can be considered 'essentially derived' from the protected variety, where the protected variety is not itself an essentially derived variety, to varieties

[11] In 2019, an agreement was reached between the government of Georgia and the EPO validation of European patents (validation agreement). Information was downloaded from the EPO website entitled 'Validation states': https://www.epo.org/about-us/foundation/validation-states.html. Downloaded 12 March 2020.
[12] Based on an informal translation of the law from Armenian into English, as an official translation is not available.

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that are not clearly distinguishable in accordance with the protected variety in terms of its distinctness,[13] and to varieties whose production requires the repeated use of the protected variety. This is in line with the UPOV Convention. The scope of the breeders' rights, however, does not cover actions performed for private and non-commercial purposes or actions performed for experimental purposes (Article 14). Also, plant breeding based on the protected material is allowed, provided that the resultant new variety is not essentially derived from the protected one, as defined by the law.

The UPOV Convention leaves it up to the member states to provide for an optional exception from the breeders' rights in order to permit farmers to use the material for propagating purposes on their own holdings, the product of the harvest which they have obtained by planting on their own holdings, and the protected variety or a variety that is essentially derived or similar to a protected variety as set out in the Convention (Article 15 (2) of the UPOV Convention). Armenia did, however, not make use of this opportunity.

The law also stipulates that the government can intervene in cases where the interests of the public overrule the interest of the breeder, as defined by the law. In such cases, adequate compensation is to be provided (Article 16). This is in line with the UPOV Convention.

Thus the legislation is close to compliant with UPOV 1991; it goes even further in terms of provisional measures during the time between the filing of an application and conferring of the right, and it makes no use of the optional exception that is often referred to as the farmers' privilege under the UPOV Convention of 1991. As shown above, however, it still differs from the UPOV Convention of 1991 to some extent. The UPOV requires full compliance with the UPOV Convention of 1991 to be accepted for membership, and so far, Armenia has not been able or willing to accomplish that. It remains to be seen whether the new law will be tabled for consideration by the UPOV Council and what the Council would then decide.

In the context of this analysis, The Law of the Republic of Armenia on the Protection of Plant Varieties is highly restrictive in terms of farmers' rights to save, use, exchange and sell farm-saved seed. In fact, this is entirely prohibited for protected varieties under the new law, except in cases where a farmer is carrying out such acts in his private capacity for non-commercial purposes. Whereas this does not affect the operations of national gene banks in providing access to local and traditional varieties (provided that the material has not been protected with intellectual property rights), combined with the strict seed laws presented above, it contributes to limiting the diversity of crop varieties available to farmers for conservation and sustainable use and maintaining and developing their customary practices in this regard.

National gene banks and their management of PGRFA

Fieldwork in Armenia carried out for this study revealed that only very few institutions are involved in the management of PGRFA in the country. The key actors were found to be the national gene banks. In addition, some very few Armenian NGOs are to a limited extent engaged in storing,

[13] Actually, the law here refers to its Article 7 on genetic uniformity. However, this is obviously a mistake, as it would not make sense in this context. In the UPOV Convention, the numbering is a bit different, and here the reference is to Article 7 on distinctness. In the Armenian law, distinctness is covered in Article 6. We assume that this is what is meant by the references.

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maintaining and distributing seeds to farmers and gardeners, mainly regenerated from national gene bank collections. Thus, our focus in this analysis is on the national gene banks, whereas relevant NGOs are analysed within this context (see next chapter).

In Armenia, there are eight gene banks registered in the FAO World Information Early Warning System (WIEWS) database, out of which five have submitted information on a total of 5,891 accessions. For this study, representatives of four gene banks were interviewed, representing gene banks which together hold 5,879 of the above-mentioned accessions. In Eurisco, 9382 accessions of Armenian origin are registered, out of which 4864 accessions are deposited in Armenian genebanks. All these 4864 accessions are stored at the four genebanks interviewed, listed in Table 1 (Eurisco 2021). Some of these gene banks were established with the support of the International Center for Agricultural Research in the Dry Areas (ICARDA) (FAO 2010). The four gene banks interviewed are listed in Table 1, with their registered accessions in Genesys – a global portal about plant genetic resources for food and agriculture.[14]

Table 1: National gene banks in Armenia

Name of gene bank	Affiliation	Location	WIEWS instcode	Accessions	Main responsibility	Most common crop names amongst accessions	Average PDCI* (range 0-10)
Research center for Plants Gene Pool and Breeding	Armenian National Agrarian University (ANAU)	Yerevan	ARM035	2313	Crop wild relatives, grasses, cereals	Goat grass, wheat	5.5
Institute of Botany	RA National Academy of Sciences	Yerevan	ARM005	1980	Wild flora, crop wild relatives	Vetch, eggplant, pepper	4.0
Scientific Center of Agrobiotechnology	Armenian National Agrarian University (ANAU)	Etchiamdzin	ARM059	981	Cereals and other commercial crops	Pepper, barley, wheat	4.1
Scientific Center of Vegetables and Industrial Crops	Ministry of Economy	Darakert	ARM008	605	Vegetables, fruits	Tomato, pepper, eggplant	3.4

Table 1 Overview of state-funded gene banks in Armenia.[15] * PDCI: passport data completeness index, an indicator of the completeness of published passport data. The PDCI uses the presence or absence of data points in the documentation of a gene bank accession, taking into account the presence or value of other data points (van Hintum et al. 2011). For example, a wild accession should have a well-defined collection site but no variety name. The PDCI ranges from 0 – 10, where 0 is the minimum score assigned to rather incomplete passport records, and 10 is the maximum score assigned to very complete passport records. Any type of accession, including wild, landrace, breeding material or modern variety, can attain the PDCI's maximal score.

The Research Centre for Plants Gene Pool and Breeding (ANAU) was the first established in Armenia in 1981, and it holds the largest collection in the country. In addition to the 2,313 registered accessions, it claims to have about 5,500 samples, covering CWRs (80% of the accessions) and grasses, as well as farmers' varieties of cereals. Due to the lack of adequate storage facilities, only 303 accessions are currently maintained under medium- and long-term conditions (Armenian Country Report 2020). The laboratory's aim is to study the genetic resources of Armenia and to produce an inventory of Armenia's genetic resources in the European Search Catalogue for Plant Genetic Resources (EURISCO). The primary purpose of the laboratory is to the study genes of CWRs,

[14] The interviews with the gene bank managers were conducted 21–24 October 2019.The fifth institution registered in Genesys is the Scientific Center of Agriculture and has only 12 accessions.
[15] Sources: FAO WIEWS and Genesys; https://www.genesys-pgr.org/geo/ARM

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whereas the secondary purpose is to analyse these resources and determine how they can survive in different environments. The ambition is to use the genetic potential of CWRs to adapt cereal varieties to the effects of climate change. As a result, new varieties with genetic traits from CWRs have been registered and are now marketed in Armenia.

The Institute of Botany is the only gene bank working solely on wild flora, including CWRs and wild food plants in Armenia. It has produced several volumes about the flora of Armenia, and the latest was published in 2010. The gene bank at the institute was established in 2011. Its aim is to collect seeds of all plants in Armenia. At present, the seed collection includes 2,464 accessions maintained under long-term conditions, of which about 1,200 accessions are PGRFA (Armenian Country Report 2020). The institute assists agricultural experts in identifying the taxonomy of plants.

The Scientific Centre of Agrobiotechnology was established in 2005 under the auspices of ANAU and is mainly concerned with collecting accessions of crop varieties and CWRs along with their regeneration, description, evaluation and documentation. The gene bank also maintains an *in vitro* collection of crop accessions with recalcitrant seeds, totalling 120 accessions of different crops, including 70 potato accessions (Armenian Country Report 2020). The gene bank is cooperating with a network of farmers to exchange seeds and propagate material, organise activities and participate in training. The centre has the primary responsibility in Armenia for information sharing on PGRFA. The gene bank has, according to managers, more than 2,600 accessions under long-term storage (Armenian Country Report 2020), although the number registered in Genesys is significantly lower.

The Scientific Center of Vegetables and Industrial Crops has as its main responsibility the storage, breeding and distribution of vegetable seeds for commercial farming. The number of accessions has increased for each subsequent year, but one challenge highlighted by the managers of this gene bank is that although the database of seed accessions is properly developed, this gene bank and Armenia lack a proper management system for conserved seeds. The center was established in 2006, and its director is Armenia's focal point for the implementation of the ITPGRFA. The seed collection contains 3,800 accessions of vegetable crops, but only 805 are stored under medium- and long-term conditions (Armenian Country Report 2020). The gene bank maintains a medium- and long-term collection and is only involved in *ex situ* conservation.

In addition, some other collections exist. These are at the Gyumri Breeding Station, which was established in 1999, but has roots as far back as 1924 (Ministry of Agriculture of the Republic of Armenia, 2020). Here, 60 out of 806 accessions are stored for long-term conservation, whereas the remaining accessions are stored at room conditions and serve as initial material for breeding (Armenian Country Report 2020). These accessions are mainly of field and fodder crops (Ministry of Agriculture of the Republic of Armenia, 2020). A field collection of apricot was created in 2011 within the frames of the FAO project on Apricot Genetic Resources Conservation and Utilization, and includes 82 local varieties, out of which 73 are traditional farmers' varieties (Armenian Country Report 2020, p. 22). Finally, a vineyard collection was established in 2016 within the framework of the FAO project on Grape Genetic Resources Conservation and Sustainable Use, which contains around 300 varieties collected from all regions of Armenia (Armenian Country Report 2020).

What all the four gene banks have in common is that their accessions are in the public domain and under the control of the authorities, and that they cater for the *ex situ* conservation of crops listed in Annex 1 of the ITPGRFA, which are thus covered by the provisions of the ITPGRFA on a Multilateral

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System of Access and Benefit Sharing (MLS). They also cater for crops that are not on the Annex 1 lists, and thus outside the MLS. This non-Annex 1 material would normally sort under the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the CBD. Since Armenia has not ratified the Nagoya Protocol, however, the country has no obligations in this regard. Armenia officially placed 1,640 accessions in the MLS on 6 November 2011.[16] According to our interviewees, the Standard Material Transfer Agreement (SMTA) of the MLS is, as a rule, used in cases of germplasm requests from seed collections in countries that are parties to the ITPGRFA. There have also been cases where the SMTA was applied for joint seed collecting missions from the wild. However, what type of agreement is used depends on the country from which the request comes. In the case of Russia, which is not a contracting party to the ITPGRFA, a memorandum of understanding is used, which specifies that the accessed germplasm is used only for research purposes. Until now, the SMTA was used for crops listed in Annex 1 to the ITPGRFA, but the Armenian gene banks plan to apply the SMTA also for non-Annex 1 plants as well in the future.

Common challenges for Armenian gene banks

The main challenge that several of the gene banks have with their collections is the lack of proper storage facilities and equipment, so that the seeds in the collections can be conserved for a longer period without regeneration. For instance, at the Research Centre of Plants Gene Pool and Breeding, many of the samples are only working samples for short-time conservation. The refrigerators and freezers at the various gene banks are often very old, and two of the gene banks in particular have limited capacity to store seeds properly. One of the gene banks is located in dilapidated buildings that are hardly suitable for proper *ex situ* conservation. In addition, there were no measures in place to counter the likely and possible risk of power outages at several of the gene banks.

The lack of sufficient governmental core funding means that opportunities to invest in necessary equipment are limited. Largely relying on foreign sources of financial support for such investments means that PGRFA management is project-based in terms of funding. This lack of sufficient core funding concerns all four gene banks. For the purposes of acquiring necessary technical equipment, attending trainings and, in effect being able to analyse genetic properties with up-to-date techniques, all gene banks rely heavily on foreign project funding. This is in line with Ishkaninan's finding regarding civil society in Armenia, that project-based support has 'turned democracy into a project and civil society into NGOs' (Ishkanian 2008), as government institutions rely on the same international project logic much in the same way as NGOs. In other words, the gene banks are not sufficiently funded by the government to perform their tasks. In some years, Armenia did not pay membership fees to the two CGIAR centres, The Alliance of Bioversity International and the International Centre for Tropical Agriculture (CIAT), and ICARDA, thereby further reducing the possibilities for the gene banks to cooperate internationally.

The Alliance of Bioversity International and CIAT host the European Cooperative Programme for Plan Genetic Resources. According to a key interviewee in Armenia, the European Cooperative Programme for Plant Genetic Resources (ECPGR) is the most effective network in which Armenia has participated. Targeted at the effective *ex situ* and *in situ* conservation of PGRFA, the ECPGR has

[16] See the ITPGRFA website of the ITPGRFA: Material available under the Multilateral System at http://www.fao.org/plant-treaty/areas-of-work/the-multilateral-system/collections/en/?page=3&ipp=12&no_cache=1&tx_dynalist_pi1[par]=YToxOntzOjE6IkwiO3M6MToiMCI7fQ==

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provided numerous trainings in the different areas of PGRFA management, promoted information sharing and established strong links amongst network members. Armenia benefited substantially from participating in the ECPGR, not the least of which has been the training of many specialists. For many accessions, characterisation and evaluation data were obtained, based on unified standards, and mechanisms were developed for effective utilisation of the conserved germplasm. Also, researchers had the opportunity to share results of their research works with colleagues through participation in thematic group meetings and international conferences. Since 2014, however, Armenia was excluded from the ECPGR because the country had repeatedly failed to pay the membership fee. Since then, Armenia has not participated in the networks' activities. Findings from our interviews largely correspond with Armenia's own reporting to The Second Global Plan of Actions' monitoring framework, which was in turn monitored by the FAO Commission on Genetic Resources for Food and Agriculture. According to this dataset, *in situ* conservation and sustainable use of PGRFA through distribution of landraces and farmer's varieties/landraces are very limited, while *ex situ* accessions are also at risk due to poor storage facilities and the fact that gene banks are not able to sufficiently regenerate their accessions (FAO 2017). However, Armenia's gene banks receive a high score for identifying gaps in collections and for organising targeted collecting missions. Nevertheless, national policies for sustainable use are insufficient and Armenia's capacity is weak, as measures for monitoring and safeguarding of genetic diversity are all but absent, and there is no documentation of farmers' varieties that are cultivated on-farm (FAO 2017). Another challenge identified is that there are no statistics on the exchange of genetic material in Armenia. Had these been in place, it would have provided important data on the use of different varieties.

The extent to which the gene banks are in direct contact with farmers varies and largely relies on their different scope as well as capacity to produce seeds that can be sold or distributed amongst farmers. Although a number of state-funded institutions take part in the management of seeds in Armenia, these institutions have limited capacity and often lack resources to buy essential equipment necessary to test and store seeds properly.

Civil society organisations involved in PGRFA management

Whereas a range of organisations are involved in agricultural development in Armenia, only a few are engaged in the management of PGRFA. NGOs may play an intermediary role between the national gene banks and farmers, and the most important organisations with regard to PGRFA are Green Lane NGO and Shen NGO.

Green Lane was established in 2004 as a membership organisation and has 500 individual and several institutional members and nine full-time employees as of 2019.[17] The organisation is aimed at promoting sustainable agriculture and improving the socio-economic conditions of target communities. This is done through advisory and educational measures and by promoting investment projects. As of 2019, the organisation had implemented 100 projects, reaching out to more than 7,000 beneficiaries, according to their own records. As part of its activities, Green Lane selects and collects, stores, regenerates and distributes seeds of a wide diversity of traditional crops to farmers and gardeners in Armenia. Green Lane also runs the Green Training Centre at Dzoraghbyur, which was established in 2015. The centre has a model farm where a selection of the plants is grown, seeds

[17] Based on an interview with the Executive Director of Green Lane, Nune Sarukhanyan, at the headquarters of Green Lane in Yerevan and at a visit to the Green Training Centre, both on 23 October 2019.

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are selected and sustainable agricultural methods are explored and exhibited. The Green Training Centre is privately owned by the founder of Green Lane and offers training primarily for farmers. Green Lane is committed to promoting the diversity of PGRFA, but struggles with a shortage of funding, thus limiting its capacity to regenerate stored seeds, multiply the seeds for distribution and to store them under optimal conditions. This is a serious constraint to their contribution to PGRFA management in Armenia.

The Shen NGO is aimed at promoting socio-economic development and empowerment of remote, vulnerable rural communities through the active involvement of community members. It was established in 1988 by teachers and students from Yerevan Polytechnic Institute to help solve some urgent humanitarian challenges in Armenia at that time. Since then, Shen has been involved in more than 350 rural communities in Armenia, with participatory rural development measures to alleviate poverty.[18] Shen organises the seed production of local varieties and collaborates closely with public gene banks. It receives seed samples and seedlings, in particular from the gene bank in Darakert, and organises multiplication for distribution amongst farmers. Shen recommends that farmers use local varieties, as it argues that these are better adapted and adaptable to local conditions. Shen is involved in teaching farmers how to cultivate and grow their own seeds. According to Shen, farmers are highly interested in local varieties for home consumption, whereas some of the produce is sold in local markets. According to Shen, the most critical factor is that the gene bank in Darakert is not able to meet the demand from farmers organised through Shen. Another challenge is that farmers have poor machinery for seed harvesting, and as a result, about 25% of the seeds are estimated to be lost.

The above-mentioned organisations are mostly involved in practical and community-oriented work, such as capacity building and seed distribution amongst farmers, rather than being involved in advocating policy changes in Armenia. So, while Armenian civil society is arguably diverse and has its share of environmental organisations (Ishkanian 2008; Ishkanian et al. 2013; Skedsmo 2019), this case study finds that few organisations, if any, are occupied with PGRFA policies and advocacy.

State of PGRFA governance in Armenia: summary of empirical findings

Armenia has clearly concentrated its efforts related to PGRFA management on *ex situ* conservation. Despite limited resources and largely project-based activities, it has been possible to collect and store much of the country's genetic diversity for food and agriculture under *ex situ* conditions. These achievements can largely be attributed to the high competence and profound commitment of individual leaders and scientists at the different gene banks and their ability to attract project funding from abroad, as political support from the government has been limited. The technical infrastructure of the institutions in question reveals that facilities for long-term *ex situ* storage are nevertheless very modest and that there is a lack of sufficient equipment to analyse the varieties' genetic properties. Thus, the norms established by the FAO for *ex situ* conservation through the ITPGRFA, the Second Global Plan of Action and the FAO gene bank standards are far from being followed. Due to capacity limitations, there are huge backlogs of seed samples in need of regeneration. The situation is not sustainable, as *ex situ* conservation is basically a long-term

[18] Based on an interview with the Director of Shen, Hayk Minasian, and the Coordinator of Agriculture Projects, Nvard Shahmuradyan, at the headquarters of Shen in Yerevan 25 October 2019.

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endeavour and requires long-term financial commitment. Thus, much of the short-term stored material is endangered.

Over the past years, some gene banks have established contacts with farmers and provided facilitated access to the gene bank material. As a result of increasing demand from farmers, gene banks have succeeded in improving the availability of diverse suitable seeds for local use. The Center for Vegetable Crops in Darakert has been particularly successful in this regard. Enabling access to suitable seeds from gene banks to such an extent is a great achievement and contribution to promoting the sustainable use of PGRFA in Armenia. Again, this achievement is not because of political support, but rather despite such support. Indeed, as this study has shown, the legislation provides barriers to the distribution of seeds from varieties that are not registered in the official list of plant varieties. At the same time, these unregistered varieties constitute the main bulk of varieties stored in the national gene banks, i. e. the plant genetic heritage of Armenia. It is a paradox that the distribution of seeds from these gene banks for growing in farmers' fields, though so important for sustainable use of PGRFA as set out in the ITPGRFA to which Armenia is bound, is not coherent with present legislation. The activities of the gene banks to promote the on-farm conservation and sustainable use of PGRFA despite this inconducive legislation can essentially be attributed to committed individuals at the gene banks taking responsibility for the country's compliance with the ITPGRFA.

It follows that there is no political support from the Government of Armenia targeting on-farm conservation and sustainable use of PGRFA. Indeed, due to the legislation prohibiting the distribution of varieties that are not listed in the official list of plant varieties, and the fact that there is no legal space for the distribution of seed and propagating material of other varieties, the legislation is hampering the implementation of the ITPGRFA, in essence making important activities necessary for the conservation and sustainable use of PGRFA, as set out in the ITPGRFA, illegal. Despite the fact that FAO and national experts in Armenia have developed a draft strategy and action plan on PGRFA conservation and sustainable use, Armenia still lacks such a policy.

What then are the effects in practice? Our knowledge about that is limited, as statistical data are lacking. According to our interviewees, some, probably few, farmers still maintain local varieties that are not listed in the official list of plant varieties in Armenia, despite prohibitive legislation, probably because the legislation is not well known and since enforcement of such legislation is a general challenge in Armenia. Such practices are probably most usual for vegetables, fruits and berries. Also, farmers continue to some extent to save seeds of protected varieties, including field crops, and use and exchange them between and amongst each other, and this is particularly widespread regarding cereals. Most farmers are simply not aware of the legislation, and thus on-farm conservation and sustainable use are continuing at a very limited scale despite obstructive legislation.

As for CWRs and wild edible plants, the legislation is favourable for their conservation and sustainable use. Nevertheless, natural habitats of CWRs and wild edible plants are being destroyed at a rapid rate, despite protective environmental legislation, due to mining, road construction, other changes in land use and untimely harvesting.

Even though farmers may access seeds from national gene banks, their opportunities to grow and utilise these resources for commercial activities or other benefit-generating activities are severely limited. It is hardly possible to organise the multiplication and further use of the rich genetic heritage

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of Armenia under the current legislation. Farmers thus have very limited access to genetic resources and even less to their utilisation.

Armenia is eligible to apply for funding from the Benefit-sharing Fund under the MLS and has, according to our interviewees, applied three times, however, without success. Such funding is aimed at supporting farmers who conserve and sustainably use crop genetic diversity, directly and indirectly.

Armenia has not been represented in the sessions of the Governing Body of the ITPGRFA since 2011.[19] This is another indication of the low priority that genetic resources for food and agriculture have in Armenia, further underscoring the limited attention paid to the rich but dwindling genetic resources of the country. There is every reason to believe that genetic erosion is continuing at a fast pace, particularly *in situ* and on-farm, but also *ex situ*, in the poorly equipped gene banks with their substantial backlogs of samples that should have been regenerated. There is little attention given to this issue from the government, and at the same time breeding companies from abroad are increasingly taking over higher shares of the Armenian seed market, to the detriment of domestic varieties. The situation is critical, and action is urgently required to save Armenia's crop genetic heritage.

Explanatory approaches: a discussion

As mentioned above, there may be several 'bottlenecks' (Kell et al. 2017) of PGRFA use, constraints and needs. It is found that Armenia lacks a supporting policy, that its institutions lack financial and infrastructural capacity and that there is limited capacity to provide access to crop genetic resources. Armenia's trajectory of being part of the Soviet command economy, its post-Soviet crisis and collapse and the present fragility of Armenia's political and economic situation are all contributing factors partly explaining this. In its final years of existence, the Soviet Union was characterised by an economy of shortage, while the Armenian Socialist Soviet Republic also experienced rising nationalism and tension over the status of Nagorno Karabakh in neighbouring Socialist Soviet Republic of Azerbaijan as well as the 1988 earthquake in Spitak, all but ensuring that Armenia's economy was significantly weakened. The first post-Soviet years were traumatic for the Armenian population, with Armenia involved in fully fledged warfare over the Armenian-dominated Nagorno Karabakh and the ensuing 1993 blockade by Azerbaijan and Turkey, hindering the direct import of most goods to Armenia (Skedsmo 2019). The blockade is still in place. With the virtual collapse in state institutional capacity after the disintegration of the Soviet Union and the fact that Armenia, in effect, was a war economy, attention towards seed management dwindled.

The temporal trajectory of Soviet stagnation and shortage, post-independence chaos and crisis led to a period of consolidation and normalisation of the situation in Armenia. From the late nineties, the economic situation in Armenia improved, and this was when Armenia ratified several relevant multilateral environmental agreements. In 2007, Armenia also ratified the ITPGRFA, and three of the

[19] Armen Harutyunyan, then Adviser to the Minister of Agriculture, Ministry of Agriculture of Armenia, participated at the 5th Session of the Governing Body of the ITPGRFA in Oman in 2013. Prior to that, Alvina Avagyan, in different positions under the Ministry of Agriculture of Armenia, participated at all the sessions of the Governing Body except for the first. Source: Reports from all the sessions of the Governing Body available at the ITPGRFA website: http://www.fao.org/plant-treaty/meetings/en/

gene banks were established in the first decade after the millennium. Additional factors that can partly explain the ongoing lack of political support are the urgency of the above-mentioned challenges in Armenia, that international obligations are not necessarily seen as relevant for Armenia and that reorganisation and high turnover in the relevant ministries after the change in political leadership in 2018 may have affected the ability to govern this important area. A way of understanding the situation in Armenia in this period and onwards is that the aid-dependent national gene banks constitute a national and international network of professionals and institutions. This network might be viewed as a system of a specific sort, as an *assemblage:* a configuration through which various forms of techno-science, economic rationalism and other expert systems gain significance (Collier 2006). Seen this way, the governance of crop genetics in Armenia can be understood both in terms of its domestic relations and as being part of a global network of institutions and funding opportunities as well as multilateral agreements that are both of a practical and normative character. The study finds that institutional cooperation between the gene banks is limited, but on the other hand, the community of professionals in Armenia involved with management of crop diversity is relatively small, and the gene bank managers are all well aware of each other and cooperate to some extent on an *ad hoc* basis. In addition, as they to various degrees take part in international professional networks through project cooperation, for instance with Kew Gardens, and as focal point to the ITPGRFA, they are part of a competent international network.

Governments around the world attempt to control the flow and exchange of seeds (Müller 2014), and Armenia is no exception with its prohibition of exchange of unregistered varieties. This recent legal and political transformation of seed exchange leads to a reconfiguration of social and historical identities, as well as bureaucratic and economic categorisation of seeds (Müller 2014). As seeds have travelled through time and across regions, they are perceived as local in a diverse range of locations, encouraged by the Soviet movement of seeds (Aistara 2014). We also see in our data how meaning, memories and emotion are ascribed to seeds and agricultural products for farmers and consumers: varieties no longer provided for in the market are vividly remembered. While national legislation in Armenia prohibits informal exchange, and in a country where residents were accustomed to the informal Soviet barter economy and where most farmers run small-scale family farms, it should probably be expected that informal exchange of seeds is quite extensive regardless. The finding that several of our interviewees expect farmers to have little awareness of the prohibition of seed exchange, combined with a lack of enforcement, may corroborate this assumption. Further research is needed to identify with more certainty how such informal exchange affects agrobiodiversity in Armenia and may in fact strengthen agrobiodiversity despite unfavourable policies and legislation.

Relevance of the findings for other countries

Halting genetic erosion in the Armenian agrobiodiversity hotspot is of great importance to maintain agriculture's ability to respond to climate change and other environmental challenges. Our findings from Armenia with regard to lacking political attention and support as well as obstructive legislation are alarming and even more so if similar situations are to be found in several of the other post-Soviet countries. Further research directed at strengthening the conservation and sustainable use of this diversity and seed security is urgently needed. Within the post-Soviet area, several countries have undergone the same socio-economic, political and cultural changes and upheaval as Armenia. At the same time, several of these countries report similar challenges regarding PGRFA as Armenia, whether

that involves a loss of agricultural biodiversity as in Azerbaijan (Ministry of Agriculture of Azerbaijan 2006), Kyrgyzstan (Dzunusova 2008,) and Tajikistan (Muminjanov 2008) or that utilisation of local varieties is low, such as in Georgia (Bedoshvili 2008). In terms of institutional change and capacities, it is considered that the findings of this study of Armenia is of relevance also for the wider post-Soviet area that has faced similar challenges over the past 30 years. In addition, findings from Armenia may have relevance for countries outside the post-Soviet area. As has been argued, the post-Soviet states – and especially the republics receiving large amounts of official development aid per capita, such as Armenia – share some characteristics usually attributed to post-colonial and developing countries (Skedsmo 2019). In order to interpret and explain the situation in Armenia, issues such as policy coherence, aid dependency and logic of project funding, which the gene banks in Armenia rely on, are also relevant in the Global South.

In general, more political attention and policy coherence in line with the country's commitments to the ITPGRFA are required to solve the challenges at hand. The short-sighted logic of project funding is not adequate to the needs of countries such as Armenia to ensure the conservation and sustainable use of PGRFA. In the absence of sufficient domestic support, development cooperation agencies are faced with the demanding task of transforming their assistance into well-targeted long-time commitments.

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Availability of data and material (data transparency): All interviews have been transcribed, and the records are kept by the FNI in accordance with the FNI data management procedures.

Code availability: Not applicable.

Authors' contributions: Both authors contributed to the study conception and design, data collection and analysis. Pål Wilter Skedsmo organised the field trip to Armenia, provided country-specific knowledge on Armenia, drafted parts of the first version of this manuscript, wrote the description and analysis of Armenian gene banks and the discussion of explanatory approaches. Regine Andersen developed the interview guideline, took the lead in conducting interviews, transcribed the interviews, developed the first outline and provided most of the information related to PGRFA, as well as analysing Armenian legislation and the sustainable use of PGRFA in relation to Armenia's international commitments. Nevertheless, both authors contributed to all parts of the manuscript and co-authored the parts that are not mentioned above. Both authors read and approved the final manuscript.

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