

GenRes Bridge

Genetic resources for a food-secure
and forested Europe



GENETIC RESOURCES STRATEGY FOR EUROPE



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817580

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The GenRes Bridge project (2019–2021) is a Coordination and Support Action funded under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 817580.

The European Cooperative Programme for Plant Genetic Resources (ECPGR – www.ecpgr.cgiar.org) is a collaborative programme among most European countries aimed at contributing to rationally and effectively conserve *ex situ* and *in situ* Plant Genetic Resources for Food and Agriculture, provide access and increase sustainable use. The Programme, which is entirely financed by the member countries, is overseen by a Steering Committee composed of National Coordinators nominated by the participating countries. The Coordinating Secretariat is hosted by The Alliance of Bioversity International and CIAT.

The European Regional Focal Point for Animal Genetic Resources (ERFP – www.animalgeneticresources.net) is the regional platform to support the *in situ* (on-farm) and *ex situ* conservation and sustainable use of animal genetic resources (AnGR) and to facilitate the implementation of FAO's Global Plan of Action for AnGR. Since 2001, ERFP has facilitated collaboration, coordination of work, and exchange of information and experience between different European countries and governmental and non-governmental organizations.

The European Forest Genetic Resources Programme (EUFORGEN – www.euforgen.org) is an instrument based on international cooperation which promotes the conservation and appropriate use of forest genetic resources in Europe. It was established in 1994 to implement Forest Europe Resolution S2. EUFORGEN contributes to the implementation of regional-level strategic priorities of the FAO Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources.

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Citation: GenRes Bridge Project Consortium, ECPGR, ERFP and EUFORGEN. 2021. *Genetic Resources Strategy for Europe*. European Forest Institute.

Layout: Maria Cappadozzi

ISBN 978-952-7426-45-6 (print)

ISBN 978-952-7426-44-9 (PDF)

This publication has been printed using certified paper and processes so as to ensure minimal environmental impact and to promote sustainable forest management.

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Foreword

This Strategy has arisen from GenRes Bridge, a Horizon 2020 project selected under the call topic “Joining forces for GenRes and biodiversity management”. The topic aimed at boosting capacities for more effective management and use of genetic resources as a basis for food and nutrition security in Europe and beyond.

As the project’s policy officer, I am honoured to have been closely linked to the work of GenRes Bridge and to witness the partners establishing such an innovative cooperation that has transcended the traditional separation between crop, forest and animal genetic resources. This “enlarged family” of genetic resources networks (ECPGR, ERFP and EUFORGEN)¹ has been highly effective in sharing its experiences and inspiring members to harmonise data, further develop standards and improve services for effective *in situ* and *ex situ* conservation in each of the respective domains.

Above all, GenRes Bridge partners have succeeded in developing a common vision of managing genetic resources in more coherent ways and embedding considerations on genetic resources more firmly in policies and practices for sustainable agriculture and forestry. The result of this vision is this *Genetic Resources Strategy for Europe*.

The Strategy is very timely, as awareness on the importance of genetic resources is now well-reflected in EU policies—notably the Biodiversity Strategy for 2030, New EU Forest Strategy for 2030 and the Farm to Fork Strategy under the Green Deal. The particular merit of the *Genetic Resources Strategy for Europe* lies in its translation of policy objectives and needs raised by stakeholders into concrete recommendations and actions at national, European and global levels. It complements existing, individual strategies for managing crop, forest and animal genetic resources and provides an integrated framework for promoting agro- and forest biodiversity. This is a novelty in itself.

I would like to congratulate the partners of GenRes Bridge for pioneering new ways of working together, and thereby increasing the visibility of the genetic resources community overall. By joining forces and successfully exploiting synergies, they have shown that “the whole is more than the sum of its parts”.

¹ The European Cooperative Programme for Plant Genetic Resources (ECPGR), the European Regional Focal Point for Animal Genetic Resources (ERFP), and the European Forest Genetic Resources Programme (EUFORGEN).

Rather than being the final output of the Genres Bridge project, the present Strategy is meant to be a point of departure for increased cooperation between the various domains and institutions dealing with the conservation and sustainable use of genetic resources in Europe and beyond. I wish all partners continued success in this important endeavour!

A handwritten signature in black ink, reading "Annette Schneegans". The signature is written in a cursive style with a light grey background behind it.

Annette Schneegans

Senior Expert

European Commission

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Preamble

The *Genetic Resources Strategy for Europe* is a product of GenRes Bridge²—a coordination and support action funded under the EU Horizon 2020 Framework Programme, involving 17 partner organizations representing a wide range of actors in plant, animal and forest genetic resources conservation and sustainable use in Europe and neighbouring countries. Central to the project has been a cooperation between the three European networks for plant, animal and forest genetic resources, ECPGR³, ERFP⁴ and EUFORGEN⁵, to identify synergies and joint actions to enhance the efficiency and effectiveness of genetic resources conservation and sustainable use activities in the region. The *Genetic Resources Strategy for Europe* is a key outcome of this collaboration and answers the European Commission's call to “provide a framework in which the existing mosaic of European, national/regional structures can join forces to develop and implement ambitious approaches and strategies for the management of crop, forest and animal GenRes.”

The *Genetic Resources Strategy for Europe* is an overarching, integrated strategy with a focus on plant, animal and forest genetic resources. Complementary to this, ‘domain-specific’ strategies^{6,7} address more concrete aspects of genetic resources conservation and sustainable use which are particular to each domain. The *Genetic Resources Strategy for Europe* and the domain-specific strategies should be seen as a suite of policy documents that together provide the framework for enabling the transition to effective genetic resources conservation and sustainable use in the region.

The *Genetic Resources Strategy for Europe* has been developed over 30 months using a robust participatory and iterative approach involving the full array of stakeholders in genetic resources conservation, sustainable use and policy development. Geographically, participation has included stakeholders from the EU Member States, other European countries, and those recognized under the European Neighbourhood Policy⁸. Participation in this inclusive process has been via workshops, meetings, surveys and interviews, bolstered with webinars, newsletters, social media announcements and other communication tools.

² genresbridge.eu – This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817580.

³ European Cooperative Programme for Plant Genetic Resources – ecpgr.cgiar.org

⁴ European Regional Focal Point for Animal Genetic Resources – animalgeneticresources.net

⁵ European Forest Genetic Resources Programme – euforgen.org

⁶ Currently under development for plant, animal and forest genetic resources.

⁷ Domain-specific strategies for aquatic, invertebrate and microbial genetic resources should be developed to complement the *Genetic Resources Strategy for Europe* in the future.

⁸ https://ec.europa.eu/neighbourhood-enlargement/european-neighbourhood-policy_en

The *Genetic Resources Strategy for Europe* comprises five chapters and an annex: Chapter 1 provides the context of the Strategy and emphasizes the need for urgent action; Chapter 2 elaborates the focal areas for strengthening and widening actions for genetic resources conservation and sustainable use; Chapter 3 outlines the necessary elements for enabling transformative change; Chapter 4 underlines the imperative for reinforcing international cooperation; and Chapter 5 provides a short conclusion. Chapters 2, 3 and 4 each contain specific recommendations for achieving the transition to effective genetic resources conservation and sustainable use in the region, and the annex presents an Action Plan detailing the actions, indicators, indicative timescales and levels of action (national and/or European) to implement these recommendations.

The *Genetic Resources Strategy for Europe*, as validated by the three European genetic resources networks, ECPGR, ERFPG and EUFORGEN, is a tangible framework to achieve the step change needed to permanently secure and sustainably utilize genetic resources in Europe, as well as consolidating relationships with neighbouring countries to strengthen the resilience of agriculture and forestry in the region by more effective and efficient genetic resources conservation and use. Vitally, its implementation will increase Europe's capacity to meet its commitments under several international agreements—notably the UN Sustainable Development Goals, the Global Plans of Action of the FAO Commission on Genetic Resources for Food and Agriculture, the International Treaty on Plant Genetic Resources for Food and Agriculture, the Convention on Biological Diversity, and the Forest Europe process.

The *Genetic Resources Strategy for Europe* is an advanced policy document developed in the context of the GenRes Bridge project for consideration by national and regional governmental bodies, including the European Commission. Its full implementation is dependent on the commitment of all involved actors, including the national and regional policymakers who will guide and monitor its implementation and provide the financial, human and institutional resources required to fully execute the Action Plan.

Acknowledgements

The development and writing of the *Genetic Resources Strategy for Europe* was led by Shelagh Kell and Nigel Maxted (Task Leaders, UoB⁹), who drafted and edited the successive iterations of the document and coordinated the inputs from all involved stakeholders, including in meetings and workshops, by email and through shared documents, and via an online stakeholder survey. We gratefully acknowledge their thorough approach and careful consideration of the interests of the different stakeholders.

The first draft document was developed from a wide stakeholder consultation, culminating in the ‘Sharing Perspectives’ workshop in October 2019, in Tuusula, Finland. Seventy-four people from 57 stakeholder organizations, based in 21 European and 5 neighbourhood countries, contributed their expertise on a broad range of issues in plant, animal and forest genetic resources. The workshop formulated recommendations to guide the development of this Strategy, and we would like to thank all participants for devoting their time, knowledge and highly-informed perspectives to establish such a comprehensive basis for our work.

We would also like to thank Mari Rusanen and Egbert Beuker (Luke¹⁰) who prepared the ‘*Report on existing strategies and sustainable use of genetic resources for food, agriculture and forestry*’ that constituted the formal basis for the development of the Strategy.

During 2020 and 2021, five successive versions of the Strategy were developed, each iteration of which was opened for feedback and input by progressively larger groups of stakeholders. The consultations involved the EU-supported GenRes Bridge project partners; the Executive and Steering Committees of ECPGR¹¹; the General Assembly of ERFP¹²; the Steering Committee of EUFORGEN¹³; the GenRes Bridge External Advisory Board; and representatives of the European Commission. We are grateful to all of them for providing invaluable feedback, supporting the process, and ensuring consultations within their respective communities and countries.

A critical stage in the Strategy development process was the ‘stakeholder feedback workshop’ convened in November 2020, in which more than 100 stakeholders from 34 countries—including management practitioners, end-users and policymakers representing national and international organizations—participated in focus group discussions on the development of the recommendations underpinning the Strategy. We gratefully acknowledge

⁹ University of Birmingham, United Kingdom

¹⁰ Natural Resources Institute, Finland

¹¹ European Cooperative Programme for Plant Genetic Resources – ecpgr.cgiar.org

¹² European Regional Focal Point for Animal Genetic Resources – animalgeneticresources.net

¹³ European Forest Genetic Resources Programme – euforgen.org

Acknowledgements

the vital contributions received from all the workshop participants. We are also grateful for the important feedback and input of the more than 70 stakeholders who took the time to respond to an online consultation carried out in March and April 2021.

We are especially grateful to those who collaborated in the numerous meetings and email discussions of an *ad hoc* Strategy development task force, which during 2021 worked tirelessly on refining the draft Strategy and developing the Action Plan, ensuring that the perspectives of the plant, animal and forest genetic resources communities were properly reflected. Besides the above acknowledged Task Leaders and the below signatories, this task force involved Marianne Lefort and Frank Begemann (ECPGR); Sipke-Joost Hiemstra, Danijela Bojkovski and Montserrat Castellanos Moncho (ERFP); François Lefèvre and Mari Rusanen (EUFORGEN); and Imke Thormann (Work Package Leader, BLE¹⁴) and Karina Klein (BLE).

Finally, we are grateful to the European Union's Horizon 2020 Research and Innovation Programme, which supported this project under Grant Agreement No 817580. In particular, we thank Annette Schneegans from the European Commission's Directorate General for Agriculture and Rural Development, our policy officer, who supported the implementation of the project and the development of this Strategy.



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List of commonly used acronyms

ABS	Access and benefit-sharing
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CGRFA	Commission on Genetic Resources for Food and Agriculture
EC	European Commission
ECPGR	European Cooperative Programme for Plant Genetic Resources
EFABIS	European Farm Animal Biodiversity Information System
ENP	European Neighbourhood Policy
ERFP	European Regional Focal Point for Animal Genetic Resources
EU	European Union
EUFGIS	European Information System on Forest Genetic Resources
EUFORGEN	European Forest Genetic Resources Programme
EURISCO	European Search Catalogue for Plant Genetic Resources
FAIR	Findable, accessible, interoperable and reusable
FAO	Food and Agriculture Organization
GPA	Global Plan of Action
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IUCN	International Union for the Conservation of Nature
MLS	Multilateral System of Access and Benefit-sharing
SDGs	Sustainable Development Goals
UN	United Nations

GENETIC RESOURCES

– THE NEED FOR URGENT ACTION

Genetic resources^{15,16} are part of the world’s vast biodiversity and **the raw materials on which humankind relies** for food, nutrition and livelihood security, and to support the bioeconomy. They include domesticated and related wild species of plants, animals, forest trees, fungi, invertebrates, and microorganisms, and the genetic diversity within them—including cultivars, breeds, populations, individuals and genes. The vast range of traits expressed in genetic resources, and their adaptive capacity, are **essential for enhancing the resilience** of agricultural production systems¹⁷ and forests, as well as for supporting advancements towards innovative, efficient agro-food systems and other bio-based value chains. Genetic resources are therefore **a key form of natural capital needed for stability and adaptability in agriculture and forestry, and for a sustainable bioeconomy** [1,2].

However, current global **trends in erosion of genetic resources and loss of genetic diversity** [3,4,5,6,7] due to a range of threats driven by social, economic and environmental factors, are not only increasing the vulnerability of agriculture and forestry to the impacts of climate change, but also reducing options for the future. Threats to genetic resources are wide-ranging, but major causal factors include land use conversion for agriculture and development, changes in markets and production systems leading to substitution of local breeds and varieties, rural–urban migration, overexploitation of natural resources, intensive farming, pollution, invasive species, and climate change. European genetic resources are not immune to these threats and genetic diversity loss. For example, at least 11% of wild relatives of food and fodder crops of significant economic importance are threatened with extinction, and a further 5% are likely to become threatened in the near future [8]. Loss of genetic diversity in the wild relatives of beet, brassicas, lettuce, wheat and alliums are of particular concern [9]. In the European and Caucasus region, 50% of mammalian livestock breeds and 42% of avian breeds are classified as ‘at risk’, and in the same region, 353 mammalian and 130 avian breeds have become extinct since 2000 [10].

¹⁵ “Genetic material of actual or potential value” – cbd.int/convention/articles/?a=cbd-02

¹⁶ fao.org/genetic-resources

¹⁷ In the context of this strategy, horticulture and livestock production are regarded as elements of agriculture.

Despite the alarming loss of genetic resources, and their **significant economic value** for many sectors (as highlighted in the EU Biodiversity Strategy for 2030 [11]), they remain of **low visibility at the European policy level**. Critically, the legal framework, infrastructure and funding for genetic resources conservation and sustainable use in Europe are insufficient to fulfil the region's commitments under: the Global Plans of Action (GPAs) for plant, animal and forest genetic resources of the FAO Commission on Genetic Resources for Food and Agriculture (CGRFA) [12,13,14]; the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)¹⁸; the United Nations Strategic Plan for Forests 2017–2030¹⁹ and Resolution S2 of the Forest Europe Ministerial process²⁰; the Convention on Biological Diversity (CBD)²¹; and the 2030 Agenda for Sustainable Development and Sustainable Development Goals (SDGs)²².

A step change is needed to afford higher priority to genetic resources conservation and sustainable use in Europe. This change is needed to contribute to the transition towards more sustainable and resilient agricultural production systems and forests; safeguard options to respond and adapt to the future impacts of global change; provide a secure basis for diverse and nutritious diets; respond to consumer demands for quality, diverse, and ethically produced food and non-food products; support a sustainable and circular bioeconomy; and meet the region's goals of upholding high standards of excellence, health and welfare in our food systems, while reducing our environmental and climate footprint.

To achieve this change, we need to **sustain and expand genetic resources conservation** and **increase and diversify genetic resources utilization**. Realising these goals demands intensified genetic resources **characterization**, improved genetic resources **monitoring**, and advancements in **documentation and information management**. Critically, to enable transformative change, we need to establish an appropriate **policy and legal framework**, increase **institutional and human capacity**, intensify **collaboration between actors and domains**, enhance **communications and awareness** of the roles and values of genetic resources, and **mobilize funds** to support and enhance their conservation and sustainable use.

¹⁸ fao.org/plant-treaty/en

¹⁹ un.org/esa/forests/documents/un-strategic-plan-for-forests-2030/index.html

²⁰ foresteurope.org/docs/MC/strasbourg_resolution_s2.pdf

²¹ cbd.int

²² sdgs.un.org/2030agenda

This genetic resources conservation and sustainable use strategy and action plan for Europe, complemented by the domain-specific strategies, provides the framework to meet these aims.

The *Genetic Resources Strategy for Europe* is pan-European in scope and **complementary to policies of the European Green Deal**—notably, the EU Biodiversity Strategy for 2030, the Farm to Fork strategy [15], the Climate Action policies²³, the Common Agricultural Policy (CAP)²⁴, and the New EU Forest Strategy for 2030 [16]. It also complements a number of other regulations and instruments that directly or indirectly affect genetic resources conservation and sustainable use in Europe, such as those related to animal breeding and seed marketing. The fundamental role of genetic resources for sustainable and resilient agriculture and forestry, and for food and nutrition security—particularly in the face of climate change—also places them at the centre of **Europe’s ambition to become climate neutral and fully adapted to the impacts of climate change by 2050**, including through the transition to a sustainable, clean, circular economy. Therefore, **the EU institutions and bodies will play an important role in contributing to the realisation and promotion of this strategy throughout Europe and globally.**

The implementation of the *Genetic Resources Strategy for Europe* will minimize the loss of genetic resources, support diversification and innovation, and build resilience in agriculture and forestry. It will enable adaptation to changes in climate, production systems and consumer preferences, and ensure that these vital resources are available for future generations—not only in Europe and neighbouring countries, but in other regions with which we are co-dependent on genetic resources. **Ensuring the conservation and sustainable use of genetic resources is a worldwide issue and Europe can play a leading role in setting global standards with this strategy.**

²³ ec.europa.eu/clima/policies/eu-climate-action_en

²⁴ ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en

STRENGTHENING AND WIDENING ACTIONS FOR GENETIC RESOURCES CONSERVATION AND SUSTAINABLE USE

2.1 Sustaining and expanding genetic resources conservation

Genetic resources—which may be of domesticated or wild origin—occur in a range of managed and unmanaged landscapes, ecosystems and habitats, including farmland and forests, wetlands and woodlands, urban areas and water bodies. Conservation of genetic resources requires interventions to ensure the ecological or management processes necessary for the preservation of populations *in situ* (including on-farm), and to support the collection and management of population samples in dedicated *ex situ* facilities, such as plant and animal genebanks. These two complementary approaches to conserve genetic resources are anchored in the CBD, the FAO GPAs for plant, animal and forest genetic resources, the SDGs, and other relevant global, regional and national legislative and policy instruments.

Both conservation approaches have an important role to play in maintaining genetic resources, although the emphasis and interplay between them varies between domains. *Ex situ* conservation has played a central role in plant genetic resources conservation for almost a century, which has been vital to facilitate their use in crop improvement programmes. However, while crop varieties are maintained on-farm, systematic *in situ* conservation of both cultivated and wild plant genetic resources has only been promoted more recently [12,17,18]. In the case of animal genetic resources, the maintenance of live breeding populations *in situ* is vital to allow for co-evolution of populations with the prevailing production systems and environmental conditions. *Ex situ* approaches, involving *in vivo* and *in vitro* (cryopreservation) methods, play an important complementary role as an insurance for long-term conservation of genetic diversity, and to support *in situ* conservation and breeding programmes for breeds at risk. For forest genetic resources conservation, *in situ* management is essential to maintain long-lived tree species (as well as the organisms associated with them), and the adaptive capacity in their populations. *Ex situ* actions play an important but less prominent role—for example, to temporarily secure genetic material of threatened forest tree species as an insurance against losses *in situ*.

Despite the variation in approaches between domains, the imperative for *in situ* conservation to maintain the evolutionary potential of genetic resources is universal—particularly to sustain adaptive capacity for resilience to climate change. The requirement for expansive and well-managed *ex situ* collections is also essential to support breeding and development, as well as to provide safety backup for potential losses *in situ*. However, *in situ* actions have been insufficient, both for wild and domesticated populations [1, 7, 10] there are significant gaps in *ex situ* collections of genetic resources, both at species and genetic diversity levels [12, 13], and there is a wide disparity in the quality of genetic resources conservation management across Europe due to differing levels of institutional and human capacity. Therefore, escalating efforts to conserve genetic resources, both *in situ* and *ex situ* is urgently needed.

As a baseline for the development and implementation of strategies for complementary conservation of genetic resources in Europe, comprehensive inventories are required—however, they are missing or incomplete for some types of genetic resources, both at national and regional levels. Similarly, while several European countries have developed national strategies and action plans for genetic resources conservation, progress is inconsistent across the region. Therefore, a first critical step is to provide resources and the impetus to fill these gaps.

Building on the examples of AEGIS²⁵, EUGENA²⁶ and a pan-European network of Genetic Conservation Units for forest tree species [19], decentralized ‘European collections’ of plant, animal and forest genetic resources actively conserved *in situ* and *ex situ* should be established to optimize genetic diversity conservation. Such collections will aim to conserve representative samples of the most important and unique genetic resources throughout the region, and promote cost-sharing among countries. European collections will consist of existing population samples identified on the basis of agreed criteria, and conserved *in situ* and *ex situ* using integrated and complementary approaches and common management standards.

Critically, the implementation of genetic resources conservation strategies must be supported by all relevant actors, as well as by management practices that meet minimum quality standards. Actors include farmers, growers, foresters, protected area managers, breeders, biotechnologists, agricultural engineers, genetic resources technicians and professional staff, environment and biodiversity specialists, academics, policymakers,

²⁵ A European Genebank Integrated System – ecpgr.cgiar.org/aegis

²⁶ The European Genebank Network for Animal Genetic Resources – eugena-erfp.net/en

government agencies and ministries, professional organizations, commercial companies, botanic gardens and arboreta, local communities, NGOs, and civil society organizations. Involving the full range of stakeholders in planning and implementing genetic resources conservation strategies is vital for the true achievement of their objectives.

RECOMMENDATIONS

to sustain and expand genetic resources conservation

- 2.1.1 Prepare, make publicly accessible, and regularly update European inventories of plant, animal and forest genetic resources conserved *in situ* and *ex situ*.**
- 2.1.2 Prepare, update and implement national strategies and action plans for integrated and complementary *in situ* and *ex situ* conservation and sustainable use of plant, animal and forest genetic resources, engaging all relevant public and private stakeholders in the process.**
- 2.1.3 Establish European collections of plant, animal and forest genetic resources actively conserved *in situ* and *ex situ*, including the necessary conservation infrastructures.**
- 2.1.4 Develop and implement quality management systems for long-term *in situ* and *ex situ* conservation of plant, animal and forest genetic resources in all countries.**

2.2 Increasing and diversifying genetic resources utilization

Agriculture and forestry are highly vulnerable to the impacts of climate change—particularly the related increase in extreme or uncertain climatic events, such as drought, heatwaves, storms, floods, and frosts, as well as unexpected pest and disease outbreaks—impacts that may be aggravated by monocultures in intensive, large-scale and specialized systems, as well as cause the greatest losses in such systems. If we are to have robust and resilient agriculture and forestry, as well as meet consumer demands, adapt to market pressures, and maintain strong value chains and competitiveness, expanding the range of species and genetic diversity we use is imperative [20,21,22]. This means increasing and optimizing the use of genetic resources to enlarge the genetic base of crops, livestock, and forest reproductive material [2] through continued genetic improvement of existing populations, the

development of new cultivars, breeds or lines, and by increasing the number of species and genetic diversity used in agriculture and forestry. To achieve this, the availability of, and access to a broad range of genetic resources is essential.

Genetic resources conservation and utilization are inextricably linked because the use of genetic resources depends on their conservation, and at the same time can contribute to their conservation. For example, *ex situ* facilities such as national genebanks provide a vital service for researchers and breeders by maintaining and enabling access to genetic resources, while *in situ* conservation of local crop varieties and breeds is facilitated through their use by farmers—often with the involvement of breed societies or seed networks. In forestry, sustainable use and development of genetic resources involves actors engaged in forest management and planning, specific conservation actions, and breeding programmes. Increasing and diversifying genetic resources utilization therefore depends on sustaining and expanding their conservation, and *vice versa*. Furthermore, unlike many natural resources that are depleted with use, the utilization of genetic resources can enhance and diversify the genetic resources base. Pertinent in this regard are strategies to broaden the genetic base of plant breeding programmes [23] and to manage genetic diversity in animal breeding programmes, which is the core strategy to maintain a broad genetic base in the livestock sector [24].

Critically, to enable the use of the broad range of genetic diversity needed to sustain agriculture and forestry, strengthening genetic resources availability and accessibility across national borders is a prerequisite. In line with the CBD principle of the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, standardized regulatory frameworks to facilitate access to genetic resources and associated knowledge while respecting the rights of the providers, came into force under the Multilateral System of Access and Benefit-sharing (MLS)²⁷ of the ITPGRFA in 2004, and under the CBD's Nagoya Protocol²⁸ in 2014. The EU and most European countries are parties to these international agreements, and are therefore committed to facilitating access to genetic resources for research, breeding and development, while implementing relevant access and benefit-sharing (ABS) regulations²⁹.

²⁷ fao.org/plant-treaty/areas-of-work/the-multilateral-system/overview/en

²⁸ cbd.int/abs

²⁹ Regulation (EU) No 511/2014 of the European Parliament and of the Council of 16 April 2014 on compliance measures for users from the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization in the Union – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R0511

While good compliance with these regulations should be promoted, measures are needed to reduce the bureaucratic burden on managers of genetic resources collections and users, which can impede, rather than promote genetic resources use, and could discourage innovation. Important in this context are the ‘ABS Elements’ developed by the FAO CGRFA, which aim to support countries in the implementation of ABS regulations for the different genetic resources domains [25]. They recognize the requirement for simplicity and flexibility in the implementation of ABS measures and promote an evolutionary approach that allows improvement of the operation of the ABS system—for example, by streamlining administrative procedures and minimizing transaction costs.

Crucially, there is a need to improve the enabling environment for the direct use of diverse genetic resources maintained on-farm—particularly to support diversification and to meet the objectives of the Farm to Fork Strategy. Initiatives involving custodians of locally adapted varieties, breeds and populations offer the dual outcome of securing genetic resources for the future and supporting rural livelihoods—for example, through the growing market for local products and short food supply chains, or through strategic alliances with rural development programmes, tourism and gastronomy [26]. Increased collaboration between the research, commercial breeding and farming communities, as well as breed societies, can help to achieve successful and sustainable outcomes of such enterprises [27]. Valorisation of the diversity of genetic resources, particularly for underutilized crops and endangered animal breeds [28] also has great potential to boost local and rural economies while sustaining diverse agro-ecosystems and creating new food and non-food value chains.

RECOMMENDATIONS

to increase and diversify genetic resources use

- 2.2.1 Provide facilitated access to genetic resources under the control of European countries and in the public domain, as well as associated non-confidential data, for research, breeding and training.**
- 2.2.2 Develop and implement policies to stimulate innovation, demand and use of a broader range of interspecific and intraspecific genetic diversity by farmers, breeders, forest owners and other stakeholders.**
- 2.2.3 Integrate genetic resources conservation and use objectives into national and regional plans related to other relevant policies (e.g. biodiversity, agriculture, rural development, forestry, environment, and climate change adaptation).**

2.3 Intensifying genetic resources characterization

The utilization of genetic resources is fundamentally dependent on their characterization—the process of identifying and describing the distinctive features of a species, population or individual³⁰ to identify genetically diverse populations, or traits such as disease resistance, abiotic stress tolerance, and distinctive market or production qualities. While the term ‘characterization’ is widely used in the context of genetic resources conservation and sustainable use, its precise meaning varies according to the different domains. With reference to plant genetic resources, characterization can include passport descriptors (i.e. data describing the biotic and abiotic attributes of a population sample) and other identity information using morphological descriptors or molecular markers. Further, it may also involve the assessment of agricultural performance traits through phenotypic and genotypic evaluation. With regard to animal genetic resources, characterization encompasses the recording of breed characteristics, and the performance and pedigree of individuals. The use of both phenotypic and genomic approaches is important—for example, to identify and make better use of valuable rare alleles in livestock breeding. In the management of forest genetic resources, characterization may refer to recording species distributions and environmental variation across their range, demographic information such as population sizes, climate resilience and suitability for future climatic conditions, as well as morphological, molecular and genomic descriptors.

The generation and dissemination of this knowledge is fundamental to increase and diversify the sustainable use of genetic resources to provide the foundations for adapting our agricultural production systems and forests to new challenges in the context of climate change, as well as to meet consumer demand for diverse and quality products. Importantly, knowing which genetic resources contain traits providing tolerance to abiotic stresses such as drought, heat, high rainfall, flooding, and to biotic stresses such as the disease and pest outbreaks that are evolving with our changing climate, is fundamental in the context of the transition to more sustainable and resilient agriculture and forestry.

Despite the recognition that characterization is crucial for effective sustainable use of genetic resources, due to insufficient financing and institutional capacity, many plant and animal genetic resources remain uncharacterized and there is relatively

³⁰ For example, a forest tree species, a population of a local crop variety or animal breed, or an individual breeding animal.

little investment in phenotypic and genotypic characterization of non-mainstream and endangered animal breeds [29]. Furthermore, genetic characterization of forest genetic resources populations has been undertaken for very few species throughout their entire range [6, 10, 30]. In addition, notwithstanding the substantial characterization and evaluation undertaken by the public and private research and breeding sectors and new developments in the European information management systems to allow better data uptake, in general the results are not easily accessible as they are not standardized or available through centrally managed platforms. This is recognized as a significant obstacle to the use of genetic resources in research and development.

These factors are severely limiting the effective use of the vast pool of genetic diversity that exists in our agricultural and natural landscapes, and in our *ex situ* collections. Building on existing initiatives such as those of "the DivSeek International Network"³¹, increased efforts in targeted and coordinated characterization, documentation, and results dissemination is urgently needed to enlarge and diversify genetic resources use. This should include well-coordinated collaborative efforts between all involved actors, including agricultural and forestry public research institutes, the breeding sector, genebanks, farmers, breed societies, and forest managers.

RECOMMENDATIONS

to intensify genetic resources characterization

2.3.1 Increase the proportion of inventoried genetic resources—especially the European collections—that are characterized and evaluated using genomic and phenotypic techniques, as well as social, economic and eco-geographical criteria.

2.3.2 Collate, store, and where appropriate, facilitate open access to characterization and evaluation data in an integrated European and national genetic resources documentation infrastructure.

³¹ divseekintl.org

2.4 Improving genetic resources monitoring

Monitoring the status of genetic resources is essential to identify trends, for early warning of genetic diversity loss, and for rolling action planning. Genetic resources monitoring is undertaken in the context of the FAO GPAs for plant, animal and forest genetic resources, the SDGs (indicators 2.5.1 and 2.5.2³²) and in the Forest Europe process (indicator 4.6 [31]). In Europe, the information systems EURISCO³³, EFABIS³⁴ and EUFGIS³⁵ provide important clearing houses to meet national and regional commitments under these policy frameworks. However, knowledge of within species diversity (both *in situ* and *ex situ*), and trends in genetic erosion, remain poorly documented. This is partly due to insufficient characterization, including with standardized molecular methods, but also because of a paucity of population data and genomic information.

Insufficient development or implementation of internationally accepted indicators of genetic diversity is also hindering genetic resources monitoring efforts. True assessment of within species genetic diversity through standardized methods [32³⁶] is needed to enhance the management of genetic resources collections by minimizing duplication of material, guiding appropriate sampling, and tracking the distribution of material and its diversity to a wide community of users.

Threat (or risk) assessment is an important indicator of trends in the health of wild and domesticated genetic resources, and provides essential knowledge for conservation planning. However, while a bespoke system is in place for assessing the risk status of animal genetic resources [33] threat assessment of wild plant and forest genetic resources is often undertaken using the IUCN Red List Categories and Criteria [34], which are carried out at species level and are therefore unsuitable for monitoring trends in the status of genetic diversity. Attempts to develop methodologies to assess trends in the genetic erosion of crop landraces have been made [35]—however, to date, no standardized methodology has been adopted.

³² SDG Indicator 2.5.1 – Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities; Indicator 2.5.2 – Proportion of local breeds classified as being at risk, not-at-risk or at unknown level of risk of extinction (sdgs.un.org/goals/goal2)

³³ European Search Catalogue for Plant Genetic Resources – ecpgr.cgiar.org/resources/germplasm-databases/eurisco-catalogue

³⁴ European Farm Animal Biodiversity Information System – fao.org/dad-is/regional-national-nodes/efabis/en

³⁵ European Information System on Forest Genetic Resources – portal.eufgis.org

³⁶ Genetic diversity indicators developed by GEO BON (geobon.org) may be of particular relevance

The methodologies, quality and effectiveness of genetic resources monitoring also differ between domains. For example, international guidelines are implemented by countries for the development of sustainable animal breeding programmes and for monitoring breed risk status and trends [36], and as part of the EUFGIS project³⁷, European countries agreed upon minimum requirements for forest Genetic Conservation Units (GCUs) to improve documentation and management efforts³⁸. Similar proposals have been made for the establishment of genetic reserves for crop wild relatives [17], and for on-farm conservation and management of crop landraces [18]. Mainstreaming the implementation of these standards would promote greater accuracy in reporting at national and regional levels, and provide a more realistic picture of the conservation and sustainable use status of genetic resources under the FAO GPAs. This will depend on sufficient financing, training and capacity building, and on strong international and cross-sectoral cooperation.

A further requirement to improve the quality and effectiveness of monitoring measures is for the provision of better guidance and financial support to European countries to enhance and extend national programmes for characterization, evaluation and documentation according to internationally agreed descriptors, as well as data transfer to the regional and global information systems to fill information gaps.

RECOMMENDATIONS

to ensure efficient and effective monitoring of genetic resources

- 2.4.1 Further engage in the development and endorsement of internationally accepted indicators of genetic diversity (as appropriate) to monitor the status and trends in conservation and use of genetic resources, and offer them for use in relevant international fora.**
- 2.4.2 Develop and endorse internationally accepted standards for assessing the threat to genetic resource collections (*ex situ*) and populations (*in situ*) to monitor trends in genetic diversity conservation.**
- 2.4.3 Undertake regular monitoring of *in situ* and *ex situ* conservation and sustainable use and carry out threat assessment using the developed indicators.**

³⁷ Establishment of a European Information System on Forest Genetic Resources – eufgis.org

³⁸ The minimum requirements are based on the concept of dynamic gene conservation which emphasizes the maintenance of evolutionary processes within tree populations to safeguard their potential for continuous adaptation.

2.5 Advancing and coordinating information management

The existing European information management systems for plant, animal and forest genetic resources (EURISCO, EFABIS and EUFGIS), managed respectively by the three European programmes, ECPGR³⁹, ERFP⁴⁰ and EUFORGEN⁴¹, make an important contribution to documenting and monitoring the status of genetic resources. These information systems are central to reporting on Europe's implementation of a range of international policy commitments—including the FAO GPAs, SDGs, and Forest Europe process—and critically, provide a point of entry for users of genetic resources. However, the value of these systems depends on the quality of data provided by the European countries.

The key components on which the data quality and quantity depend are the national inventories for plant, animal and forest genetic resources, which are provided to the European information management systems. It is therefore the responsibility of the European countries to develop comprehensive, up-to-date and harmonized inventories of their genetic resources and to transfer them to the information management systems. This relies on the sufficient capacity of countries in terms of collecting relevant data and in high quality data management. Supporting coordinated efforts and capacity across countries to develop FAIR (findable, accessible, interoperable and reusable) compliant⁴² data management plans, and associated technical resources for data collection, and submission to the European information management systems or to appropriate international data archives, is therefore essential.

To enhance their effectiveness and impact, the European information management systems require further development to enable access to reliable data—such as genomic and phenotypic characterization data—as well as to information required to monitor conservation, sustainable use and threat/risk status. Interoperability of data of the European information management systems with data from other research fields within the areas of national forest inventories, biodiversity, climate change, the bioeconomy, sociology and policy, is fundamental to promote greater integration of genetic resources into wider research and development areas.

³⁹ European Cooperative Programme for Plant Genetic Resources – ecpgr.cgiar.org.

⁴⁰ European Regional Focal Point for Animal Genetic Resources – animalgeneticresources.net

⁴¹ European Forest Genetic Resources Programme – euforgen.org

⁴² FAIR Guiding Principles for scientific data management and stewardship – go-fair.org/fair-principles

This would help to address inter-disciplinary questions that may arise in relation to the implementation of the various policies that are relevant to biodiversity, agriculture and forestry—including in the context of the European Green Deal. For example, Agricultural Knowledge and Innovation Systems [37] involving different actors (e.g. advisory services) and Farm Sustainability Data⁴³ are tools that could be used to develop integrated and sustainable systems for the conservation and sustainable use of genetic resources.

RECOMMENDATIONS

to advance and coordinate the management of information associated with genetic resources conservation and sustainable use

2.5.1 Based on harmonized standards, further expand, develop and maintain the national inventories of plant, animal and forest genetic resources, which feed into the three European information management systems, under a national mandate to deliver high quality documentation.

2.5.2 Further develop the three European information management systems to be compliant with the FAIR principles and to be recognized as trusted data repositories, including through appropriate networking activities aimed at sharing good practices and expertise.

⁴³ magic-nexus.eu/sites/default/files/files_documents_repository/fadn_concern_sheet_200831.pdfsay/initiatives/12951-Conversion-to-a-Farm-Sustainability-Data-Network-FSDN-_en

ENABLING TRANSFORMATIVE CHANGE

The intentions of national governments, civil society and the private sector in the conservation and sustainable use of genetic resources in Europe are apparent, as demonstrated by the establishment over decades of national programmes for genetic resources, three government-backed regional programmes (ECPGR, ERFPG and EUFORGEN), the Forest Europe process, a range of initiatives led by NGOs and research institutes, and several EU-funded actions. Significant progress has been made by these stakeholders and through these activities, resulting in many important achievements. These include the development of conservation planning concepts, standards and tools, public–private partnerships in research and innovation, the publication of national and regional strategies for genetic resources conservation and sustainable use, and the creation of the information management systems, EURISCO, EFABIS and EUFGIS.

However, major hurdles remain in securing and utilizing genetic resources in Europe. To adapt to the impacts of climate change and enable the transition to more sustainable agriculture and forestry will require a coherent policy and legal framework, combined with secure and appropriate financing, to strengthen national and regional programmes and enable the institutional and human capacity needed to meet the obligations of all stakeholders to conserve and sustainably utilize genetic resources. At the same time, there is an imperative to increase awareness of the value and fundamental role of genetic resources as a vital ecosystem service which provides the foundations of sustainable and resilient agriculture and forestry, as well as to improve collaboration and coordination between actors and domains.

3.1 Establishing a coherent policy and legal framework

As already highlighted, a range of global policy frameworks and legislative instruments call for genetic resources conservation and sustainable use—including the CBD and SDGs, and specifically, the FAO GPAs and the ITPGRFA. However, notwithstanding the Forest Europe process and the New EU Forest Strategy for 2030 [16], there is currently a lack of focus on genetic resources in the European policy landscape,

which is resulting in insufficient funding for their characterization, conservation and management, and a consequent loss of diversity.

Genetic diversity in agriculture and forestry was addressed under Target 3 of the EU Biodiversity Strategy to 2020, and the protection of genetic resources under Action 9b⁴⁴—however, the EU Biodiversity Strategy for 2030 acknowledges that genetic diversity in crops and livestock is in continuing decline in Europe. The 2030 Strategy highlights the need to facilitate the use of traditional varieties of crops and animal breeds to contribute to their conservation and sustainable use, and this is also reflected in the Farm to Fork Strategy, which underlines the reliance of farmers on diversity as a buffer to the impacts of climate change.

Under the 2030 Biodiversity Strategy, the European Commission is committed to taking steps to facilitate the registration of plant varieties to ensure easier market access for traditional and locally-adapted crop varieties, as well as to restoring at least 10% of agricultural land under high diversity landscape features, to strictly protecting all remaining primary and old-growth forests, as well as to increasing the quantity, quality and resilience of the region's forests. However, while these interventions may contribute to genetic resources conservation and sustainable use, genetic resources are neither explicitly nor adequately addressed in either the Biodiversity Strategy or the Farm to Fork Strategy, and together, they do not provide a consolidated vision for genetic resources conservation and sustainable use in Europe.

The achievement of the abovementioned 10% target is foreseen through a combined approach involving the use of the CAP instruments and Strategic Plans in line with the Farm to Fork Strategy, as well as through the implementation of the EU Habitats Directive⁴⁵. The post-2020 CAP is set to maintain the inclusion of the conservation, sustainable use and development of genetic resources in agriculture as one of the eligible actions. However, it is uncertain whether the new measures will make a substantial contribution to the European efforts needed for a step change to safeguard genetic resources. For example, while financial support provided through past agri-environment schemes has resulted in positive population trends for endangered livestock breeds, such measures have not always been successful in conserving genetic diversity [38]. A review of the impact of financial support mechanisms under

⁴⁴ eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0244. Target 3, 'Increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity'.

⁴⁵ Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora [eur-lex – europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043](http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043)

EU rural development policy in the period 2014–2020 concluded that inadequate financial support provided by Member States, lack of awareness among stakeholders of the availability of the measures to support genetic diversity conservation, and high levels of administrative burden, were the main factors limiting the success of such measures in supporting genetic resources conservation and sustainable use [39].

At the global level, the FAO GPAs⁴⁶ provide a framework for directing genetic resources conservation and sustainable use actions and for reporting on their implementation. They are negotiated and agreed by the FAO CGRFA, comprising a membership of 178 countries and the EU⁴⁷, and many countries in Europe have national strategies in place to implement them. However, neither Europe as a whole nor the EU has a strategy in place to facilitate the implementation of the GPAs at regional level. There is an urgent need for greater support to enable all European countries to participate equitably, as well as for better coordination to work effectively and efficiently at pan-European level.

Other policies and legislation relevant to genetic resources conservation and sustainable use in Europe include those related to animal breeding⁴⁸, marketing of seed and other plant reproductive material⁴⁹, plant variety rights⁵⁰, patents on biotechnological inventions^{51,52}, compliance measures on access and benefit-sharing⁵³, organic farming⁵⁴, the certification schemes under EU quality policy⁵⁵, the EU Habitats Directive, and research. Further, regulations such as those addressing

⁴⁶ Global Plans of Action for the Conservation, Sustainable Use and Development of Genetic Resources – fao.org/cgrfa/policies/global-instruments/gpa

⁴⁷ Members of the Commission on Genetic Resources for Food and Agriculture – fao.org/cgrfa/overview/members/en/

⁴⁸ Regulation (EU) 2016/1012 of the European Parliament and of the Council of 8 June 2016 – eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2016.171.01.0066.01.ENG

⁴⁹ EU legislation on the marketing of plant reproductive material of agricultural, vegetable, forest, fruit and ornamental species and vines – ec.europa.eu/food/plant/plant_propagation_material/legislation_en

⁵⁰ Council Regulation (EC) No 2100/94 of 27 July 1994 on Community plant variety rights – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31994R2100

⁵¹ Directive 98/44/EC of the European Parliament and of the Council of 6 July 1998 on the legal protection of biotechnological inventions – eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:31998L0044&from=FR

⁵² The European Patent Convention – epo.org/law-practice/legal-texts/epc.html

⁵³ Regulation (EU) No 511/2014 of the European Parliament and of the Council – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R0511

⁵⁴ Legislation for the organics sector – ec.europa.eu/info/food-farming-fisheries/farming/organic-farming/legislation_en

⁵⁵ ec.europa.eu/info/food-farming-fisheries/food-safety-and-quality/certification_en

invasive alien species⁵⁶, pests of plants⁵⁷ and animal health⁵⁸, all have relevance to genetic resources. Since genetic resources are a vital component of sustainable agriculture and forestry, there is an urgent need to review the policy and legislative landscape, and to coordinate actions to ensure their long-term conservation and more effective and sustainable utilization. Coherence, consistency and compatibility among all the relevant policies, regulations and support measures that could impact on the conservation and sustainable use of genetic resources, including strong and well-coordinated governance between implementing bodies, is essential to meet Europe's commitments under global policy frameworks.

To achieve these objectives, and to support the step change needed to strengthen the resilience of agriculture, the establishment of a European coordination and information centre for conservation and sustainable use of agricultural (i.e. plant and animal) genetic resources is imperative. Such a centre would need to be embedded in a legal framework⁵⁹ and would serve to: i) assist European countries and the EU Commission in establishing or further developing the policy and regulatory framework in Europe; ii) act as a European project implementation, reporting and payment agency for the conservation and sustainable use of agricultural genetic resources; iii) coordinate Europe's contributions to international cooperation in conservation and sustainable use of agricultural genetic resources, including in the context of the work programmes of the FAO CGRFA, ITPGRFA and Crop Trust⁶⁰; iv) promote and coordinate effective implementation, documentation and reporting on agricultural genetic resources conservation and sustainable use in Europe under relevant global policy and legislative instruments, including the FAO GPAs, CBD, the Nagoya Protocol, the ITPGRFA, and the SDGs; v) create awareness among all relevant European stakeholders of the roles, values and status of agricultural genetic diversity and disseminate information and knowledge on agricultural genetic resources, *inter alia* through an agricultural genetic resources portal; vi) coordinate and monitor

⁵⁶ Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R1143

⁵⁷ Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32016R2031

⁵⁸ Animal Health Law – ec.europa.eu/food/animals/animal-health/animal-health-law_en

⁵⁹ The designation of a European Union reference centre, as defined in the EU Animal Breeding Regulation (op.europa.eu/en/publication-detail/-/publication/213e7a66-3dbb-11e6-a825-01aa75ed71a1, Article 29), could be taken as a model legal framework for the establishment of a European information and coordination centre for agricultural genetic resources as one such EU reference centre. Alternatively, a European information and coordination centre could be attached to an existing European authority, or be established as an entity with a legal status similar to bodies such as the European Patent Office (epo.org/) or EU agencies such as the Community Plant Variety Office (cpvo.europa.eu/).

⁶⁰ croptrust.org

the implementation of the *Genetic Resources Strategy for Europe*; and vii) support the European cooperative programmes for conservation and sustainable use of agricultural genetic resources, and the national programmes, in implementing the European and domain-specific genetic resources strategies.

The Forest Europe Ministerial process has mandated EUFORGEN to coordinate, promote and support national programmes and to monitor progress in forest genetic resources conservation and sustainable use at continental scale. Therefore, any further developments with regard to the conservation of forest genetic resources in Europe should be based on this mandate and existing coordination programme.

RECOMMENDATIONS

to establish an appropriate policy and legal framework

- 3.1.1 Review the existing European policy and legislative landscape and instruments related or relevant to the conservation and sustainable use of genetic resources to identify gaps and needs.**
- 3.1.2 Based on the review, as appropriate, establish a specific European policy and regulatory framework for the conservation and sustainable use of genetic resources, and if necessary, amend the existing policies, regulations and programmes.**
- 3.1.3 Establish a European coordination and information centre for conservation and sustainable use of agricultural genetic resources.**

3.2 Increasing institutional and human capacities

Strengthening institutional and human capacities are strategic priority areas of the FAO GPAs for plant, animal and forest genetic resources, underscoring the imperative for increased investment in genetic resources conservation and sustainable use. In Europe, the current technical and research infrastructure is severely under-resourced, which is resulting in insufficient capacity to meet the region's commitments under the GPAs and other previously mentioned global policy and legislative instruments, as well as to achieve the objectives of the European Green Deal. For example, many national genebanks lack the space, staff and technology needed to manage genetic resources collections to international standards—yet these facilities are vital to support research and development, and ultimately the transition to sustainable and resilient agriculture and forestry.

A prevailing lack of vision and oversight at regional level in Europe is resulting in inadequate policy development and disjointed and insufficiently financed conservation and sustainable use activities. An appropriate and adequately resourced technical and research infrastructure for conservation, documentation and sustainable use of genetic resources at national and regional levels is urgently required to reinforce and significantly improve the current system. This includes the provision of adequate resourcing for coordinated actions to achieve fully complementary and integrated genetic resources conservation *in situ* and *ex situ*, improved monitoring, increased characterization, wider use of genetic resources for diversification in agriculture and forestry, and enhanced information management. This means significantly strengthening national programmes and regional networks—notably, the three pan-European networks ECPGR, ERFP and EUFORGEN, which are central to region-wide efforts, but are currently hindered by insufficient, imbalanced and unstable financing. Further, to support research in all aspects of genetic resources conservation and sustainable use, existing European initiatives such as the European Strategy Forum on Research Infrastructures (ESFRI)⁶¹ could provide an opportunity on which to build. This would help to promote the integration of the activities of European researchers, as well as to strengthen the region's international outreach, and better support European and global science policy in the field of genetic resources.

The transition to a European infrastructure with sufficient capacity to facilitate effective genetic resources conservation and characterization, their utilization in breeding,

⁶¹ esfri.eu

research and development, as well as for monitoring and documentation, also calls for a step change to enable all actors to play their required roles to full effect. A growing skills shortage and reduced opportunities for training is resulting in insufficient human capacity and technical support to undertake routine genetic resources conservation and sustainable use activities—for example, conservation planning, *in situ* and *ex situ* conservation management, characterization and evaluation, documentation, breeding, research and development, risk assessment, and monitoring trends in the status of genetic resources. If left unchecked, this lack of professional capacity will impact our ability to sustain the well-functioning region-wide genetic resources conservation and sustainable use system required to support future stability and adaptability in agriculture and forestry, and a sustainable European bioeconomy.

To rectify this professional and vocational skills shortage will require significantly increased and sustained financial resources to underpin increased human capacity in all relevant professions, including those associated with farming, forestry, conservation, characterization, breeding, and information management. There is an urgent need to develop multi-level education and capacity-building programmes—including in schools, colleges and universities—and for an initiative to develop a portfolio of continuing professional development opportunities in genetic resources conservation and sustainable use, involving the establishment of appropriate academic and workplace partnerships.

RECOMMENDATIONS

to increase institutional and human capacities

- 3.2.1 Create integrated European and national technical and research infrastructures, as appropriate, to provide a long-term foundation for the conservation, documentation and sustainable use of genetic resources in Europe.**
- 3.2.2 Strengthen the capacity of the three existing European genetic resources networks and programmes.**
- 3.2.3 Establish European and national human capacity development programmes in genetic resources conservation and sustainable use, and as appropriate, integrate genetic resources aspects into existing programmes in colleges, universities and industry.**

3.3 Enhancing awareness of the roles and values of genetic resources

Promoting awareness of the fundamental roles and values of genetic resources has a significant role to play in supporting the transition to strengthened and widened actions for their conservation and sustainable use. Messages must be clear about the link between biodiversity, food, farming, and all products of the agriculture and forestry sectors, as well as the essential requirement for genetic diversity to sustain production and stable agricultural and forestry systems. This cognizance is needed across all stakeholder groups, from the users and managers of genetic resources, such as farmers, foresters, breeders, landscape managers, gardeners, and the food chain industry, to policymakers and the public. To achieve this will demand greater efforts in education and advocacy, supported by professionally produced, appropriately tailored media designed for specific target audiences.

Current widespread consciousness of the climate and biodiversity crisis in society has led to many people making personal lifestyle choices to reduce the effects of climate change and to minimize biodiversity loss—for example, by making dietary adjustments, supporting local producers to reduce food miles, buying low environmental impact and high welfare goods, or choosing forest products from sustainably managed sources. However, there remains a lack of awareness of the roles of genetic resources in meeting the challenges of global change, and that genetic resources are a vital subset of biodiversity which we rely on for our survival.

Establishing the so far missing link between climate change, biodiversity loss and the vital roles of genetic resources is a critical next step, and will require the formulation and communication of clear and succinct messages. Communications need to underline the essential role of genetic resources for food and nutrition security, product quality and choice, and the transition to more sustainable and resilient agriculture and forestry to reduce biodiversity loss, improve the quality of the environment, adapt to, and mitigate the impacts of climate change, and improve farmed animal welfare. These messages need to promote the vital importance of genetic resources as a buffer against the climate shocks that are increasingly impacting farming and forestry, as well as their long-term insurance value for future generations.

Highlighting the total economic value of genetic resources (i.e. the overall economic value, taking into account both use and non-use values) can also convey a potent message. This includes not only examples of the monetary value of genetic resources—such as the ecosystem services provided by forests [40], the value of introducing new genes from wild plant species to crops [41], or the overall market value of genetic

resources [42]—but also their social and cultural values, and the actual and potential costs to industry, the environment, and society at large of genetic resources loss and insufficient diversity in agriculture and forestry. Understanding and integrating the economic values of genetic resources with other social and economic dimensions will also serve to raise their profile and support policy development and implementation for their conservation and sustainable use.

RECOMMENDATIONS

to enhance awareness of the roles and values of genetic resources

- 3.3.1 Increase professional awareness of the different values of genetic resources, including the relative costs and benefits of their conservation and sustainable use by different stakeholders at national and European levels, as an impetus to strengthen national and regional policy commitments to genetic resources conservation and sustainable use.**
- 3.3.2 Increase education and awareness among the general public, including children, of the values of genetic resources to society, the inter-dependence of all countries on genetic resources, and the importance of maintaining genetic diversity to sustain the provision and use of daily commodities by all households.**

3.4 Joining forces between actors and domains

Actors in genetic resources conservation and sustainable use are wide-ranging and include a diverse array of organizations, agencies, NGOs, private companies, and individuals involved in genetic resources management, use and policy implementation⁶². Individual actors include specialists in policy, research, information management, farming and forestry, genebank and protected area management, biodiversity conservation, breeding, training, advice and capacity building, and product development and marketing. Thus, the roles and areas of expertise of actors in genetic resources conservation and sustainable use are many and multifaceted. Further, they span across the genetic resources domains—some with a role or interest in only one, and others involved in cross-domain activities. This diversity undoubtedly presents a challenge in terms of pooling resources, expertise and actions, and some measures will necessarily remain domain-specific⁶³. Nonetheless, achieving effective conservation and sustainable use of genetic resources demands greater participation of, and collaboration and coordination between actors and domains.

Importantly, there remains a need for improved collaboration between the so-called ‘formal’ and ‘informal’ conservation sectors—for example, between national genebanks, research centres and conservation agencies on the one hand, and conservation NGOs, breed societies and farmers’ or foresters’ associations on the other. Increasing understanding, recognition and visibility of the respective roles of such government-led bodies, the private sector and civil society organizations in the conservation and sustainable use of genetic resources, as well as engendering cooperation and mutual trust between them, are important factors in enabling the transition to more diverse agro-ecosystems and fair and inclusive value chains.

The long tradition of public–private cooperation in conservation, research and development—for example between the breeding sector and national research institutes—also needs to be fostered. These collaborations are highly mutually beneficial in terms of pooling expertise and resources, as well as their societal impact. An example of a recent initiative to establish international public–private partnerships (PPPs) involving breeding companies, genebanks and other research centres in

⁶² Including farmers, local communities, NGOs, agricultural engineers, foresters, breeders, commercial companies, biotechnologists, policymakers, government agencies and ministries, civil society organizations, academics, protected area managers, genetic resources technicians and professional staff, and environment and biodiversity specialists.

⁶³ Strategies for conservation and sustainable use of plant, animal and forest genetic resources in Europe will complement this *Genetic Resources Strategy for Europe*.

characterization and evaluation of genetic resources, is the European Evaluation Network EVA⁶⁴. To scale out such initiatives, the recognition and promotion of their value and mainstreaming in national and European policy is needed.

Further, true complementarity between *in situ* and *ex situ* conservation—essential to promote the use of genetic resources in research and breeding, as well as to ensure the safety of population diversity that may be impacted by unknown or unexpected destructive processes or events *in situ*—would engender greater collaboration between actors. This would not only help to optimize the use of financial and human resources for genetic resources conservation, but also to drive genetic resources sustainable use and diversification.

Notably, the three aforementioned networks (ECPGR, ERFP and EUFORGEN) for the coordination of plant, animal and forest genetic resources conservation and sustainable use in Europe share similarities with regard to their mandates, commitments and organization, offering opportunities for inter-network collaboration—for example, in genetic resources information management, awareness-raising, advocacy, and policy development. Furthermore, acknowledging the importance of genetic resources outside geographical Europe—for example, in the Caucasus, Fertile Crescent and North Africa, where many crop, forest and domesticated animal species utilized in Europe originated and diversified—the networks also share the common aim of collaborating and coordinating activities with countries in these areas.

A further possibility for joining forces is the identification of genetic resources diversity hotspots and the establishment of areas in which the aim would be to conserve genetic resources through an ecosystem management approach. For example, the management of a conservation area encompassing agricultural land and forested areas could involve a cooperation framework between farmers, foresters, protected area managers and local communities, or conservation and valorisation of endangered local fruit cultivars and animal breeds could be facilitated by setting up orchard networks. This approach would foster greater participation of, and collaboration between actors and sectors, both within and between domains.

⁶⁴ ecpgr.cgiar.org/european-evaluation-network-eva

Critically, greater cooperation between the agriculture, environment, forestry and food sectors is needed to develop a coherent genetic resources policy and legal framework, to implement actions to achieve sustainable and resilient production systems, and to communicate the roles and values of genetic resources to raise awareness throughout society.

RECOMMENDATIONS

to provide added value through cross-domain and multi-actor collaboration and coordination

- 3.4.1 Foster the participation of, and collaboration between actors and domains, to identify potential synergies and greater integration of public and private genetic resources actors, as well as firm linkages with other stakeholder communities.**
- 3.4.2 Develop collaborative activities in support of information infrastructures to enable better findability, interoperability and access to all relevant sources of data and knowledge, develop a common ethic on data sharing, enhance outreach with global initiatives on linked open data, increase expertise in data stewardship among the different actors, and build capacity to address future documentation needs.**

3.5 Mobilizing funds for conservation, documentation and sustainable use

Adequate and accessible financing is vital to ensure efficient, effective and lasting conservation and sustainable use of genetic resources. Specifically, to meet the objectives and recommendations of the *Genetic Resources Strategy for Europe* and complementary domain-specific strategies, the provision of appropriate and long-term financial support for European and national genetic resources conservation and sustainable use programmes and activities, involving all actors, is essential. Although a number of funding instruments are in place in Europe, long-term investment in genetic resources conservation infrastructure, as well as to support their sustainable use—for example, by mainstreaming genetic characterization—is severely lacking. Insufficient priority is therefore frequently given to conservation, documentation and sustainable use of genetic resources at national level. Subsequently, many public institutions do not have dedicated budget lines for maintaining quality genetic resources collections and for operating genebanks according to international standards—a situation that is counter to Europe’s ambition to support high quality research infrastructures and to strengthen the region’s global outreach.

The foundation of genetic resources conservation and sustainable use is national commitment, related policy, and funding for its implementation. National support measures and incentives can be provided as a means of promoting innovation and entrepreneurship, investments (for example in processing and marketing agricultural products, and forestry technologies and processing), improved knowledge transfer, quality schemes, cooperation between actors in the food and agriculture sector (such as along the supply chain), and technical support and advisory services⁶⁵. Income support for the agricultural and forestry sectors, and rural areas compatible with the internal market⁶⁶, has also been applied by some European countries. These measures should be extended and made available into future periods to support actors involved in the maintenance and improvement of populations, species and breeds, and other related activities that promote the conservation and sustainable use of genetic resources.

⁶⁵ European Union Guidelines for State aid in the agricultural and forestry sectors and in rural areas 2014 to 2020 – eur-lex.europa.eu/legal-content/en/TXT/?uri=uriserv:OJ.C_.2014.204.01.0001.01.ENG; Commission Notice amending the European Union Guidelines for State aid in the agricultural and forestry sectors and in rural areas 2014 to 2020 as regards their period of application and making temporary adaptations to take into account the impact of the COVID-19 pandemic – eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020XC1208(03)&from=ES; Revision of the State aid rules for agriculture, forestry and rural areas – ec.europa.eu/competition/state_aid/legislation/review_aber_en.html

⁶⁶ Commission Regulation (EU) No 702/2014 of 25 June 2014 declaring certain categories of aid in the agricultural and forestry sectors and in rural areas compatible with the internal market in application of Articles 107 and 108 of the Treaty on the Functioning of the European Union – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R0702

At European level, income support via the CAP or equivalent legislative frameworks (direct payments to remunerate farmers for environmentally friendly farming and delivering public goods not normally paid for by the markets, such as taking care of the countryside)⁶⁷ has been provided. The CAP, particularly its European Agricultural Fund for Rural Development (EAFRD), has aimed among other goals to help tackle climate change and the sustainable management of natural resources, and to maintain rural areas and landscapes across the region⁶⁸. Since 2006, the EAFRD, through the agri-environment-climate measures (AECM)⁶⁹ has provided an instrument to support conservation of plant and animal genetic resources by farmers and others stakeholders, as well as for sustainable forest management. However, the take-up of these funds differs among countries, depending on national priorities and the level of administration involved, and the maximum grants are in some cases too small to be effective⁷⁰ [43].

Since (as already highlighted), genetic diversity in crops and livestock is in continuing decline, the positive impact of funding under the CAP on domesticated genetic resources is not evident across the region. Nine key objectives are foreseen for the new CAP 2023–27⁷¹, and of particular note is the intention to increase competitiveness and agricultural productivity in a sustainable way, in which the role of Research and Innovation is given prominence⁷². This includes funding through EIP-AGRI⁷³, as well as through the Horizon Europe programme for research and innovation for the period 2021–2027, within which €10 billion is ear-marked for research and innovation on food and natural resources (which includes agriculture, forestry and rural development). Eco-schemes are also proposed to support farmers and land managers who wish to transition towards more sustainable farming practices and systems [44].

⁶⁷ Regulation (EU) No 1307/2013 of the European Parliament and of the Council of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy – eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32013R1307

⁶⁸ The common agricultural policy at a glance – ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en

⁶⁹ Common agricultural policy funds – ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/financing-cap/cap-funds_en

⁷⁰ op.europa.eu/en/publication-detail/-/publication/fb693d7d-370d-11e7-a08e-01aa75ed71a1/language-en/format-PDF/source-105962170

⁷¹ The new common agricultural policy: 2023–27 – ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en

⁷² Increasing competitiveness: the role of productivity – ec.europa.eu/info/sites/info/files/food-farming-fisheries/key_policies/documents/cap-briefs-2-productivity_en.pdf

⁷³ The European Innovation Partnership for Agricultural productivity and Sustainability – ec.europa.eu/eip/agriculture

However, these financing mechanisms do not provide for long-term coordinated actions for genetic resources conservation and sustainable use across the region because they may not be a priority for some countries, thus creating an unequal situation. To support the transition to more sustainable and resilient agriculture and forestry, significant long-term investment and appropriate financing measures are required across the region to achieve targeted, coordinated and sustainable actions to conserve and expand the use of genetic resources.

RECOMMENDATIONS

to mobilize funds for genetic resources conservation, documentation and sustainable use

- 3.5.1 Provide appropriate and long-term financial support for European and national genetic resources conservation and sustainable use activities and measures, targeting the various stakeholders groups involved, and ensuring the equitable participation of all European countries.**
- 3.5.2 To strengthen the coordination of European activities, alongside national government funding, introduce a contribution from the European Commission to ensure appropriate and long-term funding of the three European genetic resources networks, ECPGR, ERFP and EUFORGEN.**

REINFORCING INTERNATIONAL COOPERATION

Conserving genetic resources and optimizing their use for food and nutrition security, renewable material supply, adaptation to climate change, and the transition to more sustainable and resilient agriculture and forestry, is a global challenge in which Europe plays an important collaborative role. The region has a long history of research, scientific discovery, innovation, technology development, and pedagogy in the field of genetic resources conservation and sustainable use, providing firm foundations for continued cooperation to strengthen collective global efforts and outcomes—vital to meet commitments under the FAO GPAs, ITPGRFA, SDGs, CBD, Forest Europe process and other relevant international agreements.

These policies and legislative instruments call for urgent actions for the conservation and sustainable use of genetic resources worldwide. An effective European contribution in the related international fora and bodies (such as the FAO CGRFA and its Intergovernmental Technical Working Groups⁷⁴, the Governing Body of the ITPGRFA⁷⁵ and its Subsidiary Bodies⁷⁶, and the Conference of the Parties of the CBD⁷⁷ and Subsidiary Body on Scientific, Technical and Technological Advice⁷⁸), is essential to meet Europe's commitments, as well as to collaborate in the global arena with greater relevance and impact. However, strengthening Europe's role and influence in the negotiations, as well as in the achievement of common global objectives, calls for well-coordinated preparations for meetings of these international fora and bodies to ensure the region presents a common position. There is a critical need for the reinforcement, or where lacking, the establishment of measures and processes to coordinate between national and regional focal points and representatives in the relevant bodies at the EU and European levels.

⁷⁴ fao.org/cgrfa/meetings/itwg/en

⁷⁵ fao.org/plant-treaty/overview/governing-body/en

⁷⁶ fao.org/plant-treaty/overview/governing-body/committees/en

⁷⁷ cbd.int/cop

⁷⁸ cbd.int/sbstta

Crucially, while Europe is rich in plant, animal and forest genetic resources, European countries are not only co-dependent on these resources, but the region as a whole depends on genetic resources from neighbouring countries and further afield for research, breeding and development, as well as for the sustainability of imported produce. Due to the search for diversity to increase resilience in agriculture and forestry in the context of climate change, this inter-dependency on genetic resources is of growing significance. Therefore, while countries have sovereign rights over their genetic resources and the responsibility for their sustainable use and management, international exchange and cooperation is essential to enhance and optimize their conservation and sustainable use across political borders. Coordinated efforts also serve to address global drivers of loss and strengthen outcomes by streamlining financial and human resource use and increasing institutional capacity—for example, through data and knowledge-sharing, research, innovation, technology and skills development, and the provision of advisory services. Europe and its various stakeholders should therefore strive to intensify international cooperation, both within and outside the region.

The three European networks, ECPGR, ERFP and EUFORGEN are central in genetic resources conservation and sustainable use efforts in Europe and neighbourhood countries, and have been a catalyst for international cooperation—for example, in data management, conservation planning, research, education, and training. However, the capacity and effectiveness of national programmes varies between countries and is a significant factor hindering progress towards a more effective Europe-wide system of genetic resources conservation and sustainable use. To maintain and enhance international cooperative efforts in and outside the region calls for a stronger European mandate and adequate financing to support national programmes and reinforce the capacity of the regional networks.

The successful implementation of the *Genetic Resources Strategy for Europe* is foreseen to be contingent on political impetus provided by the EU, and on the support of its institutions and bodies—including the European Commission. The EU already acknowledges biodiversity as a priority of its external action and as integral to efforts to meet the SDGs⁷⁹. Genetic resources, as a major component of biodiversity on which we depend to sustain the productivity and quality of our food, maintain healthy and resilient forests, ensure nutrition and food security, and support the bioeconomy, need to be given special prominence in this external action. Further, the EU is committed

⁷⁹ EU Biodiversity Strategy for 2030 – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0380

to supporting the global transition to sustainable agri-food systems and forestry, including through research and innovation in climate change adaptation, resilience and risk preparedness, prevention of food crises, inclusive and fair value chains, and nutrition and healthy diets⁸⁰—all dependent on a robust genetic resources conservation and sustainable use system.

The EU is dedicated to enabling its external action through bilateral, regional and multilateral partnerships, as well as through ‘Green Deal diplomacy’ and its forthcoming green alliances. Specifically, international cooperation in research and innovation—a strategic priority for the EU—is achieved through collaboration with associated countries, bilateral science and technology agreements, and regional dialogues⁸¹. To achieve the EU’s ambition in promoting the global transition to better biodiversity protection and sustainable agri-food systems and forestry will require a specific focus on the extension of these forms of international cooperation in the area of genetic resources conservation and sustainable use. This EU external action may be viewed in three geographic dimensions of cooperation: with the wider European region, which can build on the experience and expertise of the pan-European networks, with neighbouring regions such as the Caucasus, Near East and North Africa, and with the rest of the world.

Vitality, achieving the SDGs is a global challenge that requires strong international cooperation. Several of the goals depend on the continued availability and use of diverse genetic resources—notably ‘zero hunger’, ‘no poverty’, ‘good health and well-being’, ‘responsible consumption and production’, ‘climate action’, and ‘life on land’. To achieve these goals requires innovation in the production of food and other goods, a transition to more sustainable management practices in agriculture and forestry, and the development of inclusive and fair value chains—all predicated on the conservation and sustainable use of genetic resources.

Europe, through diverse models of collaboration can make a fundamental difference in helping deliver these SDGs globally. Based on the experiences of the three European cooperative programmes and all relevant stakeholders, the region has the knowledge and skills needed to support the progression to an efficient and effective system of genetic resources conservation and sustainable use in Europe and worldwide. However, this advancement can only be realised with a coherent policy framework,

⁸⁰ A From Farm to Fork Strategy – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0381

⁸¹ Enhancing and focusing EU international cooperation in research and innovation: A strategic approach – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52012DC0497

adequate financing, and resource mobilization, to enable the actions stipulated in this *Genetic Resources Strategy for Europe* and complementary domain-specific strategies. This undertaking will require a step change in cooperation between the actors responsible for delivering Europe's high level of ambition in rallying all efforts for the good of the world's biodiversity⁸² and in supporting the global transition to sustainable agri-food⁸³ and forestry systems, while continuing to innovate and maintain the region's competitiveness in the global market.

RECOMMENDATIONS

to reinforce Europe's international cooperation in genetic resources conservation and sustainable use

- 4.1 Promote pan-European collaboration for the conservation and sustainable use of genetic resources, and facilitate the active participation of all European countries in the implementation of the *Genetic Resources Strategy for Europe* and domain-specific strategies.**
- 4.2 Maintain and develop inter-regional partnerships for conservation and sustainable use of genetic resources with other regions, especially the Caucasus, Near East and North Africa.**
- 4.3 Reinforce, or where lacking, establish coordination measures and processes between national and regional focal points and representatives for Europe in international fora dealing with conservation and sustainable use of genetic resources.**

⁸² EU Biodiversity Strategy for 2030 – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0380

⁸³ A From Farm to Fork Strategy – eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0381

CONCLUSION

Genetic resources are fundamental for addressing the challenges the world currently faces to halt the loss of biodiversity, mitigate and adapt to the climate crisis, and ensure the wellbeing of all people. European countries and the EU, through the European Green Deal and Forest Europe process, are committed to a transition to more sustainable and resilient agriculture and forestry while ensuring food security, nutrition and health, inclusive and fair value chains, and maintaining a sustainable circular bioeconomy. To achieve this, we need to secure and sustainably use the genetic resources on which agriculture and forestry depend. Improving the vigour and diversity of agroecosystems and forests through the use of manifold genetic resources, combined with a transition to fully sustainable management practices, will reduce biodiversity decline and increase resilience to climate change.

European countries and the EU are committed to conserve genetic resources and its diversity through several global policy fora. However, the genetic resources that underpin sustainable agriculture and forestry are threatened and in decline, diminishing our options for meeting global targets under the SDGs, and for addressing future challenges. There is a pressing need for a stronger and targeted focus on genetic resources conservation and sustainable use actions, including through the development of a coherent European policy and legal framework, and adequate infrastructure and funding for its implementation. Measures are urgently required to mainstream genetic resources conservation and sustainable use into wider policies and programmes, ensure coherence between them, promote collaboration and cooperation between actors and domains, and raise awareness of the roles and values of genetic resources.

The *Genetic Resources Strategy for Europe* and its complementary domain-specific strategies together provide the missing link between policies and strategies focused on wider biodiversity issues, and those that address agriculture, forestry, and the environment. European countries and the EU have the knowledge and expertise to implement these strategies through their national programmes for genetic resources and the three government-backed regional programmes, ECPGR, ERFP and EUFORGEN, together with other relevant actors. The implementation of the strategies at European and national levels will serve to streamline activities and investments across the region, and will significantly increase and secure the genetic diversity base required for sustaining agriculture and forestry and achieving the objectives of

the European Green Deal. Critically, the realisation of the genetic resources strategies will enable Europe to meet its international commitments to genetic resources conservation and sustainable use under the FAO GPAs, ITPGRFA, CBD, SDGs and Forest Europe process, and will foster and emphasize the region's position as a key player in the global arena.

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ANNEX – ACTION PLAN

The measures presented in this action plan are associated with the delivery of the recommendations presented in chapters 2, 3 and 4 of the *Genetic Resources Strategy for Europe*.

2. STRENGTHENING AND WIDENING ACTIONS FOR GENETIC RESOURCES CONSERVATION AND SUSTAINABLE USE

2.1 Sustaining and expanding genetic resources conservation

Recommendations	Associated actions
<p>2.1.1 Prepare, make publicly accessible, and regularly update European inventories of plant, animal and forest genetic resources conserved <i>in situ</i> and <i>ex situ</i>.</p>	<ul style="list-style-type: none"> i. Develop and refine standards and templates for the inventories of actively conserved¹³³ <i>in situ</i> and <i>ex situ</i> genetic resources. ii. Publish European inventories of actively conserved or managed genetic resources online.
<p>2.1.2 Prepare, update, and implement national strategies and action plans (NSAPs) for integrated and complementary <i>in situ</i> and <i>ex situ</i> conservation and sustainable use of plant, animal, and forest genetic resources, engaging all relevant public and private stakeholders in the process.</p>	<ul style="list-style-type: none"> i. Prepare or update and implement NSAPs for integrated and complementary <i>in situ</i> and <i>ex situ</i> conservation and sustainable use of plant, animal, and forest genetic resources.
<p>2.1.3 Establish European collections of plant, animal and forest genetic resources actively conserved <i>in situ</i> and <i>ex situ</i>, including the necessary conservation infrastructures.</p>	<ul style="list-style-type: none"> i. Refine and agree principles for the establishment and management of European collections and criteria for inclusion, for actively conserved plant, animal, and forest genetic resource populations/accessions. ii. Include genetic resources populations/accessions in the European <i>in situ</i> and <i>ex situ</i> collections. iii. Make available and manage national conservation infrastructures for the European collections.

¹³¹ The indicative timescales indicate when the recommendations will be achieved: within ≤3 years or 4–7 years. Note that once a recommendation has been actioned, it may need to be repeated periodically or is an on-going commitment.

Indicators	Indicative timescales ¹³¹	Indicative level(s) of action ¹³²
<p>Agreed standards and templates for genetic resources inventories available online.</p> <p>European inventories of plant, animal and forest genetic resources are accessible online.</p>	<p>≤3 years</p> <p>4–7 years</p>	<p>European</p> <p>European and national</p>
<p>Number of NSAPs prepared or updated and implemented.</p>	<p>4–7 years</p>	<p>National</p>
<p>Principles for management and criteria for inclusion in the European collections are adopted and published by the three European genetic resources networks, ECPGR, ERFPG and EUFORGEN.</p> <p>Number of populations/accessions included in the European <i>in situ</i> and <i>ex situ</i> collections.</p> <p>Number of national <i>in situ</i> and <i>ex situ</i> collections contributing to European collections.</p>	<p>4–7 years</p>	<p>European and national</p>

¹³² The indicative level(s) of action indicate that actions are required at national and/or European levels.

¹³³ Active conservation implies at least periodic monitoring of genetic resources populations and if the trend is negative, management intervention is triggered to promote population recovery.

Recommendations	Associated actions
<p>2.1.4 Develop and implement quality management systems for long-term <i>in situ</i> and <i>ex situ</i> conservation of plant, animal, and forest genetic resources in all countries.</p>	<ul style="list-style-type: none"> i. Refine and agree quality standards for long-term conservation of plant, animal, and forest genetic resources. ii. Based on the agreed quality standards, establish, and implement quality management systems for long-term conservation of plant, animal, and forest genetic resources, especially those held in European collections.

2.2 Increasing and diversifying genetic resources utilization

<p>2.2.1 Provide facilitated access to genetic resources under the control of European countries and in the public domain, as well as associated non-confidential data, for research, breeding, and training.</p>	<ul style="list-style-type: none"> i. Refine and agree guidelines on facilitated access to genetic resources under the control of European countries and in the public domain (<i>ex situ</i> and <i>in situ</i>). ii. Raise awareness of the ITPGRFA and CBD (particularly Nagoya Protocol) policy context and practical use of MTAs for collection holders, genetic resources providers and users.
<p>2.2.2 Develop and implement policies to stimulate innovation, demand and use of a broader range of interspecific and intraspecific genetic diversity by farmers, breeders, forest owners and other stakeholders.</p>	<ul style="list-style-type: none"> i. Review existing policies related to demand for and use of a broader range of interspecific and intraspecific genetic diversity by users, and propose revised policy content where appropriate. ii. Implement, where appropriate, proposed revised policy content that broadens the use of genetic diversity.

Indicators	Indicative timescales	Indicative level(s) of action
<p>Standards for long-term conservation of plant, animal and forest genetic resources are adopted and published by the three European genetic resources networks.</p> <p>Number of countries with quality management systems for long-term <i>in situ</i> and <i>ex situ</i> conservation of plant, animal and forest genetic resources.</p>	≤3 years	European and national
<p>Number of countries that have published their guidelines for facilitated access online.</p> <p>Numbers of ABS training courses provided and trainees with increased ABS awareness.</p>	≤3 years	European and national
<p>Review of existing policies related to demand for and use of genetic diversity published.</p> <p>Increase in demand, and use of a broader range of conserved genetic resources.</p>	4–7 years	European and national

Recommendations	Associated actions
<p>2.2.3</p> <p>Integrate genetic resources conservation and use objectives into national and regional plans related to other relevant policies (e.g. biodiversity, agriculture, rural development, forestry, environment, and climate change adaptation).</p>	<ul style="list-style-type: none"> i. Review existing policies related to biodiversity, agriculture, forestry and the environment in the pan-European, EU and national contexts, as far as they affect genetic resources conservation and use. ii. Propose, where appropriate, changes to biodiversity, agricultural, forestry and environmental policies in national and regional plans to better reflect the importance of genetic diversity, conservation, and use.

2.3 Intensifying genetic resources characterization

<p>2.3.1</p> <p>Increase the proportion of inventoried genetic resources —especially in the European collections—that are characterized and evaluated using genomic and phenotypic techniques, as well as social, economic, and eco-geographical criteria.</p>	<ul style="list-style-type: none"> i. Characterize <i>ex situ</i> and <i>in situ</i> conserved collections and populations using genomic and phenotypic techniques, as well as social, economic, and eco-geographical criteria.
<p>2.3.2</p> <p>Collate, store, and where appropriate, facilitate open access to characterization and evaluation data in an integrated European and national genetic resources documentation infrastructure.</p>	<ul style="list-style-type: none"> i. Upgrade genetic resources documentation infrastructure where necessary and collate, store, and where appropriate, facilitate open access to characterization and evaluation data.

Indicators	Indicative timescales	Indicative level(s) of action
<p>Review of existing policies related to biodiversity, agriculture, forestry and the environment in the European, EU and national context published.</p> <p>Effective changes for the conservation and use of genetic diversity are visible in European, EU and national biodiversity, agricultural, forestry, and environmental policies.</p>	<p>≤3 years</p> <p>4–7 years</p>	<p>European and national</p>
<p>Proportion of <i>ex situ</i> and <i>in situ</i> conserved collections and populations characterized using genomic and phenotypic techniques, as well as social, economic, and eco-geographical criteria.</p>	<p>4–7 years</p>	<p>European and national</p>
<p>Increased quantity and quality of genomic and phenotypic characterization and evaluation data published via the genetic resources documentation infrastructure.</p>	<p>≤3 years</p>	<p>European and national</p>

2.4 Improving genetic resources monitoring

Recommendations	Associated actions
<p>2.4.1</p> <p>Further engage in the development and endorsement of internationally accepted indicators of genetic diversity (as appropriate) to monitor the status and trends in conservation and use of genetic resources and offer them for use in relevant international fora.</p>	<ul style="list-style-type: none"> i. Refine, where appropriate, current indicators of genetic diversity used to monitor the status and trends in conservation and sustainable use of genetic resources in Europe. ii. Propose to national and European fora revised monitoring indicators, where appropriate, better able to reflect the status and trends in conservation and sustainable use of domain-specific genetic resources. iii. Implement the revised indicators to establish a baseline for the status of conservation and use of genetic diversity, and regularly monitor indicator status.
<p>2.4.2</p> <p>Develop and endorse internationally accepted standards for assessing the threat to genetic resource collections (<i>ex situ</i>) and populations (<i>in situ</i>) to monitor trends in genetic diversity conservation.</p>	<ul style="list-style-type: none"> i. Review appropriateness of existing internationally accepted standards for assessing the threat to genetic resource collections (<i>ex situ</i>) and populations (<i>in situ</i>), and where appropriate propose alternative assessment methods. ii. Develop and endorse standards for assessing threats to genetic resources collections and populations.
<p>2.4.3</p> <p>Undertake regular monitoring of <i>in situ</i> and <i>ex situ</i> conservation and sustainable use and carry out threat assessment using the developed standards and indicators.</p>	<ul style="list-style-type: none"> i. Use genetic resource conservation, sustainable use and threat data as indicators to establish a baseline, and regularly assess the national conservation status of <i>in situ</i> and <i>ex situ</i> conserved germplasm, its use and threat assessment. ii. Collate national genetic resource conservation, use and threat data to build a baseline, and regularly assess at regional level, conservation, use and threat assessment for European genetic resources.

Indicators	Indicative timescales	Indicative level(s) of action
<p>Review of current indicators of genetic diversity used to monitor the status and trends in conservation and sustainable use of genetic resources in Europe published.</p> <p>Revised indicators adopted by national programmes and the relevant domain-specific communities.</p> <p>Revised indicators implemented by national programmes and relevant domain-specific communities.</p>	<p>≤3 years</p> <p>≤3 years</p> <p>4–7 years</p>	<p>European and national</p>
<p>Critical review of amended infra-specific genetic diversity threat indicators published.</p> <p>Standards for assessing threats to genetic resources are endorsed by national governments and relevant communities.</p>	<p>≤3 years</p>	<p>European and national</p>
<p>Monitoring results of national conservation, use and threat assessment for European countries regularly published.</p> <p>Monitoring results of European regional conservation, use and threat assessment regularly published.</p>	<p>4–7 years</p>	<p>European and national</p>

2.5 Advancing and coordinating information management

Recommendations	Associated actions
<p>2.5.1 Based on harmonized standards, further expand, develop, and maintain the national inventories of plant, animal, and forest genetic resources, which feed into the three European information management systems, EURISCO, EFABIS and EUFGIS, under a national mandate to deliver high quality documentation.</p>	<ul style="list-style-type: none"> i. Develop and further expand, as appropriate, national <i>in situ</i> and <i>ex situ</i> inventories of plant, animal and forest genetic resources based on harmonized standards, to provide high quality standardized data. ii. Collate national conserved genetic resource datasets to build European conserved genetic resources datasets, facilitating European monitoring and adaptive genetic resources management.
<p>2.5.2 Further develop the three European information management systems to be compliant with the FAIR principles and to be recognized as trusted data repositories, including through appropriate networking activities aimed at sharing good practices and expertise.</p>	<ul style="list-style-type: none"> i. Review the three existing European information management systems to test whether they are compliant with the FAIR principles and are fit for purpose.

Indicators	Indicative timescales	Indicative level(s) of action
<p>National <i>in situ</i> and <i>ex situ</i> inventories of plant, animal and forest genetic resources published online.</p> <p>High quality national datasets regularly received by the three European information management systems.</p>	4–7 years	National
<p>European information management systems are fully compliant with the FAIR principles.</p>	4–7 years	European and national

3. ENABLING TRANSFORMATIVE CHANGE

3.1 Establishing a coherent policy and legal framework

Recommendations	Associated actions
<p>3.1.1 Review the existing European policy and legislative landscape and instruments related or relevant to the conservation and sustainable use of genetic resources to identify gaps and needs.</p>	<p>i. Critically and regularly review existing regional policies related to genetic resources conservation and sustainable use in Europe.</p>
<p>3.1.2 Based on the review, as appropriate, establish a specific European policy and regulatory framework for the conservation and sustainable use of genetic resources, and if necessary, amend the existing policies, regulations, and programmes.</p>	<p>i. Support policy processes with domain-specific expertise at the European level and propose ways to enhance the conservation and sustainable use of genetic resources in the present European policy and regulatory framework.</p>
<p>3.1.3 Establish a European coordination and information centre for conservation and sustainable use of agricultural genetic resources.</p>	<p>i. EC to facilitate the design and establishment of a European coordination and information centre, taking into consideration existing structures, institutions, and relevant EU legislation.</p>

3.2 Increasing institutional and human capacities

<p>3.2.1 Create integrated European and national technical and research infrastructures, as appropriate, to provide a long-term foundation for the conservation, documentation, and sustainable use of genetic resources in Europe.</p>	<p>i. Review existing European and national genetic resources technical and research infrastructure and assess how well it provides a long-term foundation for the conservation, documentation, and sustainable use of genetic resources in Europe.</p> <p>ii. Implement recommendations for enhancement of the European and national genetic resources technical and research infrastructure.</p>
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Indicators	Indicative timescales	Indicative level(s) of action
Domain-specific reviews of existing regional policies related to genetic resources conservation and sustainable use in Europe published, with recommendations for improvements.	≤3 years	European
New, enhanced policy and regulatory framework for the conservation and sustainable use of genetic resources in place (if needed and as appropriate).	4–7 years	European
Centre is established and regularly reports activities to relevant authorities.	≤3 years	European
<p data-bbox="94 1264 472 1446">Analysis of the European and national genetic resources technical and research infrastructure and its fitness for purpose published, including recommendations for enhancement.</p> <p data-bbox="94 1519 478 1638">Improved European and national genetic resources technical and research infrastructure implemented and regularly monitored.</p>	<p data-bbox="516 1264 598 1292">≤3 years</p> <p data-bbox="516 1519 611 1547">4–7 years</p>	European and national

Recommendations	Associated actions
<p>3.2.2 Strengthen the capacity of the three existing European genetic resources networks.</p>	<ul style="list-style-type: none"> i. Seek formal recognition of the regional leadership role and functions provided by the three European genetic resources networks in relevant global, European, and national fora. ii. Expand where necessary the activities of the three networks to ensure the recommendations of the <i>Genetic Resources Strategy for Europe</i> can be fully implemented. iii. Involve the three networks in the co-construction of research and innovation initiatives. iv. Involve relevant actors to contribute to network activities and provide or facilitate access to relevant data for the networks' activities.
<p>3.2.3 Establish European and national human capacity development programmes in genetic resources conservation and sustainable use, and as appropriate, integrate genetic resources aspects into existing programmes in colleges, universities, and industry.</p>	<ul style="list-style-type: none"> i. Review existing European and national human capacity development programmes in genetic resources conservation and sustainable use. ii. Implement recommendations for enhancement of the European and national human capacity development programmes.

Indicators	Indicative timescales	Indicative level(s) of action
<p>The leadership role and functions of the three European genetic resources networks are formally recognized in relevant global, European and national fora.</p> <p>Expansion of network activities has significantly contributed to implementation of the recommendations of the <i>Genetic Resources Strategy for Europe</i>.</p> <p>The networks are engaged/involved in research and innovation projects.</p> <p>Relevant stakeholders contribute to network activities and provide/facilitate access to relevant data for the networks' activities.</p>	<p>≤3 years</p>	<p>European and national</p>
<p>Review of the European and national human capacity development programmes in genetic resources published.</p> <p>Improved human capacity development programmes in genetic resources implemented and regularly monitored.</p>	<p>4–7 years</p>	<p>European and national</p>

3.3 Enhancing awareness of the roles and values of genetic resources

Recommendations	Associated actions
<p>3.3.1 Increase professional awareness of the different values of genetic resources, including the relative costs and benefits of their conservation and sustainable use by different stakeholders at national and European levels, as an impetus to strengthen national and regional policy commitments to genetic resources conservation and sustainable use.</p>	<ul style="list-style-type: none"> i. Raise professional awareness of the different values associated with genetic resources conservation and use for practitioners and policymakers. ii. Assessment and quantification of the relative costs and benefits of genetic resources conservation and use.
<p>3.3.2 Increase education and awareness among the public, including children, of the values of genetic resources to society, the inter-dependence of all countries on genetic resources, and the importance of maintaining genetic diversity to sustain the provision and use of daily commodities by all households.</p>	<ul style="list-style-type: none"> i. Raise public, including children's, awareness of the different values of genetic resources to society and strengthen national and regional policy commitments to genetic resources conservation and sustainable use. ii. Implement the improved means of raising public, including children's, awareness of the different values of genetic resources to society.

Indicators	Indicative timescales	Indicative level(s) of action
<p>Increased professional support for strengthened national and regional policy commitments to genetic resources conservation and sustainable use.</p> <p>Cost–benefit analysis considered when implementing policy applications and practical genetic resources conservation and use.</p>	≤3 years	European and national
<p>Material designed to raise public awareness for adults and children of genetic resources values to help strengthen national and regional policy commitments to genetic resources conservation and sustainable use published.</p> <p>Levels of public support, including children’s, awareness of the different values of genetic resources to society regularly monitored.</p>	≤3 years	European and national

3.4 Joining forces between actors and domains

Recommendations	Associated actions
<p>3.4.1 Foster the participation of, and collaboration between actors and domains, to identify potential synergies and greater integration of public and private genetic resources actors, as well as firm linkages with other stakeholder communities.</p>	<p>i. Review existing collaboration between actors and genetic resources domains, as appropriate, to identify potential synergies and greater integration of public and private genetic resources actors and other stakeholder communities, as appropriate.</p>
<p>3.4.2 Develop collaborative activities in support of information infrastructures to enable better findability, interoperability, and access to all relevant sources of data and knowledge, develop a common ethic on data sharing, enhance outreach with global initiatives on linked open data, increase expertise in data stewardship among the different actors, and build capacity to address future documentation needs.</p>	<p>i. Undertake collaborative activities aiming at FAIR information systems, including creation of genetic resources ontologies, development of common data ethics, data sharing and information management training schemes.</p>

3.5 Mobilizing funds for conservation, documentation and sustainable use

<p>3.5.1 Provide appropriate and long-term financial support for European and national genetic resources conservation and sustainable use activities and measures, targeting the various stakeholder groups involved, and ensuring the equitable participation of all European countries.</p>	<p>i. Develop/identify financial mechanisms and resources to provide appropriate and long-term support for European and national genetic resources conservation and sustainable use.</p>
<p>3.5.2 To strengthen the coordination of European activities, alongside national government funding, introduce a contribution from the European Commission to ensure appropriate and long-term funding of the three European genetic resources networks, ECPGR, ERFP and EUFORGEN.</p>	<p>ii. The European Commission and national agencies provide long-term funding for the three European genetic resources networks (ECPGR, ERFP and EUFORGEN)—namely the secretariats and networking activities.</p>

Indicators	Indicative timescales	Indicative level(s) of action
Report on existing collaboration and potential synergies between actors and domains published.	≤3 years	European and national
Domain-specific information systems are FAIR compliant, refer to common genetic resources thesaurus and ontologies, apply common ethics concerning data sharing, and all national focal points are trained.	≤3 years	European and national
Financial mechanisms are in place and appropriate resources are available to ensure effective and efficient European and national genetic resources conservation and sustainable use.	4–7 years	European and national
Long-term funding of the three European genetic resources networks, ECPGR, ERFN and EUFORGEN is provided.	≤3 years	European and national

4. REINFORCING INTERNATIONAL COOPERATION

Recommendations	Associated actions
<p>4.1 Promote pan-European collaboration for the conservation and sustainable use of genetic resources, and facilitate the active participation of all European countries in the implementation of the <i>Genetic Resources Strategy for Europe</i> and domain-specific strategies.</p>	<p>Support participation of all European countries in the implementation of the <i>Genetic Resources Strategy for Europe</i> and in respective consultations and events of the three networking programmes.</p>
<p>4.2 Maintain and develop inter-regional partnerships for conservation and sustainable use of genetic resources with other regions, especially the Caucasus, Near East and North Africa.</p>	<p>Develop/maintain inter-regional activities on genetic resources conservation and sustainable use with countries from other regions (especially the Caucasus, Near East and North Africa) as appropriate, including the provision of bilateral funding for the development of mutually beneficial cooperation and genetic resources activities.</p>
<p>4.3 Reinforce, or where lacking, establish coordination measures and processes between national and regional focal points and representatives for Europe in international fora dealing with conservation and sustainable use of genetic resources.</p>	<p>Reinforce, or where lacking, establish coordination measures and processes between national and regional focal points to ensure European representation in international genetic resources conservation and sustainable use fora.</p>

Indicators	Indicative timescales	Indicative level(s) of action
Number of countries that participate in network-based consultations and <i>Genetic Resources Strategy for Europe</i> implementation.	≤3 years	European and national
Number of projects involving countries outside Europe funded.	≤3 years	European and national
Coordination mechanisms allow effective and timely European contribution to international fora.	≤3 years	European



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817580



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The GenRes Bridge project is coordinated by the European Forest Institute