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The State of Plant Genetic Resources for Food and Agriculture in Norway

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SAMMENDRAG/SUMMARY:

Plantegenetiske ressurser utgjør det biologiske grunnlaget for all plantebasert landbruksproduksjon. I det genetiske mangfoldet ligger muligheter for å justere, forbedre og tilpasse produksjonen av nytteplanter til dagens eller fremtidens behov. I tillegg representerer diversiteten av arter og sorter i norsk landbruk en viktig del av vår kulturarv. Bevaring og bærekraftig bruk av plantegenetiske ressurser er et globalt anliggende og FAO har utarbeidet en global handlingsplan som synliggjør en rekke prioriteringer for å bevare og bruke plantegenetisk mangfold på nasjonalt nivå. Denne statusrapporten peker på resultater, trender og utfordringer innenfor dette feltet i Norge og er det norske bidraget til FAO rapporten «Third State of the World´s Plant Genetic Resources» (forventet 2023).

Plant genetic resources form the biological basis for all plant-based agricultural production. In the genetic diversity lie opportunities to adjust, improve and adapt the crop production to current or future needs. In addition, the diversity of species and varieties in Norwegian agriculture represents an important part of our cultural heritage. Conservation and sustainable use of plant genetic resources is a global concern and FAO has established a global action plan that highlights priorities for conservation and use of plant genetic diversity at national level. This report points to results, trends and challenges within this field in Norway and is the Norwegian contribution to the FAO report "Third State of the World's Plant Genetic Resources" (expected 2023).

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This report was written in spring 2022 and is an abridged version of the country report which was submitted electronically to the Food and Agriculture Organization of the United Nations (FAO) in 2021. The national report considers the period 2014 to 2020 and presents the status of conservation, sustainable use and development of plant genetic resources for food and agriculture in Norway in this period. All relevant areas of the Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture has been addressed, including gaps and needs. The national report has been prepared by the Norwegian Genetic Resource Centre in NIBIO in accordance with the guidelines provided by FAO. The full electronic report is available through FAO's database WIEWS - World Information and Early Warning System on Plant Genetic Resources for Food and Agriculture.

The Norwegian Genetic Resource Centre would like to express its gratitude to those institutions and persons who have provided data for the compilation of this report. This includes the Norwegian clonal archives, the Norwegian Food Safety Authority, Graminor AS, the Norwegian Community Seed Bank, KVANN – Norwegian seed savers, Solhatt økologisk hagebruk, the Nordic Genetic Resource Center, as well as several different departments in NIBIO.

The Ministry of Agriculture and Food and the Norwegian Agriculture Agency have been actively involved in the reporting process and we greatly appreciate the inputs and advice along the way.

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Ås, 26.09.22

Linn Borgen Nilsen

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Executive summary

The utilization of genetic diversity has always been at the core of agriculture and food production. Through time, it has enabled us to develop plant varieties that are resistant to disease, that are adapted to different climatic conditions and suitable for a range of farming systems. In a world where food production is confronted by environmental challenges, a rapidly changing climate and shifts in consumer preferences, conservation and sustainable use of genetic resources remain vitally important.

It is well documented that biological diversity is declining rapidly in all parts of the world. This trend is also evident in species and varieties associated with agriculture. Plant diversity in farmer's fields is decreasing and the threats to survival of crop wild relatives and wild food plants are increasing. To prevent further genetic erosion and make sure that plant genetic resources are sustainably used, FAO has facilitated the elaboration of a global framework and action plan for this area of work. The Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture (Second GPA) lays out a series of priorities and actions to protect and use plant genetic diversity. The Second GPA is implemented at national level and this report is reflecting the status of its implementation in Norway, highlighting achievements and trends in 17 different areas of PGRFA conservation and use in the period 2014 to 2020. The report is also highlighting gaps and needs that should be prioritized for the upcoming period.

In situ conservation and management

The first section of the report addresses *in situ* conservation and management, which is the protection of genetic resources in their natural habitat – either in nature or in the production systems where they are grown. This involves efforts to document diversity, and to implement conservation activities in nature and in farmer's fields. Both the conservation of crop wild relatives (CWR) *in situ* and the management of landraces and other traditional cultivars "on-farm" are identified as important in the Norwegian context. Particularly regarding CWR there has also been significant progress during this reporting period. The knowledge base of CWR species has been strengthened, including information about their distribution, risk status and genetic diversity. A checklist of 206 CWR species recommended for *in situ* conservation has been elaborated, and concrete conservation activities has been implemented in Jomfruland National Park and Færder National Park, both in the southern part of the country.

On-farm management refers to the continuous maintenance of landraces and traditional varieties in production systems, including the selection and harvesting of seeds. On-farm management is closely linked to food culture, agricultural traditions and the management of the cultural landscape. There are farmers and groups of farmers in Norway that are actively growing and maintaining landraces and traditional varieties. Nevertheless, on-farm management is not established as a formal conservation strategy, and there is no national monitoring of diversity in farmer's fields. The project "Conservation in use - new local varieties in the meadow plants timothy, fescue and red clover" is an example of an approach where populations of timothy, meadow fescue and red clover are conserved and monitored on-site in managed meadows. The Norwegian Community Seed Bank was also established in 2018, enabling better access to planting material of landraces and traditional varieties of grain and vegetables. There seem to be an increasing interest in local and traditional produce among consumers. To agree on a strategy for the implementation of on-farm management and to further improve the conditions and opportunities for farmers who wish to grow landraces and traditional cultivars on-farm remain important in the coming period.

Ex situ conservation

Complementary to *in situ* conservation and on-farm management, PGRFA should also be conserved *ex situ* in accordance with relevant international standards (FAO, 2013). *Ex situ* conservation refers to

the safeguarding of PGRFA outside their natural habitats, such as in genebanks. This form of conservation is particularly important to ensure access to the material for research and development purposes. The responsibility for *ex situ* conservation of PGRFA in Norway is shared between the Nordic Genetic Resource Center (NordGen) and the Norwegian Genetic Resource Centre in NIBIO. While seed propagated species are stored at NordGen's facilities in Alnarp, vegetatively propagated species, including fruit trees, berries, potatoes and vegetables and ornamental plants are maintained as live samples in Norwegian clonal archives. The Norwegian Genetic Resource Centre is keeping the oversight of the collection at national level and coordinating national and international reporting. The clonal archives are mostly field genebanks, hosted by various institutions such as botanical gardens, research centers and local museums. There is also one facility for *in vitro* conservation at NIBIO in Ås and one facility for cryopreservation at Sagaplant AS in Telemark. The plant varieties conserved *ex situ* have increased in the reporting period, both at national and Nordic level. At the end of 2020, 1 151 unique crop varieties are maintained in Norwegian clonal archives and more than 34 000 accessions are maintained at NordGen (approximately 2000 of Norwegian origin).

The work and organization of *ex situ* conservation of PGRFA is well established in Norway and the oversight and reporting from the collections have improved significantly during this reporting period. Still, only about 50% of the accessions in Norwegian clonal archives are adequately secured in back-up collections at other sites. There are also challenges related to proper identification of some of the conserved material and it is expected that up tp 15% of the accessions in the clonal archives are duplicates. Given that the *ex situ* conservation system involves many different stakeholders, there are also large differences in the capacity of the clonal archives to maintain collection in line with the international Genebank Standards, including timely regeneration, documentation, and safety duplication.

Sustainable use

One of the main goals of the national program on PGRFA is to ensure and promote the sustainable use of these resources. Plant genetic resources from Norwegian and Nordic genebanks are used regularly by researchers and research institutions, as well as in Nordic pre-breeding projects. In addition, a broad range of traditional varieties and landraces are used directly in small scale production. Sustainable use of PGRFA is thus referring to both direct uses, as well as utilization of conserved material in research and development.

With climate change affecting our food production and demanding the implementation of a more environmentally friendly agriculture, the relevance of plant genetic resources in research and breeding is high. To identify plant material that may be of interest for inclusion in breeding programmes, it is necessary to assess and describe its morphological traits. This is referred to as characterization. Ideally, characterization should be established as a routine task by all genebanks. In Norway, the description and testing of material in *ex situ* collections is rather subject to individual research projects and inadequate funds and human resources constitute a major constraint.

Plant breeding is the most important tool to improve crops and adapt them to new conditions, practices, and consumer requirements. All plant breeding of agricultural crops in Norway is done by the company Graminor AS, which is partly owned by the Norwegian state. There are currently active breeding programmes in eight food crops and sixteen perennial grass and meadow legumes. Graminor is also an active participant in research and development, including in four pre-breeding programmes coordinated by NordGen. To further promote the increased utilization of conserved germplasm, more knowledge about the material and better linkages between the conservation- and user communities are essential elements.

The Norwegian seed system is highly regulated, but is recognising farmers' rights to save, use and exchange seeds and propagating material on a non-commercial basis. This is an important perquisite for on-farm management, as well as direct use of landraces and traditional varieties in production.

Production for the commercial market is still dominating the agricultural system in Norway, and the amount of diversity in alternative production systems is not very well documented. It is therefore hard to say if there has been a decrease or increase in the direct use of landraces and traditional varieties in the reporting period. When the import ban on planting material of apple and strawberries was lifted in 2015, the production and sale of Norwegian apple and strawberry plants dropped markedly. This has contributed to decreased use of many traditional apple varieties. The Norwegian Community Seed Bank and seed company Solhatt Organic Horticulture has nevertheless contributed to increased access to seeds of traditional Nordic grain and vegetables to producers and has observed an increased interest in this material. KVANN – Norwegian Seed Savers is similarly noticing an increaseing interest in plant diversity and exchange of plant material among hobby growers.

Building institutional and human capacities

The National strategy for the conservation and sustainable use of genetic resources for food and agriculture[1] was published in 2019 and provides the overarching framework for genetic resources conservation and use in Norway. The national PGRFA programme is defined by the National strategy and sectoral action plans and jointly implemented by the Ministry of Agriculture and Food, the Norwegian Agriculture Agency and the Norwegian Genetic Resource Centre. These entities have different roles and responsibilities and promotes oversight, coordination, implementation and financing of activities to conserve and use PGRFA at national level.

It is an important goal for the national PGRFA program to ensure that there are people with adequate skills and expertise available, that the organizational set-up of the program is efficient and that there is an enabling environment in place for its implementation. The programme is also providing a linkage to regional and global efforts in the PGRFA sector.

Norway invests considerable efforts in national and international networks. The network of actors involved in PGRFA conservation and use at national level has been formalized through written agreements during this reporting period. Norway is also actively participating in Nordic and European networks, including more than 20 thematic- or crop-specific working groups under the auspices of NordGen and the European Cooperative Programme for Plant Genetic Resources. KVANN – Norwegian Seed savers was also established in this reporting period and has grown into an important national network for hobby growers and plant enthusiasts.

Despite many achievements, a continuous strengthening of capacities - both of staff, organizations, and networks - active in the conservation and use of PGRFA remain important. To improve the information systems for PGRFA and strengthen the level of oversight by the national program is also a priority for the coming period. In particular, the establishment of a publicly accessible database with information about all the accessions that are maintained *ex situ* in Norwegian clonal archives is of high importance.

It is also crucial to make the topic of PGRFA known and relevant beyond the narrow network of stakeholders currently working in this area. This could be achieved by lifting the topic on the political agenda and sharing information about the value and importance of genetic resources for food and agriculture to a wider range of sectors and organizations.

[1] https://www.regjeringen.no/contentassets/de2f09351b904a4aa00c2a9a97f2efae/m-0754-e-lmd_strategy_eng_high.pdf

Introduction

Genetic diversity is a fundamental component of biodiversity. It represents the genetic variation within a species and allows a population to continuously adapt to their surroundings. Through selection and production of animal breeds and crop species with desired traits, humans have utilized this diversity actively since the beginning of agriculture. Through time, we have developed an impressive range of breeds and varieties, from which we get food, feed, oil, textiles, and other biological products. The genetic diversity in agricultural crops is an asset for many reasons. It allows the development of varieties that are more robust, better adapted to a particular environment or resistant to critical pests and diseases. It also allows the development of varieties whose production has a smaller environmental footprint, that provides us healthier or better products or are preferrable for other reasons. This makes plant genetic diversity an essential factor in the complex challenge of ensuring food-, livelihood- and income security. In addition to this, the genetic diversity that is represented in agriculture is an important part of our traditions and cultural history.

In 1987, the Report of the World Commission on Environment and Development: Our Common Future drew attention to the rapid loss of biological diversity and placed this as as one of the world's greatest challenges. Thirtyfive years later the loss of biological diversity is only acellerating. Global reports, such as the State of the World's Biodiversity for Food and Agriculture (FAO, 2019) and the IPBES Global Assessment Report on Biodiversity and Ecosystem Services (2019) point to the immense loss of biodiversity that has happened over the past decades, including diversity which is essential for food and agriculture. This trend is among other causes a result of population growt, massive deforestation, habitat fragmentation and modern agricultural practices. Plant genetic resources for food and agriculture (PGRFA) refers to both wild- and domesticated species and varieties, including traditional varieties, modern cultivars, crop wild relatives, and other wild food plants. It is well documented that PGRFA are lost both through a decline of species and varieties, as well as in the reduction of genetic variation within certain species or varieties. Genetic erosion creates a potential risk for agriculture's ability to withstand and adapt to new challenges and may compromise our ability to ensure sufficient and sustainable food production in the future.

International cooperation is important in order to ensure the conservation and sustainable use of genetic resources for food and agriculture. For several decades, Norway has actively participated in international fora and instruments, including processes in FAO's Commission on Genetic Resources for Food and Agriculture (CGRFA). This commission is the only permanent intergovernmental body that specifically addresses genetic diversity for food and agriculture. It aims to reach international consensus on policies in this area and oversees the preparation of global status and progress reports.

In 2010 the Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture was published. This review was based on national reports[2] reflecting the conservation and use of PGRFA at country level and submitted to CGRFA. The State of the World Reports highlight achievements in PGRFA conservation and use, but are also identifying considerable challenges, gaps and needs. In response to the Second Report, the Commission revised the Global Plan of Action on Plant Genetic Resources for Food and Agriculture (GPA). The Second GPA was adopted by the FAO Council in November 2011.

[2] https://www.fao.org/agriculture/crops/core-themes/theme/seeds-pgr/sow/sow2/country-reports/en/

The overall objective of the Second GPA is to ensure the conservation of plant genetic resources for food and agriculture (PGRFA) and promote their sustainable use as a basis for food security, sustainable agriculture, and poverty reduction in an evolving social and environmental context. The Second GPA includes 18 priority activities, which are organized into four main groups, namely:

- *In situ* Conservation and Management
- *Ex situ* Conservation
- Sustainable Use and
- Building Sustainable Institutional and Human Capacities.

To allow the compilation of a Third Report on the State of the World's Plant Genetic Resources for Food and Agriculture (Third Report), countries were requested to submit a national report to FAO on the implementation of the Second GPA at national level. These reports should reflect the trends and achievements in the two reporting periods 2012-14 and 2014-2019 and highlight remaining gaps and needs. The reports were submitted electronically in WIEWS – World Information and Early Warning System on Plant Genetic Resources for Food and Agriculture, which is FAO's reporting tool for the Second GPA. Norway submitted a national report in WIEWS at the end of 2021.

The full report follows a reporting formal consisting of 48 questions, 58 indicators and 18 narrative sections. The current report is a written compilation of the full report that was submitted to FAO. It addresses 17 of the 18 priority activity areas[3], including the most essential data and information for each of these. The Third National Report to FAO is largely reporting developments in the period 2014 to 2019, but is also considering data from 2020. It constitutes the third national report on conservation and sustainable use of plant genetic resources for food and agriculture in Norway and follows the national reports published in 1995 and 2008. The aim of the national report is to provide an outline of the status of plant genetic resources conservation and use, highlighting trends and achievements, gaps and needs for all relevant areas of the Second GPA.

The report has been prepared by the Norwegian Genetic Resource Centre in NIBIO, with inputs and recommendations from the Ministry of Agriculture and Food and the Norwegian Agricultural Agency. In addition to the sources listed as References, the report is also based on unpublished reports submitted to the Norwegian Genetic Resource Centre, as well as personal communication. The report is structured according to the Second GPA, with four main sections and chapters reflecting each of the priority activity areas.

Due to the broad range of aspects related to plant genetic resources, a national report like this has limitations. Some aspects are addressed with more detail than others and for some of the priority activity areas there is currently limited data available. The report is therefore not claiming to be exhaustive in all parts. Finally, the national report is written from the perspective of the national PGRFA program, jointly administered by the Ministry of Agriculture and Food, the Norwegian Agriculture Agency and the Norwegian Genetic Resources Centre in NIBIO. There are many different stakeholders that contribute to the conservation and sustainable use of PGRFA in Norway. It may therefore be that relevant activities, organizations or results have not been mentioned or done full justice in this review.

A good national system for the conservation and sustainable use of plant genetic resources is crucial to prevent loss and be able to benefit from a wide variety of plant genetic resources in the future. The third national report points to many significant achievements over the reporting period 2014-2020. By indicating gaps and needs it aims to contribute to the progress of implementing the Second GPA in Norway.

[3] Priority activity area 3 in the Second GPA «Assisting farmers in disaster situations to restore crop systems» was not regarded relevant in the context of Norway.

1. *In situ* Conservation and Management

A population of sand leek (*Allium scorodoprasum*) in Færder national park. Photo: Linn Borgen Nilsen, NIBIO.

In situ conservation and management refers to the protection of genetic resources in their natural habitat – either in nature or in the production systems where they are grown and managed. Protection of crop wild relatives (CWR) and wild food plants in nature is referred to as *in situ* conservation, while the continuous growth and maintenance of landraces and other traditional crop varieties is called on-farm management (FAO 2010). Both *in situ* conservation and on-farm management are important in order to allow species and varieties to develop over time and adapt to changes in environment, climate or production conditions.

The work on *in situ* conservation of CWR has been identified as an important area of work in Norway and the knowledge of CWR species has increased significantly in the reporting period. In addition to this, relevant areas for *in situ* conservation has been identified and strategic partnerships have been established. Similarly, on-farm management is recognized as central to the work on conservation and use of plant genetic resources (Ministry of Agriculture and Food, 2019). This form of conservation is closely linked to food culture, agricultural traditions and the management of the cultural landscape. To maintain diversity in production is also essential in order to keep and develop the knowledge about the characteristics and use of various species and varieties. In addition, *in situ* conservation and on-farm management are both highly dependent on the participation of farmers and environmental authorities in the conservation system. The current chapter illustrates achievements, trends and gaps when it comes to three sub-sections of *in situ* conservation and on-farm management, namely 1.1 surveying and inventorying, 1.2 support to on-farm management and improvement and 1.3 promotion of *in situ* conservation and management of crop wild relatives and wild food plants.

1.1 Surveying and inventorying

In order to elaborate policies and strategies for the conservation of plant genetic resources *in situ* and on-farm, national programmes need to know which species and crop varieties that exist in their country, their distribution and the extent to which they are already being conserved. A national checklist and inventory provides baseline data that enables diversity assessments, monitoring and planning of appropriate conservation actions (Maxted *et al*., 2008). A national CWR checklist is a list of crop wild relatives and wild food plant taxa present in a country. The full checklist is normally narrowed down to only include taxa that is considered most important or for which monitoring and/or active conservation is considered necessary. The prioritized checklist forms the basis of a national CWR inventory, in which a broader range of information on taxa is added, such as origin, distribution, functional traits and characteristics.

1.1.1 Achievements

Regarding surveying and inventorying of plant genetic resources *in situ* and on-farm, the following main achievements were made in the reporting period:

- Observations of more than 2 million wild vascular plants, including many CWR, were included in the online species observation system by the end of 2019 (Artsdatabanken, website).
- A checklist of 206 CWR species that should be prioritized for conservation actions has been elaborated (Sæther et. al., 2020).
- The Norwegian Community Seed Bank and Solhatt Organic Horticulture Collection has tested Norwegian varieties of grain and vegetables and established a list of 25 landraces of grain and 15 traditional vegetables of Norwegian origin that are multiplied and disseminated to growers.
- KVANN - Norwegian Seed Savers has established an inventory of 281 Norwegian varieties of potato, vegetables, fruit, berries and herbs that are exchanged between members (KVANN, 2020).

1.1.2 Status and trends

Surveys and inventories of wild plant species

There is detailed knowledge of plant species growing in Norway, due to comprehensive floras, an active botanical community and an online species observation system[4] that allows people to register sightings of species throughout the country. The system is developed and operated by the Norwegian Biodiversity Information Centre (Artsdatabanken[5]) on behalf of the Ministry of Climate and the Environment and helps to document biodiversity in Norway. Observations of 2 million vascular plants were included in the database by the end of 2019, including many CWR. This is therefore a a valuable source of information on the presence of CWR species in Norway, and for developing relevant checklists and inventories.

[4] https://www.artsobservasjoner.no/

[5] https://www.artsdatabanken.no/

A complete Crop Wild Relative (CWR) checklist for Norway, with 2 538 species, was elaborated and published as part of a PhD project in 2013-16 (Phillips, J. 2017). The checklist was derived from the Crop Wild Relative Catalogue for Europe and the Mediterranean (Kell et al., 2008), updated and harmonized with the Flora of Norway (Lid & Lid, 2005) and cross-checked with national experts to ascertain the commonly used taxonomy for the Norwegian flora.

Based on the research done by J. Phillips, a checklist of 206 CWR species recommended for conservation actions was elaborated by the Norwegian Genetic Resource Centre. The checklist was discussed and validated by botanists and other local experts and has been published in Nøkkeltallrapporten from 2018 onwards[6]. The criteria for establishing the list included:

- Economic value of related crop (gross production value).
- Inclusion of the related crop in Annex 1 of International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).
- Identified as having specific importance to Norwegian research, culture or environment.
- Taxa within the Harlan and de Wet inventory (Vincent et al., 2013) which contains 29 priority crops of global importance.

Of the species in the inventory, 44% were relatives of forage plants, 43% of food plants and 13% a mixture of medicinal plants, forest trees and ornamental plants. More than 22% of the species on the checklist are considered threatened according to the Norwegian Red List of species, including 13 Endangered or Critically Endangered species; 12 Vulnerable and 21 Near Threatened and (see table 1).

Table 1. An overview of CWR species that are considered threatened in Norway.

Botanical name	Norwegian Name	Relative of	IUCN Red List Categories[7]	
Phleum arenarium	Sandtimotei	Medow/fodder	Critically Endangered	CR
Thymus serphyllum serphyllum	Smaltimian	Herb	Critically Endangered	CR
Allium fistulosum	Pipeløk	Vegtable	Endangered	EN
Allium senescens montanum	Kantløk	Vegtable	Endangered	EN
Arnica montana	Solblom	Medicinal	Endangered	EN
Elymus fibrosus	Russekveke	Medow/fodder	Endangered	EN
Festuca hyperborea	Polarsvingel	Medow/fodder	Endangered	EN
Lathyrus palustris	Myrflatbelg	Medow/fodder	Endangered	EN
Poa lindbergii	Knutshørapp	Medow/fodder	Endangered	EN
Poa arctica caespitans	Tuerapp	Medow/fodder	Endangered	EN
Rorippa islandica	Islandskarse	Vegtable	Endangered	EN
Vicia lathyroides	Vårvikke	Medow/fodder	Endangered	EN
Vicia pisiformis	Ertevikke	Medow/fodder	Endangered	EN
Alopecurus pratensis aplestris	Finnmarksreverumpe	Medow/fodder	Vulnerable	VU
Lactuca sibirica	Sibirturt	Vegetable	Vulnerable	VU
Malus sylvestris	Villeple	Apple	Vulnerable	VU
Phleum phleoides	Smaltimotei	Medow/fodder	Vulnerable	VU

[6] www.gen-nokkeltall.no

[7] See www.iucnredlist.org for information related to the Red List Categories and Criteria

Phyteuma spicatum	Vadderot	Vegetable	Vulnerable	VU
Poa arctica	Jervrapp	Medow/fodder	Vulnerable	VU
Poa x jemtlandica	Jemtkandsrapp	Medow/fodder	Vulnerable	VU
Rosa spinosissima	Trollnype	Rose	Vulnerable	VU
Rubus hallandicus	Grisnebjørnebær	Blackberry	Vulnerable	VU
Rubus septentrionalis	Lodnebjørnebær	Blackberry	Vulnerable	VU
Thymus praecox subsp. Britannicus	Norsk timian	Herb	Vulnerable	VU
Trifolium fragiferum	Jordbærkløver	Medow/fodder	Vulnerable	VU
Acorus calamus	Kalmusrot	Medicinal	Near Threatened	NT
Allium scorodoprasum	Bendelløk	Vegetable	Near Threatened	NT
Allium ursinum	Ramsløk	Vegetable	Near Threatened	NT
Avenula pratensis	Enghavre	Oat	Near Threatened	NT
Fragaria viridis	Nakkebær	Strawberry	Near Threatened	NT
Hippophae rhamnoides	Tindved	Berry	Near Threatened	NT
Mertensia maritima	Østersurt	Vegetable	Near Threatened	NT
Peucedanum ostruthium	Mesterrot	Vegetable	Near Threatened	NT
Phleum pratense nodosum	Villtimotei	Medow/fodder	Near Threatened	NT
Poa abbreviata	Puterapp	Medow/fodder	Near Threatened	NT
Poa flexuosa	Mykrapp	Medow/fodder	Near Threatened	NT
Poa hartzii	Strirapp	Medow/fodder	Near Threatened	NT
Poa remota	Storrapp	Medow/fodder	Near Threatened	NT
Rosa rubiginosa	Eplerose	Rose	Near Threatened	NT
Rubus caesius	Blåbringebær	Raspberry	Near Threatened	NT
Thymus pulegioides	Bakketimian	Herb	Near Threatened	NT
Thymus serphyllum tanaensis	Tanatimian	Herb	Near Threatened	NT
Trifolium campestre	Krabbekløver	Medow/fodder	Near Threatened	NT
Trifolium montanum	Bakkekløver	Medow/fodder	Near Threatened	NT
Vicia cassubica	Sørlandsvikke	Medow/fodder	Near Threatened	NT
Vicia orobus	Vestlandsvikke	Medow/fodder	Near Threatened	NT

Surveys and inventories of cultivated plants

There has also been a significantly positive trend in terms of documenting traditional varieties of grain and vegetables. The Norwegian Community Seed Bank (Bruksgenbanken) and the seed company Solhatt Organic Horticulture (Solhatt Økologisk Hagebruk) are identifying, collecting, testing and documenting traditional varieties in use and are also making it available to growers (see 3.4 and 3.5). Together the two organizations have assessed more than 150 varieties of grain and vegetables, many of Norwegian or Nordic origin. Lists of the varieties they are multiplying and distributing at the end of 2020 includes 25 landraces of grain from Norway and other Nordic countries[8] and 15 traditional Norwegian vegetable varieties[9].

The organization KVANN - Norwegian Seed Savers has also elaborated a large inventory of native and non-native plant varieties that are currently grown in Norway. Their catalogue included 281 varieties of potato, vegetables, fruit, berries and herbs of Norwegian origin (KVANN, 2020). These are made available for others through sharing and direct sale through members. The activities of KVANN are further described in chapter 1.2 and 3.4.

1.1.3 Gaps and needs

- The list of 206 priority CWR species should be reviewed and form the basis for a more detailed CWR inventory, with information about taxon, gene pool, use, distribution, crop socio-economic value, species biology and conservation and management measures.
- Work remains to identify and map CWR populations in the wild, especially in parts of the country where this is not yet conducted.
- The establishment of a common national checklist and inventory of landraces and traditional varieties of vegetables and grains that are currently grown in Norway should be elaborated, published and updated regularly.
- All checklists and inventories that have been elaborated should be made easily accessible to users and other interested, e.g. on the website of the Norwegian Genetic Resources Centre.

[8] A current list of available varieties can be found at: www.norskbruksgenbank.no/korn/

[9] Solhatt Økologisk Hagebruk: https://solhatt.no/

1.2 Supporting on-farm management and improvement

The large majority of Norwegian farmers grow conventional produce, combining livestock with crop and fodder production (Statistics Norway, online). There are however farmers that continue to grow and maintain landraces or other traditional varieties on their farms. Several organizations and initiatives are also seeking to explore or expand the direct use of historically important planting material. Few of these varieties are officially recognized[10] and produced for sale, but rather maintained in the custody of individual farmers or cooperatives, who produce, exchange or sell seed on a non-commercial basis. Continuous on-farm management contributes to conservation and use of plant genetic resources and is essential for preserving and developing knowledge about the varieties, their use and characteristics. On-farm management is not yet formalized as a conservation strategy in Norway, so in this chapter we also point to initiatives that contribute to the continued use of traditional varieties.

1.2.1 Achievements

Regarding on-farm management and improvement, the following key achievements were made in the reporting period:

- It is allowed for farmers and others to use farm-saved seeds in own production and echange planting material on a non-commercial basis (Lovdata, 2021a). The legal provisions for on-farm management is therefore secured.
- The role and rights of farmers when it comes to plant genetic resources and the importance of on-farm management is specified in the National strategy for the conservation and sustainable use of genetic resources for food and agriculture (Ministry of Agriculture and Food, 2019), the Strategy of the Norwegian Genetic Resource Centre (2013) and the Action Plan on PGRFA (Sæther, 2020).
- Important knowledge about genetic diversity and adaptation of crops managed in an on-farm system has increased due to projects such as "Conservation in use - new local varieties in the meadow plants timothy, fescue and red clover" (Sæther et. al., 2019).
- The establishment of the Norwegian Community Seed Bank (Bruksgenbanken) in 2018 has allowed farmers to access planting material of landraces and other traditional varieties of grain. The seed bank is currently storing, propagating and distributing planting material from 51 varieties of grains, including 25 landraces, to interested farmers.
- Due to the active work of KVANN – Norwegian Seed Savers, the access to and use of traditional varieties and other underutilized crops has increased among hobby growers over the last few years. In 2020, KVANN's network shared more than 600 species/varieties within their network, including 281 plant varieties of Norwegian origin (KVANN, 2020).

[10] The official list of varieties is published yearly by the Food Safety Authorities.

1.2.2 Status and trends

Regulations and policies

The rules for approval of plant varieties and sale of seeds have seen major changes during the last two decades. From 2004 to 2010 it was illegal to exchange or give away seeds that were not officially approved. This effectively prevented any wide promotion of on-farm management. The regulations changed in 2010 and farmers could again exchange and sell seeds on a non-commercial basis (except for seed potatoes). This established an important prerequisite for active on-farm management. It also became possible to apply for approval for so-called conservation varieties. These can be sold within certain limits and restrictions (see chapter 3.4 for further information).

In synchrony with the legal developments, the role of farmers in conservation and management of plant genetic resources has been emphasized and better established during this reporting period. The National strategy for the conservation and sustainable use of genetic resources for food and agriculture[11] confirms the role, rights and participation of farmers and specify the importance of allowing farmers to use farm-saved seeds in their production. Furthermore, the Strategy for the Norwegian Genetic Resource Centre (Skog og Landskap, 2013) and the action plans on conservation and use of plant genetic resources (2016-2019) and (2020-2025) specifies goals and measures to strengthen the work on on-farm management in Norway (Sæther, 2020).

Farmers contribution to on-farm management

There are no data on the amount of land under cultivation of farmer's varieties, but traditional varieties of grain and vegetables are normally produced in organic systems and at a smaller scale than commercial varieties. There is a clear trend in Norway towards fewer and larger agricultural holdings (Knutsen, 2020). The total area under organic farming also decreased from 2012 to 2019 and is currently accounting for 4,2% of total cultivated land (Statistics Norway, online). This indicates that the total area under cultivation of farmer's varieties and other traditional varieites is not increasing.

Although few large farmers see the profit in growing landraces or other traditional varieties, there are many examples of active maintenance and management of crops and varieties on-farm, as well as initiatives that indicates an interest in alternative crops and varieties. The Norwegian Community Seed Bank was established in 2018 with an aim to promote crop diversity and make old varieties commercially interesting. The seed bank is collecting material from genebanks and farmers, and test and propagate those varieties which are considered most suitable. This has created an important link between conservation and use and allows producers easier access to seeds. At the end of the 2020, planting material from 51 varieties of grains, including 25 landraces, were made available to interested growers. Approximately 20 farmers received planting material in 2020, a number which is expected to increase. The Norwegian Community Seed Bank is further described in chapter 3.4.

In line with an increased interest for traditional grain varieties, two new mills have also been established in this reporting period, focusing specifically on organically produced grain, landraces and other traditional varieties. In addition to Holli mølle (established 2007) and Økologisk Spesialkorn (established 2008), the newly established mills are Norsk urkorn (established 2014) and Gullimunn (established 2015). The farmers' cooperatives operating these mills provide an essential service to farmers who produce alternative crop varieties and play an important role in promoting these both among producers and consumers. Økologisk spesialkorn is also certified as a seed producer for certain traditional varieties (see 3.5).

[11] https://www.regjeringen.no/contentassets/de2f09351b904a4aa00c2a9a97f2efae/m-0754-e-lmd_strategy_eng_high.pdf

Use and maintenance among hobby-growers

There has been an increase in interest among hobby growers towards crop diversity, often traditional or local varieties. In 2016, Norwegian "plant clubs" were merged to establish KVANN - Norwegian Seed Savers. KVANN is a national interest organization and network who promote diversity and access to traditional crops and varieties – particularly targeting gardeners and hobby growers. The organization work to preserve traditional Norwegian food plants, as well as non-native species and varieties and facilitate the sharing of planting material in their network. At the end of the reporting period, KVANN had more than 2300 members and 20 active plant networks. The organization holds a list of 629 plant species/varieties that are promoted and shared among network members, including 281 fruit, berries, vegetables and potato of Norwegian origin (KVANN, 2020). This is contributing to the continuous growth of historic crops and varieties in fields and gardens and is promoting the knowledge and interest for this in the general public.

In collaboration with the Norwegian Genetic Resource Center, KVANN has also been administrating a "potato project", with production and distribution of "mini tubers" of traditional potato varieties. Virus-free material is received from the *in vitro* "potato genebank" at NIBIO, Ås and multiplied at Overhalla Klonavlssenter. KVANN is normally offering 6-10 potato varieties to interested hobby growers on a yearly basis. The idea is that the growers produce their own seed-potato and thereafter manage a small potato-production of diverse varieties. Approximately 150 growers received mini tubers from KVANN every year from 2018 onwards. Given that seed potatoes can spread serious potato diseases, the access to propagating material is highly regulated. Growers that are receiving material from KVANN are not allowed to pass on seed potato to others.

One type of scheme characterized by high crop diversity is Community Supported Agriculture. Community Supported Agriculture has seen a strong increase in Norway in the reporting period, counting 72 active cooperative farms in 2019, with 4313 shares (Sæther et. al., 2020[12]). This system allows consumers to subscribe to the harvest of certain farms or cooperatives, creating an alternative market with direct link between producers and consumers. This is a type of agricultural model that support crop diversity, and which also allow non-farmers to contribute to the use and management of traditional and local varieties.

Projects and initiatives relative to on-farm management

There are several relevant initiatives and on-going projects, capable of filling a larger role in on-farm management in Norway, once this is better established. The project "Conservation in use - new local varieties in the meadow plants timothy, fescue and red clover" was established in 2003 and aims to conserve and renew the genetic variety of timothy, meadow fescue and red clover in managed meadows. At the end of the reporting period, there were active fields at nine localities in Norway, and in average 20 different seed lots of each of the three meadow plants. Long-term monitoring of fields and harvesting of seed samples, has contributed with more knowledge about genetic diversity of populations, as well as the degree of adaptation to place and climate over time. This is also demonstrating an alternative model and important compliment to *ex situ* conservation.

The Selected Agricultural Landscapes Project (Utvalgte kulturlandskap i jordbruket) was established in 2006 and there are currently 46 agricultural landscapes of particular historical and biological value (Norwegian Agriculture Agency, website) The purpose of this initiative is to secure continued management of selected areas that have been shaped by long-term, traditional farming. Selected Agricultural Landscapes is an interdisciplinary, joint initiative between the Ministry of Agriculture and Food and the Ministry of Climate and the Environment. The initiative points to particularly interesting agricultural landscapes, many with a high degree of crop diversity.

[12] The original source of the data is the secreteriat for the project on Community Supported Agriculture at Økologisk Norge.

1.2.3 Gaps and needs

- Principles and procedure for on-farm management og plant genetic resources have not been officially discussed or established in Norway. It is therefore no commonly shared understanding of what on-farm management should or could entail nor a strategy for its implementation. This should be addressed and clarified in the coming period.
- There is a lack of data when it comes to which, where and to what extent landraces and traditional varieties are grown. A national inventory of traditional grain, vegetables, fruit, berries and potato maintained on-farm in Norway would provide a better overview of their status, support procedures for promoting and conserving traditional varieties and landraces on-farm, and help monitor diversity over time.
- More knowledge about the type of production system that harbors traditional crops and varieties, as well as factors that are impacting on-farm management positively and negatively is desirable. It would also be relevant to further explore and document the plant genetic diversity maintained on-farm in specific areas and to identify hotspots. The Selected Agricultural Landscapes project could provide a starting point for such analyses.
- Norway is in a good position to promote the value and opportunities of landraces and traditional varieties, for instance through new products and business opportunities. More accessible information about such varieties would contribute to increased awareness of their potential value and use, and therefore better marketing opportunities.
- There are no official financial incentives to promote, establish or support on-farm management. Subsidy schemes or other financial incentives could be explored to promote diversity on-farm.

1.3 Promoting *in situ* conservation and management of crop wild relatives and wild food plants

With climate change, there is a need to adapt our crops to new challenges such as drought, flooding, reduced snow cover and new emerging pests and diseases. Many Crop Wild Relatives (CWR) are known to harbor traits that can be used by plant breeders to increase robustness and resistance in cultivated varieties (Maxted et al., 2008). The need to conserve CWR and promote their use is therefore increasingly recognized – also in Norway.

Being wild plants, CWR can successfully be conserved in their natural surroundings (*in situ*). This allows CWR populations to continue evolving and generate new genetic variation that is adapted to current conditions. In the wild, the plant species are also an integral part of their surroundings and contribute to ecosystem functions and services. Unfortunately, the natural habitats of CWR populations are threatened by climate- and land-use change. Knowledge of the existing variation, how populations respond to changes in land use, fragmentation, overgrowing and grazing and environmental changes is therefore important in order to implement appropriate conservation strategies *in situ*.

1.3.1 Achievements

Regarding the promotion of *in situ* conservation and management of CWR and wild food plants, the following main achievements were made in the reporting period:

- Ecogeographic- and DNA diversity analyses of CWR species were conducted in the period 2013-16, increasing the knowledge base and identifying suitable locations for *in situ* conservation (Phillips, 2017).
- An assessment of specific drivers of change when it comes to CWR in Norway was conducted in the period 2013-16 (Phillips, J. 2017).
- Færder National Park has been identified as a hot spot for CWR diversity and a set of CWR species have been monitored in the park since 2013. CWR is also recognized in the management plan for the national park (Færder nasjonalpark, 2017).
- A genetic conservation unit for *Malus sylvestris* (crab apple) was established in 2020 as part of Jomfruland National Park in the south of Norway (Sæther et. al., 2020, Fjellstad and Skrøppa, 2020).
- Norway has taken an active part in three collaborative projects on CWR coordinated by NordGen, which has supported activities at the national level (Palmé et al, 2019).

1.3.2 Status and trends

The National strategy for the conservation and sustainable use of genetic resources for food and agriculture (2019) is highlighting CWR as important plant genetic resources to conserve. There has also been increased focus on CWR in Norway in this reporting period, due to an improved knowledge basis and collaborative research projects.

Research and collaboration

Research, collaborative projects and publicly available information about CWR has increased in the reporting period and established a solid fundament for further efforts. A comprehensive survey of crab apple *Malus sylvestris* in Norway was carried out in the period 2008-2013. This project was conducted by the Natural History Museum at the University of Oslo, the University of Agder and NIBIO. The study highlighted extensive hybridization between crab apple and garden apple and emphasized the need for implementing conservation efforts for *Malus sylvestris* in Norway (Tollefsrud et al., 2014).

A comprehensive CWR diversity analysis was conducted in Norway, resulting in national recommendations for *in situ* and *ex situ* conservation of 204 priority CWR. The work was published by Phillips et. al. in 2016. The study identifies the key drivers of change that are negatively affecting CWR populations in Norway, including environmental changes in key habitats, changing practices of grazing and mowing, invasive species and harvesting of wild species for consumption. The research also highlights taxa for immediate surveying, pinpoint locations that are suitable for establishing *in situ* conservation and identifies taxa that need to be collected for *ex situ* conservation. The study concludes that the majority (85%) of the prioritized CWR is found in national parks and other protected areas, but that CWR species are inadequately conserved – both *ex situ* and *in situ*. The overall recommendations presented in this study, states that *in situ* conservation of CWR in Norway should focus on implementing protection in existing hotspots, preferably associated with national parks or protected areas. The study identifies Færder National Park as a suitable area for conserving many of the CWR species *in situ*. (Phillips, J. 2017).

Two examples of CWR growing in Færder National Park. To the left, Blackthorn (*Prunus spinosa*) and to the right Sand timothy (*Phleum arenarium L.*). Photo: Anne Sjømæling

Important research- and project collaboration in the area of *in situ* conservation of CWR was established within the Nordic region in the reporting period. NordGen has led two collaborative projects (from 2015-16 and 2017-19), with participation from all Nordic countries. These initiatives were funded by the Nordic Council of Ministers and have allowed substantial progress regarding CWR conservation planning, including development of a Nordic CWR checklist (Fitzgerald H, Helpdesk G N (2020), a priority Nordic CWR checklist (Fitzgerald et al 2021) as well as the identification of suitable sites for CWR conservation. A set of recommended future actions has also been developed, with the most important one being initiation of active *in situ* conservation of CWR in all Nordic countries (Palmé et al, 2019).

In situ conservation measures

In 2009, the archipelago east of Nøtterøy and Tjøme was identified as a particularly valuable cultural landscape through the initiative «Selected cultural landscapes in agriculture». A few years later, in 2013, most of the area was included in Færder National Park. The aim of the park is to preserve a larger natural area along the coast in the outer Oslofjord. In the management plan for Færder National Park (2017-2027), protection of genetic diversity is included as a goal. By the end of 2019, several CWR species (e.g. *Phleum arenarium L.*) are regularly monitored and the park aims to conserve the genetic variation for approximately 100 CWR species, defined by the Norwegian Genetic Resource Centre (Management Plan for Færder National Park, p. 23, 2017). Although no concrete management practices have been implemented to actively protect CWR in the area, it is assumed CWR species benefit from the general protection of the park.

In 2020, a genetic conservation unit for *Malus sylvestris* (crab apple) was established as part of Jomfruland National Park in the south of Norway. Pure crab apple trees were identified and marked, and garden apples and hybrids were subsequently removed from the area (Fjellstad and Skrøppa, 2020).

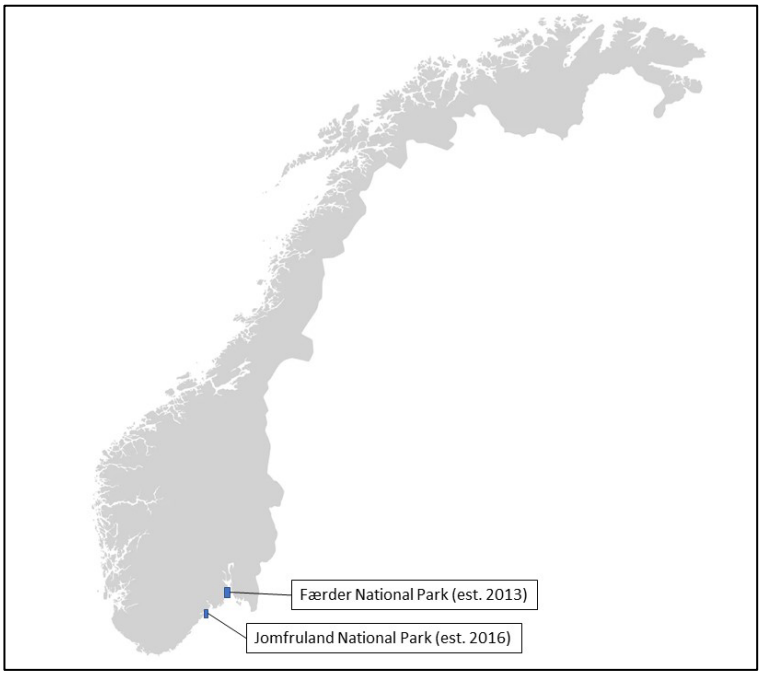


Figure 1. The location of two national parks were *in situ* conservation measures for CWR species has been implemented.

1.3.3 Gaps and needs

- There is currently no official procedure for designating *in situ* conservation areas for CWR and most protected areas do not include CWR or genetic management as an objective. It is therefore recommended to develop a procedure for designating conservation areas for CWR and establish such areas where relevant. Genetic conservation areas for CWR should implement protection and necessary management measures, regular monitoring of CWR species and reporting, as well as regulated access to the material by users. It should also be emphasized that *in situ* conservation is a long-term approach, where the timescale of concern is effectively open-ended.
- Based on the surveying and regular monitoring of CWR species in Færder National Park, the need for active conservation measures should be assessed and, if required, also implemented. It has for instance not yet been evaluated if specific CWR species or populations need active interventions to maintain healthy populations. It is therefore a priority to identify what type of management practices that is needed and to implement these in the coming period.
- The assessment and mapping of CWR is limited in most parts of Norway. It is therefore a need for continuous mapping of CWR populations, particularly in areas where this has not previously been conducted.
- CWR conservation can be a challenge, as the responsibility falls between the agricultural and environmental sectors. It is difficult to decide which organizational entity should assume the technical and financial responsibility for conservation measures. Increased information flow and facilitation of a closer collaboration between agricultural- and environmental authorities, both at national and local levels, are consequently needed.
- CWR is still not a sufficiently known plant genetic resource in Norway. Information-sharing and communication will therefore remain highly relevant also in the coming period. It is particularly important to address this topic in fora with representatives from both the agricultural and environmental sectors (see point above), and to include the topic in discussions with researchers, breeders and local government.

2 *Ex situ* Conservation

A collection of apple varieties in a field genebank at Lier bygdetun in Norway. Photo: Linn Borgen Nilsen, NIBIO.

Ex situ conservation refers to the safeguarding of plant genetic resources outside their natural habitats. This can be done in different ways, depending on the characteristics of the material. Desiccation-tolerant orthodox seeds can be stored *ex situ* in seed banks, such as in the joint Nordic gene bank in Alnarp, Sweden. Vegetatively propagated plants, or species that produce non-orthodox seeds and which cannot be stored in conditions of low temperature and humidity are conserved *ex situ* through other methods. The most used method for *ex situ* conservation of vegetatively propagated species is to maintain living clones in field genebanks. Plant germplasm can also be conserved through slow growth (*in vitro*) or cryopreservation.

It is a goal for the national PGRFA program to prevent loss of plant genetic resources that are considered national, i.e., native to Norway or imported before 1950, adapted to Norwegian agriculture and climate and of cultural, historical or commercial significance. Complementary to *in situ* conservation and on-farm management, this material should also be adequately conserved *ex situ* in accordance with relevant international obligations such as FAO's gene bank standards (FAO, 2013). *Ex situ* conservation is also important in order to ensure access to the material for research, development and teaching.

The work on *ex situ* conservation of plant genetic resources is well established in Norway and a significant amount of material has been collected and stored in suitable *ex situ* facilities. This form of conservation does require proper identification of the material, high technical know-how, close monitoring, and an information system that allows users to access the material and related information. The following three subchapters highlight achievements and trends and gaps and needs when it comes to support for targeted collection of plant genetic resources for food and agriculture (2.1), sustaining and expanding *ex situ* conservation of germplasm (2.2) and regenerating and multiplying *ex situ* accessions (2.3).

2.1 Supporting targeted collecting of plant genetic resources for food and agriculture

The national PGRFA program aims to prevent loss of plant genetic resources that are considered national and that has conservation needs, i.e., they are few in numbers, threatened or unidentified. To ensure that the national *ex situ* collection is as complete as possible, it is important to assess the existing collections and establish an agreement on which crops and varieties that Norway should prioritize for conservation. Based on this, current gaps in *ex situ* collections can be identified and collection missions to fill the gaps can be implemented.

2.1.1 Achievements

Regarding the targeted collecting of plant genetic resources, the following main achievements were made in the reporting period:

- An assessment of the *ex situ* collection of fruit and berries has been conducted. The result is a registry of varieties of apple, pear, plum, cherries, strawberries, blackcurrant, redcurrant and raspberries recommended for conservation in Norway (Sæther et. al., 2020).
- There have been targeted collection missions for vegetables, herbs, roses and other ornamental plants and crop wild relatives during this reporting period. Approximately 480 samples were collected during such missions (Norwegian Genetic Resource Centre, received reports).
- Collection missions by NordGen: 32 species of CWR has been collected during three NordGen projects and stored *ex situ* at NordGen's facility in Alnarp (Data: NordGen and the Natural History Museum, UiO).

2.1.2 Status and trends

Assessment of collections

Most of the material in Norwegian gene banks has been collected and stored prior to this reporting period. Some of the material is well documented, while approximately 15-25% remain poorly identified. It is therefore expected that the *ex situ* collections harbor both duplications and material that is not eligible for conservation. An important initiative is therefore to conduct thorough assessments of all collections in Norway and establish a registry of the material that should be conserved *ex situ*. That would allow the removal of duplications and unwanted samples and enable assessments of gaps.

Important assessments of varieties in the *ex situ* collection for fruit- and berries have been carried out. This has resulted in the elaboration of a registry (conservation lists), identifying varieties that should be permanently conserved in *ex situ* collections in Norway. The suggested registry contains 81 varieties of apple, 12 varieties of pear, 14 varieties of plums, 15 varieties of cherries, 16 varieties of strawberry, 8 varieties of black currant, 5 varieties of red currant and 14 varieties of raspberries. In addition to these, the assessment also identified varieties that are currently undocumented and that may be subject to conservation given proper identification. A similar assessment has been conducted on potatoes but is not yet finalized.

Collection missions

A few important collection-missions have still been conducted since 2014, including vegetables (especially onions), herbs and roses. Based on reports to the Norwegian Genetic Resource Centre, 480 samples were collected during these missions and are now part of the *ex situ* collection in Norway. Minor collection missions, for instance to replace accessions that have been lost, have not been systematically reported.

There has been more focus on CWR in this reporting period, including targeted collection of CWR species. Seeds from species that are not categorized as threatened have been sent to NordGens genebank in Alnarp, for long-term storage. Seeds from CWR species that are threatened (according to the Red List assessment) have been stored in the national seed bank at the Natural History Museum, University of Oslo. This includes seeds of the threatened CWR species, as indicated in table 1.

Several collection missions of CWR have been conducted in the reporting period. Samples of 32 different species have been sent to NordGen at the end of the reporting period.

2.1.3 Gaps and needs

- A registry or inventory of crops and varieties that should be permanently conserved in Norway, has not yet been developed for all plant groups. Combined with many undocumented varieties in the collections, it is a challenge to identify varieties missing from a specific collection. A thorough assessment of the stored accessions of potato, vegetables, ornamentals and medicinal and aromatic plants (MAPs) should be prioritized. The list produced from the assessment of the collection on fruit and berries should be officially approved and form the basis for an inventory and eventually inclusion on GeNBIS (see 4.3 and 4.4).
- Targeted collection of PGRFA requires that all the material in *ex situ* collections is identified and documented and that it is possible to conduct a gap analysis to identify missing material. Depending on the outcome of such assessments, it might be necessary to conduct collecting missions to supplement existing collections.
- Norwegian clonal archives are currently responsible for their own collections, including reporting of losses and addition of new accessions. An official strategy for identification of gaps in genebank holdings would be useful, to ensure better coordination and support to collections for identification of accessions and evaluation of collections.
- Targeted collection of CWR species should be promoted from various parts of Norway and stored at NordGen or (if threatened) at the national seed bank at the University in Oslo. All the CWR species on the Red List should be collected and stored.

2.2 Sustaining and expanding *ex situ* conservation of germplasm

Sustaining *ex situ* conservation of germplasm refers to the ability to adequately secure plant genetic resources in genebank facilities, such as in seed banks, field collections, or in *in vitro* and cryoconservation facilities. It is a national goal to safeguard the national gene pool for future agriculture and food production (Ministry of Agriculture and Food, 2019). To reach this goal, it is essential to have an efficient and sustainable system for *ex situ* conservation of both seed and vegetatively propagated crops, complementary to *in situ* conservation measures. Conservation efforts should focus on crops and varieties that are considered national and have conservation needs, i.e., they are few in numbers or threatened in other ways.

2.2.1 Achievements

To sustain and expand *ex situ* conservation, the following key achievements were made in the reporting period:

- The *ex situ* conservation system is well established, both for seed- and vegetatively propagated crops, involving a network of responsible institutions and back-up collections (Sæther et. al., 2020).
- The number of unique accessions in the clonal archives has increased from 566 in 2007 (Asdal, 2008) to 1151 in 2020 (Sæther et. al., 2020).
- The number of unique accessions at NordGen has increased with more than 6000 during this reporting period, including 364 accessions of material with Norwegian origin (Asdal, 2008 and NordGen, 2020).
- An inventory of all unique accessions in the Norwegian clonal archives has been established in the reporting period, as well as a yearly reporting structure from the archives to the Norwegian Genetic Resource Centre. The figures are published in a yearly report.[13]
- Written agreements between the Norwegian Genetic Resource Centre and all 27 clonal archives have been updated, formalizing the collaboration, and specifying the responsibilities of each party.
- Storage facilities for samples *in vitro*- and cryoconservation has been further established in this reporting period. At the end of 2020 there were 98 accessions of 5 different species stored in liquid nitrogen at Sagaplant and 219 accessions of potato stored *in vitro* at NIBIO in Ås (reports to the Norwegian Genetic Resource Centre, 2020).

[13] Nøkkeltall fra Norsk genressurssenter: www.gen-nokkeltall.no

2.2.2 Status and trends

The responsibility for *ex situ* conservation of plant genetic resources in Norway is shared between the Nordic Genetic Resource Center (NordGen) and a network of clonal archives, coordinated by the Norwegian Genetic Resources Centre. The clonal archives maintain collections of plant genetic resources for conservation purposes. This set-up remains unchanged from the last reporting period and is illustrated in figure 2.

The national seed bank at the Natural History Museum in Oslo collects and store endangered and rare plant species. This includes most of the 220 plants on the Norwegian Red List, including the 46 threatened CWR species.

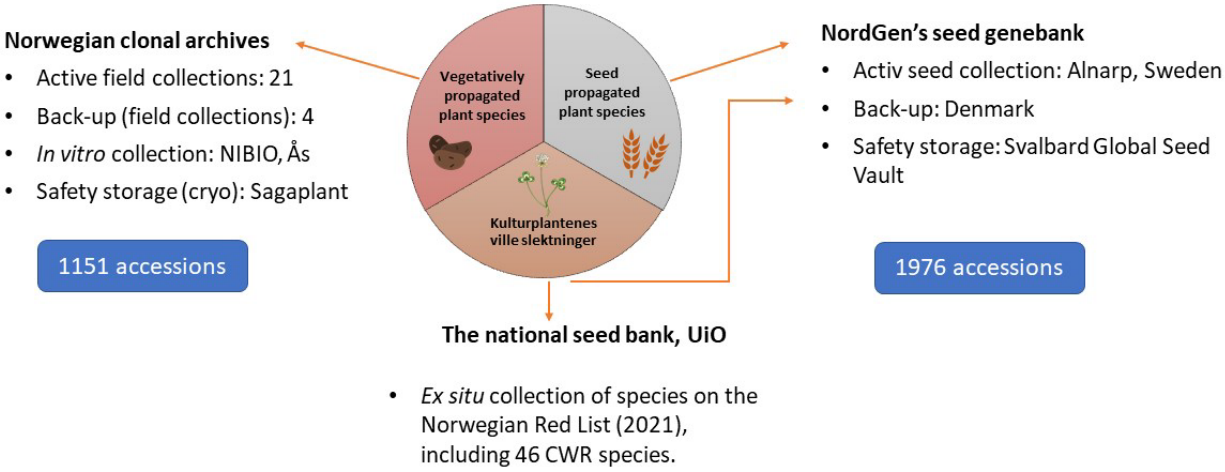


Figure 2. An overview of the *ex situ* conservation system in Norway.

Collection of vegetatively propagated species in Norwegian clonal archives

The vegetatively propagated material is maintained in clonal archives in different regions of the country. This encompasses 21 field gene banks with active collections, four back-up collection sites, as well as one *in vitro* facility for potato at the Norwegian Institute of Bioeconomy Research (NIBIO) and one cryoconservation facility at Sagaplant AS. Of the 219 accessions of potato stored *in vitro*, 109 is identified as unique and of particular interest to the conservation program.

The clonal archives are established at different types of institutions, including at botanical gardens, at NIBIO's research stations and in local and regional museum gardens. The locations of the clonal archives are indicated in figure 3.

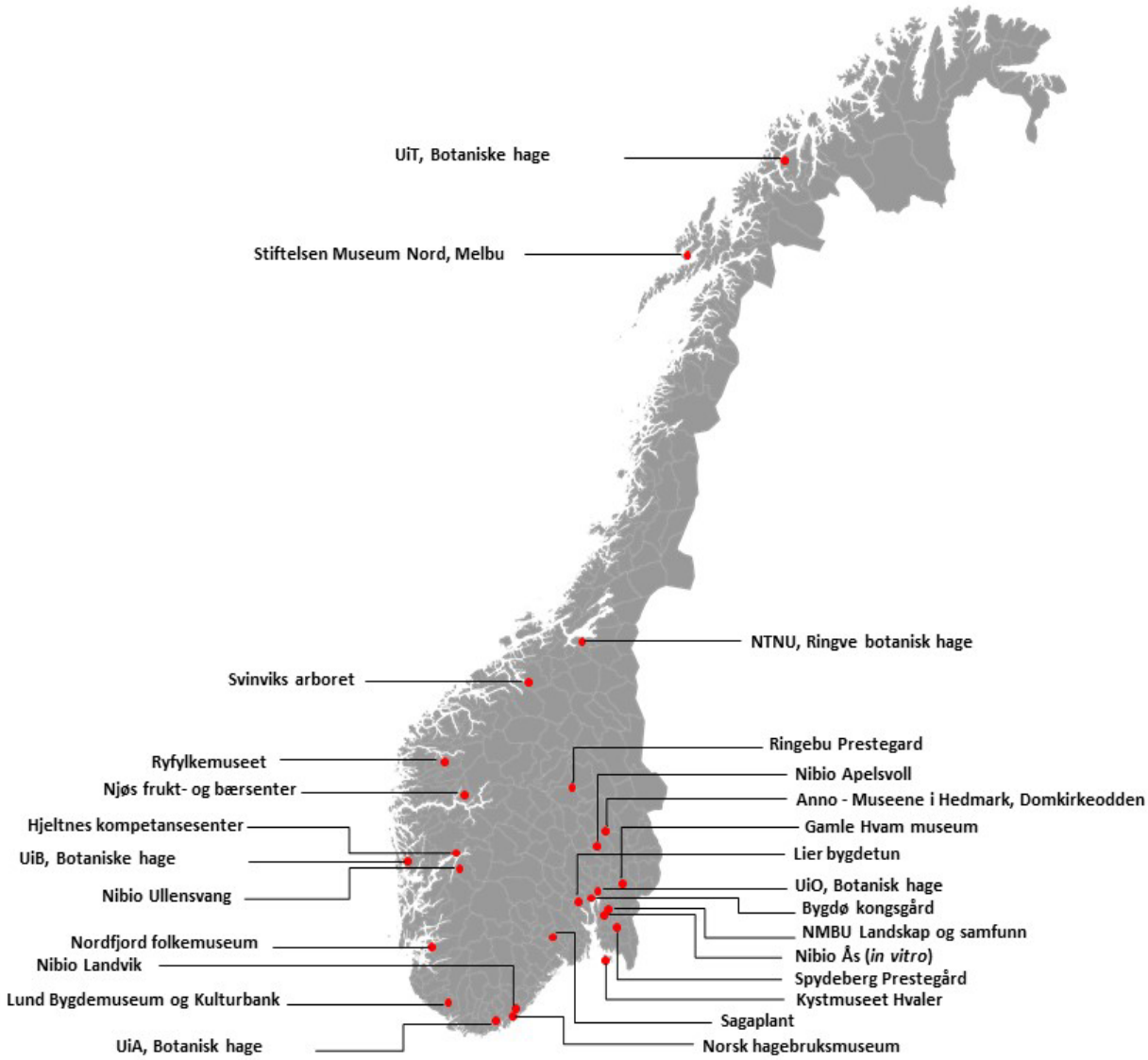


Figure 3. Map of Norway with the location of the 27 clonal archives.

The decentralized system for conservation of vegetatively propagated crops has several advantages. It facilitates the inclusion of species and varieties that are adapted to different geographical and climatic regions, from the artic north to the temperate climate further south. It also stimulates the formation of voluntary groups, building of expertise and promotion of plant genetic resources through demonstration plots and museum gardens in different parts of the country.

In the Norwegian clonal archives, there are currently over 6000 accessions stored. Figure 4 shows the trends in number of accessions maintained in the clonal archives in 2007 (Asdal 2008), 2017, 2018, 2019 (NIBIO 2020) and 2020 (NIBIO 2021). It is important to note that these numbers include some duplications between accessions.

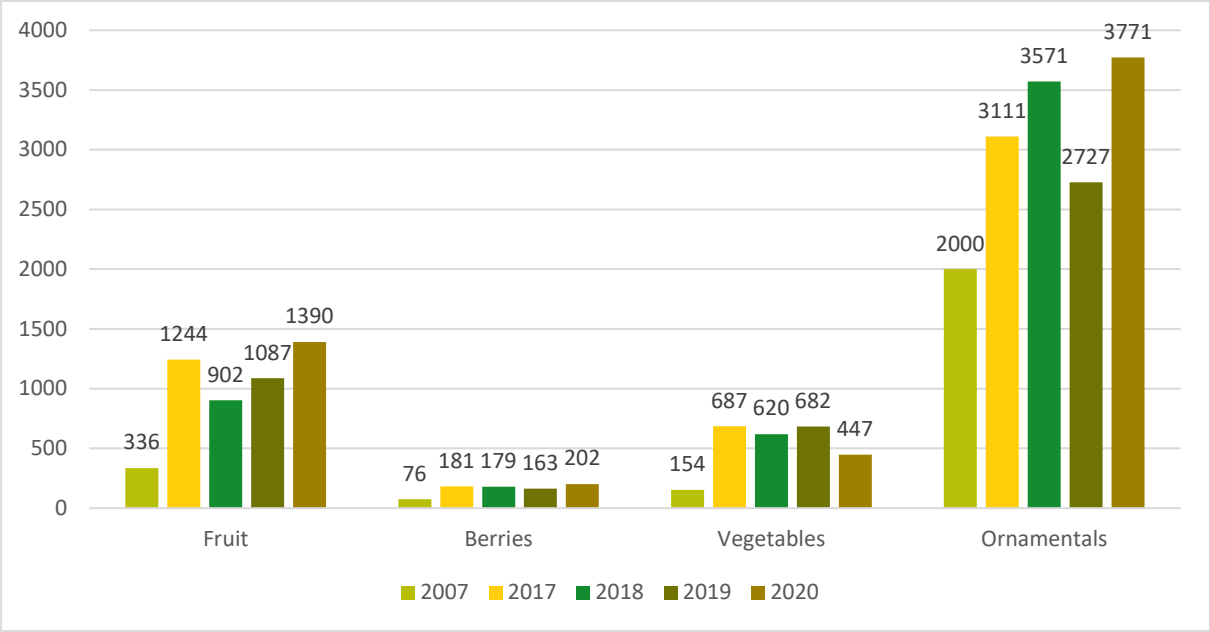


Figure 4. Number of accessions of fruit trees, berries, vegetables and ornamental plants maintained in Norwegian clonal archives in 2007, 2017, 2018, 2019 and 2020.

Based on available information about places of origin for conserved varieties, it has been estimated that approximately 15% of the varieties in the clonal archives may be duplicates (Sæther et. al., 2018). The number is likely to be even higher in the group of ornamental plants. Efforts to reduce the number of duplicates in collections have been prioritized in this reporting period. Table 2 shows the number of unique accessions of fruit trees, berries and vegetables and potato stored in *ex situ* collections from 2007 to 2020, indicating changes from the last national status report (Asdal, 2008). The largest efforts to remove duplicates have been made in fruit trees, where it is estimated that 652 accessions are of unique varieties. In berries and vegetables, the number of unique accessions has also been identified. For the group of ornamental plants, there are still duplicates in the collection.

Despite this, the number of unique accessions in the clonal archives have increased from 566 in 2007 to 1151 in 2020. This is partly the result of targeted collection, but increased identification of stored material and an improved reporting-structure from the collections is likely to have contributed positively as well.

Table 2. Number of unique accessions stored in Norwegian *ex situ* collection in 2007 and 2020.

Clonal archives Norway	**2007 ***	**2020 ****
▪ **Fruit trees**	336	652
▪ **Berries**	76	181
▪ **Vegetables and potato**	154	318
Total	***566***	***1151***

* Figures from «State of Plant Genetic Resources and Food and Agriculture in Norway» (Asdal, 2008).

** Figures from the yearly report from the Nowegian Genetic Resources Centre (Sæther et. al., 2021).

Sagaplant AS is a national plant health center and is producing elite plants and planting material of strawberries, raspberries and fruit trees. Sagaplant is also specialized in cryopreservation of plant genetic material. The company started experimenting with cryotechnology in 2007 and has in this reporting period received funding to develop the cryo-storage methods for fruit further. In 2014 systematic conservation of berries and potato varieties started and in 2020 there were 118 accessions of 5 different species (potato, strawberry, raspberry, blackberry and black currant) in cryo-storage. It is expected that the number of samples in cryo-storage will increase in the forthcoming period.

Potato varieties stored *in vitro* at NIBIO in Ås. Photo Dag-Ragnar Blystad.

Overview of the samples stored in liquid nitrogen at Sagaplant. Photo Linn Borgen Nilsen

Documentation and reporting

Several important improvements have been done with regard to documentation of accessions and establishment of a yearly reporting system. This has allowed the Norwegian Genetic Resource Centre to maintain a better overview of the collections and monitor changes and trends. Through the standardized reporting format, an updated overview of each *ex situ* collection is received every year and published in the report "Key figures from the Norwegian Genetic Resource Centre"[14]. The collaboration between the clonal archives and the Norwegian Genetic Resource Centre has also been formalized in this reporting period. This has involved the elaboration and/or revision of written agreements concerning long-term safeguarding of *ex situ* collections. At the end of 2020, there are written agreements between the Norwegian Genetic Resource Centre and all the 27 clonal archives. This has contributed to easier collaboration and more clarity around actors' roles and responsibilities and is also referred to in chapter 4.1 and 4.2.

[14] The yearly reports «Nøkkeltallrapporten» can be accessed from this webpage: www.gen-nokkeltall.no

Seed collection at NordGen

Samples from seed propagated crops are stored at NordGen's facilities in Alnarp, Sweden, with duplicates in Årslev, Denmark. The collection also has a safety back-up in the Svalbard Global Seed Vault. At the end of the reporting period, NordGen stored approximately 34 000 seed accessions from 536 different plant species (NordGen, 2020), including 1975 accessions of Norwegian origin. Table 3 shows an overview of the *ex situ* collection at NordGen, including the samples of Norwegian origin. The number of seed samples in the table also includes samples of wild relatives from the various plant groups. The collection is largely dominated by cereals, which counts for 64% of the samples. However, the samples of Norwegian origin is largely dominated by forages, which account for more than 75%. All the accessions which are conserved at NordGen are listed in the Nordic Baltic Genebanks Information System (GeNBIS).

Table 3. Number of seed samples from various plant groups in the Nordic seed collection at NordGen, including those of Norwegian origin (NordGen, 2020 and GeNBIS).

Plant groups	Total samples NordGen	Samples NordGen of Norwegian origin
Cereals	21 826	190
Grain legumes	2 859	34
Vegetables	2 121	87
Forages	4 815	1 518
Oil, fibre and root crops	1 607	42
Medicinal species	489	88
Ornamentals	275	1
Potatoes	128	15
Total	**34 120**	**1975**

NordGen's new localities in Alnarp campus, Sweden. Photo: NordGen.

NordGen's seed laboratory. Photo: Linn Borgen Nilsen

Like the vegetatively propagated crops, the collections of seeds at NordGen have also increased from the last reporting period to 2020. The number of accessions stored at NordGen in 2007 and 2020 is reflected in the figure below (Asdal, 2008 and NordGen, 2020).

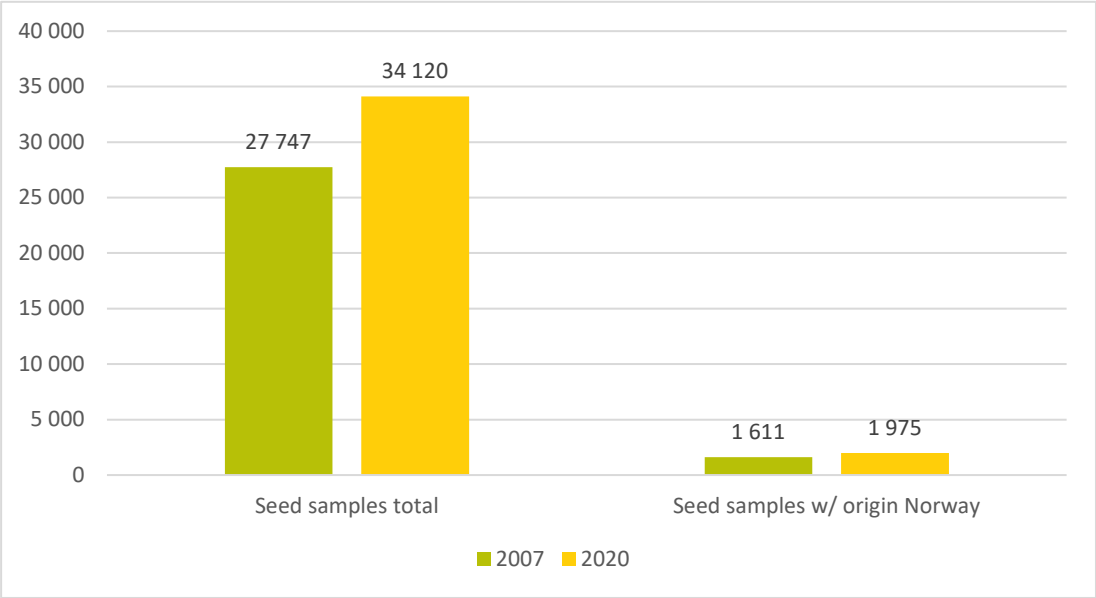


Figure 5. Number of accessions stored at NordGen's collection in 2007 and 2020, including seed samples with Norwegian origin.

Due to the common genebank for seeds at NordGen, the regional collaboration on *ex situ* conservation of seed propagated species is very good. There is regular communication and meetings between the two institutions, which for instance includes a working group GeNBIS (see 4.2 for more information about networks).

Svalbard Global Seed Vault

Svalbard Global Seed Vault is established and owned by Norway and operated in a partnership between the Norwegian Ministry of Agriculture and Food, NordGen and the international organisation Crop Trust. Svalbard Global Seed Vault is storing 1 125 419 safety duplicates of seeds from 89 genebanks around the world, including 28 170 accessions from NordGen (Svalbard Global Seed Vault's Seed Portal, numbers from 2021).

2.2.3 Gaps and needs

- The *ex situ* conservation system in Norway is decentralized, involving many different types of institutions across the country. As highlighted in section 2.2.2, this has several advantages. It does however require all the clonal archives to assume reporting and other administrative responsibilities and it makes oversight and coordination more challenging for the Norwegian Genetic Resource Centre. A reorganization of the *ex situ* conservation system, leaving the responsibility for active conservation of collections to fewer institutions may decrease the vulnerability and contribute to a more efficient management of collections, in accordance with the international Genebank Standards (FAO, 2013).
- Some of the material that is currently maintained in *ex situ* collections in Norway has not been properly identified and remain undocumented. Efforts to identify and document all the accessions in the *ex situ* collections and remove duplications is a priority.
- The clonal archives manage living plant material and the chance that accessions are lost due to disease or other environmental factors are far greater than for material preserved in more controlled environments. A close follow-up on plant health and plant health concerns is important. Furthermore, it is important that the clonal archives have access to new and fresh material when there is a need to replace dead and/or diseased material (see chapter 2.3).
- All the material that is conserved *ex situ*, either as seeds in the genebank at NordGen or as living plants in field collections, are in principle available through the Multilateral System of the International Treaty on Plant Genetic Resources for Food and Agriculture. The system of decentralized collections does however not facilitate for easy access to the material. There is therefore a need to agree on a procedure to ensure that access to the vegetative planting material in the clonal archives can be guaranteed, including access to associated documentation.
- A crucial gap in the *ex situ* conservation in Norway is the lack of a centrally managed and accessible register/database. To establish this is an important need and priority for the coming reporting period. To include all data in a digital register such as the Nordic Baltic Genebanks Information System (GeNBIS), will improve documentation, reporting and access to the material. This point is further elaborated in chapter 4.3.

2.3 Regenerating and multiplying *ex situ* accessions

Even under optimal *ex situ* storage conditions, all accessions eventually require regeneration. This is an important task and an integral responsibility of any genebank that maintains an active collection. Seed accessions should be generated when the viability has dropped below a minimum threshold (i.e., below 85% of initial viability) or when the remaining seed quantity is too small for three sowings of a representative population. In the context of vegetatively propagated material, regeneration refers to the re-establishment of germplasm samples that are genetically similar to the original and should be done when the vigour and/or plant numbers are low (FAO 2013).

2.3.1 Achievements

To ensure regeneration and multiplication of *ex situ* collections, the following achievements were made in the reporting period:

- The estimated number of accessions stored at NordGen that need regeneration has decreased from 50% to 21% and funding to address remaining regeneration needs has been secured (NordGen, 2019).
- Regeneration needs have been assessed locally in all clonal archives and reported on since 2018 (Sæther et. al., 2020).

2.3.2 Status and trends

Seed propagated material

NordGen is responsible for maintenance and quality of the seed propagated material stored at NordGen's facilities in Sweden. NordGen has implemented a routine for initiating regeneration activities when the seed germination is below 60%, which means that seed viability is maintained with a high frequency. This involves regular germination tests and assessment of all the stored material.

The size and wide range of diversity that is conserved in the genebank at NordGen does however present challenges concerning seed management and regeneration. A backlog of accessions that need regeneration has therefore accumulated (NordGen, 2020). Activities to reduce the backlogs have been prioritized in this reporting period and the status of NordGen's collection has therefore improved. From 2015 to 2018, the estimated numbers of accessions that need regeneration has decreased from 50% to 21% and the number of accessions that need germination tests has decreased from 17% to 3% (NordGen, 2019). In 2019, extraordinary funding from the Nordic Council of Ministers was also secured to further expand NordGen's regeneration activities and a project to eliminate the backlogs in the genebank collection by 2024 was adopted (NordGen, 2020).

Vegetatively propagated material

As specified in chapter 2.2. vegetatively propagated material is maintained at 27 clonal archives in different regions of Norway. These archives are responsible for the collections, including regeneration and propagation of the plants in the collection. Data on regeneration needs have been reported on since 2018 and confirm that there are high regeneration needs of vegetatively propagated material. Based on report from the clonal archives, the total need for renewal of the existing collections was estimated at between 53% and 69% for the three consecutive years 2018, 2019 and 2020, as reflected in figure 6 (Sæther et.al., 2021).

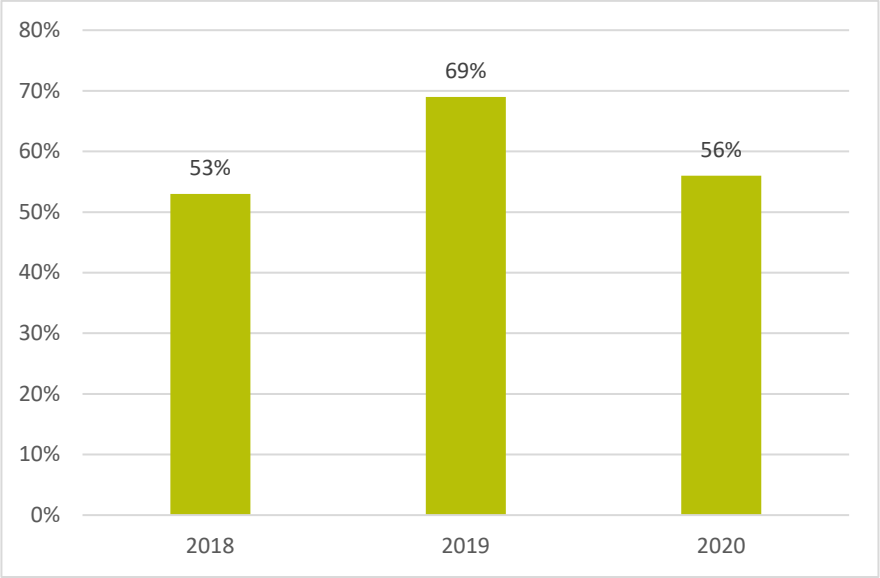


Figure 6. The diagram shows the regeneration needs of vegetatively propagated material in Norwegian clonal archives in three consecutive years (Sæther et. al. 2019, 2020 and 2021).

The total need for renewal of the existing collections has remained constantly high over the reporting period, and the backlog of material in need of regeneration is high. This is partly due to plant health issues in the fruit collections, especially apple, pear and plums. The two quarantine diseases phytoplasma mali (apple proliferation) and pear decline have particularly affected some of the clonal archives in this reporting period. These diseases have caused damage to the archive material and had serious and very costly consequences for the collections. Due to this, there has been an increased need for regeneration and multiplication from back-up collections.

An important achievement has been to establish a reporting structure, where regeneration needs are assessed and reported on from the clonal archives. This allows for a closer monitoring of the situation and creates more awareness about regeneration needs for institutions and personnel involved in the conservation system. Several clonal archives have also done a good job in highlighting their need for regeneration and has received funding for regeneration-projects.

2.3.3 Gaps and needs

The gaps and needs below are particularly related to the vegetatively propagated material, conserved in Norwegian clonal archives.

- There are regeneration needs in every germplasm collection, but these needs have not been thoroughly assessed or addressed in all clonal archives. Collecting and analyzing data on the number of accessions that are being regenerated by the clonal archives every year would improve the oversight.
- Each archive normally receives funding from the government to sustain the collection and replace accessions in events of disease or hazards. There is however no budget for regeneration at accession-level. Inadequate funds and human resources constitute major constraints for regular regeneration of collections in Norway and will need to be assessed in the coming reporting period.
- The clonal archives have different capacity to deal with regular regeneration of material. Botanical gardens and research institutions are generally having access to more personnel and expertise and are therefore able to conduct plant assessments and regular regeneration to a larger extent than local museums. A reorganization of the conservation system, with a clearer identification of responsibilities, needs and funding is a priority for the coming period. A plan for how to prevent genetic erosion in the clonal archives should be elaborated, and it would be timely to do this once the *ex situ* conservation system for vegetatively propagated plants is reorganized.
- Lack of proper identification of material in *ex situ* collections of vegetatively propagated material leads to the maintenance of unwanted duplicates in a collection. Efforts to fully identify and characterize the material in the collections is therefore essential in order to prioritize accessions for long-time storage and regular regeneration.

3 Sustainable Use

At Sagaplant, every parent plant gives rise to thousands of identical strawberry plants. Photo: Linn Borgen Nilsen, NIBIO.

One of the main goals of the national program on plant genetic resources is to ensure and promote the sustainable use of these resources. Sustainable use of plant genetic resources refers to use which does not compromise the ability for future generations to use it in a similar way. Such use will help to secure genetic resources for the future and develop our knowledge about the material. With climate change affecting our food production and with the urgent need to develop a more environmentally friendly agriculture, the relevance of genetic resources in research and breeding is high. Germplasm collections harbour diversity that may be essential in addressing these challenges.

Plant genetic resources from Norwegian and Nordic genebanks are regularly used in pre-breeding efforts as well as by researchers and research institutions. In addition, a broad range of traditional varieties and landraces are used directly in small scale production. Sustainable use of plant genetic resources is thus referring to both direct uses, as well as utilization of conserved material. The National strategy for the conservation and sustainable use of genetic resources for food and agriculture highlights the need to encourage increased and sustainable use of Norway's genetic resources in breeding programmes and business development (Ministry of Agriculture and Food, 2019).

The current assessment is that most of the plant material that should be conserved in Norway is reasonably well and safely preserved, at least in the short and medium term. However, there are gaps and challenges when it comes to assessing and documenting the material's properties, and the link with user communities still needs to be strengthened. This chapter highlights achievements and trends, gaps and needs when it comes to characterization and evaluation (3.1), plant breeding, genetic enhancement and base-broadening efforts (3.2), diversification of crop production (3.3), commercialization of landrace and underutilized species (3.4) and seed production and distribution (3.5).

3.1 Expanding the characterization, evaluation and further development of specific collection subsets to facilitate use

Characterization in the context of plant genetic resources is to describe the plant material with regard to a particular set of morphological traits. Accessions can be characterized by observation or by using modern biotechnological tools such as molecular markers (FAO 2013). On a global level, characterization has been carried out on a wide range of species, particularly with regard to traits of agronomic importance, quality attributes and tolerance and resistance to biotic and abiotic stresses. Characteristics and traits for crops are defined by crop experts and a wide range of crop descriptor lists have already been established.[15] Evaluation of plant genetic resources refers to an assessment of the material under particular environmental conditions. It involves the methodical collection of data on agronomic and quality traits through experimental trails (FAO, 2013).

Both characterization and evaluation of conserved material is of great value. It enables the collection and documentation of knowledge about the material, and it helps to provide a secure identification of a particular accession. This information is essential for those who wish to use it, such as farmers and plant breeders. Both characterization and evaluation are regarded technical and labor-intensive and standards for these activities are referred to in FAO's Genebank Standards for Plant Genetic Resources for Food and Agriculture (FAO, 2013).

3.1.1 Achievements

To ensure characterization, evaluation and further development of specific collection subsets to facilitate use, the following main achievements were made in the reporting period:

- Characterization, including molecular characterization, have been carried out in the reporting period, including for apple, sweet cherries, plums and forage grasses. (Kovi et al 2015, Fjellheim et al. 2015, Wonneberger et al. 2017, Meland et al. 2018, Fuad et al. 2016, Kenan et al. 2017 and Gaši et al. 2016, Kanlić et al., 2017).
- NIBIO, the Norwegian Agricultural Advisory Service (NLR) and NOFIMA are conducting research projects on a regular basis to assess characteristics that are important for production and consumption of different varieties of grain, fruit and vegetables.
- Graminor is routinely characterizing and assessing varieties they use or consider in their breeding work (Graminor, 2020).

3.1.2 Status and trends

The previous status report highlighted clear needs for increased characterization and evaluation of priority crops and publication of findings (Asdal, 2008). Important efforts have also been conducted over the past years, and several characterization projects have received financial support from the Norwegian Agriculture Agency and the Norwegian Research Council. This has included characterization and DNA analysis of varieties of apple, sweet cherries, plums and potatoes (Kovi et al 2015, Fjellheim et al. 2015, Wonneberger et al. 2017, Meland et al. 2018, Fuad et al. 2016, Kenan et al. 2017 and Gaši et al. 2016, Kanlić et al., 2017), resulting in more than ten published studies. Several forage grasses have also been characterized.

[15] Bioversity international has published a wide range of crop descriptor lists (Alercia A., 2011). Regional and national descriptor lists are also available such as USDA National Plant Germplasm System descriptors.

Most clonal archives have been describing and documenting the varieties they maintain in their collections. Morphological characterization has also been an essential tool for identifying undocumented material in the fruit collections (Sæther et. al., 2020). Characterization and evaluation are however subject to project finance and none of the clonal archives have systematically characterized all accessions in their collection.

Many projects to assess cultivation- and other characteristics have been carried out in the reporting period. The European Cooperative Program for Plant Genetic Resources (ECPGR) has initiated the project "Common ECPGR protocols and tools available for Characterization & Evaluation of Malus / Pyrus genetic resources" (short name Pomefruit - C&E), with a total of 22 partners in 18 countries (ECPGR, homepage). Njøs næringsutvikling is the Norwegian partner in this project, and contributes to the preparation, testing and completion of joint European descriptor lists for apple and pear.

NIBIO, the Norwegian Agricultural Advisory Service (NLR) and NOFIMA have also been involved in projects aimed at characterizing. One example of this is the project "Increased value creation for Norwegian Brassica plants" (KålSmak) led by NOFIMA in the period 2016-2020. KålSmak has mapped approx. 50 varieties of cabbage, cauliflower and leaf cabbage for cultivation characteristics, external quality, sensory properties and plant substances related to health, smell and taste. Clear differences have been found between the varieties, which provides a basis for diversification of production to cater to different areas of use.

3.1.3 Gaps and needs

- There is still undocumented material in the collections of vegetatively propagated material in Norway. Characterization of conserved accessions should be used to ensure proper identification of the material that remain undocumented.
- Characterization of material in *ex situ* collections is not done systematically but is subject to external funding. Lack of characterization and evaluation data prevents users from considering the material, and it hinders the national program in obtaining an adequate overview of the knowledge we have about the conserved material. Inadequate funds and human resources constitute a major constraint in this regard and should be assessed by the national programme, public administration, genebank-staff, plant breeders and researchers in the coming reporting period. The aim should be to ensure that characterization and evaluation is established as a routine by all genebanks.
- Characterization efforts or projects have not always resulted in officially published documentation on the number of descriptors used or traits evaluated. There is also no national register containing characterization data. In order to improve the management of collections and encourage an increased use of germplasm, documented characterization data must be publicly available. Efforts should be made to standardize data and include accessions and associated information in the Nordic Baltic Genebanks Information System (GeNBIS) for the next period.
- Genebanks should be encouraged to identify useful traits and establish specific collection subsets that may have a particular interest to users. This could for instance be traits that may be essential in adaptation to climate change in the Nordic region.

3.2 Supporting plant breeding, genetic enhancement and base-broadening efforts

Plant breeding is the most important tool to improve crops and adapt them to new conditions, practices and consumer requirements. With climate change we need crops that are able to withstand

i.a. new diseases and precipitation pattern. Extreme weather will also mean that the varieties must be more robust against rain, drought and wind. Through plant breeding, we can select for special properties, and we often select for properties that provide an economic or production advantage. Plant breeding requires genetic variation and the ability to use this variation in numerous alterations of crossing, testing and selection. Development of new varieties is a resource-intensive task, which requires continuous work over many years.

Germplasm collections can hold varieties with specific traits that can be useful for developing new varieties and to broaden the genetic base of breeding programmes. Pre-breeding or genetic enhancement is often necessary in order to produce material that can be used in breeding programmes. To ensure that the conserved material is applied by plant breeders to improve sustainability, resilience, and adaptability, it is necessary to encourage the use of techniques that allow plant breeders to apply the material, and to ensure a close link between gene banks and plant breeders.

3.2.1 Achievements

To support plant breeding, genetic enhancement and base-broadening efforts, the following achievements were made in the reporting period:

- There are currently active breeding programmes for eight food crops, in addition to 16 various perennial grass and meadow legumes (Graminor, website).
- Graminor is an active participant in research- and development, and has participated in 30 national, Nordic and international projects in the reporting period (Graminor, 2017, 2018, 2019, 2020).
- Four PPP-projects on pre-breeding in apple, strawberry, barley and ryegrass have been established by NordGen in this reporting period, involving Graminor, NIBIO and the the Norwegian University of Lifesciences (NordGen, 2020).

3.2.2 Status and trends

National plant breeding programmes

Norway has some of the world's northernmost agricultural areas, which require plants that are adapted to the particular conditions here. To develop adapted varieties and maintain agriculture in all parts of the country is a political priority in Norway (Berger et. al., 2021). This is also a necessity, given that imported material may be less suitable for the short and intense growing period so far north. Given the limited commercial value in the global market, the Norwegian state is investing in plant breeding activities for ten crops, in addition to 16 different meadow crop species. Many of these breeding programmes have a long tradition in Norway. Norwegian variety development in fruit and berries has for instance been carried out for almost a century. Examples of varieties that have been developed in breeding programmes and are still important in the production today includes the apple variety Aroma and the plum varieties Opal, Jubileum and Edda. The Norwegian pear production has also produced the pear varieties Ingeborg and Celina (referred to as QTee abroad).

Pear variety “Celina”, Photo: NIBIO

Plum variety “Edda”. Photo: NIBIO

All plant breeding of agricultural and horticultural crops in Norway is carried out by Graminor AS. Graminor is partly owned by the Norwegian state, Felleskjøpet Agri (a cooperative owned by 44,000 farmers), Strand Unikorn AS and Gartnerhallen AS. The goal of Graminor is to develop and deliver new plant varieties adapted to Norwegian and Nordic growing conditions. Graminor undertakes research, breeding and testing of new varieties of cereals, potatoes, strawberries and forage grasses in greenhouses and through field pilots. Testing of grass-varieties for the northern regions of Norway takes place at NIBIO in Tromsø and breeding and testing of fruits and raspberries at Njøs Research Station in Leikanger.

The number of crops with active breeding programmes has remained more or less the same over the reporting period focusing on crops most relevant for Norwegian agriculture. Graminor has active breeding programmes for wheat, oat, barley, potato, apple, plum, raspberry, strawberry, as well as 16 different perennial grasses and meadow legumes such as timothy grass, festuca grass, red clover and white clover. There are no breeding programmes for vegetables in Norway. There is only propagation of seeds on varieties that were previously developed in Norway, including varieties of turnip (*Brassica rapa*) and rutabagas (*Brassica napus*) (LOG Sortsliste Grønnsaker 2020 and NORGRO Sortsliste 2020 Grønnsaker). There is also some seed breeding of so-called cultural heritage varieties (after withdrawal of seeds from a gene bank), including of Kvit Mainepe (turnip), Laskala onion and several old sugar peas (Solhatt Organic Agriculture).

In addition to proven methods of crossing and selection, new technologies are also in use, e.g. to help shorten the time it takes to achieve progress or be more focused in bringing out characteristics in the varieties. Graminor is increasingly participating in projects related to use of new technologies in plant breeding, including genetic editing. At the end of the reporting period, Graminor is implementing new technologies in their breeding programmes, including marker-assisted selection and genomic selection (Graminor, 2021). Breeders in Norway is aware of the dangers of a narrow genetic base of crops and is regularly introducing new germplasm into elite breeding lines. Such efforts are contributing to broadening the genetic base of crops. Graminor is also receiving material from genebanks, including from NordGen and the Norwegian clonal archives for use in their breeding activities, especially in the Nordic pre-breding projects.

Both Graminor, Njøs frukt- og bærsenter and Overhalla klonavlsenter are maintaining active collections of plant genetic material locally. These collections are not part of the conservation system as such but remain an important resource for breeding and pre-basis production. In 2017, a new climate-regulated seed storage at Graminor was completed. This storage is functioning as a local gene

bank, storing material with interesting traits and properties that can be used in breeding programs. Most of Graminor's already approved plant varieties are also stored locally (Graminor, 2018).

Public-Private-Partnership (PPP) on pre-breeding

Given the importance of strengthening capacities in breeding and ensuring adapted material in the Nordic region, Nordic co-operation has increased. In 2011, a Public-Private-Partnership (PPP) was established on pre-breeding in the Nordic and Baltic countries[16]. The collaboration has led to six pre-breeding projects targeting perennial ryegrass, barley and fruit and berries (*Malus domestica* and *Fragaria ananassa*), as well as one project focusing on the application of automated field phenotyping in pre-breeding efforts (NorsGen, 2020). The projects are briefly described in table 4. Graminor has participated in all six projects, the Norwegian University of Life Sciences (NMBU) has participated in the project "Pre-breeding in Perennial Ryegrass (*Lolium perenne L.*)" and the Norwegian Institute for bioeconomy (NIBIO) has participated in the project Pre-breeding for Future Challenges in Nordic Fruit and Berries (NordGen, 2020).

Table 4. Nordic PPP-projects on pre-breeding in the reporting period. Kilde: NordGens nettside og personlig kommunikasjon.

Project	2012 - 2014	2014 - 2017	2018 - 2020	2021 – 2023	Partners
PPP Pre-breeding in Barley	x	x	x		Boreal Plant Breeding, Graminor, Lantmännen, Nordic Seed, Sejet Planteforædling, Landbúnaðarháskóli Íslands, Natural Resources Institute Finland (LUKE), University of Copenhagen (PLEN), and Swedish University of Agricultural Sciences (SLU).
PPP Pre-breeding in perennial ryegrass	x	x	x		Boreal Plant Breeding, DLF Trifolium, Estonian Crop Research Institute, Graminor, Lantmännen, the Lithuanian Research Centre for Agriculture and Forestry, Landbúnaðarháskóli Íslands, Research Institute of Agriculture, Latvia, University of Aarhus, and Norwegian University of Life Sciences (NMBU).
PPP SustainPotato				x	Graminor, Danespo, NordGen, Swedish University of Agricultural Sciences (SLU) and NIBIO.
PPP CResWheat				x	Swedish University of Agricultural Sciences (SLU), Graminor, Norwegian University of Life Sciences (NMBU), Natural Resources Institute Finland (LUKE), Boreal Plant Breeding, Nordic seed AS, Aarhus Universitet, Lantmännen Lantbruk og Sejet Planteforædling.
PPP Norfruit apple	x	x	x	x	Graminor, Swedish University of Agricultural Sciences (SLU), Natural Resources Institute Finland (LUKE), Universitetet i København, NIBIO, Estonian University of Life Sciences, Latvia University of Life Sciences and Technologies, and Lithuanian Research Centre for Agriculture and Forestry.
PPP Nordic Plant Phenotyping – 6P		x	x	x	Agricultural University of Iceland, Danespo, DLF, Findus, Graminor, Lantmännen, Natural Resources Institute Finland (LUKE), Norwegian University of Lifesciences (NMBU), Sejet Planteforædling, Swedish University of Agricultural Sciences (SLU), Tystoftefonden, University of Copenhagen i København, Estonian Crop Research Institute and Lithuanian Research Center for Agriculture and Forestry.

Import and export of planting material

Graminor has limited potential for export to larger markets, but is selling planting material of barley, strawberry, pear, red clower and timotei abroad, mainly to Finland, Sweden, Canada and the Baltic states. The pear variety Celina / QTee® ('Broket Juli' x 'Williams') was launched from the Graminor's

[16] Ref to NordGen's page on

department in Njøs and has made an international impact, with plantations in Austria, Belgium, France, Italy, Spain and South Africa. (Graminor, 2018, 2019 and 2020). Graminor is also testing foreign material and make those that are suitable for Norwegian conditions and needs available in the market. The particular growing conditions in Norway, limits the selection of foreign varieties that are suitable for production here.

From 2015 it became legal to import fruit- and berry varieties, including apple trees and strawberry plants. Since then, most of the planting material to Norwegian fruit- and berry farms is imported and only raspberry-production is dominated by planting material produced in Norway. This has dramatically changed the market and reduced the production and sale of locally bred varieties. For the garden market, there is still an interest in Norwegian material, where Graminor's production makes an important contribution. Sagaplant is testing and distributing material from more than 80 fruit varieties, including 30 varieties that are regarded as important historical varieties by the National PGRFA Program.

3.2.3 Gaps and needs

- The crops and varieties conserved in the clonal archives can contribute with resources in pre-breeding and breeding programmes. It is, however, not known how much of the material in the gene banks that are being actively used in breeding programmes. More information about the use of conserved material, as well as the results of the use, would be an asset for the national PGRFA program.
- To make the material more interesting and relevant for breeders, characterization and evaluation are tasks that should be prioritized and carried out in cooperation with breeders and researchers (see chapter 3.1).
- To promote increased utilization of the conserved material in plant breeding, genetic enhancement and base-broadening activities, better linkages between the conservation- and user communities is essential. Sound and up-to-date information-sharing mechanisms are particularly important, allowing potential users to access information about the accessions in any collections. This require that information about the material exists.
- The current breeding programs are targeted main crops and conventional farming methods. To promote diversification of production systems, more efforts need to be made in adapting planting material to these systems. Funding could be earmarked research and breeding for crops and varieties that are suitable in alternative production systems (e.g., organic).
- There is a need to improve varieties adapted to the climatic conditions in the northernmost regions of Norway, where several of the currently used cultivars are performing sub-optimally (Uleberg et al. 2014).
- Crop wild relatives (CWR) is a group of species that may harbour interesting traits for plant breeders, but that is currently not assessed systematically for use in Norwegian breeding programmes. Assessing traits and characteristics in CWR species that may be interesting for plant breeders would be valuable.

3.3 Promoting diversification of crop production and broadening crop diversity for sustainable agriculture

Monocropping does not only reduce biodiversity, it also poses a considerable risk for crop failure and losses in times with increasing unpredictability in weather and disease patterns. A higher diversity in production systems and crop diversity can increase the ability of agriculture to withstand and adapt to the new challenges, for instance by breaking disease cycles and erosion, reducing weeds, supplement soil nutrition and reducing farmers' risks (Tamburini et. al., 2020). A larger diversity can also stimulate the exploration of niche markets and create new industries.

3.3.1 Achievements

To promote diversification of production systems and crop diversity, the following achievements were made in the reporting period:

- There have been political efforts, including financing and elaboration of national strategies, to facilitate organic production and urban agriculture in Norway (LMD, NLR).
- There has been a systematic and targeted support for organic production in Norway over the past decade. This has resulted in a new national strategy (2020), important collaborative activities, as well as incentives for organic producers (Økologisk Norge and Jordbruksavtalen).
- There are regular initiatives to introduce new exotic crops in Norway, including sweet potato (*Ipomoea batatas*) and cold-tolerant leafy vegetables.

3.3.2 Status and trends

The national framework conditions for agriculture in Norway is given through laws, regulations and price systems together with various reports to the parliament. These reports provide background for political decisions or directions, e.g., for the design of support schemes. Agricultural policies in Norway pursue four main objectives: food security; agriculture throughout the country; increased value creation; and sustainable agriculture with lower emissions. These are implemented through the annual agricultural agreements between farmers and the government; strong border protection; farmers' responsibility for marketing balance through producer co-operatives; and a property policy to secure family-owned farms (OECD 2021).

Diversification of production systems

The Report to the Storting (white paper) 9 (2011-2012) points out that changes from small-scale agriculture into larger units with less variation in forms of production are causing loss of genetic resources and associated knowledge (Ministry of Food and Agriculture, 2011). Nevertheless, the steep decline in active farms is continuing. In 2020, it was below 40,000 agricultural holdings in Norway, compared to around 70,000 in 1999 (Statistics Norway, table number 05988). The total agricultural area has not decreased similarly, and the average area per farm has therefore increased significantly, from 76 dekar (approx. 19 acres) in 1979 to more than 250 dekar (approx. 62 acres) in 2019 (Prestvik et. al., 2020). The trend towards fewer and larger farms is also evident in the horticultural sector (Norsk landbruksrådgivning, 2020). This development has led to a strong rationalization of the whole agricultural sector, with more focus on large volumes for grocery chains and industrial processing.

There are many ways to increase the diversity of the biological components within production systems, and these may involve specific practices (e.g., intercropping), as well as broader integrated approaches (FAO, 2018). In this section we have chosen to focus on the promotion of organic agriculture, urban

agriculture, and community supported agriculture, which are production forms that are associated with a higher level of crop diversity than conventional farming.

Less than 5% of the agricultural area in Norway is organic (Statistics Norway, website). The area under organic production has also reduced steadily, from approximately 500 000 dekar (approx. 123 551 acres) in 2012 to 420.000 dekar (approx. 103 783 acres) in 2020 (Statistics Norway, table 12661). The number of farms producing organically was similarly reduced from 2577 to 1962. It has nevertheless been invested a considerable amount in organic farming throughout the reporting period, counting up to 130–160 million NOK per year. An initiative that should ensure profitability for organic farmers and market access for organic products was also implemented in 2016. This project, "Landbrukets Økoløft", was the first time agricultural organizations joined forces in a binding and systematic collaboration to promote organic farming in Norway. In 2018, a new national strategy for organic farming was also published by the Ministry of Agriculture and Food in 2018. Even if organic agriculture is not very significant in terms of area planted, it may still have an important effect on the overall genetic diversity used in crop production. “Jordbruksavtalen” (the annual agreement between farmer associations and the government) specifies the incentives for farmers that are producing organically (Ministry of Agriculture and Food, Jordbruksavtalen[17]).

Urban agriculture can help reduce the downscaling and fragmentation of natural areas, green structures and biodiversity and can also be a useful tool to increase agricultural diversity. Small areas of land, which are managed more manually, are highly suitable for growing traditional plant varieties. Through research from NMBU, NIBIO and the Norwegian Veterinary Institute, the knowledge base for urban agriculture has improved. A national strategy to facilitate urban agriculture in Norwegian cities and towns has also been prepared in the reporting period (Norwegian Ministries, 2021).

A more streamlined agricultural sector, combined with more awareness about food, climate and sustainability and new marketing channels have stimulated various forms of cooperative agriculture. Common to most of these is that they are based on direct sales to consumers. There have for instance been numerous projects related to Community Supported Agriculture ("andelslandbruk") in the reporting period (Økologisk Norge, website), and the development of this type of farming has accelerated since 2014. Økologisk Norge reports that 96 Community Supported Agriculture projects were established in the reporting period.

Diversification of crops and varieties

The Norwegian official variety list shows the varieties of agricultural and horticultural crops that have been approved by the Norwegian Food Safety Authority for certified production in Norway. At the end of 2020, 344 varieties from 72 species were approved for certified production (Norwegian Food Safety Authority, 2020a). This is a decrease from 547 varieties and 96 species in 2014 (Norwegian Food Safety Authority, 2014). Despite this trend, Graminor has a relatively wide portfolio of breeding programmes, compared to similar companies abroad and new varieties are produced or imported and tested on a yearly basis. This is helping to ensure the availability of diverse planting material adapted to Nordic conditions.

Re-introduction of traditionally grown crops is very interesting in terms of PGRFA conservation and use. Efforts to reintroduce hop plants (*Humulus lupulus*) has been conducted in this reporting period, and a collection of 33 varieties of hops has been established at NIBIO in Apelsvoll. This may be of interest to for instance microbreweries who may wish to use local ingredients and varieties.

[17] The most resent Agricultural Agreement (Jordbruksavtalen) can be found on LMD’s home page: https://www.regjeringen.no/no/tema/mat-fiske-og-landbruk/jordbruk/innsikt/jordbruksoppgjoret/id2354584/

There is a renewed interest in Norwegian hop plants (*Humulus lupulus*). Photo: Erling Fløistad, NIBIO

Containers with hops at NIBIO Apesvoll. Photo: NIBIO

Other projects to increase diversity have been implemented by both public and private actors. One example of this is the project "Increased value creation for Norwegian Brassica plants" (KålSmak) led by NOFIMA in collaboration with NIBIO, NLR, BAMA and other actors in the period 2016-2020. KålSmak has mapped approx. 50 varieties of cabbage, cauliflower and leaf cabbage for cultivation characteristics, external quality, sensory properties and plant substances related to health, smell and taste (Nofima). Clear differences have been found between the varieties, which provides a basis for diversification of production to cater to different areas of use.

Traditional food products have also been joined by a widening selection of Norwegian-produced food with an international origin. The Norwegian government has called for more investigation and testing of vegetable varieties adapted to Norwegian conditions in this reporting period (Jordbruksavtalen 2019-20, Norsk landbruksrådgivning 2020). The demand for exotic vegetables, spices and herbs is also increasing in Norway. The introduction of new vegetables is often taking place in a relatively closed cycle, established through direct communication between grower and wholesaler. There has however been a well-documented trail on sweet potato (*Ipomoea batatas*) with production in the southern part of Norway.[18] NIBIO is also conducting research and testing of other exotic vegetables, and there is small-scale production of species such as maize, okra, amaranth, chard, chili pepper, lemon grass, zucchini, borlotti bean, edamame beans, eggplant, pak choi and other cold-tolerant leafy vegetables among individual farmers and hobby growers. As a result of warmer climate, Norway may have good opportunities to introduce new crops in the coming decade, for instance from southern Europe. This may contribute to a larger diversity of suitable planting material but is also a threat to traditional varieties and crop species developed in Norway.

In recent years, Norwegian farmers and food producers have shown great innovation. New market opportunities has allowed more direct sale from producers to consumers, creating opportunities for farmers who want to produce alternative crops and varieties not accepted by the daily stores. There has also been an increased focus on local food and specialties, contributing to increased diversity and local business development.

[18] https://www.nibio.no/nyheter/har-tro-pa-norskproduserte-sotpoteter?locationfilter=true

3.3.3 Gaps and needs

- Crop diversity in existing production systems is not very well documented, and there is no registration- and information system specifying where which variety is produced. It should be a priority to identify suitable indicators and collect data to assess these on a regular basis.
- More knowledge about the role and benefits of genetic diversity in various agricultural systems should be prioritized, including the application of traditional crops and varieties.
- The trend towards larger and fewer farms is evident. To counteract loss of diversity, it is a need to incentivize systems and practices that promote diversity in all farming systems, including in large-scale, commercial farming. Policies and financial mechanisms that support diversification programmes can include traditional crops and varieties as an important resource.
- There is currently an undersupply of organic planting material in Norway and much of what is currently used is imported (Serikstad, 2021). More resources should be allocated to the development of adapted planting material, suitable for organic production in the Nordic region.

3.4 Promoting development and commercialization of all varieties, primarily farmers' varieties/landraces and underutilized species

Production for the commercial market is dominating the agricultural system in Norway, which is limiting the number crops and varieties that is produced. There are however a diversity of alternative crops and varieties, including farmers varieties and landraces, still in use by individual farmers and small cooperatives of farmers. Direct use of landraces and underutilized species contributes to their conservation in addition to maintaining and developing knowledge about the material. As consumers are willing to pay a higher price for better quality, special products and/or local produce, many traditional varieties may have a potential for wider use.

3.4.1 Achievements

To develop and commercialize farmers' varieties/landraces and underutilized species, the following achievements were made in the reporting period:

- A favorable seed regulation allows registration and marketing of "conservation varieties" and "traditional varieties of vegetables" in limited quantities and by approved seed companies. (Lovdata 2021a)
- Establishment of the Norwegian Community Seed Bank in 2018 is making planting material from 51 varieties of grains, including 25 landraces, available to interested growers (Bruksgenbanken, website).
- Solhatt Organic Horticulture is making approximately 20 Norwegian heritage varieties of vegetables available for growers (Solhatt, website).
- "Conservation through utilization - new varieties of meadow species" is a long-term project which aims to develop famers varieties of meadow species. (NIBIO, report to the Norwegian Genetic Resource Centre)

3.4.2 Status and trends

Laws and regulations

The regulation on seed products ("Forskrift om såvarer"[19]), established by the Ministry of Food and Agriculture on 13 September 1999, aims to ensure the production and sale of seeds with the best possible health and quality. Since 2010, it has been allowed for farmers and others to trade seeds (except seed potatoes) on a non-commercial basis (Andersen, 2011). To be allowed to sell seeds and other planting material commercially, the variety have to be approved and listed in the Norwegian Official List of Varieties (Norwegian Food Safety Authority, 2020b) or in the European Union's common catalogue of varieties (EC, 2002), which lists agricultural plants and vegetable species which can be marketed in the EU.[20] The regulation on seed products also allows registration and marketing of certain "conservation varieties" and "traditional varieties of vegetables" in limited quantities and by approved seed companies. It is also possible for farmers to establish their own authorized seed shops and sell conservation varieties and traditional varieties of vegetables. Approval of conservation varieties require no official examination but is decided by the Norwegian Food Safety Authority on the basis of relevant and documented information. Although the legal framework recognizes conservation

[19] Lovdata: https://lovdata.no/dokument/SF/forskrift/1999-09-13-1052

[20] The EU database of registered plant varieties offers a search tool for all the agricultural and vegetable plant varieties whose seed can be marketed throughout the European Union.

varieties and the rights of farmers to use and exchange planting material, it is still a challenge for producers to gain access to sufficient planting material of varieties that are no longer in commercial production.

Commercialization of farmers varieties and landraces

In order to promote the use and commercialization a wider specter of grain varieties in Norway, the Norwegian Community Seed Bank was established in 2018. The goal of the seed bank is to propagate and make alternative plant material, including from landraces and other traditional varieties, available for producers. The seed bank is currently storing, propagating and distributing planting material from 51 varieties of grains, including 25 landraces, to interested farmers. The number of farmers receiving planting material from Bruksgenbanken is increasing, counting 20 farmers on average in the reporting period. The Royal Norwegian Society for Development holds the secretariat for the Community Seed Bank.

Solhatt Organic Horticulture (Solhatt Økologisk Hagebruk AS) was established in 2011 and is one of the co-owners in the Norwegian Community Seed Bank. The seed company seeks to increase the production and use of organic and biodynamic horticultural seeds in Norway, including from traditional varieties and landraces. Solhatt started seed breeding in 2012 and is making approximately 40 varieties of Norwegian-grown vegetable seeds available to hobby- and small-scale producers through their webshop. This includes 20 Norwegian heritage varieties of vegetables, such as the snow pea “Engelsk Sabel”, the pea “Jærert”, the cabbage “Mikeli” and the tomato “Ansofs gule”. These are varieties that would otherwise not be marketed.

It has been an increased focus on short-distance food and drink and knowledge about the origin of food and ingredients. Several different sales channels have emerged in recent years, such as the Farmer's- and REKO markets[21], specialty shops and various forms of direct sale from producers. In these arenas, local and specialized food producers meet customers who seek alternatives to what they can buy in traditional grocery stores. The products offered are often produced locally and can be niche products based on local or regional plant varieties or other food products based on these. If this trend consist, increased opportunities for sales and earnings may contribute to an increase in the number of producers who focus on local varieties, landraces and underutilized species. At the same time, it will contribute to making consumers more familiar with a greater diversity of food and agricultural products.

The project “Conservation through utilization - new varieties of meadow species” started in 2003 and is still ongoing. The purpose of the project is to develop new landraces of the most common meadow species in Norway, including timothy (*Phleum pratense*), meadow fescue (*Festuca pratensis*), and red clover (*Trifolium pratense*). For each species the goal is to develop several local populations adapted to different climatic conditions and different farming systems. The project was referred to under chapter 1.2 Supporting on-farm management and improvement but is also a good example of a project that is contributing to the development of landraces that could become commercially interesting (Sæther et. al. 2019).

[21] The REKO retail and distribution model offers customers a way of ordering products directly from the producer, without the need for middlemen.

Trademark PLANTEARVEN ®

PLANTEARVEN® ("plant heritage") is a trademark owned by the Norwegian Gene Resources Center and was established to use in marketing and sales of plants and plant products based on national genetic resources. Criteria for a plant to be awarded the trademark are, among others, that it is associated with Norwegian cultural heritage and have interesting qualities, characteristics and/or history. It must also have a commercial potential in the Norwegian market.

Figure 7. The logo used by PLANTEARVEN®

In 2012, around 130 perennials and a few other products were approved for sale under the "PLANTEARVEN"-brand. Propagation, marketing and sale of PLANTEARVEN-plants has however encountered a number of practical problems, including time-consuming propagation of plants and lack of marketing of products. At the end of the reporting period, the exact status on the use of the trademark is unknown. It is however expected that people are increasingly interested in products with a local significance and seek more information about the food and plants they buy. Trademarks such as PLANTEARVEN could be and excellent way to commercialize and promote plants that are of interest to the PGRFA-program.

3.4.3 Gaps and needs

- The Ministry of Agriculture and Food, the Norwegian Agriculture Agency and the Norwegian Genetic Resource Centre need to continuously monitor and evaluate the effects of the Norwegian regulations on seeds and planting material. If the regulations hinder the conservation and use of plant genetic resources, solutions will have to be discussed and identified in collaboration with the Norwegian Food Safety Authority.
- Old varieties and landraces can be a good option for farmers who prefer to work with alternatives to conventional production systems or who are seeking alternative and more planting material. It is a challenge however to get access to planting material of orphan crops[22], landraces and varieties. The Community Seed Bank and Solhatt Organic Horticulture are contributing to access of material and these efforts should be strengthened, based on the needs and wishes of the producers.
- The inclusion of a wider range of species and varieties in Norwegian agricultural systems is a priority. The use of traditional varieties and landraces should be promoted and supported further, including at policy level. Financial mechanisms and other suitable incentives should be explored in order to promote seed production and commercialization of alternative planting material.
- A system which register users and monitor the use/production is important to ensure more technical and financial support to producers of traditional varieties.
- The trademark PLANTEARVEN ® is currently not actively used. It should be explored if there is interest from the producers to continue using this trademark and what would be needed in order to support its re-estabslihment.

[22] species where there is no longer any breeding or seed production

3.5 Supporting seed production and distribution

Seeds and planting material are fundamental assets in all crop production. Effective seed systems ensure that farmers have access to planting material, in adequate quantity and quality, in a timely manner and at reasonable costs (FAO 2011b). The expansion of seed trade has significantly impacted both agricultural research and local seed systems in most countries, and informal seed channels remain an important source of planting material for many farmers, serving a wide range of agricultural regions, preferences and production systems.

3.5.1 Achievements

To support seed production and distribution, the following achievements were made in the reporting period:

- The Norwegian seed system is highly regulated, but farmers' rights to save, use and exchange own seeds and propagating material is ensured (Lovdata 2021a, Andersen, 2011).
- The number of formally registered seed enterprises in Norway has increased from 57 in 2014 to 76 in 2019 (Norwegian Food Safety Authority, 2020d).
- The access to planting material from old and traditional varieties has increased, largely due to the efforts by the Norwegian Community Seed Bank and Solhatt Organic Horticulture (see also 3.4).
- The establishment of KVANN - Norwegian Seed Savers has strengthened the informal seed system and facilitated the sharing of planting material and knowledge among its members (see also 4.2).

3.5.2 Status and trends

Laws and regulations

The Norwegian seed system is highly regulated and follows EU policies. At national level it is organized within the frames of the law on food production and food safety (Food Act) and the regulation on seed products (Forskrift om såvare, Act No 1052 of 1999 on seeds). The Food Act aims to ensure safe food, good plant and animal health and that there are considerations for health, quality and environment along the production chain. The regulation on seed products ensures the production and sale of seeds with the best possible health and quality. It also intends to contribute to *in situ* conservation and sustainable use of plant genetic resources through special seed rules that allow for local production and trade of seed from conservation varieties and traditional vegetables (see chapter 3.4). Since seeds can carry serious pests and diseases, there are requirements for the quality of seeds that are sold commercially. "Regulations on seed products" (Lovdata 2021a) describe these requirements.

The regulation on seed products allows farmers to use seeds or other planting material from their own crop for sowing. Random exchange of seeds from one farmer to another is also allowed (except for seed potato) and farmers can establish a system of propagation and transaction of seeds in between themselves. Active sale of seeds and planting material can only be done by registered seed enterprises though.

The Norwegian Official List of Varieties lists the varieties approved for certified production of plant propagating material in Norway. To be approved and listed, the variety must be distinct from other known varieties, uniform, and retain its characteristics in propagation (The Norwegian Food Safety Authority, website). This is investigated using the so-called DUS test (Distinct, Uniform, Stable). In

Norway, an approved variety is placed on the variety list for ten years and is subject to renewal (Norwegian Food Safety Authority 2020b).

Seed production

Graminor AS is responsible for developing and testing plant varieties that are suitable for Norwegian conditions (see chapter 3.2). Graminor ensure the pre-basic production of agricultural and horticultural crops which is then sold to seed companies for further propagation and sale. For production of seeds for grain and meadow crops, Graminor is collaborating directly with a wide range of seed companies. For potatoes, Graminor collaborates with Overhalla Klonavlssenter AS who is producing the first two generations of pre-basic starting material for all certified seed potato cultivation in Norway. For fruit and berries, Sagaplant is responsible for the production of elite plants and raw materials for strawberries, raspberries and fruit.

To meet the demand for other species and varieties than those developed in Norway, Norwegian seed companies import seeds of foreign varieties that are then tested in Norway over several years. Some varieties will be on the market, while others are replaced after a few seasons, for example because they turned out to have weaknesses that did not appear in initial testing.

There are significant costs for seed companies to produce (by contract cultivation) and distribute seeds of many varieties, and to keep these on the variety list after the initial 10 years. This puts pressure on the entire seed sector in the direction of adopting new varieties. Given this situation, there is a significant risk that varieties disappear.

Crops and varieties officially certified

At the end of 2020, 344 varieties from 72 species were approved for certified seed production in Norway. This is a decrease from 547 varieties and 96 species in 2014. The number of approved conservation varieties and traditional vegetables increased from 3 species and 5 varieties in 2014 to and 8 species and 15 varieties in 2020 (Norwegian Official list of varieties, 15.03.2014 and 07.12.2020). In the period 2012-14, 32 new varieties were released, including two conservation varieties. This number increased to 57 new varieties released in the period 2014-2019, including six conservation varieties. With regard to formally registered seed enterprises. It increased from 57 to 76 from the first to the second reporting period (the Norwegian Food Safety Authority, 2020d).

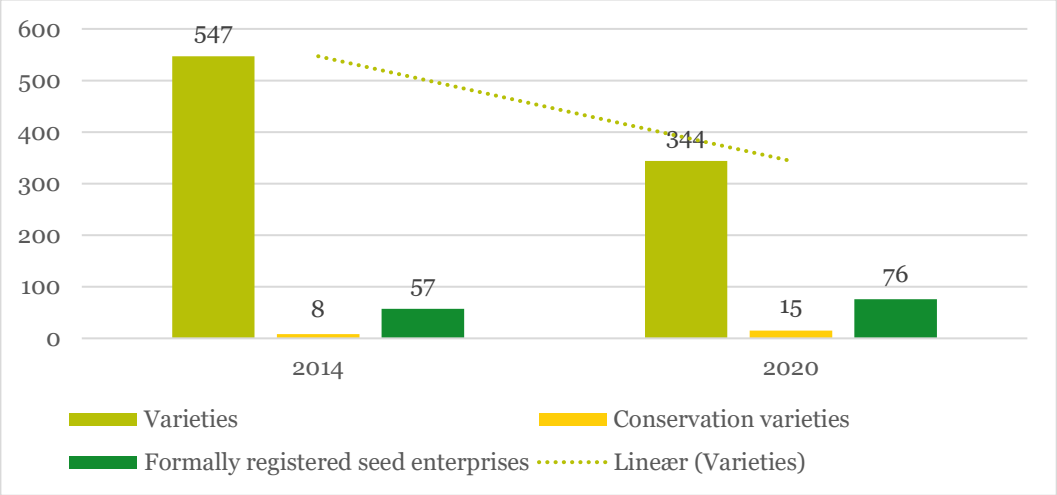


Figure 2. Diagram showing the total number of varieties that are officially certified (green), the number of certified conservation varieties and traditional vegetables (blue) and the number of formally registered seed enterprises (yellow) (Norwegian Food Safety Authority, Official List of Varieties, 2014 and 2020).

Production of material that is not on the official list of varieties

The marketing of seeds from varieties that are not on the official list is illegal. However, as discussed in chapter 3.4, conservation varieties can be included on the official list, requiring a simplified application process (Norwegian Food Safety Authority, 2020d). The Norwegian regulations also provide an opportunity to produce seed on a smaller scale. Farmers can establish their own seed store for the sale of seeds. A closed system for seed transactions can also be established if this is registered as a seed store. Gene banks and non-profit organizations can distribute seeds to users for the purpose of conservation and sustainable use of plant genetic resources, including research.

To increase the availability of planting material from traditional varieties and landraces, the seed company Solhatt Organic Horticulture (Solhatt Økologisk Hagebruk) and the Norwegian Community Seed Bank are very important. The Norwegian Community Seed Bank is currently collecting, testing and maintaining a collection of old Norwegian and Nordic grain varieties, and collaborate with Økologisk Spesialkorn[23] (now Sigdal mølle) and Norges Vel[24] to propagate and distribute seeds to interested growers. The Community Seed Bank is offering small quantities of seeds (1-2 kg) of approx. 50 traditional grain varieties to users.

Solhatt Organic Horticulture is currently offering more than 50 different varieties, including approximately 20 traditional Norwegian varieties of vegetables (see 3.4). This is important in terms of making seeds of traditional varieties of vegetables accessible to hobby- and small-scale producers and is contributing to the use of organic and biodynamic horticultural seeds in Norway. Another organization that is especially important for hobby growers is KVANN – Norwegian Seed Savers. KVANN was established in 2016 and are working actively to promote the maintenance and exchange of crop diversity, including through the distribution of seeds and other planting material between network members.

3.5.3 Gaps and needs

- Most conventional farmers in Norway have access to high-quality and adapted planting material. Farmers focusing on alternative production systems, such as organic or biodynamic, face limitations in terms of suitable planting material. It is therefore a continuous need to broaden the assortment of planting material to a wider diversity of production systems. More comparative field trials under organic cultivation conditions could be a way to identify material of interest to organic growers.
- There are relatively few conservation varieties on the official list. To promote the production and distribution of a wider range of seeds, could be to increase the number of conservation varieties on the Norwegian variety list.
- To increase the market-share and production of Norwegian grain and vegetable seed, it is necessary to support initiatives such as Solhatt and the Norwegian Community Seed Bank, and to continue to make seeds of traditional varieties available, including associated information and knowledge.
- There is still a need to explore options for how vegetative planting material of traditional varietieies can be produced and distributed, within existing laws and regulations.

[23] Website: https://sigdalmolle.no/
[24] Website: https://www.norgesvel.com/home/

4 Building Sustainable Institutional and Human Capacities

A project meeting of Nordic experts on Crop Wild Relatives in Oslo, organized by NordGen. Photo: Linn Borgen Nilsen

A national program for conservation and use of genetic resources is dependent upon adequate and sustainable institutional and human capacities. Capacity is generally understood as the ability of people, organizations and society as a whole to define and achieve their own objectives. By developing capacities either at individual level, through organizational development, or by establishing a supportive institutional environment, the performance will increase.

It is a goal for the Norwegian PGRFA program to ensure that there are people with adequate skills and expertise available to the program, that the organizational set-up of the program is efficient and that there is an enabling environment in place. The following five subchapters highlight achievements, trends, gaps and needs when it comes to institutional and human capacities relevant to PGRFA conservation and use in Norway: 1) Building and strengthening national programmes 2) Promoting and strengthening networks for plant genetic resources for food and agriculture, 3) Constructing and strengthening comprehensive information systems for plant genetic resources for food and agriculture, 4) Developing and strengthening systems for monitoring and safeguarding genetic diversity and minimizing genetic erosion of plant genetic resources for food and agriculture, 5) Building and strengthening human resource capacity and 6) Promoting and strengthening public awareness of the importance of plant genetic resources for food and agriculture.

4.1 Building and strengthening national programmes

A National PGRFA programme promotes oversight, coordination and implementation of activities to conserve and use plant genetic resources at national level. It is also providing a linkage to regional and global efforts in the PGRFA sector. A national programme should be formally recognized and supported by all relevant actors, including the relevant authorities. The National PGRFA programme in Norway is defined in the currently relevant national strategy and action plan for this area and implemented in collaboration between the Ministry of Agriculture and Food, the Norwegian Agriculture Agency and the Norwegian Genetic Resource Centre in NIBIO.

4.1.1 Achievements

To build and strengthen the national PGRFA program, the following achievements were made in the reporting period:

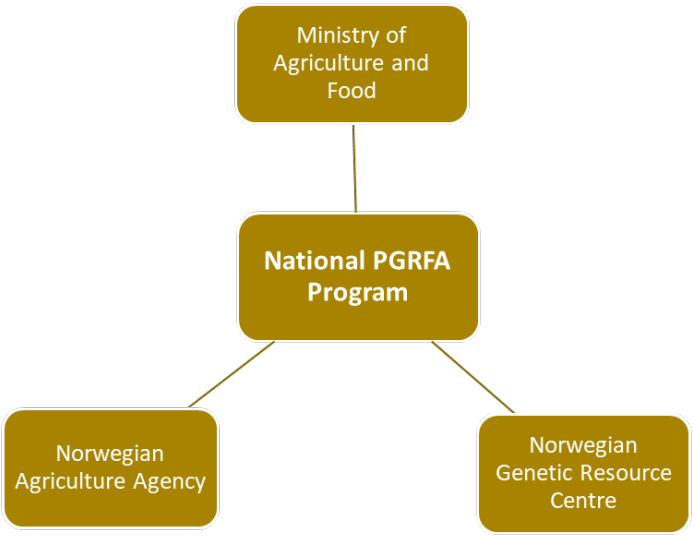
- A National Strategy for the Conservation and Sustainable Use of Genetic Resources for Food and Agriculture was elaborated and published in 2019 (Ministry of Agriculture and Food, 2019).
- The national programme on plant genetic resources aims to implement the National Strategy and is jointly administered by the Ministry of Agriculture and Food, Norwegian Agriculture Agency and the Norwegian Genetic Resource Centre.
- A professionalization of the national program, including the establishment of a more efficient division of labor between the three administrators.
- A yearly, national reporting structure on status and trends on plant genetic resources was established in 2017 (NIBIO, 2017).

4.1.2 Status and trends

An important achievement of the national program in the reporting period was the elaboration of a national strategy for genetic resources for food and agriculture. The National Strategy was published in 2019 and provides an overarching framework for genetic resources conservation and use in Norway (Ministry of Agriculture and Food, 2019). An national action plan with clearly defined goals is necessary to operationalize the national strategy and will be developed in a subsequent phase. This action plan will provide the new platform and mandate for the National PGRFA Program.

The national program for plant genetic resources follow the national strategy for genetic resources (Ministry of Agriculture and Food, 2019) and the sectorial action plan for plant genetic resources (Sæther, 2020). The program is jointly implemented by three public institutions, with different roles and mandates. The Ministry of Agriculture and Food is the responsible authority in the area; the Norwegian Agriculture Agency is administrating the financial instruments and the Norwegian Genetic Resource Centre acts as an advisory body and is also responsible for monitoring, reporting and coordination of activities. With an aim to professionalize the system, the responsibilities between the three actors were adjusted in the reporting period, including by giving the Norwegian Agriculture Agency responsibility for allocation of funds to eligible stakeholders. Dividing responsibilities between three institutions in the public administration require a close dialogue. Good routines, including regular communication and collaboration, have therefore been established.

Left: National Strategy for the Conservation and Sustainable Use of Genetic Resources for Food and Agriculture



Right: Institutions responsible for planning and implementing the National PGRFA Program.

The National Focal Point (NFP) on plant genetic resources is nominated by the Norwegian Genetic Resource Centre and officially appointed by the Ministry of Agriculture and Food. The focal point is coordinating the national portfolio on plant genetic resources and maintain contact with a wide range of national and international partners, including FAO, ECPGR and NordGen. The NFP is also responsible for monitoring and reporting on status for plant genetic resources, both nationally and internationally.

Accomplishments of the national program depend on close cooperation with a broad range of partners. The national network ha expanded slightly and became more formalized in the reporting period. As part of the professionalization, the Norwegian Genetic Resource Centre has revised and renewed agreements with entities that conserve genetic resources in *ex situ* collections and/or play an important part in providing access to or use of the material (see 4.2). This includes the 27 clonal archives, as well as the Norwegian Community Seed Bank and KVANN.

Better systems for documentation and reporting have also been implemented and largely supporting the reporting of the national program. This has for instance allowed the elaboration of a yearly report highlighting status and trends for plant genetic resources in Norway. Yearly Figures from the Norwegian Genetic Resource Centre (*"Nøkkeltallrapporten" in Norwegian*) reports on animal, forest- and plant genetic resources and has been published every year since 2017 (see 4.3).

4.1.3 Gaps and needs

- The National Strategy for Genetic Resources for Food and Agriculture lays out the overall direction of the national program, but a concrete action plan for its implementation still needs to be elaborated. This action plan should specify goals and responsibilities within the three sectors plant-, animal- and forest genetic resources, and further clarify the roles of the Ministry of Food and Agriculture, the Norwegian Agriculture Agency and the Norwegian Genetic Resource Centre.
- There is a need to establish a good monitoring system for the implementation of the national strategy and action plan and regularly assess the targeting of the various activities and instruments and ensure necessary adjustments.
- The yearly report "Key figures from the Norwegian Genetic Resource Centre" (Nøkkeltallrapporten) will remain an important tool for monitoring the progress of the national program. The report may need to be adjusted to the information- and reporting needs of the national program, especially considering the national strategy and subsequent action plan (point above).
- The reporting burden has increased since the last reporting period and the need for clear indicators, sources and reporting procedures is high. A monitoring table should be developed for the national PGRFA program, identifying indicators, sources, and reporting intervals. This would allow a more efficient reporting process and better alignment between national and international reporting activities.
- Conservation and use of plant genetic resources remain relevant for several sectors, including agriculture, environment, industry, and innovation. There is a continuous need to increase the consideration of genetic diversity in other sectors.
- The National PGRFA Program is comprehensive and involves many different actors (Annex 1). The capacity to coordinate and oversee the program falls on very limited personnel, which is likely to become a bottleneck in the implementation of the national strategy. It is highly recommended to explore solutions to this point, including elaboration of priorities.
- Information about the goals and results of the National PGRFA program should be highlighted to political leadership, public administration and the general public.

4.2 Promoting and strengthening networks for plant genetic resources for food and agriculture

Progress in conservation and use of plant genetic resources depends on the work and initiatives of numerous actors. To ensure that these actors can collaborate and complement each other, the continuous facilitation of knowledge sharing through networks remain vitally important. Well established networks of people and organizations are also essential for stimulating to collaboration, developing capacities, and facilitating scientific discussions. Networks are largely driven by the active participation of stakeholders but should be funded on a clear purpose and organizational structure. Both national and international networks remain important for the work on PGRFA in Norway.

4.2.1 Achievements

To promote and strengthen networks for plant genetic resources, the following achievements were made in the reporting period:

- The network of Norwegian clonal archives, counting 27 institutions, was strengthened through agreements, collaborative activities and meetings (Sæther et. al., 2020).
- Norway is actively participating in Nordic and European networks, including more than 20 thematic/crop-specific working groups under the auspices of NordGen and ECPGR.
- A national network for hobby growers and plant diversity enthusiasts, KVANN – Norwegian Seed savers, was established. This network promote access to knowledge about existing crop diversity and facilitate the sharing of material between members (KVANN, website).

4.2.2 Status and trends

National network related to conservation

Norway has a tradition of cooperation and open exchange of information in both formal and informal networks. Activities in support of conservation and sustainable use of plant genetic resources is carried out by a number of actors and stakeholders in Norway. These include government and public institutions, research, teaching and educational organizations, breeding organizations, voluntary organizations and other interest groups (see Annex 1. List of relevant stakeholders in Norway). There have been continuous efforts to strengthen the national network for PGRFA in this reporting period through regular meetings, communication and collaborative projects.

Norway has also formalized organizational processes within the national network, including revising formal agreements between the Norwegian Genetic Resource Centre and stakeholder involved in the conservation and use. Elaboration of written agreements has contributed to easier collaboration and more clarity around actors' roles and responsibilities. Elaboration of harmonized and easier reporting formats has also allowed better collective reporting from the network, e.g., from the 27 clonal archives who are holding the gene bank for vegetatively propagated material in Norway (see 2.2).

The Norwegian Genetic Resource Centre is facilitating regular workshops targeting many different actors involved in genetic resources conservation and use at national level. These seminars contribute to information-sharing and networking within and between sectors and were organized every year in the reporting period.

National network related to use

Related to the use of material, the association KVANN - Norwegian Seed Savers was founded in 2016 and is a large network of private growers in Norway. This network has expanded over the years, from less than 400 members in 2014 to more than 800 members in 2020. The association focuses on the use of plant diversity for private growers, and shares seed and planting material between members. It is an important network of users which link the general public, with the Norwegian clone archives and NordGen's genebank for seeds. KVANN also offers courses and activities to increase people's knowledge about plant care, propagation methods, plant health etc. The growing interest in the network KVANN indicates an increased interest in plant diversity and hobby growing in Norway.

Nordic network

Since the establishment of NordGen in 2008, the collaboration within the Nordic region has been largely improved, and the network around NordGen is important for Norway and the National PGRFA Program. NordGen manages a shared Nordic genebank facility for seeds in Alnarp, Sweden, and is facilitating eight thematic working groups and several Nordic projects. This network is actively contributing to scientific discussions and in establishing collaboration on several levels in the Nordic region. A central part of NordGen Plants is the seven different Working Groups on plant genetic resources that together with the national programs constitute the very core of NordGen's network of Nordic experts. They are an important link between the Nordic and the national technical work within a specific species group. The working groups contribute with insights to each Nordic country's operations with genetic resources and is also important for knowledge exchange and network contacts (NordGen, 2020).

A gathering of people working in the area of PGRFA at NordGen in Sweden.

Photo: Linn Borgen Nilsen

International network

Norway's collaboration with international institutions has remained constant throughout the reporting period and discussions within the European networks remain important for national planning and prioritization. Norway also remains an active counterpart in other international networks, such as the European Cooperative Programme for Plant Genetic Resources (ECPGR). This program is offering a platform for collaboration through 24 crop-specific working groups, where Norway is represented in 13, namely Allium, Avena, Berries, Brassica, Grain legumes, Malus/Pyrus, Medicinal and aromatic plants, Potato, Prunus, Umbellifer crops, Wheat, Cryopreservation and On-farm management. At the end of the reporting period, Norway also provided active participation in the development of the European Genetic Resources Strategy, through the European sector-specific networks ECPGR, EUFORGEN and ERFP. Major changes in Norway's participation in European networks has not been noted in the reporting period.

4.2.3 Gaps and needs

- Facilitating and strengthening national networks requires continuous attention from the national PGRFA program. Setting clear common goals for the network of PGFRFA actors, ensuring a pertinent information flow and creation of arenas for discussion and collaboration remain important in Norway.
- Norway is actively participating in crop-specific networks at Nordic and European level, but there are currently no formally established thematic networks at national level. To establish and facilitate active working groups centered around specific crops or themes would strengthen relevant networks nationally. It would also contribute to capacity building.
- There are currently too few linkages between professionals from the conservation area and professionals in the area of research and development. More collaboration between these sectors is likely to facilitate more and better use of plant genetic material. Efforts to involve participants from both areas in meetings and joint activities should be prioritized.
- In an increasingly more complex environment, where it is necessary to look beyond individual sectors, it is an asset for the PGRFA network to increase its collaboration with networks, organizations or individuals from other sectors, e.g. from the environmental sector, business- or local development sector.

4.3 Constructing and strengthening comprehensive information systems for plant genetic resources for food and agriculture

Policies, programmes and activities related to conservation and use of plant genetic resources must be based on reliable information. The development of digital tools for information management has been prominent over the last two decades. This provides new and more effective ways of managing data related to plant genetic resources. Information management and exchange is also recognized as one of the supporting components of the International Treaty and several databases and information portals have been established at the global level, including GRIN-Global[25] and Genesys[26].

4.3.1 Achievements

To establish and strengthen the information systems for PGRFA, the following achievements were made in the reporting period:

- The Nordic Baltic Genebank Information System (GeNBIS) has been established as the new database for conserved germplasm in the Nordic region. Currently all seed propagated crops of Norwegian origin have been included in GeNBIS. [27]
- Compilation and publication of yearly reports "Key Figures from the Genetic Resources Centre".[28]
- The establishment of a database with information about fruit- and berry varieties was established by Njøs fruit and berry center.

4.3.2 Status and trends

Information and reporting

On a general basis, the information availability and sharing at national level has improved during this reporting period. The establishment of a yearly reporting procedure, which gathers and compiles data from the Norwegian *ex situ* collections (clonal archives) has been important in terms of strengthening the overview and information sharing on *ex situ* conservation and is further described in chapter 4.4.

From 2017, the information collected from the clonal archives has been published in a yearly report called "Key figures from the Norwegian Genetic Resource Centre" (*Nøkkeltallrapporten*). This report shows the status of the *ex situ* collection of vegetatively propagated crop species in Norway. It also defines concepts and highlights data and trends in the genetic resources work in the country. It is the first time this information is publicly available in one document and the yearly report has been established as a key reference document for the Norwegian Genetic Resource Centre.

The website of the Norwegian Genetic Resource Centre function as an information-hub for plant genetic resources in Norway and is well visited. It includes descriptions of crops and varieties and provides information about conservation methods, clonal archives, policies and regulations and international processes. The Norwegian Genetic Resource Centre is also active through social media

[25] https://www.grin-global.org/
[26] https://www.genesys-pgr.org/
[27] GeNBIS database: https://www.nordic-baltic-genebanks.org/gringlobal/search.aspx
[28] www.gen-nokkeltall.no

channels, informing network members about results, activities or events. Information sharing in social media channels has increased among all relevant actors in the reporting period.

Other information relevant to plant genetic resources which is published or updated on a regular basis, include the Norwegian Official List of Varieties. The list is published by the Norwegian Food Safety Authority and updated four times a year. Both KVANN and the Community Seed Bank are also working to establish digital registers or databases of all the material they are disseminating.

Databases and registers

The accessions of seed propagated crops which are conserved at NordGen's facilities in Sweden, were all included in the SESTO database in this reporting period. To improve the functionality, NordGen decided to replace SESTO with a database that is using the international system GRIN-Global. The Nordic-Baltic Genebank Information System (GeNBIS) was implemented towards the end of the reporting period and has been active since 2020. Through GeNBIS, users can access information and material from 1955 accessions of Norwegian seed-producing crop plants, including older cultivars, landraces and crop wild relatives. GeNBIS is also enabling Nordic Countries to include national collections of plant genetic resources (such as vegetatively propagated crops) in the database and actively use it for moniotoring purposes.

Search portal of the Nordic Baltic Genebanks Information System (GeNBIS)

A database for fruit varieties[29] has been established by Njøs fruit and berry center, a research and breeding station for Norwegian fruit and berries and one of the clonal achieve. This has allowed for a digital overview of fruit varieties grown in Norway and includes varieties under conservation.

[29] www.fruktsorter.no

4.3.3 Gaps and needs

- Some of the material in *ex situ* collections remain undocumented. It is therefore a priority to establish, maintain and publish updated lists of plant genetic resources that Norway is responsible for conserving. These lists should be made publicly available by the Norwegian Genetic Resource Centre, for instance on their website. Given the amount of undocumented material in the clonal archives, the lists should be subject to regular reviews and updates.
- Apart from the database on fruit varieties there is no inclusive digital database with information relevant to the conservation and use of vegetatively propagated plant material in Norway. The most important need for strengthening the information system on plant genetic resources is therefore to include all accessions that are maintained *ex situ* in Norwegian clonal archives in a publicly accessible database. This could be done by including the accessions in the Nordic Baltic Genebanks Information System (GeNBIS) or by establishing a separate national register. It is essential that the database provide a full overview of the stored material and allow users of germplasm an easier access to information about it. A publicly accessible database would also contribute positively to the national networks (chapter 4.2) and for the monitoring and safeguarding of genetic material (chapter 4.4).
- There is currently no publicly available digital information system for crop wild relatives conserved *in situ*, and only a few species have been characterized and geographically mapped. It is a priority to improve the information system related to CWR, including *in situ* conservation activities. It could be explored if populations conserved *in situ* could be included in GeNBIS.
- There are examples of systematic growth and maintenance of landraces and traditional crop varieties by farmers (see chapter 1.2). By the end of 2020 there was however no publicly available information about where this takes place and which varieties and landraces that are maintained on-farm by producers. This need to be considered and strengthened if on-farm management is more firmly established as a conservation method.
- There are currently several registers and information systems being developed in parallel, including GeNBIS, www.fruktsorter.no, the lists of varieties maintained in Norwegian clonal archives and the list of material that is available for users (e.g., through the activities at the Norwegian Community Seed Bank and KVANN). To avoid any duplication or confusion, and ensure their accessibility, the national PGRFA program may consider establishing an information sharing platform which serves as a "one entry point" where links to the various databases and information points are gathered.
- Information systems, focusing on the use of plant genetic resources would be valuable for the national program. To enable this, suitable indicators and reporting processes would have to be established, involving a larger part of the user community, including researchers, plant breeders and farmers. It would be highly relevant to include more indicators related to use in the annual report “Key figures from the Norwegian Genetic Resource Centre”.

4.4 Developing and strengthening systems for monitoring and safeguarding genetic diversity and minimizing genetic erosion of PGRFA

Through the Convention on Biological Diversity (CBD), the global community recognized the need to conserve and protect biological diversity, including genetic resources (UN, 1992). Still, several international reports, including the State of the World's Plant Genetic Resources for Food and Agriculture (FAO, 2010), the State of the World's Biodiversity for Food and Agriculture (FAO, 2019) and the Global Assessment Report on Biodiversity and Ecosystem Services (IPBES, 2019), point to a steep decline in biodiversity, including plant genetic resources. Erosion of plant genetic resources occurs in farmer's fields, but also in nature and in *ex situ* collections. To prevent erosion of these resources, identify drivers and ensure an effective monitoring the genetic diversity in Norway is a priority for Norway.

4.4.1 Achievements

To develop and strengthen systems for monitoring minimizing genetic erosion of PGRFA, the following achievements were made in the reporting period:

- A formalized reporting structure for accessions in Norwegian clonal archives was established in 2016 and has allowed a yearly monitoring of the crop diversity maintained *ex situ* (NIBIO).
- Several mapping and surveillance programmes, including NINA's "ANO" and NIBIO's "3Q" programme, are assessing changes in nature types, species composition and species, including wild vascular plants. This data may allow for further analysis and monitoring of CWR species in Norway (Evju et. al., 2017, Pedersen et. al. 2020).
- Red list assessments allow for a regular assessment of the status of many CWR species (Artsdatabanken website and Artsdatabanken, 2021).

4.4.2 Status and trends

Norway has committed itself to the protection of natural habitats, including species and their genetic diversity (CBD, 1992 and Lovdata 2021c). Like in many parts of the world, the loss of biodiversity in Norway is nevertheless increasing. As many as 2752 species (12% of all assessed species) and 74 habitat types (29%) are considered endangered in the country (Artsdatabanken, 2018 and 2021). Loss and fragmentation of habitats are considered some of the biggest threats to biodiversity, also in Norway (Jakobsson and Pedersen, 2020).

Monitoring of wild species and nature types

In order to achieve the national objectives of zero extermination of species and habitats, it is required that we have a good overview of which species exists in Norway, and that these are regularly monitored. The Norwegian Red List of Species provides an overview of species that are at risk of extinction in Norway. The list is prepared by the Norwegian Biodiversity Information Centre (Artsdatabanken[30]) in collaboration with experts.

[30] https://www.artsdatabanken.no/

An online species observation system[31] allows people to register sightings of species throughout the country is operated by the Norwegian Biodiversity Information Centre. In recent decades, there has been a growing interest in, and awareness of, biodiversity among the public. This has resulted in an increased mapping activity and has significantly improved knowledge base for several species groups since the Red List 2015 was presented (Artsdatabanken, 2021). Observations of 2 million vascular plants were for instance included in the online database by the end of 2019, including species relevant to food and agriculture (see chapter 1.1).

Regarding crop wild relatives, the priority list of 206 species (see chapter 1.1) is the starting point for monitoring CWR diversity. 13 of the species on this list are characterized as "threatened" according to the Norwegian Red List of Species. These are CWR species that are regularly surveyed and monitored.

There are also other systems in place for monitoring biological diversity and nature-types. This includes the "Area-representative nature monitoring (ANO)" a national monitoring program which collects data on nature types, species, and species compositions in an area-representative network (Norwegian Environment Agency, website). NIBIO's "3Q program" (*Tilstandsovervåking og resultatkontroll i jordbrukets kulturlandskap, in Norwegian*) is monitoring species in agricultural landscapes in Norway (Stokstad et al. 2016). These systems are well established and can be useful for monitoring crop wild relatives in nature or identify biodiversity hotspots. None of the surveillance systems are however designed to capture changes in populations of CWR specifically or measure the effect of any implemented measures.

Monitoring of ex situ collections

In the last reporting period, only the accessions held at NordGen were being systematically documented and monitored. From 2016 onwards there has been focus on establishing a good system for monitoring diversity that is stored *ex situ* in the Norwegian clonal archives. A yearly reporting structure and process was established and agreed upon, ensuring that the Norwegian Genetic Resource Centre receives updated overviews from the clonal archives every year. The reporting format is standardized and allows for an easy analysis of data. This has enabled the national PGRFA program to identify and document the material that is being conserved and assess whether the requirements for safety duplications are fulfilled. Given that the clonal archives also submit data on health status and regeneration needs, the national program can monitor the status of each collection and, if needed, suggest implementation of measures to avoid genetic erosion. The system is also registering losses from any *ex situ* collections. A summary of the data collected is published in the yearly report "Key figures from the Genetic Resource Centre", as described earlier. The regular reporting form, together with the yearly report is considered an important achievement in order to strengthen the system for monitoring and safeguarding diversity conserved *ex situ*.

When the Norwegian clonal archives were established in the early 2000's, there was less focus on ensuring safety duplications in a different location. Still today, about 50% of the vegetatively propagated material is only stored in one location. Local back-up of the material is more common, and approximately 77% of the stored material is duplicated locally. Figure 9 shows the percentage of the material that is secured with back-up accessions of the material in another location. Due the health issues in some of the collections, as well as a very dry and warm summer in 2018, the percentage vary considerably from year to year.

[31] https://www.artsobservasjoner.no/

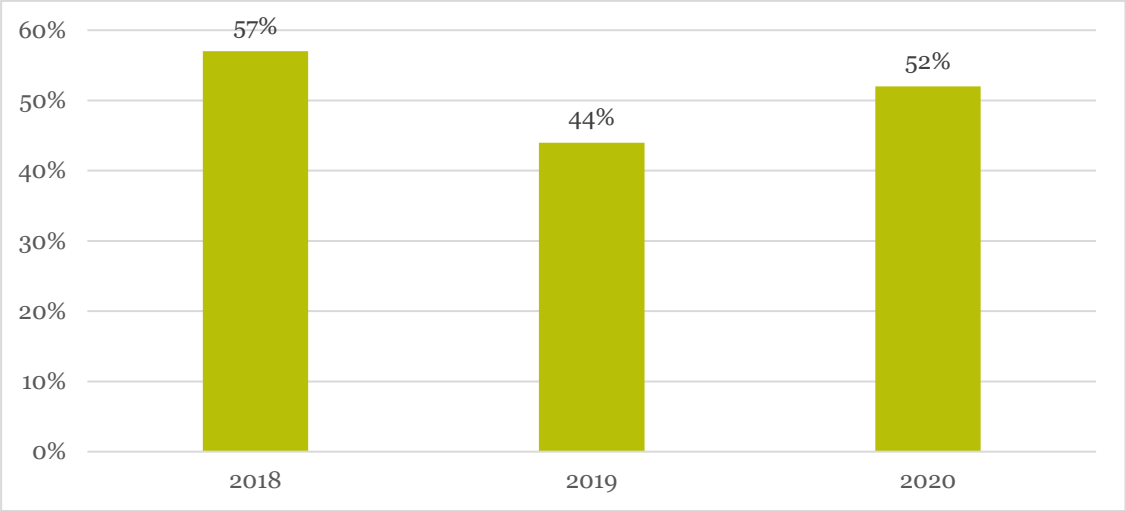


Figure 3. Accessions in the Norwegian clonal archives that are secured in back-up collections (Sæther et. al., 2020 and Sæther et. al., 2021).

Monitoring of diversity in farmer's fields

There have been two important initiatives to map the crop diversity that exists in the fields and gardens of farmers, hobby growers and other custodians. The Norwegian Community Seed Bank and KVANN - Norwegian Seed Savers have both collected information about existing diversity and supported access to it (see chapter 1.1 and 3.5). This information is valuable in order to allow monitoring over time of crop diversity in use. As highlighted in chapter 1,2 there are no systematic monitoring of diversity on-farm.

4.4.3 Gaps and needs

- To consider and protect biological diversity require knowledge of where species and particular nature-types are located. For many species, such as CWR, information about their distribution, habitat and population size is poorly known. All efforts to strengthen the monitoring of biodiversity that is relevant for food and agriculture should be prioritized in the coming period. Efforts to explore how existing data sets could be used to analyze trends in CWR diversity is recommended.
- Mapping and monitoring require good expertise in species and habitat types. When it comes to plant genetic resources, knowledge of genetic diversity, population structures and gene flow between areas is also crucial. It is currently no regular monitoring of such data in Norway. Research projects to create more knowledge on these aspects should be promoted.
- Plant genetic diversity managed on-farm is not systematically implemented or monitored in Norway. It is a priority to address this in the coming period (see chapter 1.2), including documenting plant genetic diversity maintained on-farm. A monitoring system for crop diversity maintained in farmer's fields would be a great asset to monitor trends and prevent genetic erosion.
- Only about 50% of the *ex situ* accessions in Norwegian clonal archives are secured in back-up collections at another location. An assessment to identify the material that is inadequately safeguarded should be conducted.

4.5 Building and strengthening human resource capacity

Capacity building at all levels remains an important component of conservation and use of plant genetic resources. Lack of human resource capacity has also been highlighted as a major challenge for conservation and use of PGRFA at global level (FAO, 2010). The rapid development of new technologies and methods and the need to analyze an ever growing amount of data require a continuous development of national capacity. Building human capacity relevant to plant genetic resources requires close collaboration between PGRFA stakeholders and educational institutions and organizations offering training and skills development programmes. It is also necessary to consider and address capacity needs in national policies and promote an environment which supports collaboration, communication and knowledge exchange.

4.5.1 Achievements

To build and strengthen human resource capacity, the following achievements were made in the reporting period:

- The National PGRFA program has been strengthened, delegating the administration of the official financial instrument to genetic resources conservation and use to the Norwegian Agriculture Agency.
- There is a clear push from the Government to prioritize capacity development and strengthen stakeholders' skills and knowledge base on genetic resources (Ministry of Agriculture and Food, 2019).
- There are educational opportunities to develop competence in plant genetic resources through studies in biology at ten universities and in agronomy at five universities/colleges. Vocational education (3 years) in nature uses and agriculture is offered at 23 schools[32] across Norway.

4.5.2 Status and trends

Research and education

The Government has high ambitions for Norwegian research and higher education and has emphasized the need for up-to-date, high-quality skills and knowledge (Ministry of Education and Research, 2017). In keeping with its political platform, the Government will increase investments in higher education and research and establish mechanisms for ensuring that new knowledge is put to use (Ministry of Education and Research, 2018). The Government has also specifically emphasized that a high level of competence and knowledge about agriculture's genetic resources and their value is a prerequisite for their sustainable management (Ministry of Agriculture and Food, 2011 and 2019). A range of educational institutions and organizations are currently supporting these efforts.

Biological diversity, genetics and ecology are important parts of the biology curriculum in Norwegian high schools (Utdanningsdirektoratet, 2006). There is also a vocational educational programme in nature use, offered (fully or partly) at 37 upper secondary schools in Norway. The offers of vocational educational trainings have decreased sharply over the last 20 years, and there are currently only a few schools left offering for instance education in gardening (NIBIO, 2020d).

When it comes to provision of higher education, including graduate and post-graduate courses, ten universities in Norway offer higher education in biology, agriculture, plant science and/or genetics.

[32] www.utdanning.no

Five universities or colleges offer higher education in agronomy[33]. All these institutions also provide opportunities for research theses on bachelor-, master- and doctoral level in topics related to PGRFA. The Norwegian University of Life Sciences (NMBU) holds the largest professional environment for agriculture (animal husbandry, plants, forests, veterinary medicine) in Norway and host several research groups that work on questions related to PGRFA.

Other research institutes, including Fridtjof Nansens Institute (FNI), the Norwegian Institute for Nature Research (NINA) and the Norwegian Institute of Bioeconomy Research (NIBIO) contribute to relevant capacity development, for instance through the hosting and supervision of research theses on topics related to plant genetic resources. The National Strategy for conservation and use of genetic resources still highlight the need for universities, colleges, and vocational schools to include genetic resource perspectives in their programmes to a greater extent (Ministry of Agriculture and Food, 2019).

Many of the traditional agricultural educations at higher level struggle to attract students, even though the candidates are in demand by both industry and public administration. At the same time, there are increased interest in topics related to environment, sustainability, and green industries (NIBIO, 2020d). This may weigh positively for the development of capacities in topics related to the conservation, use and management of PGRFA.

Information and knowledge sharing

The Norwegian Agricultural Advisory Service (Norsk Landbruksrådgivning, NLR) is an umbrella- and service organization for ten regional advisory units with a total of 24,000 members and 370 employees across Norway. NLR is offering training and individual coaching to farmers on a wide range of subjects, including topics that is relevant to plant genetic resources. Considering changes facing the agricultural sector and the need for continuous learning, the role of agricultural extension service in building capacity may increase.

Joint professional meetings, courses, demonstrations and excursions are widely used methods for developing competence and knowledge. Many of the stakeholders and networks associated with PGRFA in Norway, such as botanical gardens, clonal archives and KVANN, are offering courses, events and exhibitions at regular intervals. This contributes to information sharing and awareness, but also to capacity strengthening of people that are involved. The Ministry of Agriculture and Food, the Norwegian Agriculture Agency and the Norwegian Genetic Resource Centre are also contributing regularly to capacity development activities.

Capacity of the National PGRFA Program

The capacity of staff contributing to the work of the national PGRFA program has remained similar from the last reporting period although some changes have been noted. The Norwegian Agricultural Agency took over responsibilities related to the official financial schemes for genetic resources conservation and use. This strengthened the administrative capacities within the program with one person. Relevant staff resources in the Ministry of agriculture and food and at the Norwegian Genetic Resource Centre has remained unchanged, counting two and one staff respectively. In total it is therefore four staff members within three different organizations that are responsible for planning, implementing and monitoring the national PGRFA program, in addition to other tasks.

The plant genetic resources committee was discontinued in 2019. With this, the national program lost an external advisory body, which discussed topics and decisions relevant to the national program. The total number of permanent staff that is coordinating and reporting on the national PGRFA program is therefore very limited. Lack of sufficient staff reflects the situation in many other institutions as well

[33] www.utdanning.no

and is clearly a limiting factor regarding the capacity of the national program to deliver on all aspects of PGRFA conservation and use.

4.5.3 Gaps and needs

- The national strategy foresees large and important activities to be conducted in the area of plant genetic resources in the coming period (2020 onwards). The implementation of this will be the responsibility of the national program, coordinated by the Ministry of Agriculture and Food, the Norwegian Agriculture Agency and the Norwegian Genetic Resource Centre. This is likely to require a strengthening of capacity in one or several of these organizations (see also 4.1).
- Several organizations contributing to conservation and use of PGRFA in Norway are vulnerable to lack or loss of expertise. A continuous strengthening of capacities - both of staff, organizations and networks - active in the conservation and use of plant genetic resources sector remain important.
- It is also important to monitor the capacity and capacity needs of actors involved, to be able to identify gaps and needs. A plan for capacity development of actors contributing to the national PGRFA programme, could be a useful instrument.
- A detailed overview of study programs and post-graduate courses offered in the area of plant genetic resources management should be elaborated. This information may help to promote plant genetic resources among students and young professionals. More post-graduate courses in PGRFA-management, targeting people from different sectors and roles would greatly benefit the national program. This could for instance be promoted among staff working on practical aspects of PGRFA conservation and use, including in clonal archives, botanical gardens, gardening/plant-schools, farmers organizations, extension services etc. It could also be used for targeted training of staff in the agricultural sections of the local government.
- New research, technology and innovations are rapidly contributing to novel areas of research and work. This might also offer new opportunities for conservation and use of PGRFA. Efforts should be made in identifying areas where plant genetic resources can play a direct and vital role in addressing future challenges, such as climate change adaptation and mitigation, sustainable agriculture, and nutrition.

4.6 Promoting and strengthening public awareness on the importance of plant genetic resources for food and agriculture

Information about PGRFA needs to be provided to different target groups, including both policy-makers and the general public. Public awareness around the value and use of plant genetic resources helps to ensure that the topic remains high on the public agenda. Increased awareness and knowledge of PGRFA is important in order to inform people of the value and relevance of the work and create interest and commitment.

4.6.1 Achievements

To promote and strengthen the public awareness on the importance PGRFA, the following achievements were made in the reporting period:

- The Norwegian Genetic Resource Centre hosts an up to date and active website, with information about the plant genetic resources sector, as well as examples, links and related policy documents.
- The Norwegian Genetic Resource Centre has established an active social media channel on Facebook, reaching approximately 1500 people (2020).
- Regular media coverage and articles have been published in Norwegian newspapers, magazines, and websites throughout the reporting period (Norwegian Genetic Resource Centre).

4.6.2 Status and trends

One of the main goals of the national program for plant genetic resources is to promote and strengthen the public awareness of the importance of PGRFA in Norway. The following chapter reflects on selected awareness activities within the national program and is therefore centered around work done at the Norwegian Genetic Resource Centre in NIBIO. It must therefore be emphasized that many other actors in Norway play an important role in providing information and creating awareness, which may not be referred to below.

Webpages and social media

Webpages are the most important platform for information-sharing and outreach, especially to the general public. The active use of webpages and web-based tools and social media platforms continue to be important. The Ministry of Food and Agriculture, the Norwegian Agricultural Agency and the Norwegian Genetic Resource Centre are using their webpages actively to reach out to stakeholders with news, information, and publications. The rising trend is indicated by figure 10, showing the increase in visits to the Norwegian Genetic Resource Centre website, including the pageviews of the thematic area of plant genetic resources. The visits to the webpage increased from 84.000 to 350.000 from 2018 to 2021. The visits to the thematic area of PGRFA has risen even more sharply, from 10.000 visits in 2018 to more than 150.000 visits in 2021.

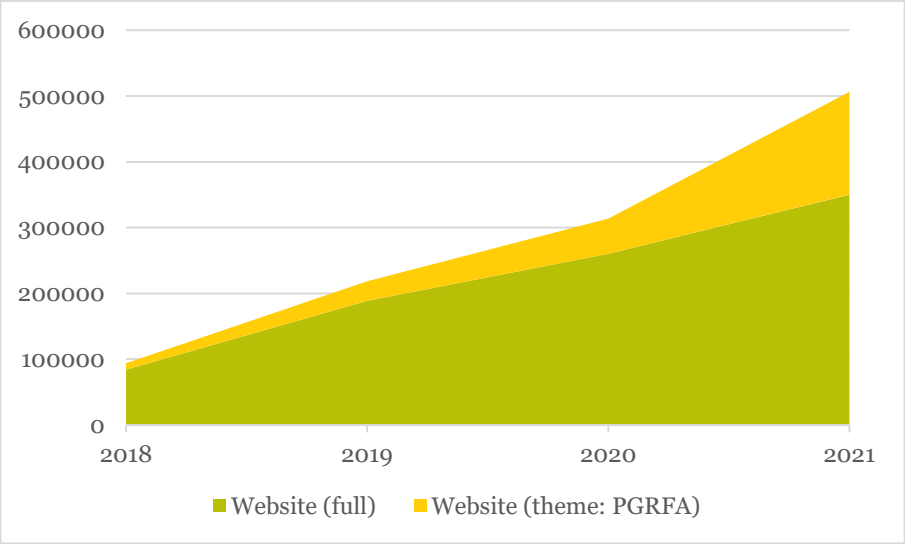


Figure 4. There is a rising trend in visits to the webpage of the Norwegian Genetic Resource Centre in the last part of the reporting period, including in the thematic pages on plant genetic resources (NIBIO, internal).

The Norwegian Genetic Resource Centre has prioritized the creation and maintenance of an up to date and informative website[34]. The website includes information about the national program, including national strategy and sector-specific action plans, as well as information about conservation strategies, stakeholders, plant breeding and approval of new varieties and international collaboration. A series of "plant portraits", with information about traditional fruit varieties, vegetables etc., has also been included on the website, attracting many visitors. The thematic pages on plant genetic resources are very well visited, with more than 150 000 users on a yearly basis in 2021 (NIBIO, internal).

In the last reporting period, a newsletter was sent out by email to subscribed members. This was replaced by an active account on Facebook with 1471 followers at the end of the reporting period. Posts with news, activities, plant portraits and other relevant information is being posted regularly. The Norwegian Genetic Resource Centre is also noting that an active social media account is an important platform in order to reach many people.

Publications and presentations

As mentioned in earlier chapters, the report "Key figures from the Norwegian Genetic Resource Centre" has been an important tool for information sharing from 2017 onwards. In addition to this, there has also been production and distribution of posters, brochures, and other printed material, targeted the general public.

A printed book called "Pion, pors og potet og andre utvalgte kulturplanter" (translated as "Peony, bog-myrtle, potato and other selected cultivated plants") was compiled in the reporting period, and published in early 2020 (Asdal, 2020). The book includes 53 short articles which portraits plants that have an important place in the cultural history of Norway. The book has received good reviews and are currently still on sale for the general public.

Various stakeholders, including the Norwegian Genetic Resource Centre and the Ministry of Agriculture and Food have been contributing with lecturers at workshops and seminars, both nationally and internationally. This has contributed to information sharing and awareness creation of aspects that are relevant to Norway.

[34] www.genressurser.no

Signs with relevant information about PGRFA has been established at several of the clonal archives. This provides visitors to the collections with more information about the collection, but also the value of genetic resources for food and agriculture.

Figure 5. An exhibition with information about CWR was developed in the Nordic CWR project at the end of the reporting period. Here from the display at the botanical garden in Oslo. Photo: Dag Inge Danielsen, UiO.

Seminars

An annual scientific seminar has been arranged by the Norwegian Genetic Resource Centre, with alternating topics. The seminar has been open to the general public and well visited. There has also been arranged smaller seminars and workshops, related to specific issues of plant genetic resources conservation and use. These have been arranged at irregular intervals, often in collaboration with other organizations.

Many of the actors involved in the PGRFA sector also perform important tasks in informing, teaching and providing trainings on aspects of genetic resources, both in the form of seminars, demonstrations and digital presentation on websites and other platforms. This work is very important, especially in terms of reaching out to local organizations and individuals.

Awards and media attention

The "Plant-heritage prize" (Plantearven-prisen) has been awarded every year in the reporting period[35]. The prize is presented to a person or organization in appreciation for special efforts that promote the conservation and sustainable use of plant genetic variation and diversity in Norway. The award ceremony is normally taking place at the yearly seminar arranged by the Norwegian Genetic Resource Centre and is attracting media publicity.

The establishment of Svalbard Global Seed Vault in 2008, increased the media coverage and public discussions on plant genetic resources also in Norway. This has had a positive effect on media interest and attention also in the current reporting period. We can also assume that attention on the rapid decline in biodiversity (as highlighted by FAO, IPBES, IUCN, WWF and others) and the agreement on the Sustainable Development Goals, where target 2.5 is specifically addressing genetic resources, may have contributed to increased awareness of genetic resources in the general public. Despite these global milestones, it is still evident that genetic resources conservation and use remain a topic that is less considered in many sectors.

[35] https://www.nibio.no/tema/mat/plantegenetiske-ressurser/plantearven-prisen?locationfilter=true

4.6.3 Gaps and needs

- Sharing of information about the value and importance of genetic resources for food and agriculture to the public remains important. Good means for creating public awareness is through professional gatherings and networking, visibility in the media/social media channels and through active, updated websites. It is also important for the National PGRFA program to take part in the public debate, e.g., through articles or opinion pieces in newspapers or other relevant fora.
- There are many actors that contribute to conservation and use of PGRFA in Norway. Increased recognition of the work done by stakeholders is likely to increase the public awareness of the importance of plant genetic resources for food and agriculture.
- Social media and networking tools are excellent ways to engage a large number of people, and from different generations. Efforts to increase the relevance and attractiveness of the content on social media is important. A communication plan for content on website and social media will help to ensure targeted and well-planned communication from the Norwegian Genetic Resource Centre.
- Not all clonal archives have signs or information about the plant genetic resources they maintain on site. Botanic gardens, arboreta and field gene banks should be encouraged to provide more information about plant genetic resources they maintain, for instance through information signs, guided tours and other forms of information about the collections. More public awareness materials could be prepared and offered to stakeholders that are in need of it.
- In the future, it will be particularly relevant to link plant genetic resources conservation and use to the context of sustainable and climate smart agriculture. These are aspects that should be strengthened in future communication from the Norwegian Genetic Resource Centre.
- The organization of meeting arenas, such as yearly seminars that bring stakeholders together, continue to be important in terms of making sure that information, experiences and expertise is shared within and across sectors.

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Abbreviations and Acronyms

ABS	Access and Benefit-Sharing
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CGRFA	Commission for Genetic Resources for Food and Agriculture
CWR	Crop Wild Relatives
EC	European Commission
ECPGR	European Cooperative Programme for Plant Genetic Resources
EUCARPIA	European Association for Research on Plant Breeding
EURISCO	European Plant Genetic Resources Search Catalogue
FAO	The Food and Agriculture Organization of the United Nations
GPA	Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IUCN	International Union for Conservation of Nature
MAP	Medicinal and aromatic plants
MLS	Multilateral system
NFP	National Focal Point
NIBIO	Norwegian Institute of Bioeconomy Research
NordGen	Nordic Genetic Resource Center
PGR	Plant genetic resources
PGRFA	Plant Genetic Resources for Food and Agriculture
SSB	Statistisk sentralbyrå (Statistics Norway)
UPOV	International Union for the Protection of New Varieties of Plants
WIEWS	World Information and Early Warning System

Annex 1. List of relevant stakeholders in Norway

Public administration (National PGRFA program):	**Offentlig forvaltning (nasjonalt program for PGR):**
▪ Ministry of Agriculture and Food	▪ Landbruks- og matdepartementet (LMD)
▪ Norwegian Agricultural Agency	▪ Landbruksdirektoratet
▪ Norwegian Genetic Resources Centre	▪ Norsk genressurssenter
Public administration (related areas)	**Offentlig forvaltning (relevante områder):**
▪ Ministry of Climate and Environment	▪ Klima- og miljødepartementet (KLD)
▪ The Norwegian Environment Agency	▪ Miljødirektoratet
▪ Ministry of Education and Research	▪ Kunnskapsdepartementet
▪ Norwegian Food Safety Authority	▪ Mattilsynet
▪ The Research Council of Norway	▪ Norges forskningsråd
▪ County Governor (departments of agriculture and environment)	▪ Statsforvalteren (landbruks og miljøvernavdelinger)
▪ Agricultural Extension Office	▪ Norsk landbruksrådgivning
Research and education:	**Forskning og undervisning:**
▪ University of Oslo	▪ Universitetet i Oslo (UiO)
▪ University of Bergen	▪ Universitet I Bergen (UiB)
▪ Norwegian University of Life Sciences	▪ Norges miljø- og biovitenskapelige universitet (NMBU)
▪ Norwegian University of Science and Technology	▪ Norges teknisk-naturvitenskapelige universitet (NTNU)
▪ University of Tromsø - the Arctic University of Norway	▪ Universitetet i Tromsø - Noregs arktiske universitet (UiT)
▪ University of Agder	▪ University of Agder (UiA)
▪ Norwegian Institute of Bioeconomy Research	▪ Norsk institutt for bioøkonomi (NIBIO)
▪ Fridtjof Nansen Institute	▪ Fridtjof Nansens Institutt (FNI)
▪ Hight schools in nature use	▪ Videregående skoler naturbruk
▪ Other research institutions	▪ Andre FoU-institusjoner
Organizations with *ex situ* collections:	**Organisasjoner med *ex situ* samlinger:**
▪ Botanical gardens (UiO, NMBU, NTNU, UiB, UiT, UiA)	▪ Botaniske hager tilknyttet universitetene
▪ Anno Museum, Domkirkeodden	▪ Anno - Museene i Hedmark, avdeling Domkirkeodden

▪ Hardanger production school, Vestland county municipality	▪ Hardanger produksjonsskule, Vestland fylkeskommune
▪ Lier Municipal Museum	▪ Lier Bygdetun
▪ Lund Municipal Museum	▪ Lund Bygdemuseum og Kulturbank
▪ Museum in Nordmøre, Svinviks arboretum	▪ Stiftelsen Nordmøre museum; Svinviks arboret
▪ Museum Nord, Lofot museum and Melbo manor	▪ Stiftelsen Museum Nord, Lofotmuseet og Melbo hovedgård
▪ Museum of cultural history in Ryfylke	▪ Ryfylkemuseet
▪ Museums in Akershus, Gamle Hvam museum	▪ Museene i Akershus, Gamle Hvam museum
▪ Museums in Sogn og Fjordane, Nordfjord Municipal Museum	▪ Stiftinga Musea i Sogn og Fjordane, Nordfjord folkemuseum
▪ Museums of Grimstad, the Norwegian Museum of Horticulture	▪ Grimstad bys museer, Norsk hagebruksmuseum
▪ NIBIO research stations (Apelsvoll, Landvik, Ullensvang and Ås)	▪ NIBIO forskningsstasjoner (Apelsvoll, Landvik, Ullensvang and Ås)
▪ Njøs Fruit and Berry centre	▪ Njøs frukt- og bærsenter
▪ Nordic Genetic Resource Center	▪ Nordiskt Genresurscenter (NordGen)
▪ Norsk Folkemuseum, Bygdø Royal Farm	▪ Norsk Folkemuseum, Bygdø Kongsgård
▪ Ringebu vicarage	▪ Stiftelsen Ringebu prestegård
▪ Sagaplant AS	▪ Sagaplant AS
▪ Spydeberg vicarage	▪ Stiftelsen Spydeberg prestegård
▪ Østfold museums, Hvaler coastal museum	▪ Østfoldmuseene, Kystmuseet Hvaler
Plant breeding, seed and production:	**Foredling, såvare og produksjon:**
▪ Graminor AS	▪ Graminor AS
▪ Sagaplant AS	▪ Sagaplant AS
▪ Njøs fruit and berry	▪ Njøs frukt og bærsenter
▪ Overhalla pre-basis center for seed potatoes	▪ Overhalla klonavlsenter
▪ Seed companies	▪ Såvarevirksomheter
▪ Norwegian Community Seed Bank	▪ Norsk bruksgenbank
▪ Solhatt Organic Horticulture	▪ Solhatt økologisk hagebruk AS
▪ Nurseries	▪ Gartnerier og planteskoler

Associations and voluntary organizations:	Interesselag og frivillige foreninger:
▪ Norwegian Seed Savers	▪ Kunnskap og Vern av Nytteplanter i Norge (KVANN)
▪ The Norwegian Garden Society	▪ Det norske hageselskap

NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

NORWEGIAN GENETIC RESOURCE CENTRE
genressurser.no

NIBIO - Norwegian Institute of Bioeconomy Research was established July 1 2015 as a merger between the Norwegian Institute for Agricultural and Environmental Research, the Norwegian Agricultural Economics Research Institute and Norwegian Forest and Landscape Institute.

The basis of bioeconomics is the utilisation and management of fresh photosynthesis, rather than a fossile economy based on preserved photosynthesis (oil). NIBIO is to become the leading national centre for development of knowledge in bioeconomics. The goal of the Institute is to contribute to food security, sustainable resource management, innovation and value creation through research and knowledge production within food, forestry and other biobased industries. The Institute will deliver research, managerial support and knowledge for use in national preparedness, as well as for businesses and the society at large.
NIBIO is owned by the Ministry of Agriculture and Food as an administrative agency with special authorization and its own board. The main office is located at Ås. The Institute has several regional divisions and a branch office in Oslo.

The **Norwegian Genetic Resource Centre** has been established by the Ministry of Agriculture and Food, as a subsection at NIBIO.

The Norwegian Genetic Resource Centre coordinates expertise and activities regarding the conservation and utilisation of national genetic resources. The centre has been commissioned to contribute to the effective management of genetic resources in farm animals, crops and forest trees.

The centre also acts as an advisory body to the Norwegian Ministry of Agriculture and Food.

Cover photo: Cover photos show (clockwise from the upper left): Dahlia (Dahlia x pinnata), the potato variety “Rød Kvæfjord”, Red Emmer, crops regenerated at NordGen’s facilities in Alnarp, surveying and collection of crop wild relatives in Færder National Park and the apple variety “Ingrid Marie”. Photo credits: Åsmund Asdal (Rød Kvæfjord), Finn Måge (Ingrid Marie) and Linn Borgen Nilsen.

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