Study to Assess the Feasibility of Establishing a Svalbard Arctic Seed Depository for the International Community

Prepared for the Ministry of Foreign Affairs and the Ministry of Agriculture

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Nordic Gene Bank

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Introduction and Background

Plant genetic resources are the biological foundation of agriculture and the raw material for all plant breeding. Generated over thousands of years, the genetic diversity contained within cultivated plant species is immense. Over 6 million accessions – samples – of this diversity are conserved (principally in the form of seed) in cold storage facilities in various locations around the world. As Professor Jack Harlan, one the most imminent experts in the field stated before his death in 1999, “these resources stand between us and catastrophic starvation on a scale we cannot imagine.” Our existence on earth rests on how well we care of these seeds; and their existence depends on us. In many ways, it really is that simple.

International standards promulgated in 1994 for the conservation of plant genetic resources for food and agriculture call for each “unique” accession to be duplicated and stored in at least one additional location, ideally in a different country, because, as FAO’s State of the World’s Plant Genetic Resources (1998) documented, individual genebanks are vulnerable to a host of problems that can endanger their collections, including poor management, lack of adequate funding, equipment failures, and natural catastrophes. In addition to these threats, we now recognize the need to provide protection against potentially more cataclysmic dangers: civil strife, war, and acts of terrorism.

In undertaking this study, the Committee recognized and accepted the compelling need of the international community to plan for the “worst case scenario,” the need to ensure the long-term conservation of plant genetic resources, protecting them from both old and new threats, routine as well as unprecedented occurrences. The Committee, therefore, undertook to assess whether a facility located in Svalbard might provide ultimate “fail-safe” protection for the world’s most valuable natural resources, and whether it might be able to do so in a manner that is efficient, sustainable, inexpensive, and politically and legally acceptable.

Our conclusion, detailed in this report, is that a Svalbard facility can provide all of these things, and can thus make a major contribution to food and environmental security and to the safety and well-being of human beings for as far into the future as we can see.

The Basic Undertaking

The fundamental premise upon which this Feasibility Study is based is that a facility at Svalbard should offer the highest feasible level of long-term protection to the

international community for the world's unique plant genetic resources for food and agriculture – security against "worst case scenarios" including nuclear war, civil strife, catastrophic failures at or major acts of terrorism affecting existing genebanks, etc. It should function as a source of "last resort" – an ultimate safety net, a backup reservoir to replenish materials that have been permanently lost in all other collections.
In order to meet international needs, address technical and political concerns and ensure a high level of confidence, the Committee believes that a facility at Svalbard must meet the following requirements:

- The facility should be constructed to last essentially "forever." For practical purposes, we propose that the facility's internal structure (exclusive of the protective sandstone enclosure) be designed with a life expectancy of 200 years.

- The facility should, in normal times, meet the highest international technical standards for conservation. It should also be designed so as to offer effective, long-term conservation even without the functioning mechanical back-up cooling systems envisaged and human assistance that would ordinarily be available.

- The location and facility should offer robust, credible protection against natural and human-induced accidents as well as deliberate attempts at sabotage. The total security package offered by the Svalbard facility should be second to none in the world.

- The initiative should attract international political support and funding. It should be operated under clear and supportive national legislation and within a proper international legal and technical framework – the International Treaty on Plant Genetic Resources and the rational system of ex-situ collections foreseen under the FAO Global Plan of Action.

- Operating and management procedures should be simple, efficient, and transparent, and not require significant administration, staffing or maintenance. Low operating costs will make an important contribution to the sustainability of the initiative.

- Those managing the world's most important collections should indicate a clear interest in using the facility as a safety depository.

A Norwegian initiative that meets these requirements would provide security and insurance against the unimaginable and thus help guarantee the long-term survival of the world's most precious biological resources, thereby making a major and lasting contribution to food security.

Svalbard: The Advantage of Location

Svalbard offers a number of advantages as the possible home for the facility described elsewhere in this Study.

At 74 - 81 degrees North, Svalbard, a group of islands nearly a thousand kilometers north of the northernmost tip of mainland Norway, is “remote” by anyone’s definition. The climate is an arctic, dry, cold, wind-swept semi-desert. About 60% of the land mass of 63,000 Km^2 is covered with various size glaciers. And more than 50% of the land area is officially protected, either as national park, nature reserves or bird sanctuaries.

From 26 October to 16 February, Svalbard lies in total darkness (“polar night”). Average temperature in the summer is +6C, in the winter it is -14C. Extended periods of -20 to -30C are common during the winter, added to which is a considerable wind chill factor. Polar bears can be found anywhere on the Svalbard islands at any time.

The climate – including that at Svalbard – is probably changing. Models present different pictures of the future. The farther into the future the prediction, the less precise and more controversial it is. Nevertheless, change at Svalbard will not come particularly quickly, at least for deep permafrost areas. The top 2-4 meters is particularly sensitive to changes in air temperature and thus subject to thawing and refreezing. At 10 meters or more, there is little fluctuation, with the temperature equaling the mean annual temperature above, i.e., approximately -6C, until several hundred meters is reached, when temperatures begin to rise again. Thus at least for the next hundred years, it would appear that Svalbard would offer relatively stable conditions for the type of facility foreseen in this report. Note: while we refer conservatively in this report to permafrost conditions offering -3.5C, it is possible (but contingent on where the facility is actually located) that the temperature actually achieved might be as low as -6C.

Svalbard has several small settlements, the largest being Longyearbyen, (population: approximately 1700), the administrative center. Despite its remoteness and small population, Longyearbyen offers excellent infrastructure, a dependable power supply (using locally-procured coal), and good communications. Its airport is the farthest north in the world serviced by regular flights – approximately one a day.

The Nordic Gene Bank has, since 1984, successfully maintained a safety backup of its collection in permafrost conditions in an underground tunnel, in Svalbard. Through an agreement with SADC, certain collections from southern African countries are also maintained for those particular countries in Svalbard.

The Committee reaffirms the finding of previous studies that Svalbard is a unique and appropriate location for an international seed facility. No location can offer 100% security from natural and human dangers. Some degree of vulnerability will always exist. A location far away from all human presence would still, for example, be vulnerable to deliberate sabotage. The Committee, however, judges Svalbard to offer a level of security that would be difficult to match any where else.

The Committee identifies the advantages of Svalbard as the following:

- Climate and geology. An underground facility in Svalbard could take advantage of permafrost conditions (permanent, below zero Celsius temperatures) and utilize the considerably colder winter temperatures combined with the insulating qualities of a chamber excavated out of sandstone inside a mountain, to provide storage conditions that meet the highest international standards for long-term conservation, -18C, at a low cost and with relatively little dependence on mechanical technologies. There is no volcanic or significant seismic activity. Radiation, low even in the coal mines, should not be a factor in sandstone, the preferred option. Potential sites would not be affected by a rise in sea levels, should this occur. A suitably constructed facility would be far more secure and permanent than any existing genebank.

- Security. Svalbard's remote location provides unrivaled security against the myriad dangers to which most collections are exposed. Access to Longyearbyen is effectively limited to one plane flight a day and the occasional boat during summer. Frigid temperatures, ice flow (and waters), polar bears, the presence of Norwegian authorities, and the inherent security of a reinforced underground location with locked vault-like doors combine to present a formidable obstacle to any who might contemplate an act of terrorism.

- Political / Social Stability and Infrastructure. Today, Longyearbyen is a base for arctic research and administration. Successive Norwegian governments have committed themselves to maintaining the excellent infrastructure in Svalbard and preserving the natural environment. The local community and government enthusiastically supports the use of Svalbard for an international conservation facility. There is no political instability or significant crime, nor is any likely in the future. Svalbard already has an international character. The Treaty of Svalbard (1920)[1] gives Norway sovereignty over Svalbard, and imposes a number of limitations on activities there, including a prohibition against the establishment of military fortifications and naval bases. The Treaty also obligates Norway to provide equal rights to citizens from all parties, including entrance to Svalbard.

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[1] Parties to the Treaty of Svalbard are: Afghanistan, Albania, Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Chile, China, Denmark, Dominican Republic, Egypt, Estonia, Finland, France, Great Britain, Germany, Greece, Holland, Hungary, India, Iceland, Italy, Japan, Monaco, New Zealand, Norway, Poland, Portugal, Romania, Russia, Saudi Arabia, Spain, Switzerland, Sweden, South Africa, United States, and Venezuela.

The Committee did not uncover any major, inherent or insurmountable obstacle to the placement in Svalbard of the type of facility foreseen in this report.

The Initiative

Proposed Mandate

The Committee proposes that the mandate of the facility be to provide an ultimate safety net to the international community for the world's unique plant genetic resources for food and agriculture. The Svalbard facility would create an extra layer of security for existing genebank collections and thus guard against catastrophic losses that might be caused, for example, as a result of large-scale disasters.

The Svalbard facility would be open for the conservation of seed only.[2] Samples eligible for conservation at Svalbard must already be housed in two conventional long-term genebanks elsewhere in keeping with current international standards. As the Svalbard facility would not function like or be used as a regular genebank, routine access to samples conserved in Svalbard would be granted to duplicates stored by other genebanks, not by the Svalbard facility. (Retrieval of samples from Svalbard would only be as a last resort in keeping with its mission of providing an ultimate safety net.)

All seed accepted for storage would have to be duplicates of samples that are legally available for access under the terms laid out in the International Treaty on Plant Genetic Resources for Food and Agriculture. This requirement would establish the facility as serving international as opposed to strictly national or institutional needs.

Countries/institutions making use of the facility would do so on a voluntary basis. While the Svalbard facility would be capable of housing 100% of the estimated unique samples in ex situ collections today - with enough capacity to allow for a significant number of additional samples over the coming decades - other countries would, in the future, be entirely free to propose and construct similar facilities.

Norway would offer use of the facility without warranty or exposure to any future liability for any losses or other eventualities.

Operation and Management

The Committee believes it appropriate that Norway retain ownership of the physical facility and the land. It would recommend the establishment of a Council to oversee operations. (See Annex I.) It would see either Norway, or the Council contracting on a long-term basis with the Nordic Gene Bank (NGB), as the implementing agency, to

[2] This seed would be what specialists term , "orthodox seed," namely seed that can be effectively conserved when dried and stored in cold conditions.

operate the facility. For purposes of the following discussion, NGB is used as the implementing agency.

NGB would liaise with suppliers for the shipment of seeds to Svalbard, in some cases via NGB in Alnarp, Sweden. SAS Cargo operates three flights a week to Longyearbyen during the summer months.

Depositors of seed would be required to place the seed in specified, standard-size foil packages inside optimally full, standard-size boxes. In certain cases, financial assistance to do so might be provided by the Global Crop Diversity Trust, and technical assistance to do so might be given by Centers of the CGIAR and by the NGB. Provision of such assistance, particularly in the case of the Trust, would only be granted in connection with collections that satisfy the Trust's criteria of protecting the world's unique and valuable germplasm – this would function to support the priorities of the initiative.

Seed would be stored under "black box" arrangements, meaning that seed packages and boxes would not be opened. Authorization will be needed from the Norwegian Food Safety Authority (Ås) for an exemption from quarantine regulations in order to import and store the seeds. In the draft Agreement formulated in conjunction with Norway's previous offer in the 1980s, the government undertook to exempt germplasm imported for the purpose of storage in Svalbard from phytosanitary inspection, licensing, quarantine, etc., provided that importation was carried out in accordance with certain specifications and procedures.

Seed would be accepted for storage in Svalbard subject to the terms of a Material Transfer Agreement (MTA). In this Agreement, the depositor would, *inter alia*, warrant that the samples to be deposited were materials that had not previously been sent to or received from any Centre of the CGIAR (which would routinely duplicate at Svalbard all materials held by them), or were to their knowledge, already housed in the facility at Svalbard. The Council would be responsible for developing the MTA and ensuring that it functioned to support the priorities of the initiative.

Given expressions of interest that have already been communicated to the Committee, it is assumed that the facility would begin operations with a nucleus consisting of the CGIAR materials and those of certain key national genebanks and that this "founding collections" would discourage subsequent unnecessary duplication of materials within the Svalbard facility.

It is important to note that the facility would *not* function as a traditional genebank It would only be a source of germplasm when the material had become unavailable from all other sources. Retrievals would therefore be rare, not routine. NGB might, at its discretion, make access available only at set intervals (e.g., once a year) in order to reduce management costs.

NGB would establish and maintain a public on-line database of samples stored in Svalbard. In addition, both a hard and electronic copy would be kept inside each box in the facility. Depositors of seed will provide a complete electronic inventory of the samples with generally recognized passport, characterization, and evaluation data when available. All records would indicate both a Svalbard and a depositor identification number. NGB will not open, access or use the stored materials. Nor will NGB assume any responsibilities for testing of materials (e.g., for germination) or for subsequent regeneration or multiplication. NGB might, in certain circumstances, offer assistance in packaging. Selected duplicate samples for germination testing should be maintained by the depositor at -18C storage conditions at the home site to monitor the samples deposited.

The Facility

Size

Determining of the appropriate size of the Svalbard facility involves consideration of two complicated questions:

1. How many seed samples meet the criteria for storage, and what proportion of these would one expect to attract to the facility, and
2. How much physical space is required to store this number of samples (a question that requires one to estimate average volumes, because different seed – maize and alfalfa – are very different in size.

No precise, mathematical answer can be given to these questions. Too many variables are involved. (See Annex II for a discussion of this topic.) For purposes of this report, we propose that the Svalbard facility have a capacity to house 2-3 million samples. FAO (1998) and various independent studies (Lyman 1984, Fowler and Hodgkin 2004) have estimated that there are approximately 1-2 million "unique" samples in genebanks today. The Svalbard facility would then be capable of securing all of this unique diversity, and have sufficient room for expansion in the future, both important features for a long-term initiative such as this. The added costs associated with constructing and maintaining a facility designed to house all unique genetic resource samples as opposed to one based on the assumption, for example, that the facility would only attract 75% of the diversity, is negligible. It is important, we believe, that the facility be seen as having the capacity to meet all legitimate needs.

The facility foreseen in this report would likely have capacity to store both the original accessions deposited now, *and* future regenerated samples of these accessions deposited later, thus providing added insurance against genetic drift associated with regeneration. At least one NGO has also mentioned that this feature would, de facto, allow for the maintenance of a largely GMO-free collection of current existing diversity, a political consideration that might make the facility more attractive to some.

In calculating space requirements, we have considered "wheat" to represent the median seed size, and we have examined the implications of various packaging and storage (shelving and boxing) options. (See Annex II for more detailed information on these calculations.)

Physical Structure

The physical structure intended to provide ultimate protection for the world's agricultural biodiversity must be designed and built to stand the test of time. It should be simple and elegant, capable of meeting international standards for long-term storage in normal times with a minimum of management and expense, and of providing effective protection and conservation even in the event of global catastrophe, including lengthy disruptions in electricity and human involvement serving the Svalbard facility. The facility, with a combination of natural and mechanical cooling systems in a secure location would therefore be designed and constructed to provide a service that no genebank or consortium of genebanks can offer.

No physical structure comes with a guarantee that it will last forever. The Svalbard facility, however, could combine the advantages of durable, natural features present in Svalbard such as stable sandstone formations, with extremely robust construction materials to provide the most durable and secure facility feasible, one that we could be rather certain would function properly centuries into the future, and even longer.

The Committee proposes the construction of a reinforced concrete vault, 60 cm thick, inside a chamber carved out of solid sandstone underground or within a mountain (Figure 1) near Longyearbyen, Svalbard. Preliminary calculations indicate the total size of the excavated containment structure would be approximately 16.2m X 53.8m X 6.2m and would include provisions for a small reception/working area and mechanical room in addition to the seed storage room (Figure 2).

The facility would have one entrance at the surface level, ringed on the outside by a heavy security fence to prevent all but serious entry attempts by non-authorized personnel (Figure 3). Other than the one entry point, all other sides would be enclosed and impervious to access without heavy drilling and excavating equipment and significant time to use it. Access from the "outside world" to the facility proper (beyond the fencing) would be through a very strong security door and airlock into the small working / reception area. A second robust security door and airlock would separate this area from the seed storage vault. This vault would measure 5M X 40M X 5M. The inside of the seed storage vault will be lined with insulated panels (in addition to the thick concrete wall) to help maintain the cold temperatures.[3]

Maintaining the optimum constant temperature of –18C will require refrigeration (freezing) equipment, compressors, condensers, and evaporators to act in support of the climatic conditions surrounding the facility. Given the climate of Svalbard and the unparalleled insulation provided by the combination of insulation panels, heavy reinforced concrete, and the thick sandstone layers plus overlying soil – all in a

[3] Note: The features indicated in this paragraph and in those dealing with operational matters such as shelving are presented by the Committee as reasonable and workable options. We recognized that changes may be made to this scenario as the Government moves from "vision to reality."

permafrost environment – the Committee estimates that the required back-up cooling equipment will be modest in size and will be operating only at sporadic intervals.[4]

An Air Handling System will be designed to draw the cold Arctic Air into the vault, automatically and without human intervention, obviating the need for on-going mechanical refrigeration to maintain the proper temperature. The mass of the facility will maintain the temperature requirements during the extremely cold season and if during warmer periods the inside temperature rises above –18C, the refrigeration equipment controller will engage, the equipment will come on line and restore the proper conditions. Calculations indicate at current temperature conditions, the –18C requirement, once achieved would be statically maintained by the combination of insulation, permafrost and cold outside air for 9-10 months. With no artificial assistance, temperatures in the vault would not rise above approximately –3.5C, and would take months in the winter and weeks in the summer to warm to that level from –18C were electricity supplies to fail, providing an opportunity in normal times for corrective actions to be taken if problems arise.

In addition to the physical attributes of the facility that combine to provide unparalleled security, the facility would also be equipped with motion detectors and possibly TV monitoring. Electronic transmitters linked to a satellite system could monitor temperatures, etc., and send this information back to the appropriate authorities at Longyearbyen and at the Nordic Gene Bank.

<u>Sites</u>

The Committee investigated a number of potential sites for the facility during its visit to Svalbard, including the current location of the back-up collection of the Nordic Gene Bank. The Committee considers it inappropriate to establish the facility in a coal mine due to the risk of fire, explosion and roof collapse inherent in such structures. Access by others (whether miners, or in the case of Mine 3, tourists) is also problematic. Instead, the Committee feels it wise to establish a location that is not in close proximity to any commercial facility (coal, satellite tracking, etc.). A number of promising sites exist near Longyearbyen. It was beyond the mandate or competence of this Committee to identify a precise site for the facility. The Committee notes, however, that a trade-off exists between the increased security (lack of visibility, difficulty of access) of a site and accessibility, convenience of access and reduced costs of constructing the facility along an existing road (such as the road to Mine 3, for example). Further consideration should be given to geotechnical conditions, climatic conditions and construction staging issues, among others, before a final determination is made of the site.

A small committee[5] should be established to research and determine the precise location for the facility, taking into account the nature of the facility (desired depth below ground

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[4] Nevertheless, the Committee encourages consideration of the practicality of using alternative sources of power, specifically solar during summer when power needs will be greatest.

[5] This committee might be composed, *inter alia*, of the following: a geologist knowledgeable of conditions in Svalbard, a hydrologist (perhaps the same person as the geologist), a representative of local government, the environmental officer associated with the Office of the Sysselmann, the director of the Nordic Gene

level, etc.), security considerations (such as rock characteristics and stresses), electricity supplies, geo-technical conditions (measurements of rock stresses, etc.), construction staging questions, and cost.

Expected Results / Benefits

A number of countries and institutions have indicated a desire or a willingness to enter into discussions about placing a safety duplicate of their genebank materials in a Svalbard facility. Indeed, each country/institute contacted thus far has indicated such an interest. Collectively, this would already represent well over half of the estimated diversity in existing genetic resource collections.

Seeds stored at -18C, will (depending on the species) remain viable for many years. Dried to the proper moisture content and packaged properly, it is estimated that seed of most major food crops can be successfully stored at -18C for hundreds of years, and seed of many crops, including some of the major grains, can be stored for thousands of years. The Nordic Gene Bank has found no meaningful decline in viability of seeds stored in permafrost conditions at Svalbard in the 18th year of a 100-year experiment.

Budget

The following represents an estimate of the potential cost of the facility. Costs have been escalated 5-10% due to the unknowns associated with designing and constructing the facility. The costs include geo-technical investigation, structural design, electrical & mechanical equipment design, excavation or tunneling for the structure, shelving, insulated panels, shipping, utility (electrical distribution), security features, and the cost of material procurement. It has been assumed that no land purchase or development would be included in the cost estimate since the land belongs to the Government of Norway.

Item	**Cost (NOK)**
Engineering/Geology/Specifications	2, 070, 000
Excavation/Tunneling	1, 758, 700
Concrete	7, 348, 500
Reinforcing Steel	793,500
Insulated Panels	1, 035, 000
Air Handling (Motors & Ducts)	345, 000
Electrical	345, 000
Refrigeration Equipment	690,000
Miscellaneous Architectural Aspects (Doors, Int. Walls)	103, 500
Lighting	34, 500
Shelving	1, 035, 000
Shipping	414, 000
Fencing	82, 800

Bank, and the chair of this Feasibility Study Committee. They, in turn, would consult with others, including mining engineers, construction personnel, etc. as needed.

Security System	586, 500
Satellite Monitoring	517, 000
TOTAL	**17,159,000**

In providing this budget, the Committee has used cost estimates it believes to be generous. However, given the uncertainties associated with constructing a facility in Svalbard, we believe the Government should consider an allocation of NOK 20 million. This figure does not take into consideration costs associated with establishment of the proposed Council or those associated with the time and travel expenses that might be incurred by government employees involved in establishing the facility.

It is also important to note that if the Government chooses to move forward with the establishment of a Seed Depository at Svalbard, much more detailed engineering plans will be required. These should be elaborated in tandem with determining the best location for the facility. These exercises will produce more precise and reliable budget figures. The plan put forward in this Study calls for the facility to be located reasonably near the surface. Were engineering and climate reports (not available at the time of writing) to indicate that there might be considerable advantages (e.g., reliable and steady drops in temperatures) to be achieved by placing the facility farther in the permafrost structure, then excavation and concrete expenses would necessarily increase.

An Analysis of Political Support / Opposition

In Annex III we provide a brief assessment of the reasons why Norway's original offer to host a facility in Svalbard received insufficient support to move forward.

Conclusions

The Committee concludes that a Svalbard facility as described in this report would make a major contribution to the ultimate security of plant genetic resources, the irreplaceable and invaluable biological foundation of agriculture and world food security. There are no significant technical impediments to the construction of such a facility at Svalbard. Moreover, the estimated cost of the facility is trivial compared to the benefit of having a secure seed depository in an increasingly insecure and unpredictable world.

Political conditions have changed dramatically since Norway's previous offer 15 years ago. The technical characteristics of the facility proposed herein are also very different. All indications point now to a political climate that will be favorable to the establishment of a Svalbard facility. In discussions with a wide range of political actors, no opposition was detected. Enthusiasm and political support appears to be widespread.

Annex I
Establishment of a Council to Oversee Operations of the Facility

This Study foresees the creation of a Council to provide oversight, legitimacy and comfort for the international community. The Council would be diverse, representative of major actors involved with the facility, and high-level. Initially, it may need to meet to formalize a management contract with the Nordic Gene Bank and to draw up and adopt a Material Transfer Agreement under which samples would be transferred to the Svalbard facility. After this, meetings, when required, might take place electronically. It is assumed that the Government of Norway would oversee the construction of the facility, or delegate this responsibility to a relevant institution.

The Council might be composed of the following:

- A representative of the King
- The Governor of Svalbard or his/her representative
- The Chair of the Board and/or the Director of the Nordic Gene Bank
- The Chair of the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture
- A nominee of the FAO Commission on Genetic Resources for Food and Agriculture
- A representative of FAO
- The Director General of the International Plant Genetic Resources Institute
- The Executive Secretary of the Global Crop Diversity Trust

Annex II
Determining the Optimal Size and Storage Capacity of a Facility at Svalbard

How many samples should the Svalbard facility be designed to hold? This number is a function of the following variables:

1. The total number of accession of PGRFA that are currently conserved in genebanks globally (A)

2. The proportion of these that are conserved as orthodox seeds (B)

3. The proportion of these that can be identified as "unique", given a reasonable (minimal?) degree of effort (C)

4. The proportion of these that are covered by the terms of the multilateral system under the International Treaty or that the holder is willing to make available on the same terms and conditions regarding access and benefit-sharing (D)

5. The proportion of these that the holder is willing to place in a long-term safety repository (E)

6. The proportion of these that the holder is willing to place in Svalbard as opposed to other long-term safety repositories that might be developed elsewhere (F)

7. The number of new accessions meeting the above conditions that will be added over time (G)

8. The decision on whether or not the original samples deposited will be removed from the repository as fresh seed is provided. (H, where H = 1 if no original seed is retained and H =2 if the original samples are retained)

This gives the number of accessions to be stored at Svalbard (N) as:
N = H (A x B x C x D x E x F + G)

Given this large number of variables, we are left with making a reasonable guess for planning purposes. As our report indicates, we believe that a facility designed for 2-3 million accessions will meet all current and most future needs associated with protecting the world's unique plant genetic resources for food and agriculture.

Space considerations were calculated utilizing 500 seeds and an average seed size and seed weight for wheat (*Triticum aestivum*) and rice (*Oryza sativa*). These two species make up somewhere in the neighborhood of 33-50 percent of the CGIAR collections in the protected public domain. Maize (*Zea mays*) and beans (*Phaseolus vulgaris*) are somewhat larger but sorghum (*Sorghum vulgare)*, millets (*Pennisetum glaucum)*, and lentils (*Lens culinaris*) are slightly smaller. Previous study estimates utilized wheat as a standard for planning storage volumes.[6]

Storage bags are water tight aluminum foil with a heat-sealing compound on the inside. The bags measure 26.5 x 9 cm when flat with a 7 cm gusset for expansion. When 500 wheat seeds are relatively evenly distributed with bags lying flat, 100 bags occupy a space of 26.5 x 9 x 16 cm. Bag size may be altered by not using the gusset for wheat and smaller sized seeds thus saving on bag cost.

Box size is calculated to hold 400 bags in 4 rows of 100 bags. Outside dimensions of boxes are 60 cm long (55 cm inside) by 40 cm wide and about 28 cm high. The estimate for wheat is very conservative since such a size will likely hold more than 400 bags. In a tight pack condition for wheat, one can theoretically get 55/16 x 4 x 100 or 1375 bags. Box weight will vary with the kind of seed but space allowances will result in about 4.5-5.5 kg per box.

Mobile shelving was not considered due to 1) expense, 2) possible concrete floor shifting preventing the movement of the shelves, and 3) long-term placement of boxes requiring infrequent removal. Fixed shelving was calculated to be 3 meters high with a shelf at the bottom and above each set of three boxes (2 shelves) plus a top shelf with one box on top of it. This allows 10 boxes from top to bottom on the shelving. Space above the top box will allow air circulation from the evaporator coils. Shelving will be two boxes deep (2 x 60cm).Verticals will be at two boxes wide (2 x 40cm) and a 10 cm allowance for the vertical and clearance space gives 90 cm for the width required. This allows 40 boxes per bay. Two-row boxes of the same length can be considered and will fit four across between verticals. All calculations here, however, are based on the four-row model. Cross bracing will be located between verticals behind the shelves and between verticals front to rear. There will be no impediments in the front of the shelves making them totally accessible from the aisle.

The long tiers of shelving will go the length of the vault from front to rear. Approximately 35 bays long (allowing clearance at the ends for circulation), there will be 35 x 40 boxes/bay (1400 boxes) housing some 560,000 sample bags (at 400 per box). The vault would have four long tiers thus allowing 4 x 560,000 bags or 2,240,000 bags. Since the estimate of 400 bags per box is conservative based upon the wheat/rice example, one can estimate that the vault could hold even more samples based on species, their seed sizes, and tightness of pack in the box.

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[6] The Design of Seed Storage Facilities for Genetic Conservation. 1982. International Board for Plant Genetic Resources. Rome.

Annex III
Norway’s Previous Offer to Host an International Seed Bank

In the late 1980s discussions took place in a number of forums (CGIAR, FAO Commission on Plant Genetic Resources, Government of Norway) about the possibility of establishing an international seedbank at Svalbard. A consultant’s report (Smith 1989) concluded that “the choice of Spitzbergen, Svalbard, cannot be bettered.” Subsequently, FAO convened the Svalbard International Seedbank Expert Consultation Meeting (1990), which concluded that “Svalbard is uniquely qualified to be the site of such an international facility.” The need for such a facility was never seriously disputed; indeed a survey of 750 scientists by FAO and the International Board for Plant Genetic Resources (now IPGRI) revealed considerable interest among holders of plant genetic resources in using the proposed Svalbard facility (FAO/IBPGR 1991). Nevertheless, the Norwegian offer to construct and host a facility in Svalbard ultimately met political opposition within the FAO Commission.

Opposition / lack of sufficient support stemmed from four factors (Table 1). Significantly, *none* of these factors exist today. Yesterday’s political roadblocks have been removed.

Table 1. Factors Influencing the Political Reaction to a Svalbard Facility

Earlier Reasons for Opposition / Lack of Support	Current Situation – New Conditions
The political/legal status of plant genetic resources was highly controversial and under debate and negotiation at FAO. The absence of clarity on this issue created a belief that the proposal to create a facility housing international collections might be premature.	The International Treaty on Plant Genetic Resources firmly establishes the status of the resources and creates a multilateral system of facilitated access. In addition, the FAO Global Plan of Action, endorsed by 150 countries in 1996, calls for a rational and secure system of conservation that would arguably be advanced by the existence of a facility at Svalbard.
The proposed facility would have stored seed under permafrost conditions (approximately -3.5C), whereas international standards for long-term storage at the time called for a considerably lower temperature (-18 to 20C).	The proposal of the present Committee calls for a facility that would meet international standards for long-term storage, while taking advantage of permafrost conditions to reduce costs and offer security in the event of technical failures or disruptions.
Political tensions associated with the Cold War led some to believe that the Svalbard location might be vulnerable to military actions.	Political tensions are reduced and while no location can guarantee complete safety, Svalbard provides considerable security.

No institutions or dedicated funds existed to support on-going, long-term expenses for operating the proposed facility. The lack of identified funding led some in Norway to conclude that political support and commitment was less than enthusiastic.	The Global Crop Diversity Trust, an endowment fund to provide financial resources for long-term conservation efforts now exists and has expressed interest in supporting a Svalbard facility. (See Annex IV) Moreover, maintenance and running costs are expected to be very modest.

Annex IV

The document appended below was received by the Committee from the Interim Secretary of the Global Crop Diversity Trust

<u>The Global Crop Diversity Trust and the Svalbard International Seed Repository</u>

The Global Crop Diversity Trust is being established as an independent international fund that aims to support the development and long-term maintenance of an efficient and effective global arrangement for *ex situ* conservation. It operates within the framework of the International Treaty on Plant Genetic Resources for Food and Agriculture. Although still in the planning stage, it is envisaged that such an arrangement would comprise collections that:

- are nationally and internationally important
- are widely used as a key resource for sustainable development
- collectively cover the major part of the genepool of the crops concerned (both cultivated species and their wild relatives)
- are viable and healthy
- are accessible under the terms of the International Treaty with respect to access and benefit-sharing
- are well documented and the information on them is freely and widely available
- become more useful over time as additional data become available
- are maintained by institutions committed to their long-term conservation and availability
- are housed in facilities that meet the scientific and technical standards necessary to ensure long-term conservation
- are managed efficiently and effectively within the context of a rational system having appropriate coordination mechanisms and shared responsibilities for specific conservation and distribution activities
- are duplicated in at least one other genebank for safety – avoiding excessive duplication – as well as in a secure long-term repository

The proposed repository at Svalbard is seen as an appropriate facility to provide for long-term security in the event of major disasters and could thus play a critical role in the proposed global arrangement. As such it would be eligible to receive funds from the Trust, subject to the approval of its Executive Board.

Two types of funding support could be foreseen:

1. support for the Svalbard facility and operating agency to provide appropriate conservation services to depositors of collections,

2. support to the holders of eligible collections to enable them to prepare and ship samples to the facility.

It is envisaged that the Trust would enter into a long-term funding agreement with the agency responsible for operating the Svalbard facility. The agreement would specify that the Trust's intention would be to provide funding *in perpetuity*, subject to periodic review, to partially or fully support the costs of items such as:

- electricity
- routine upkeep and maintenance
- shipping seed between the operating institution and Svalbard
- full or part-time assistance at Svalbard and/or the operating agency
- the governance and technical oversight of the facility and the services it provides

It is further envisaged that the Trust would include provisions within its regular support to holders of eligible collections to help cover the costs associated with:

- seed preparation (this would generally be done as part of routine seed regeneration activities),
- packing,
- inventorying
- shipping

In conclusion, the proposed facility at Svalbard is seen by the Global Crop Diversity Trust as being highly relevant to its long-term conservation mission and goals. As such it would he eligible to receive long-term funding support, subject to the approval of the Trust's Executive Board.

Annex V
Feasibility Study Committee Composition

Committee

Professor Cary Fowler (chair)

Director of Research, Center for International Environment and Development Studies, Agricultural University of Norway, and Senior Advisor to the Director General, International Plant Genetic Resources Institute; former Secretary, FAO International Technical Conference on Plant Genetic Resources

Mr. William George

Professional Engineer. Senior or consulting engineer for genebanks in the United States, Russia, India, and for the International Maize and Wheat Improvement Center (CIMMYT)

Dr. Henry Shands

Director, National Center for Genetic Resources Preservation (USA); former Assistant Administrator for Genetic Resources, US Department of Agriculture

Dr. Bent Skovmand

Director, Nordic Gene Bank; formerly Principle Scientist and Director of the Wheat Collection and Genebank, International Maize and Wheat Improvement Center (Mexico).

Ms. Marte Qvenlid, (Research Assistant to the Committee) MSc. candidate, Center for International Environment and Development Studies, Agricultural University of Norway

Observer

Dr. Geoff Hawtin

Interim Executive Secretary, Global Crop Diversity Trust; former Director General, International Plant Genetic Resources Institute

Annex VI
Acknowledgments

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Knut Flå (Svalbard Samfunnsdrift As)
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Jørgen Stenvold (Store Norske Spitsbergen Kullkompani)
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Alv Orheim (associated with Store Norske Spitsbergen Kullkompani)
Bjørn Fjukstad (Longyearbyen Lokalstyre)
Sigmund Engdahl (Longyearbyen Lokalstyre)
Helen Flå (Universitetssenteret på Svalbard)
Frode M. Nilsen (Leonhard Nilsen & Sønner Store Norske AS)
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Even Bratberg (Agricultural University of Norway)
Pål Prestrud (Centre for International Climate and Environmental Research)
Bjørn Lind (Norwegian Radiation Protection Authority)
Chris Walters (National Center for Genetic Resources Preservation, USA)
Vijal Jadav (Nordic Gene Bank)
Dag Terje Endresen (Nordic Gene Bank)
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Jan Valkoun (International Center for Agricultural Research in Dry Areas, Syria)
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Emile Frison (IPGRI)
Jan Engels (IPGRI)
Kameswara Rao (IPGRI)
Jan Borring (Ministry of Environment)
Grethe Evjen (Ministry of Agriculture, and chair, Board of Trustees, Nordic Gene Bank)