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Global initiative for the secure long-term preservation of clonal and recalcitrant crop genetic resources collections via cryopreservation

Clonal crop Community of practice

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The Alliance of Bioversity International and CIAT, CIP, IITA and Global Crop Diversity Trust

Tropentag 2021, BMZ/GIZ Session:

Bringing innovations into practice – for a healthy and sustainable future

Thursday, 16 September 2021

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Ex situ conservation of clonally propagated crop collections

Clonal crops:

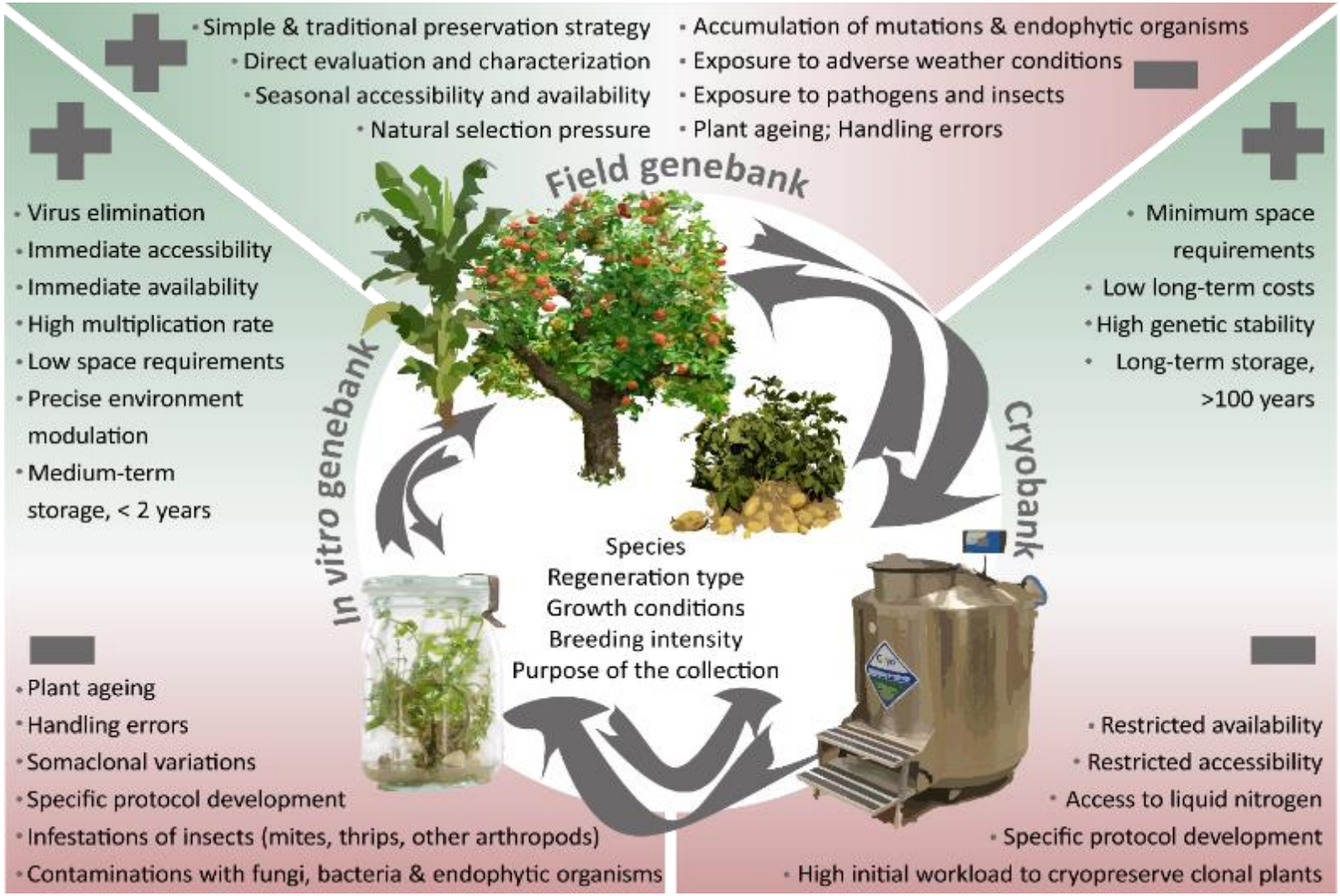
- Hardly produce seeds or in very few and irregular way
- Intermediate heterogeneous seeds
- Vegetatively propagated using propagules (vegetative parts)
- Usually have relatively long life cycle




Clonal crop GR (climate change context)**:**

- **Offer untapped genes for crop improvement and productivity**
- **New sources of tolerance and resistance to stresses**

CG clonal crop *ex situ* conservation systems



Panis *et al.*, 2020

Main objectives: Safeguard, long-term storage, safety duplication, rationalization and cost efficiency

Ex situ conservation of clonally propagated crop collections

Mainly conserved in field or *in vitro* genebanks





Collections are very expensive to maintain and are not securely backed-up

Cryopreservation can provide an economic solution

Long-term conservation of clonally propagated crop collections

Cryobank

- Conservation at ultra-low temperature (in liquid Nitrogen at -196° C)
- Complementary to other conservation methods (integrated conservation strategy)
- Most reliable method for clonal crop long-term storage and safety duplication

Advantages:

- Long-term storage (in perpetuity)
- Overcome disadvantages of other conservation methods
- Potential virus elimination effect
- Minimum maintenance
- Lower risk of induced variations
- Energy- and cost-effectiveness

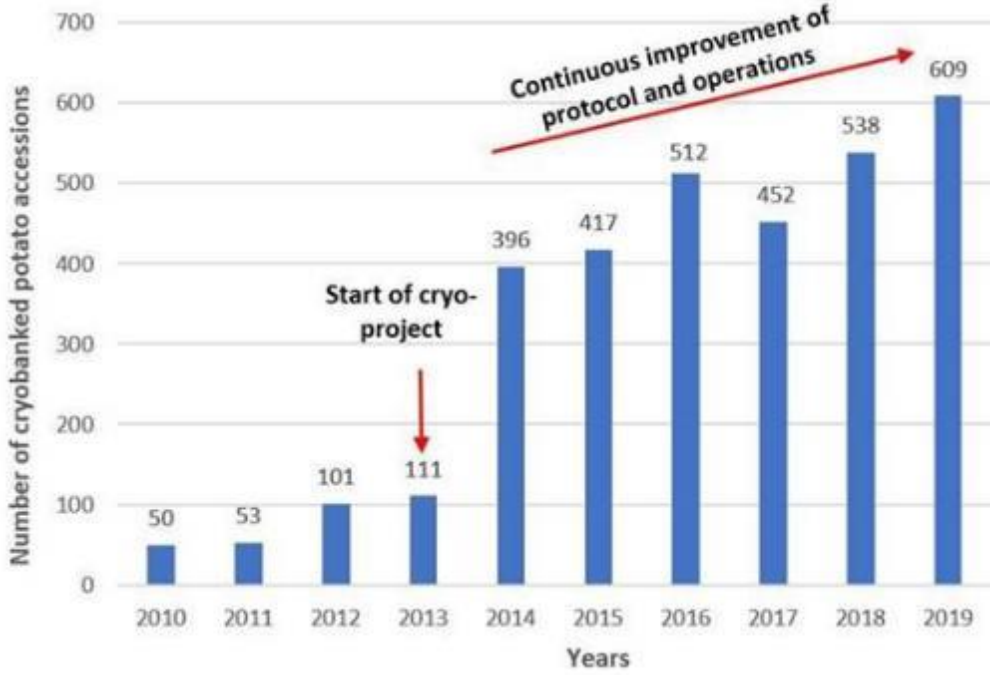
Long-term conservation of clonally propagated crop collections

Case study: Conservation of potato at the International Potato Center (CIP)

Cost of maintaining 1 accession:

- *In vitro* (4,809 accessions)= **$50-$60/yr** (~$250K/yr)
- Cryobank (3,587 accessions) = ~**$2/yr**

RoI: ~8yrs (for in perpetuity storage)



Cryo team: 16 cryo-trained technicians

Rate of cryopreservation implementation: >550 potato and ~65 sweetpotato accessions into cryobank/year

50% of the *in vitro* collection cryopreserved in 5 years

Long-term conservation of clonally propagated crop collections

Cryopreservation requirements

Strategy, protocols and procedures

Infrastructure

Human resources

Routine and reliable workflow

Continuous management

QMS and risk management

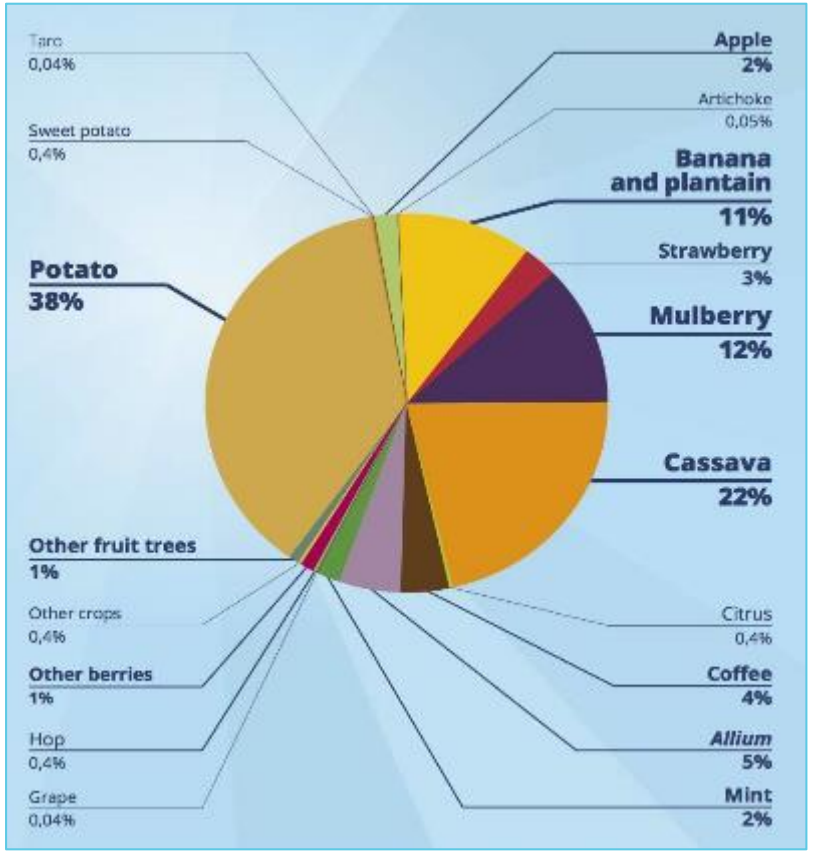
Challenges :

- Technical and financial
- Lack well-developed cryo-protocols
- Amenability across diverse genotypes?
- Implementable by all institutes?

Long-term conservation of clonally propagated crop collections

Operational for very few crops: ~12 **crops with >100 acc**:

Potato, Mulberry, Strawberry, Banana/plantain, Allium, Cassava, Coffee, Mint



Few cryobanks:

USDA, NBPGR, RDA, IPK, Kew, Vavilov Inst., NARO, CGIAR, (CIP, Alliance Bioversity-CIAT and IITA), …





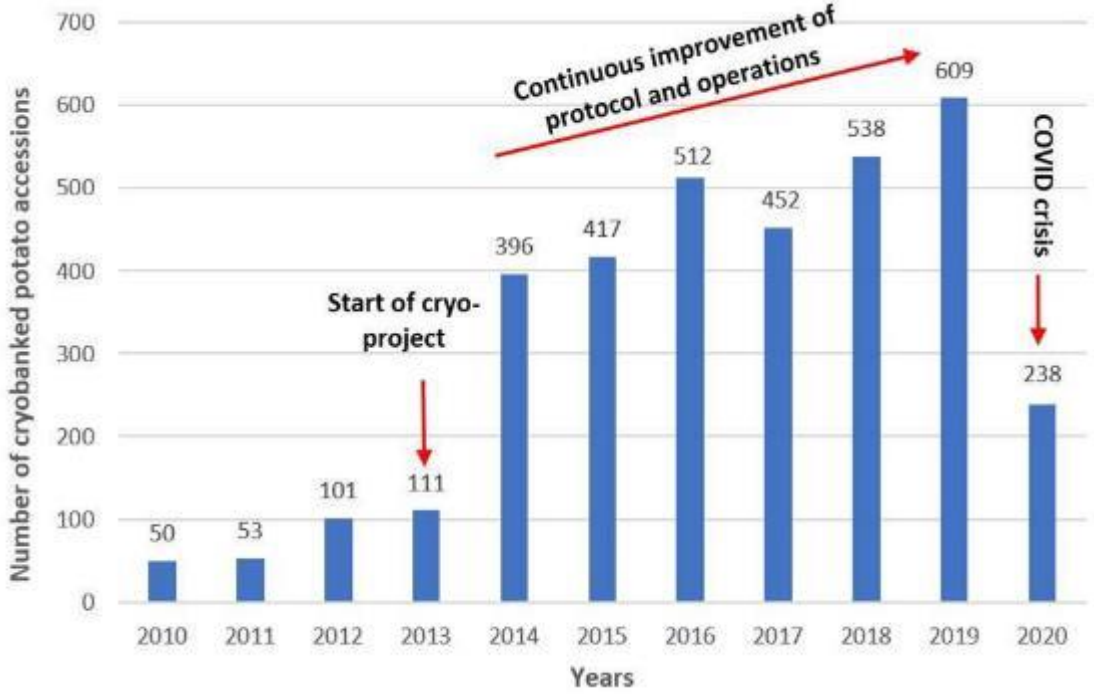

While…

Long-term conservation of clonally propagated crop collections

Too many examples of threats to diversity and loss of collections

- Yam cultivar loss in a 5-years period: up to 74% (Togo) and 65.8% (Benin Rep.) (Dansi et al. 2013, Loko et al. 2013)
- Coconut field collections are threatened by lethal yellowing, cadang-cadang and Bogia coconut diseases
- Samoan taro collection destroyed by taro leaf blight (Onwueme, 1999)

Effect of Covid-19 pandemic restrictions on CIP cryobanking rate



COVID highlighted collection vulnerability

Restrictions of Covid-19 pandemic demonstrated the susceptibility of collections to new threats

Maintenance of collections compromised for some clonal genebanks during pandemic

- Up to 75% reduction in staff (still ongoing)
- All non-essential work stopped
- Efforts focused on rescuing/keeping collections alive
- Reduction in stock of accessions maintained (below critical level)
- No restocking of international safety back-ups
- No distributions

If collections were cryopreserved, they would be secure…

Urgency to back-up collections

Ex situ conservation of clonally propagated crop collections

Svalbard Global Seed Vault for seed collections safety back-up

No equivalent for clonally propagated or recalcitrant crops

Genetic resources collections conserved in field or *in vitro* genebanks (at-risk, not long-term)

Feasibility study:

Establish a safety back-up facility for cryopreserved collections of crops that are vegetatively propagated and have recalcitrant seeds

Financial support from Australia, Germany and Switzerland

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Conclusions of the Feasability study

- Cryopreservation = <u>best long-term conservation option</u> for genetic resource collections of clonal and recalcitraint seed crops

  - (+) Lower running costs, increased longevity, greater genetic stability
  - (-) High initial costs, skill and technical challenges

- Cryopreservation has <u>huge benefits for long-term safety back-up</u>

  - *In vitro* (costly & difficult transport, need to continually subculture)
  - Infrastructure needs modest (5k accessions) but should double in 10yrs

- Critical need to accelerate cryopreservation to safeguard clonal and recalcitrant seed crop collections for food security and livelihoods of the worlds poorest

~100,000 Annex 1 accessions are currently at risk in field and *in vitro* genebanks

Recommendations of the Feasability study

- **Cryopresevation reported on >40 different crops**

  But only very few crops with >100 accessions in cryobank…

  Difference between developing a vaccine with some efficacy vs vaccinating an entire population

- **The primary need is long-term secure conservation of <u>collections</u>**

  - Globally, everyone needs the capacity to secure their collections

  - Not everyone needs/can actively do *in vitro* and cryopreservation

- **Genotyped and disease-free starting material is critical**
  - Confirm trueness-to-type and uniqueness
  - Disease-free to facilitate germplasm movement and leave a clean legacy

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Recommendations of the Feasability study

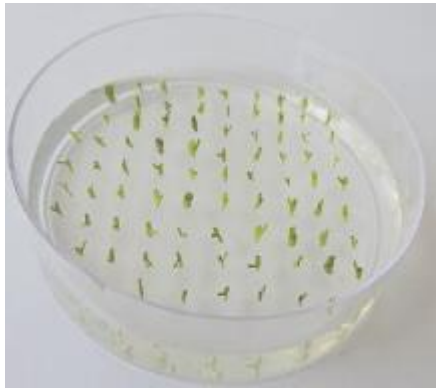
- **Wide range of explants can be cryopreserved**

  pollen, seeds, shoot tips, dormant buds, cell suspensions, embryonic cells and callus

  One size does not fit all - no one method works for everything…

- **Most cryo methods require *in vitro*** (exceptions pollen, seed, dormant buds)

  Opportunity and curse – *in vitro* can be the limiting factor



High standard Cryopreservation

Cryopreserved material should be viable anytime rewarmed (centuries)

Also, we need to leave a proud legacy for future generations

Requires collective and unified effort to:

- Ensure quality of the material in the cryobank
- Develop guidelines for monitoring viability over time
- Plan for safety back-up when putting material into cryo
- Set up cryo safety back-up capabilities globally

Quality Management System (QMS) for plant cryobanks

Large-scale implementation of cryopreservation

Secure, long-term and cost-effective means for safety back-up of clonal and recalcitrant seed collections

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Response…

Global Cryopreservation Initiative for Clonal and Recalcitrant Crops

Including:

- Focus on clonal and recalcitrant seed crop collections in the developing world
- Cryo Regional centers of excellence/capacity (hubs)
- Capacity building

  know-how, awareness, support
- Cryo safety back-up
- Global plant cryo network

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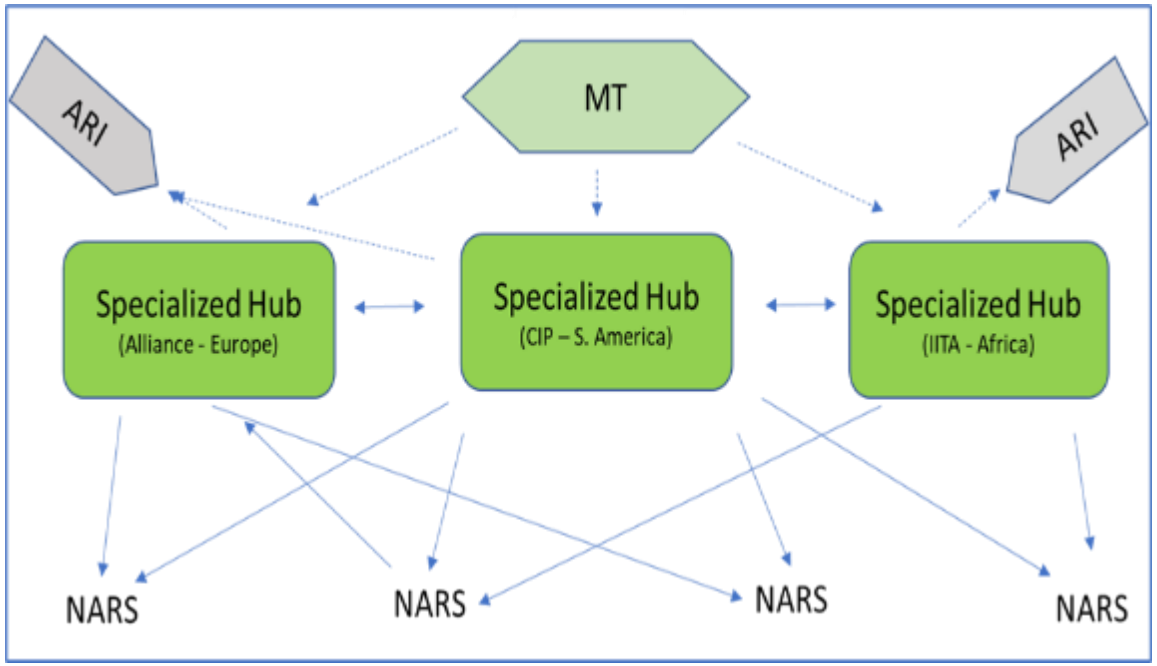
System built around specialized cryo hubs

Specialized hubs based on:

- Existing and functional cryobank infrastructure
- Experience, expertise and operational cryopreservation programs
- Regional presence and access to local partners in the developing world



e.g. CG centers cryobanks:

- **European Hub** - Alliance-Bioversity - *in trust* banana collection
- **Americans Hub** – CIP- *in trust* potato and sweetpotato collections
- **African Hub -** IITA – *in trust* cassava, yam, and banana collections

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Specialized cryo hubs

Hubs will:

- Contribute expertise to methodology development
- Move research results into operational protocols
- Lead and facilitate capacity building activities
- Provide service for operational cryobanking
- Provide cryo safety back-up
- Coordinate development and maintenance of database and network

Dynamic and evolving system:

Hubs could be added, modified or changed based on crop, need and donor opportunity

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Ten initial target crops

- **Seven Annex 1 crops:** *Musa* spp., cassava, potato, aroids, coconut, sweetpotato, yam
- **Three non-Annex 1 crops:** ulluco, coffee, cacao








All parties will be encouraged to transfer material with the Standard Material Transfer Agreement (SMTA) of the ITPRGFA

Focus will be on collections, not research unless protocol development is needed

- Build on success of potato and banana
- Expand to cassava, aroids, sweetpotato, yam, ulluco, coffee, cacao and coconut in initial 5-year period

Network for Integrated Global Plant Cryo CoP

Network:

- With Specialized Hubs as a foundation, a focused cryopreservation network for global clonal and recalcitrant crop genetic resources collections
- Engagement with NARS and other interested parties (NGOs, industry groups, donors)

CoP:

- Database of clonal and recalcitrant seed collections
- Directed workshops to train staff, to maintain contact and to monitor status of collections
- Forum for sharing experiences (CoP), knowledge, concerns, information, ideas…
- Provide capacity and coordinate movement of phytosanitary clean materials

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High time for a Global Cryo Initiative!

First steps…

- Proposal + summary drafted
- Steering committee = CGIAR Clonal CoP
- The government of Belgium is willing to host and provide initial funding to set up cryo back-up facility
- Launching fundraising campaign and initiate project(s)

Invitation to all relevant interested stakeholders in supporting this initiative

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Contacts and information…

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Thank you!