

Breeding foresight:

Exploring opportunities around climate-smart breeding for future food and nutrition security



Workshop convened by CCAFS Learning Platform 1
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Background

CCAFS Learning Platform 1, “Ex-ante evaluation and decision support for climate-smart options”, is one of six learning platforms in CCAFS, designed as mechanisms to integrate climate change work across CRPs while providing a facilitated platform for knowledge sharing, integration and coordination. LP1 is one of the three clusters of activities in Flagship 1 of CCAFS, and several centre projects in the CCAFS portfolio contribute directly and indirectly to the work of this CoA. The objectives of LP1 are:

- To address ex-ante evaluation of climate-smart practices, technologies and policies
- Help set realistic CSA targets
- Interface with CRP breeding programs and foresight modelling

This workshop aims to address the third objective above.

Workshop Objective

The workshop objective was to identify concrete actions that can add value through linking future climate modelling and foresight work with commodity breeding programs to enhance the climate resilience of agricultural systems to the middle of the century.

Workshop participants came with a wide variety of expertise, including plant biotechnology, plant breeding, agricultural and development economics, food policy, ex-ante impact assessment, foresight and targeting, systems analysis, spatial analysis, ecophysiology, crop modelling, and food security.

One of the tasks of the meeting was to explore the state of play and opportunities for collaboration concerning foresight and prioritization in climate-smart breeding. This includes informing the development of product profiles for breeding programs and prioritizing CSA-related traits within a profile. The participants also planned to discuss current knowledge and thinking around the key challenges that breeding needs to overcome to deliver climate-resilient cropping systems in the coming years. This needs to be done in a way that complements the considerable amount of foresight work that is going on in the CGIAR, so identifying the added value of possible new activities was a key part of the workshop. We also hope that some of the discussion around a medium-term plan of work to develop a compelling research strategy (the what and the where) will result in ideas for possible inclusion as one of the global challenges in the CGIAR’s Special Initiative on Climate Change from 2022 onwards.

Morning sessions on Day 1

Introductions and overview

The workshop began with all participants introducing themselves. The convener, Philip Thornton (Flagship 1 Leader of CCAFS), then gave an overview of how Learning Platform 1 fits into the context of CCAFS and its activities so far. There has been a special issue of *Agricultural Systems* on “Prioritising CSA interventions at different scales” with authors from 8 Centres and 4 strategic partners. There was also a writeshop during the Galway CCAFS Science conference that resulted in a journal article describing a framework for assessing CSA research and action investments ([Thornton et al. 2018](#)). There have also been feed and forage suitability analyses done as a partnership

between ILRI, CIAT, NUI Galway and the LIVESTOCK CRP. This workshop was made possible through a seed grant from CCAFS central funds.

Philip then went on to describe some of the different frameworks that exist for foresight and priority setting. These two terms may sometimes be used interchangeably, but they in fact describe different processes. Foresight is an activity in which we try to explore what the world may look like in the future based on alternative scenarios. Priority setting is an activity in which decisions are made on which avenues of research (or policy or investment) to pursue based on what the future is likely to hold and other considerations. There are then further steps beyond priority setting to reach the intended goals (Fig. 1).

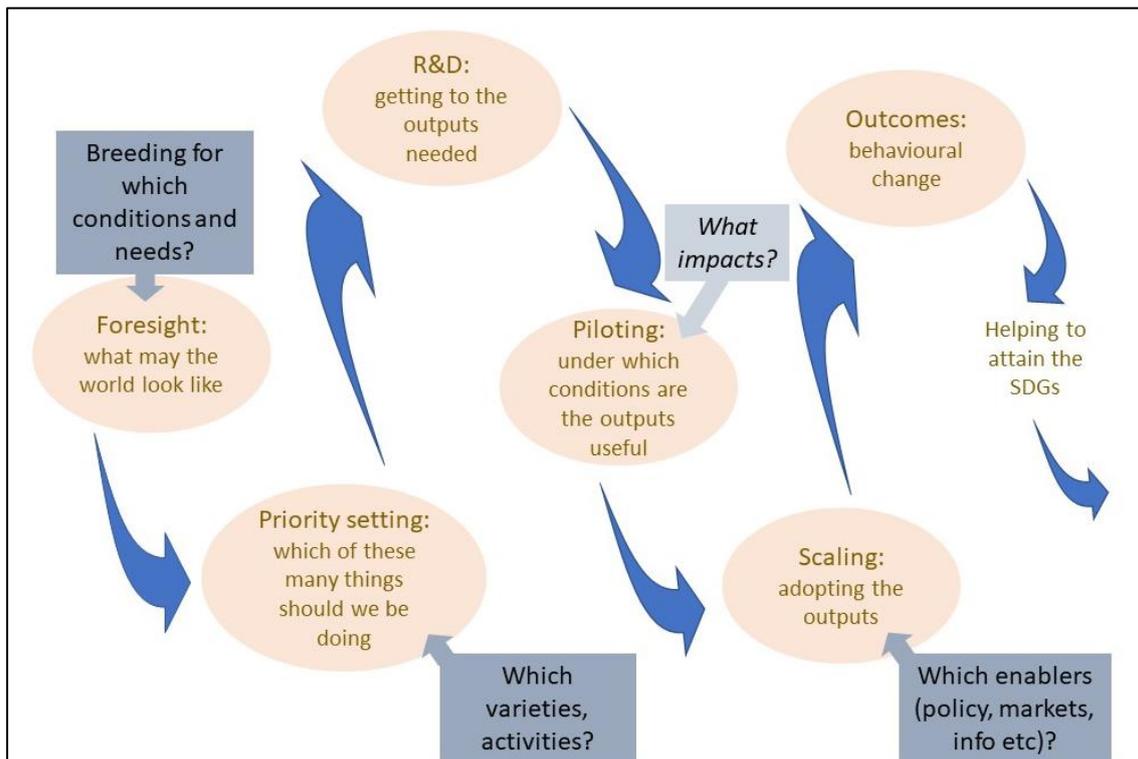


Figure 1. Slide from presentation showing pathway from foresight to outcomes

One question that arose during the discussion was the means through which this group and CCAFS Learning Platform 1 will engage with actual breeders in CGIAR centers. One possible way of accomplishing this will be to work through CGIAR’s Excellence in Breeding (EiB) platform.

Box 1. Some of the questions related to foresight in agricultural research

Will current trends continue to 2030?

- Feminisation of agriculture in SSA?
- Continued migration of youth out of the rural areas?
- Some land consolidation, but hundreds of millions of farmers producing food on shrinking land holdings?
- Increasingly globalised trade, regional trade subject to increasingly severe production / price fluctuations?
- Private sector and market development?

→ How might different combinations of these trends affect breeding strategies for food and nutrition security in a warmer, more populous future?

Centre and CRP updates related to breeding and foresight

After the introduction, all participants shared with the group what is happening in their Centres and CRPs related to foresight and priority around breeding.

Michael Friedmann, Roots, Tubers and Bananas (RTB) CRP

1. Looking into the future: working on downscaling climate change data and crop models, identifying and incorporating drivers of yield loss
2. Identification of key RTB traits and development of product profiles
3. Medium term: select traits with respect to end-user needs, preferences. Huge genetic potential still to be exploited for heat tolerance.
4. Long term: genomic research to accelerate the process
5. Developing management options for climate smart varieties
6. Deployment/seed systems: traits for the planting material itself

Keith Wiebe, IFPRI and Policies, Institutions, and Markets (PIM) CRP

1. IFPRI foresight update: Crops to End Hunger work. Report with USDA-Economic Research Service prepared for USAID in June 2018. Note: is not a prioritisation report. Rankings would depend on your objectives.
2. PIM perspective: *Global Food Security* special issue – livestock, fish, hind/foresight, RTB crops already published. Others in the pipeline (cereals, smallholders, employment, trade-offs). 2018 demand side projects – animal source foods, RTBs, major cereals, GLDC crops. Inputs to the ISPC foresight activities.
3. CGIAR foresight report: Multi-centre, multi-CRP effort. Steering committee of CGIAR science leaders. Inform CGIAR as well as funders and national partners using various approaches. Inventory and scoping, analysis, synthesis, drafting in 2019, publish in 2020.

An Notenbaert, CIAT tropical forages team

1. Importance of livestock for people, effects on the planet etc. Feeds and forages – big effects on, from climate change. Feed could be a real triple win in relation to CSA
2. Brachiaria grasses breeding – different varieties are adapted to different types of drought
3. Heat stress mapping – LIVESTOCK heat stress mapping in pigs in Uganda. Heat load index, use daily data, other species, regions, hotspot mapping, link to early warning?
4. Suitability change mapping – Ecocrop modelling, and some updated maps for TZ, KY, ETH, RW, being used in some EA projects. They have country-level data bases, will be an online tool
5. Targeting – feasibility mapping, feed constraints in EA. And bring in adoption facts like access to markets, land availability etc
6. For the future: Suitability changes, to quantitative quant / qual changes; Breeding site selection – a new program for EA; Cluster analysis to identify representative sites in Colombia that fit EA. Then develop product profile.

Jean Balie, IRRRI

1. Foresighting for policy making – not really being done at present, but IRRRI wants to move into this. Asking the policy cluster to lead the breeding work targeting.
2. What's the future of the rice economy? Emphasis on Asia and Africa (using CGE and PE models)
3. Philippines Govt – changes in tariffs, big shocks. EU protection on rice imports (Italy and Spain), effects on big exporters like Cambodia.
4. Rice-based food system transformations – implications for the future
5. Breeding foresight – not much so far. AGGRi alliance project, Gates, future breeding program at IRRRI. Foresight work planned with the breeders. Quant and qual analyses.

6. Challenges: product profiling, for three market segments – producers, consumers, processors/traders. Different profiles may be hard to reconcile.

Camila Rebolledo, RICE CRP and CIAT

1. Two evaluations done. Pipeline of breeding of rice in CIAT. Product design: breeders, trait integration, trait discovery, impact assessment, phenomics, grain quality. Impact of rice varieties released over the last 50 years in LAC.
2. Two pipelines, irrigated and upland. A lot of the work is project-driven, so may not be working on the traits that are really wanted by smallholders (led by the private sector, sometimes).
3. Need to better define the specific agroclimatic regions (TPE) and to replace a variety. GxE models to predict phenotypes from genetic and environmental inputs (ideotyping).

Elisabetta Gotor, Bioversity / RTB

1. Aligned with the Global Futures program / project. Now working with WUR on trade-offs around agroecological intensification at the farm level.
2. Participatory selection of varieties, also pests and diseases – link a spreadsheet model with the IMPACT model. Still need to define how to develop these links.

Gideon Kruseman, CIMMYT / MAIZE, WHEAT

1. A dedicated foresight team, for 3 years now, coming out of the Global Futures work. Climate change, crop modelling, within CIMMYT. Changing diets and food systems, new and emerging pests and diseases, rural transformation (urbanisation, population, land consolidation, etc). Looking at what can be expected in our target geographies through time.
2. Also looking at technologies that are coming from outside of agriculture that may be game changes – block chain, big data, and so on.

Chris Jones, ILRI

1. ILRI is just starting out with foresight work, mostly via Galway MSc students. There will be future hotspots work from LIVESTOCK in 2019. Some of the work is on adaptation and mitigation related to feeds (Todd Crane).
2. Selection of species, accessions for the current climate, then looking at the future climates.
3. Planted forages as a focus. Selecting best bets, applying new technologies in relation to how to select these cultivars – multigenic traits.
4. Forages in marginal lands, predominantly drought, elevated CO₂, also waterlogging too. Climate resilience is not so straightforward. Undermanaged environments.
5. Water use and temps, also spread of diseases and pests. New sources of resistance? Microbiome is also important.
6. Other big issues are forage seed prices and cross-border trade.

Afternoon sessions on Day 1

After the lunch break, two external participants joined the discussion through weblink. Both gave short presentations followed by questions and answers and discussions.

Tim Byrne, AbacusBio

AbacusBio is a consultancy firm with offices in Edinburgh and New Zealand (and elsewhere). Their focus is on the application of science and technology to agriculture. One of their major foci is user participation in the formulation of trait priorities and breeding programs. The purpose of involving users in such a way is to create mandate for change, prioritise research and development activities,

apply monetary values to difficult traits, increase adoption and engagement, rate of genetic gain, and rates of product development.

What's different in this approach is that it is more balanced, bringing in non-economic drivers of breeding priorities, quantifying the views of farmers, and providing insight into farmer segmentation. It is underpinned by an online survey that captures: who the farmers are, farmer trait preferences and perceived value (using 1000Minds® software), choice patterns (product profiles), and can then cluster farmers into typologies and examine what is different between typologies.

Tim gave an example of how the approach was used in Australia to survey dairy farmers in relation to dairy cow traits.

During the discussion, Tim was asked whether this approach could be used for future traits (e.g. climate change). He responded that you may have to do workshops and consultations and help people think about possible futures.

[Marianne Banziger, CIMMYT/Excellence in Breeding \(EiB\) platform](#)

Marianne gave a short presentation on foresight and breeding in view of climate change. She first asked, "who do we want to inform?" We might want to inform funders and/or the information might be for breeders. To her, the macro questions are more interesting than micro questions.

There was a gap analysis in the IFPRI Crops to End Hunger report. The assumed productivity increase that will be achieved in the future is from a variety of sources, so there is no breakdown on how much increase can or will be achieved through breeding. The role of local versus international prices influences the results along with the issue of thin markets.

One of the key questions is, "where and for what crops is breeding the limiting factor?" Conversely, we must also know where value chain-driven seed systems and adoption is the issue limiting yield increases. There is likelihood of high rates of adoption of new varieties with product profiles that respond to farmers' requirement and consumer preferences.

Breeding can bring different value propositions. It can help increase yield through varieties that perform in higher temperatures and can help preserve yields with varieties that perform better under droughts, pests and diseases, for example.

Taking a higher-level perspective on climate change and breeding, we should consider issues such as rural employment, local food prices, imports/exports, and migration. Prioritized needs for breeding may include shifts in maturity, drought and heat tolerance, nutritional value, and disease resistance. She asked whether CCAFS can help give more guidance on prioritized interventions.

Some of the discussion following Marianne's presentation focused on the importance of partners outside CGIAR and shifts in the future regarding where food will come from.

[Interactive gaps session](#)

After the two presentations from the online participants, the attendees in the room then did an exercise to list what they perceive as the major gaps in foresight and priority setting after digesting what was presented in the morning and early afternoon sessions. All participants were given three post-it notes on which to write what they thought are the key gaps in knowledge/tools/etc. After everyone had written their top three choices, we placed them on flipcharts and tried to group them into some common themes.

The common themes and gaps mentioned were:

Data

- Climate model data (variability, spatial / temporal appropriateness, future environments)
- Interoperability of / access to repositories (including trial data, trait preferences, household data...)

Knowledge

- Future trait preferences (existing, yet-to-be-discovered) of different actors
- Genetic response to future environments (quantitative, qualitative)
- Reducing system complexity so it becomes model-tractable
- Effectiveness / efficiency of breeding versus other interventions (value proposition)

Methods

- Homologues+ (climate, soils, farming systems, ...)
- Capturing interlinkages horizontally and vertically (scale, substance)
- Impacts of genetic gain (multiple traits)

Behaviour

- More multidisciplinary team approaches (NARS, policy partners)
- Better engagement outside (farmers, seed companies, ...) and inside (processes to influence the debate) the CGIAR
- More focus on longer-term outputs (not just quick results)
- Facilitating an on-going process of foresight analysis and dialogue that links ex post and ex ante to inform decision making

Other

- Understanding smallholder development / evolution pathways in relation to breeding objectives / targets
- Work around dietary diversity – breeding inputs versus other inputs
- Role of new technology (gene methods, alternative foods / feeds, ...)



Photo 1. Participants discuss commonalities among the listed gaps



Photo 2. Participants debate priorities among gaps

Morning sessions on Day 2

Plenary recap and discussion

After a recap of yesterday's discussions and debates, the group received an update from a new participant who joined on the second day, Frank Place. Frank is the director of the PIM CRP and had just come from a workshop on the future food systems that was held in Addis Ababa.

The future of food systems will need to take into account the future of food production systems. For example, how will capital intensive smallholder systems in Africa develop? There is a growing medium-scale sector, especially for grains, who are the first users of the varieties. There also needs to be a lens around healthier diets. The rise of obesity is a complicated issue and cannot be ignored. Some people have begun to think about carbohydrates in the basic grains, and the private sector is already working on a low-carb potato in the Netherlands. Is there a role for breeders in reducing carbs?

The quality and safety of food, including pest and disease resistance, may become higher priority. We'll also need to think about feed systems as well as food systems. There is momentum to reduce beef consumption in Western countries, and in parts of East Asia and Africa there is more pig and poultry consumption. Are we doing enough breeding for feeds?

Changing energy costs – solar, wind, renewables – will affect the possibility of growing indoor high-value commodities. Do we have varieties for growing in non-soil and artificial light environments? Vegetables and fruits? It's not clear who is looking at such issues.

After Frank's summary, the group had a brief discussion on some of the points, including whether it should be a priority of CGIAR to work on initiatives such as breeding for low-carb grains. To some extent, we must meet consumer needs. Gideon gave the example of the baking industry which wants high gluten content in the branless flour. Jean mentioned that IRRI is breeding for low glycaemic index rice and high protein content rice plus micronutrients such as vitamin A and zinc. There are trade-offs, however, including social acceptance issues when genetic modification technologies are used in such breeding efforts.

Such efforts lead to a macro question as Marianne discussed on the previous day: do what extent should we aim for technological solutions to problems rather than tackling underlying issues such as dietary diversity? These are not easy questions to answer, but deserve a space for debate in CGIAR.

Another issue relates to mixed use of crops and how to prioritize breeding strategies when farmers make multiple uses of their harvests. For example, the use of stover as feed stock – farmers in the mixed systems may like the tall varieties for this reason. They are “reversing” the Green Revolution, during which crops were bred to have short statures. There is also demand for dual purpose sweet potato, from which the tubers can be eaten by people and the vines fed to livestock. The same is happening with cassava peel in Nigeria. It is being used to make a mash to replace 20% of maize meal for chickens; this is possible for fish in the future.

Marta raised a key point of how to embed the breeding in a systems perspective. This is a huge gap – we need to talk to others agroforestry systems, fish, fruit and veg. We need to look at the diversity of the system – and to address the resilience – in those places where there is a lack of markets. What’s the outcome objective? There will be trade-offs between short term benefits and longer term benefits.

The discussion shifted to the fact that we need to not only focus on rural, remote smallholders going into the future. There is a growing urban population, and food systems need to function well enough to feed those populations as well.

Another issue is how host governments and donors want the private sector involved heavily. The consumer side is now developing very rapidly too – food prep outside the home, supermarkets, etc. Food preparation also affects nutrition.

Small group discussions

Participants split into two smaller groups to discuss potential ways to address the gaps identified on the previous day. One group discussed the topics of data, knowledge and methods, while the other group discussed the behaviour topic and the ‘other’ category.

The group that discussed behaviour agreed that more multi-disciplinary team approaches were needed to take a broader view of breeding and priority setting. Social scientists need better links with breeders so they can give inputs on priorities for product profiles. The Crops to End Hunger work through IFPRI is an opportunity to help inform donor discussions about priorities, but further work is needed. The work on rice in Latin America was given as an example in which there is a very engaged network on rice breeding.

The CGIAR foresight report offers an opportunity for engagement and longer-term dialogue. A steering committee is currently developing a plan for the report; Keith is involved. It is still to be determined who will contribute to analysis and writing.

There is also an opportunity that may be opening up to engage with the Gates Foundation. Bill Gates recently said that he would like to see CGIAR as a \$2 billion a year system. It is possible LP1 could work with others in CGIAR to pitch something to them, such as an annual meeting on breeding priorities and the foresight report. We could conceptualize a common theory of change and lay out the comparative advantage of the whole CGIAR system.

The group that discussed data, knowledge and methods talked about the need to really integrate ex ante and ex post impact assessment within CGIAR. This would go a long way to helping understand

what interventions really make a difference. It could help evaluate the accuracy of ex ante evaluations.

Afternoon session, Day 2

In the afternoon, the group reviewed and provided comments on one of the ‘grand challenges’ included in a draft document for a CGIAR Special Initiative on Climate Change: “Tackling multiple climate-induced stresses through supporting holistic breeding strategies”. The general consensus was that the title of the grand challenge should be modified to something around foresight and trait prioritisation. In the current structure of the write-up, the three elements (policies, climate-informed advisories, developing strategies & technologies) do not really fit this grand challenge. The work around missing markets, role of private sector, institutions, seed systems, and policy work relates to issues are similar across all the geographic GCs.

An alternative view is the following. Product profiles are the basis of EiB. Currently, these product profiles are assumed to appear from somewhere. Strong agreement that this grand challenge could play a big role in providing informed advice as to what these product profiles should look like. Then it is the job of EiB to facilitate the development of varieties through the Centre breeding programs.

There was a strong feeling in the group that this grand challenge is about foresight and prioritisation, because without this challenge, it is very unclear who would set up CGIAR breeding priorities. EiB is involving the private sector and is looking for information to help modernise existing breeding platforms in the Centres.

The grand challenge could thus address issues such as:

- From a multi-commodity perspective, how do new varieties fit into sustainable production systems and healthy diets?
- What kind of product profiles around “alternative crops” could help to address diet diversity considerations?
- What kind of product profiles are needed for feeds and forages, also livestock breeds and fish?
- As climatic suitability changes, how to think about considerations of moving the food system in a particular place towards including different food or cash crops, for example, or new niche crops? There could be enormous opportunities (in addition to challenges).

In addition to intervention points for this grand challenge at the start of the pipeline, there could be points at the other end of the pipeline too. One example from RTB is that farmers are starting to store sweet potato storage roots in sand to wait for rains to plant. As temperatures rise, there may be a need to breed for root heat tolerance (something along those lines) – so there are post-harvest issues too.

Unresolved questions and meeting closing

There were several issues raised during the two-day meeting that require further discussion and debate.

- How do we better inform priorities between breeding and other work on agricultural research for development?
- How can we better understand future pathways for smallholder systems?
- What will be the role of new technology in future farming and food systems? How will lower energy costs and other emergent trends affect the priorities for breeding?

- To what extent should CGIAR prioritize technological (i.e., breeding) solutions over social behavioural change interventions on topics like dietary diversity?
- What role is there for (improved) breeding within livestock and aquaculture systems?

At the end of the meeting, the group decided that there is a need to go beyond a community of practice and to collaborate on a positioning paper or Op Ed that expounds on some of these issues. LP1 would be a natural place to look for climate change connections. It can help influence the contents of the CGIAR foresight report.

There needs to be coherence within CGIAR on foresight in breeding. One possibility is to develop a Theory of Change laying out the unique contribution and including the value proposition.

As a next step, the group will work toward producing an Info Note laying out some of the issues arising during the meeting and proposing a suggested agenda for future activities.

Annex 1. Participant List

	PARTICIPANT	ORGANISATION	EMAIL
1	An Notenbaert	CIAT-Kenya	a.notenbaert@cgiar.org
2	Chris Jones	ILRI	C.S.Jones@cgiar.org
3	Elisabetta Gotor	Bioversity	e.gotor@cgiar.org
4	Frank Place	PIM-IFPRI	F.Place@cgiar.org
5	Gideon Kruseman	CIMMYT	G.KRUSEMAN@cgiar.org
6	Jean Balie	IRRI	j.balie@irri.org
7	Keith Wiebe	IFPRI	K.Wiebe@cgiar.org
8	Laura Cramer	CCAFS	L.Cramer@CGIAR.ORG
9	Camila Rebolledo	CIAT	m.c.rebolledo@cgiar.org
10	Marta Kozicka	Bioversity	M.Kozicka@cgiar.org
11	Michael Friedmann	RTB-CIP	M.Friedmann@cgiar.org
12	Philip Thornton	CCAFS	P.THORNTON@CGIAR.ORG

