

# The Business of Plant Breeding:

*Market led approaches to new variety  
design in Africa*

**Executive Summary**

# Overview

1. Principles of demand-led plant variety design
2. Visioning and foresight for setting breeding goals
3. Understanding clients' needs
4. New variety design and product profiling
5. Variety development strategy and stage plan
6. Monitoring, evaluation and learning
7. Making the business case for investment in new variety development

# 1. Principles of demand-led plant variety design

## **Objectives**

1. To understand the current status and challenges facing African agriculture
2. To review modern variety adoption in Africa
3. To understand the principles of demand-led breeding and similarities and differences with current practices

# Transformation of Africa's agriculture

- Africa's agriculture is at a tipping point; moving from subsistence systems to more **market-led** systems
- Smallholder farmers are generating **surpluses** of products to sell in local, national, regional and international markets
- **Demand for products** is rising with population growth, urbanization and changing lifestyles
- **A new breed of consumers** – focused, choosy and ready to pay for quality and safety of food

# Transformation of Africa's agriculture

- Enabling small scale farmers to **access** the expanding markets is a critical challenge facing policy makers
- **Participation** of smallholders in markets requires:
  - Identification of market demands
  - Developing products with suitable characteristics to meet market requirements

# New Variety Adoption in Africa

- DIIVA study by Walker et al (2014) shows about 35% adoption of new varieties of 20 crops in 30 African countries over previous 15 years
- Compares with average of 60% new variety adoption in Asia and 80% in Latin America

# Adoption of Modern Varieties of Food Crops in Africa

Crop	Country observations	Total area (ha)	Adopted area (ha)	% MVs
Soybean	14	1,185,306	1,041,923	89.7
Maize–WCA	11	9,972,479	6,556,762	65.7
Wheat	1	1,453,820	850,121	62.5
Pigeonpea	3	365,901	182,452	49.9
Maize–ESA	9	14,695,862	6,470,405	44.0
Cassava	17	11,035,995	4,376,237	39.7
Rice	19	6,787,043	2,582,317	38.0
Potatoes	5	615,737	211,772	34.4
Barley	2	970,720	317,597	32.7
Yams	8	4,673,300	1,409,309	30.2
Groundnut	10	6,356,963	1,854,543	29.2
Bean	9	2,497,209	723,544	29.0
Sorghum	8	17,965,926	4,927,345	27.4
Cowpeas	18	11,471,533	3,117,621	27.2
Pearl millet	5	14,089,940	2,552,121	18.1
Chickpea	3	249,632	37,438	15.0
Faba bean	2	614,606	85,806	14.0
Lentils	1	94,946	9,874	10.4
Sweetpotato	5	1,478,086	102,143	6.9
Banana	1	915,877	56,784	6.2
Field peas	1	230,749	3,461	1.5
<b>Total/weighted average</b>	152	107,721,630	37,469,577	<b>34.78</b>

DIIVA project  
(2014)

# Variety Adoption in Africa

- Constraints and issues in low adoption
  - Awareness
  - Availability
  - Profitability
- Measuring adoption levels
  - Pros and cons of various methods
  - Quality of data is the key requirement
  - Expert opinion, focus groups and survey data

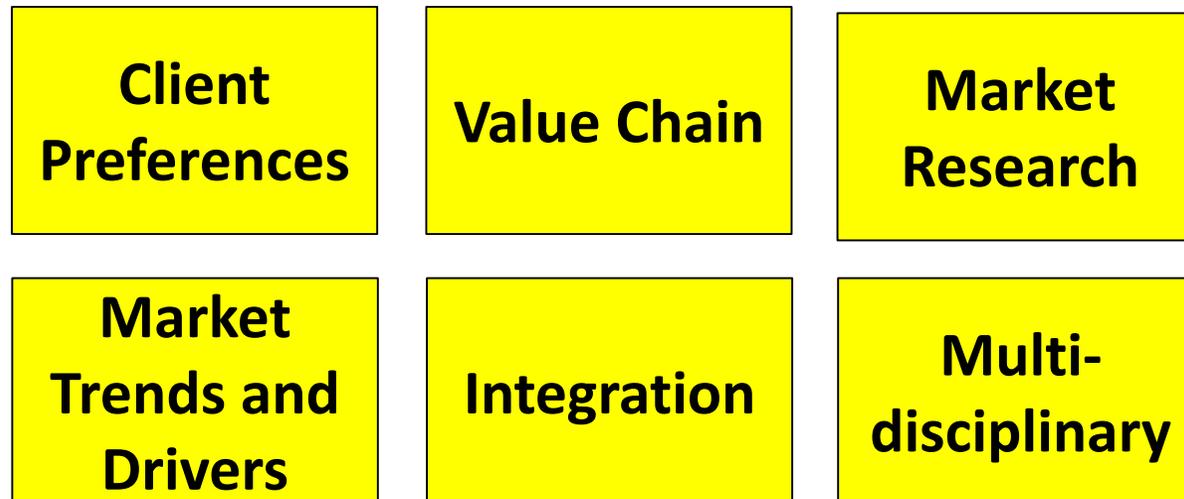
# Breeding Goals and Objectives

- Trait trade-offs
  - Categorize and rank priority traits
- Categories of traits
  - Plant traits; Tolerance to abiotic and biotic stresses;
  - Consumer/market preferred traits;
  - Balance of traits i.e.
- Basic traits all varieties must have;
- Traits to increase market share; and
- New traits not available in existing cultivars.

# Principles of Demand-Led Breeding

## What is demand-led plant breeding?

- **Demand-led breeding** is an approach that enables plant breeders to develop higher performing varieties that meet customer requirements and market demand
- It is based on six core principles



# Demand-led Breeding goes beyond Participatory Plant Breeding

## Participatory Plant Breeding

- Highly localised activity
- End products are designed to suit specific environments
- The key actors in PPB are the farmers and the breeders
- PPB focuses on local needs, largely in subsistence food systems
- PPB focuses on local practises and harnesses expertise of farmers and breeders
- Seed distribution in PPB is limited to the locality of its operations

## Demand led breeding

- Broader in scope and targets large areas or agro-ecological zones where the crop can be produced at national, regional and global levels
- Targets all actors in a value chain and innovation system
- Emphasizes markets, their demands, trends, and uses a broad range of tools such as market research, modern product promotion tools and value addition
- Seeks to combine the best practises from both public and private sectors
- Aims to disseminate seed of new varieties widely within national borders, regionally and globally.

# Summary

- Demand-led approaches aim to ***make the business of plant breeding in Africa more responsive to market demands***
- Demand-led approaches go beyond farmer participatory breeding approaches to inclusivity of all the key stakeholders in the value chain
- Demand-led breeding retains emphasis on the value of the breeders' eyes and experience

# Summary

- An appropriate balance is required between using demand-led approaches and technology/innovation push to maximise market creation for new varieties
- Role of plant breeders is much more than just leading crossing or selection programmes.
- The breeder must also be an integrator of inputs and be able to take on board information from a broad range of sources, including non-technical experts

## 2. Visioning and foresight for setting breeding goals

### Objectives

1. To empower plant breeders and R&D leaders to consider future agricultural landscapes in Africa.
2. To equip breeders with methodologies to design new varieties that will remain relevant and satisfy market demands over time.
3. To identify drivers that may affect whether farmers adopt new varieties in the future.

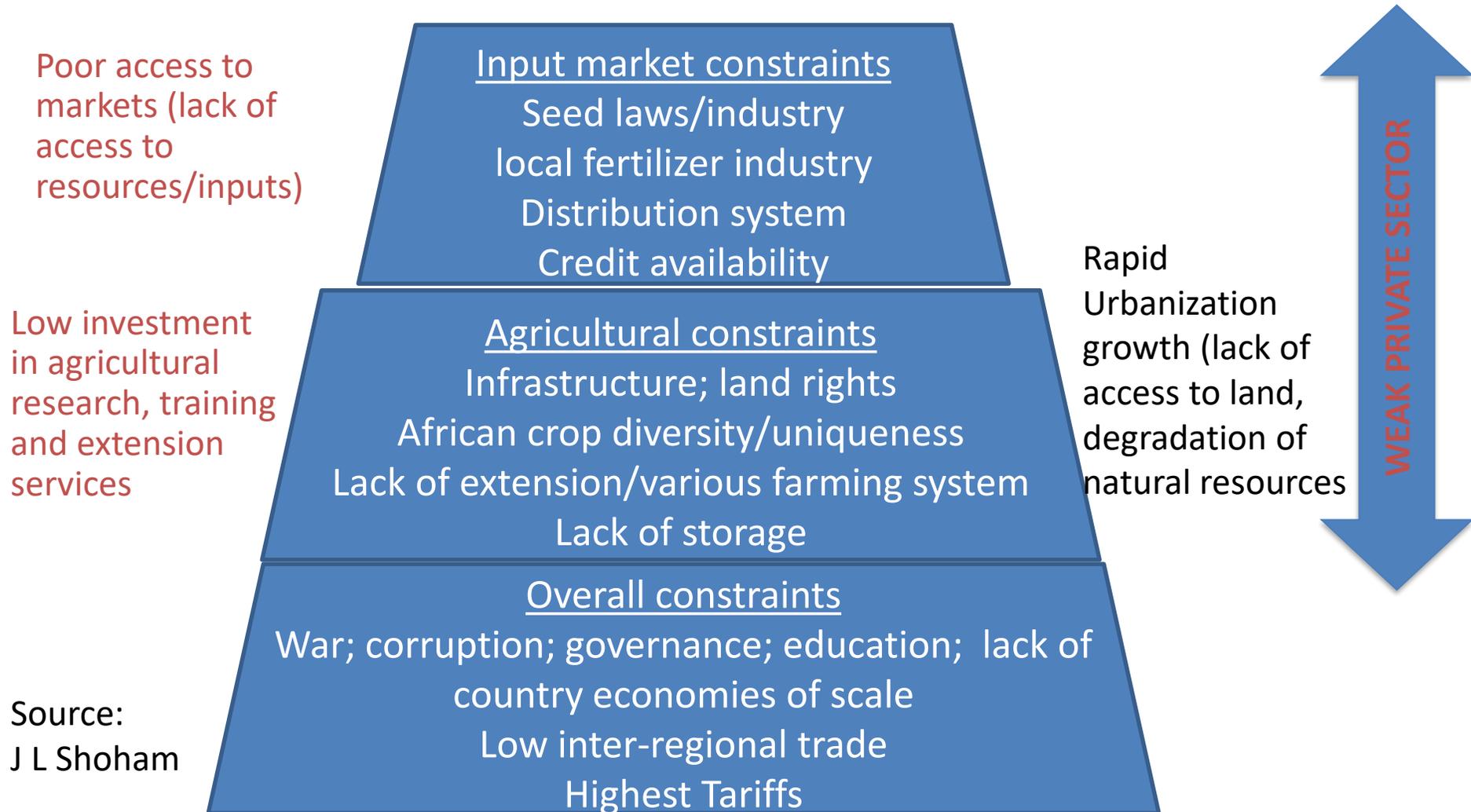
# Africa at a Glance: Agricultural landscape

## *Food supply vs. demand*

### *Demand*

- Demand growth is fastest in the world
- SSA population c. 800 million
- 220 million undernourished
- Mean population growth in SSA is c. 3%  
(-ve Europe, 0.5% Rest of the World)
- Population size expected to double in 35 years
- Population growth is double in urban vs. rural areas

# Reasons for the Low Productivity



# Strategies for Transforming African Agriculture

- Improving agricultural productivity
- Availability and widespread use of quality farm inputs and technologies, including crop biotechnologies
- Facilitating growth in agricultural markets and trade
- Investing in public infrastructure for agricultural growth
- Reducing rural vulnerability and insecurity
- Improving agricultural policy and institutions
- **Foresight and visioning to meet market/consumers' demands**

# Integrating foresight into new variety design

- Foresight methods are used to review existing variety designs or as a starting point to create new designs.
- Every trait characteristic in each product profile should be analysed and a decision taken if the trait and benchmark is likely to remain relevant over time required for variety development.

# 3. Understanding clients' needs

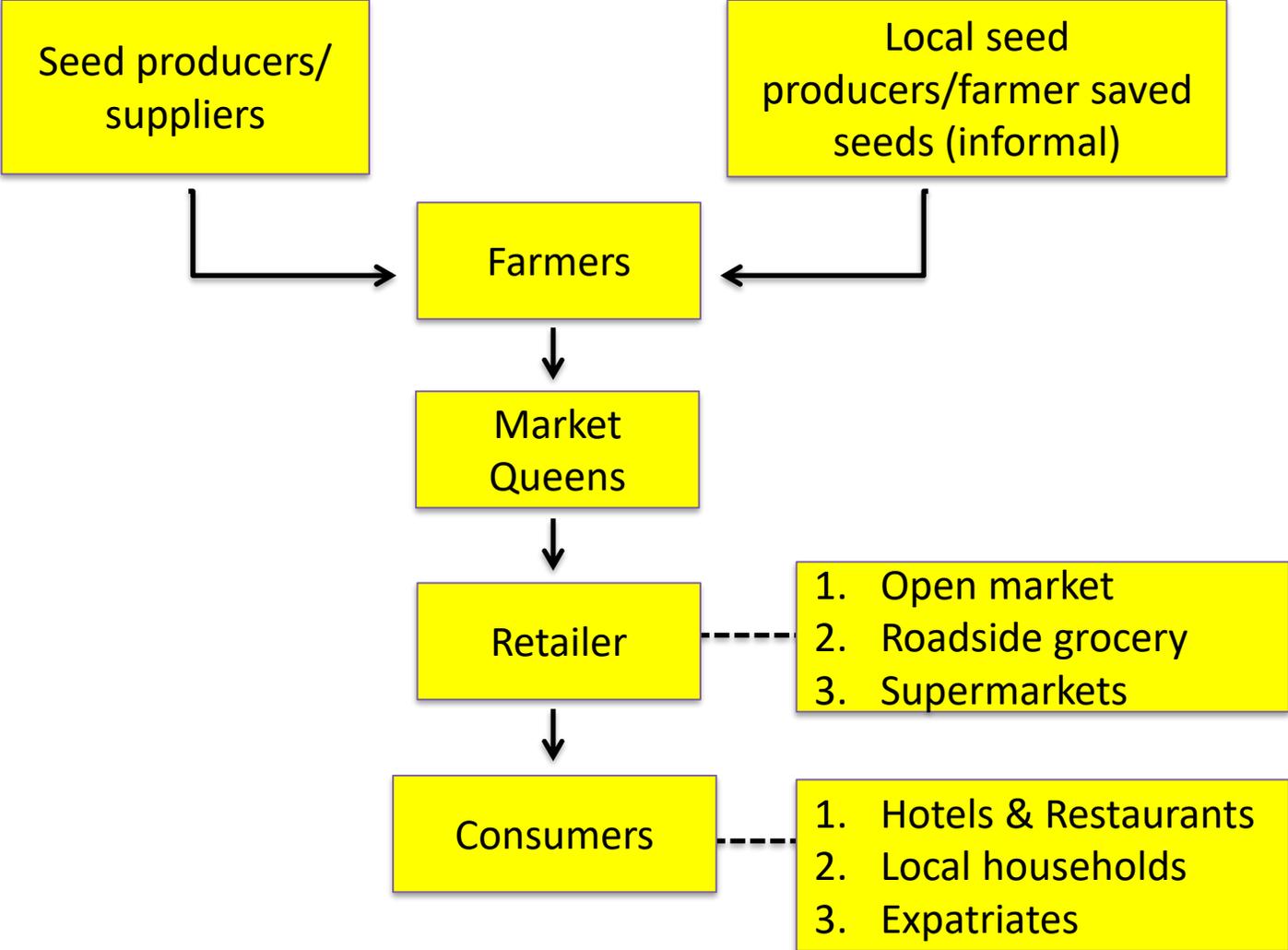
## Objectives

1. To equip breeders with the knowledge and methods to understand clients and their value chains, their needs, what they prefer and are prepared to pay for in a new variety.
2. To understand markets and the need, importance and principles of market research and best practices to guide the information gathering from clients and crop value chains to drive and validate new variety designs.

# Understanding Clients' needs

1. Crops and their Uses
2. Clients and Stakeholders
3. Markets and Market Segments
4. Clients within Value Chains
5. Understanding Markets and Market Research

# Simplified Tomato Value Chain in Ghana Market Segments



# Fresh Tomatoes, their Uses and Pricing Segments



Type: Large tomatoes  
Use: Fresh sliced, cooking  
Pricing: Economy price



Type: Cherry (on the vine)  
Use: Salads  
Pricing: Mid-range price

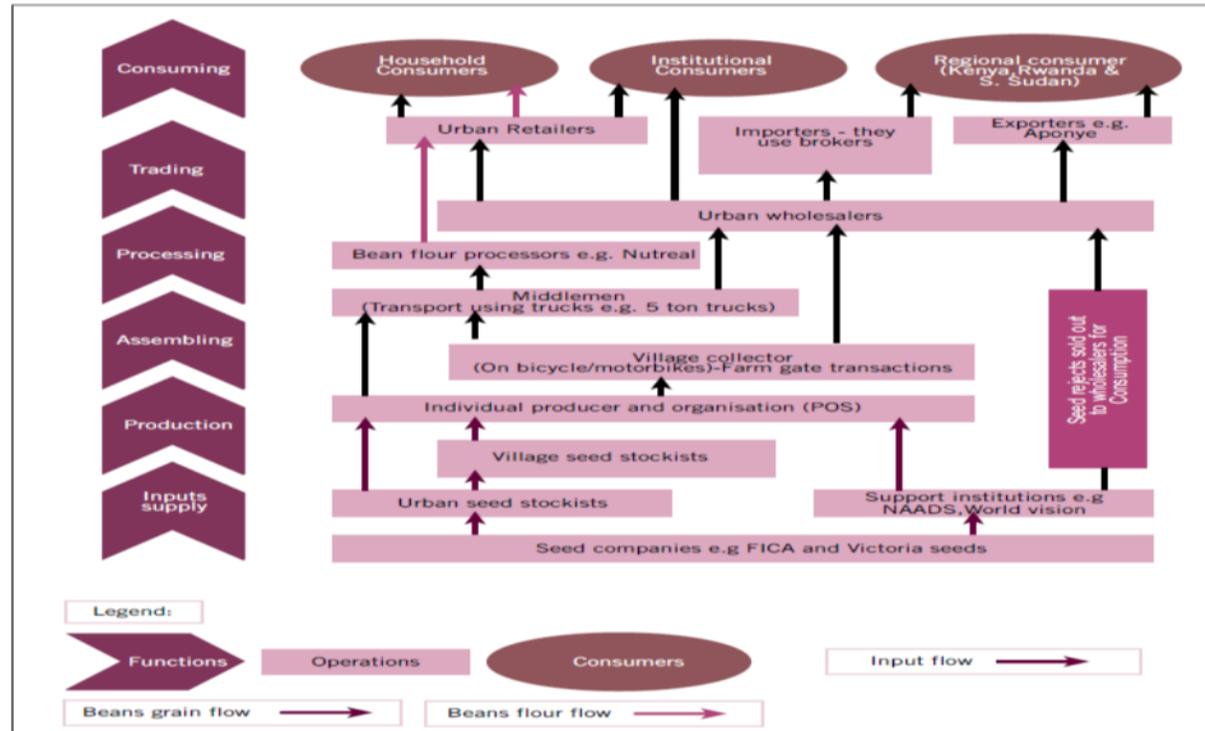


Type: Mini, amber plum  
Use: Salads and snacking  
Pricing: Premium price

# Clients within Value Chains

- Different clients in value chains have different requirements and often cannot all be satisfied with the same variety, especially when there are specialist properties required for processing
- Breeders should have regular contact with clients in all parts of the value chain and involve them in new variety design

# Ugandan bean value network



# Implications for the Role of the Breeder

- **The business of breeding** – Demand-led approaches require breeders to learn the “*business of plant breeding*” and be able to gather and assimilate information from multiple clients and sources within crop value chains
- **Partnering and collaboration** – Breeders need to broaden their reach, influence and know-how beyond their technical competencies and to be able to manage collaborations and partnerships with both the public and private sectors

## 4. New variety design and product profiling

### Objectives

1. To understand the **core method of product profiling** to:
  - Characterize existing varieties used by farmers; and
  - Identify future properties important to clients and other stakeholders along the value chain
2. To understand **how to create new designs and set benchmarks** to meet client needs
3. To understand how to **prioritize a range of traits** using demand-led approaches and make trade-off decisions
4. To **translate new variety designs into a practical breeding program** with clear goals and objectives

# New Variety Design

- **Target clients** – Define who the new variety is targeted to serve i.e. what market segment(s)
- **Value chain needs** – Understand clients and stakeholders along the whole targeted value chain
- **Crop uses** – Define all uses of the crop as food, feed, energy, propagation seed or other purposes
- **Variety identity and descriptors** – Understand every facet of the crop plant, pre and post harvest and differences between varieties

# New Variety Design and Product Profiles

## Key messages

- Up-to-date *qualitative and quantitative market research* data on clients' needs are essential to make decisions.
- A key aspect in the design (often overlooked) is the cost and feasibility of *seed multiplication*
- To understand and create an *advocacy program* with *government regulators* to adapt current registration requirements to include new, market-led design features that offer additional benefits to farmers and consumers

# Client and Market Importance

The core goal for a demand-led breeder is to create a new variety that meets a client demand by either:

- Improving design features within existing varieties, - or
- Providing new benefits that will increase new varietal adoption.

The four main inputs required for new variety design are:

- **Market research**
- **Variety performance**
- **Traits required**
- **Trait prioritization**

# What is a Product Profile?

- The name given to the full range of **technical attributes** of a new variety with quantitative measures
- Also called “*ideotype*” or “*product specification*”
- The best product profiles always set a **target benchmark for the required performance of each trait**; by comparisons vs. the performance of existing varieties and/or expressed on a numeric or photographic scale
- Trait descriptors/dictionaries are compiled and published by the CGIAR International Research Centers and national research intuitions

# Creating a Product Profile

Trait category	No	Trait	Trait description	Variety benchmark	Performance required (=, >, >=, >>)
Crop yield	1				
	2				
Plant architecture	1				
	2				
Seed production	1				
	2				
Biotic stress	1				
	2				
Abiotic stress	1				
	2				
Crop handling, harvest, storage, transport	1				
	2				
Value chain clients, consumers, processors	1				
	2				

# Priority of Traits

- Important and challenging decision for every breeder
- Market evaluation for each trait has two dimensions

## **1. Differentiation**

- Willingness to pay price premium
- Opportunity to grow market share

## **2. Market demand**

- % growers/area that need this trait

# Trait Prioritization

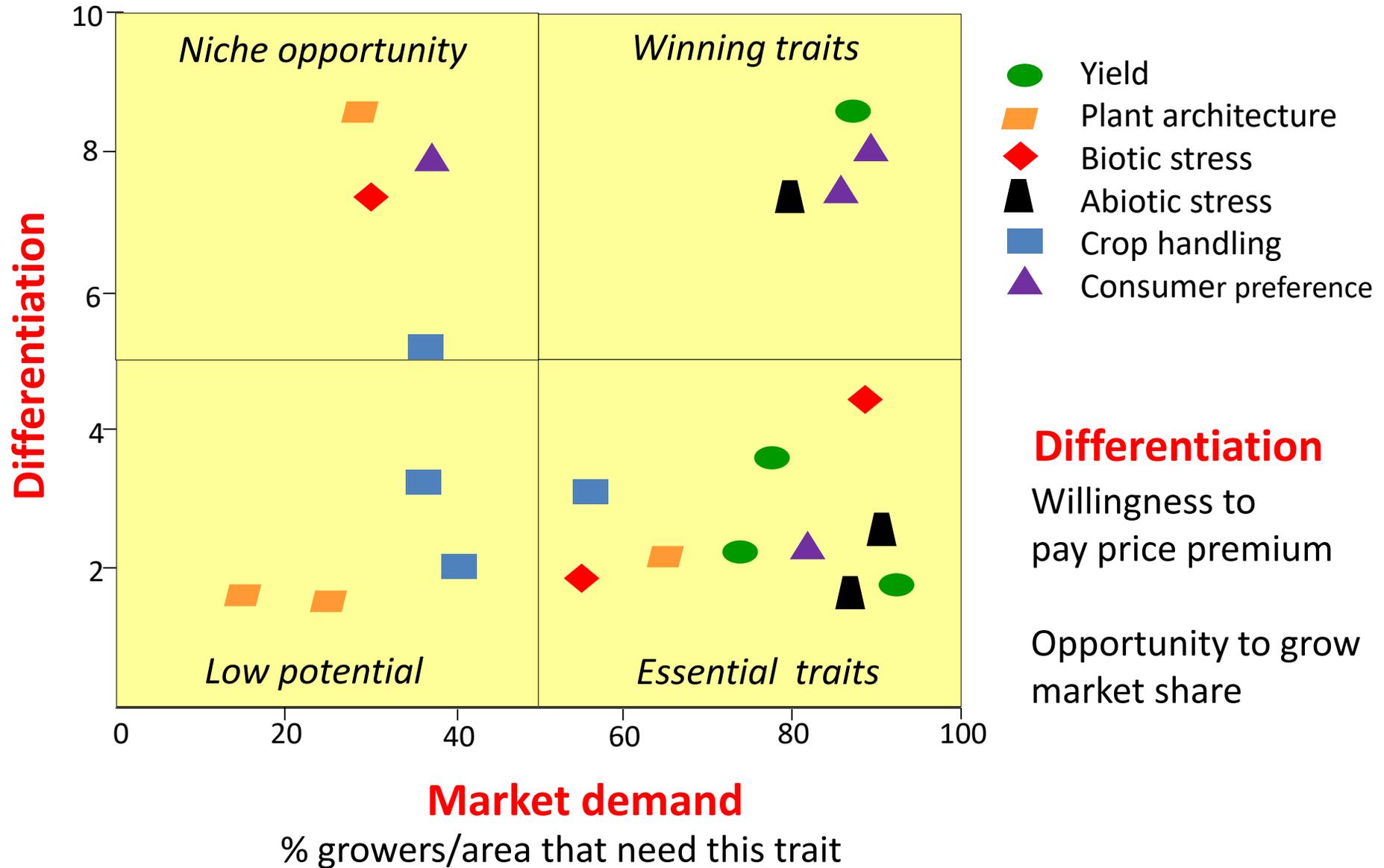
Willingness to  
pay price  
premium

Opportunity to  
grow  
market share



**Market demand**  
% growers/area that need this trait

# Trait Prioritization



# Translating Product Profiles into Breeding Objectives

- Product profile aligns with a set of measurable breeding goals and objectives
- Successful demand-led variety design and development creates new varieties that are fit-for-purpose, high quality, and feasible
- The breeding science and its technical and practical feasibilities depend on defined goals and objectives

# Translating Product Profiles into Breeding Objectives

- New varieties are highly innovative and require new combinations of traits
- The new varieties are: Distinguishable (D), Uniform (U), Stable (S) and Novel (N) - meeting the DUSN trial requirements
- Product profiles may require some revisions to increase the probability of delivery
- Innovation and ease of delivery can be inversely correlated; Paradigm shifts may require supporting investigative science programs and pre-breeding activities

# How is Demand-led Variety Design Different from Current Practice?

- 1. Competitor product profiling** - Analysis of characteristics of existing varieties and landraces and their differentiating characteristics at each stage in the value chain
- 2. New variety design** – A product profile is created that contains many traits and characteristics (typically > 40) with performance benchmarks to create breeding objectives
- 3. Quantitative benchmarks** – A target quantitative benchmark for each trait for line progression to variety release.
- 4. Trade-off decisions on traits** – A decision process to determine final variety design that takes account of client needs, technical feasibility and fiscal considerations.

# Implications for Role of the Breeder

- **Variety identity** – In depth understanding about the full range of characteristics that comprise each variety and landrace used by clients
- **Registration officials** – Early dialogue with registration officials to develop a detailed understanding about the variety registration processes and requirements.
- **Co-ordination and consultation** – Greater consultation and co-ordination time and liaison skills are needed to understand the needs of clients all along the value chain.
- **Communication skills** - Demand-led breeders need to present new variety designs to a range of clients, non-technical professionals, government officials and investors

# Challenges

- In the large private sector seed industry,
  - Demand-driven product design successfully introduced into productive plant breeding programs
  - Combined with excellent science and technology, development rigor and appropriate awareness campaigns with farmers and customers,
  - Leads to significant gains in adoption rates and market share of new varieties.

# Challenges

- The challenge is finding cost-effective ways to tailor demand-led approaches to new variety design, product profiling and success criteria into public sector and small seed company breeding programs in developing countries
- Need to harness skills and cooperation of the private sector; and better understand tropical crop value chains and market trends
- Opportunities for new public and private sector partnerships to solve problems together

# 5. Variety development strategy and stage plan

## Objectives

### 1. Variety development strategy and stage plan:

- To enable plant breeders to construct a high quality, well-documented demand-led breeding strategy and a development stage plan, to enable good governance, rigorous decision-making and activity planning within a demand-led breeding project.

### 2. Stakeholder engagement:

To ensure the variety development strategy and stage plan allow for involvement of stakeholders at key decision points on:

- The design, development and release of new varieties;
- Enabling new varieties to reach farmers; and
- Provide feedback on product performance and farmer adoption.

# Variety Development Strategy

- A ***development strategy*** defines the core breeding goal and creates a framework for decision-making and investment.
- The strategy analyses the external environment, defines problem and answers key questions on the product being developed: '***what***', '***why***', '***for whom***' and '***how***'?
- The strategy has a broader scope than a development plan and considers the end product and adoption. It should precede preparing the development stage plan.

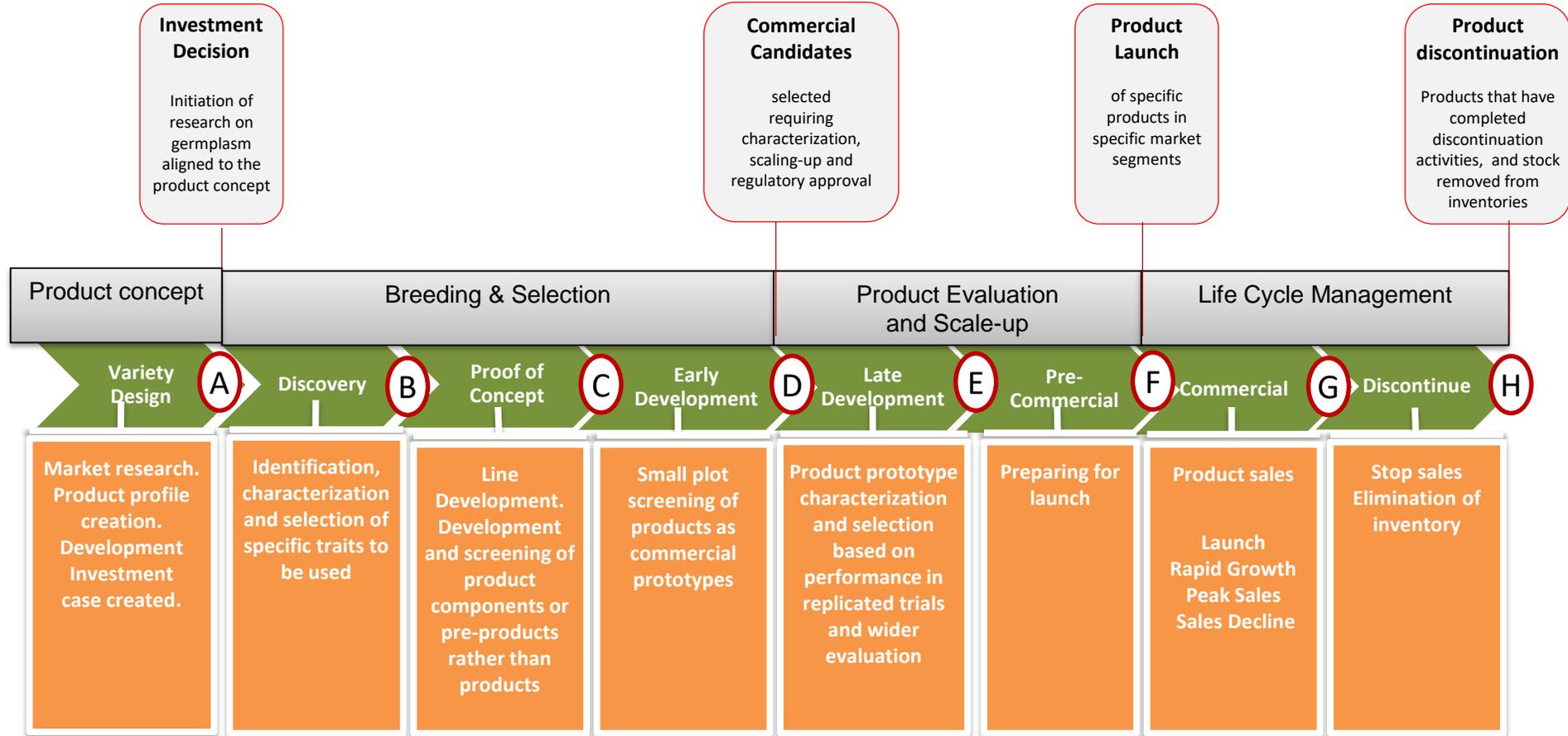
# Development Stage Plan

A Stage Plan includes the following key activities:

- Development planning
- Variety design
- Breeding, testing and evaluation
- Variety registration and scale up
- Seed production
- Monitoring and evaluation – at all stages of the variety development process

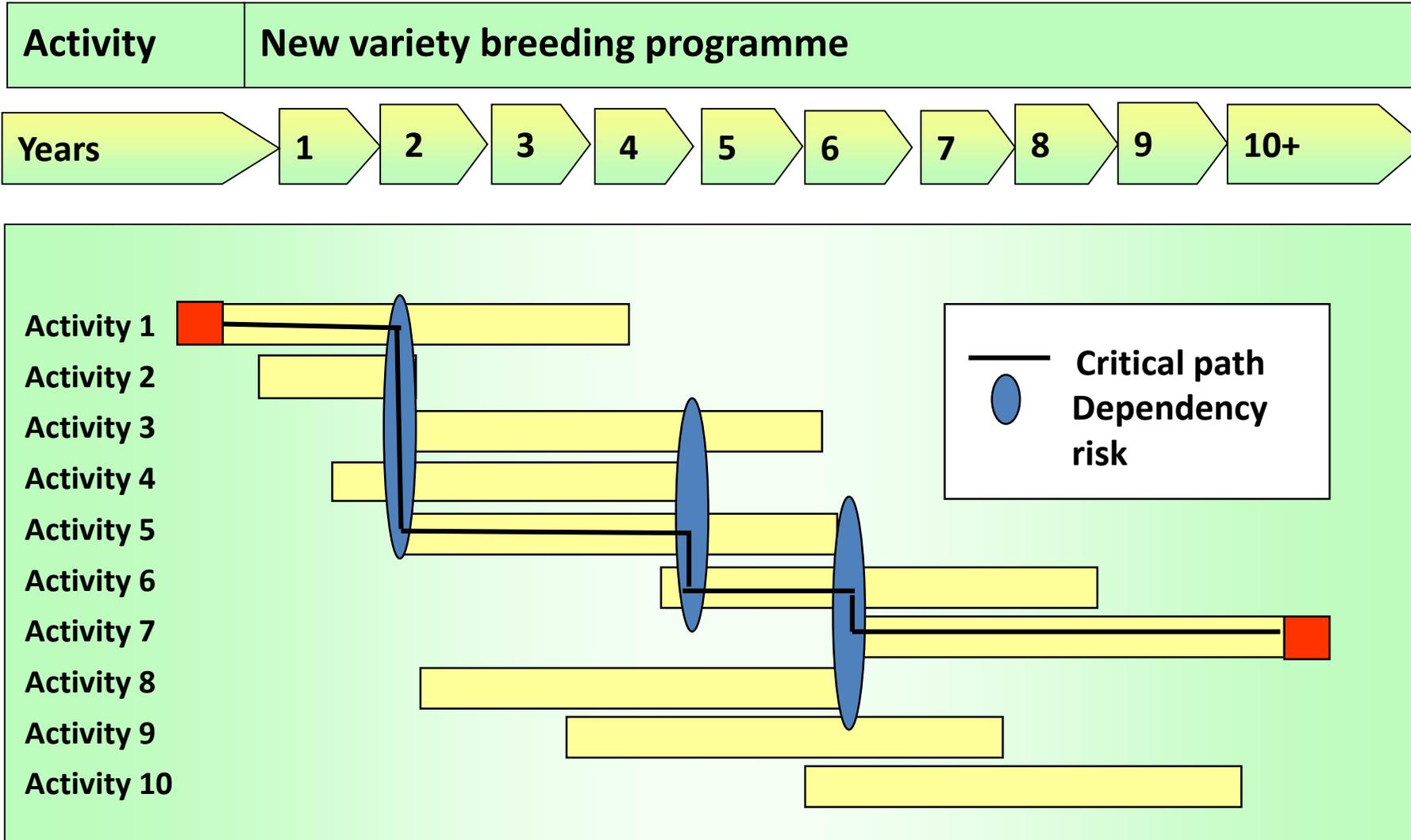
# Demand-led Breeding Stage Plan

## Line progression decisions



Modified version of Syngenta Seeds stage plan

# Critical Path Analysis Diagram with Risk Dependencies



# Importance of Timelines and Critical Path

- Understand the timelines and associated costs to develop and register a new variety.
- Clear understanding about critical paths and approaches to risk reduction.
- Develop risk mitigation strategies.
- Understand costs and rewards associated with risks.
- Critical path analysis and pro-active risk management will help breeding team to develop new varieties that meet farmers and value chain needs in a timely and cost-effective manner.

# Demand-led Variety Registration

- Consumer traits and regulatory hurdles.
- Demand-led breeding is complex and can take longer- so a smooth registration process is a key factor.
- Regional harmonization may influence market size and subsequent investment decisions.
- Demand-led variety registration may be influenced by international regulations such as UPOV, breeders' rights and national registration agencies.

# 6. Monitoring, evaluation and learning

## Objectives (1)

**1. Performance benchmarking:** To enable breeders to devise a realistic performance assessment plan for their demand led breeding program so:

- (i) It is incorporated into strategies and stage plans for new variety design and engages with clients and stakeholders in the value chain;
- (ii) It develops key performance indicators tailored for new variety development and delivery of a demand led breeding program's goals and objectives.

# 6. Monitoring, evaluation and learning

## Objectives (2)

### 2. Variety adoption and performance tracking

- (i) To enable breeders to appreciate the importance of variety adoption assessment in demand led breeding
- (ii) To design pathways for monitoring progress in demand led breeding with value chain clients, with defined responsibilities for the various actors
- (iii) To explore improved, low cost methods for variety tracking to assess adoption of new varieties

# Monitoring

- Monitoring is a continuous observation and checking procedure on the progress of on-going breeding activities.
- Compares progress of activities against milestones and timelines for decisions in the stage plan
- Compares estimated and actual costs of the project against its approved budget
- The purposes of monitoring are:
  - To support reaching the milestones and targets set for the project in a timely manner;
  - To determine if corrective action is required to solve emerging problems or any delays;
  - To identify improvements that need to be made to the stage plan.

# Evaluation

Four key decision points in the stage plan when critical evaluation needs to be undertaken to support investment and progression decisions, are:

- **Investment decision:** Decision to start a breeding project and invest in creating a new variety, based on a demand-driven product profile
- **Commercial candidates:** Deciding on lead lines to be developed and scaled up
- **New variety release**
- **Post-launch adoption and impact assessment.**

# How is M&E integrated into Demand- led Breeding Projects/Program?

- M&E is an important component for success and continuous improvement in demand-led breeding
- M&E for demand-led breeding is designed to be primarily **target driven** (and not breeding activity driven).
- **Key performance indicators** of success include **metrics** on:
  - Performance of new varieties, meeting trait specifications
  - Client satisfaction
  - Use of new varieties by farmers and their value chains

# Variety Adoption and Performance Tracking

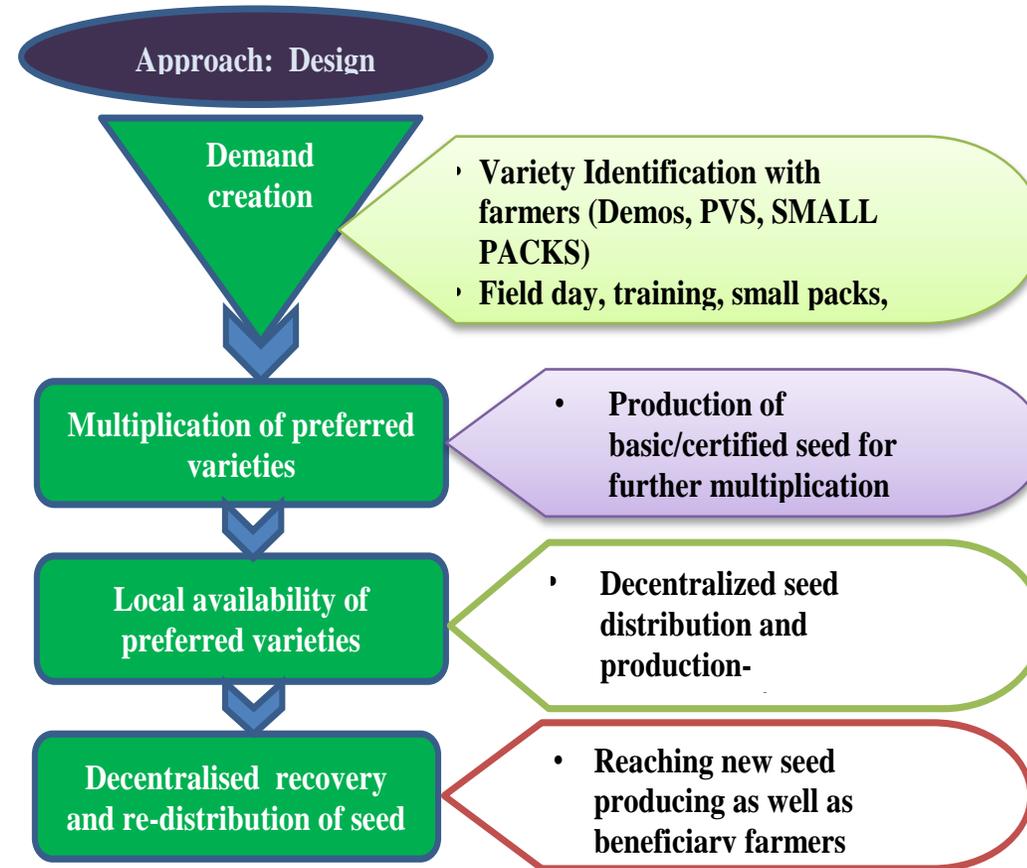
- Success of a breeding program can only be verified if the adoption pathways and performances of the products are tracked and documented
- Breeders need to be aware of all variety identity and tracking technologies available e.g. phenotypic and low cost molecular approaches
- Evaluate each tracking option in terms of accuracy, technical feasibility and cost
- Select and incorporate the most appropriate tracking methods into the development strategy and stage plan

# Learning and Communication

- Learning is an important aspect of a breeding project that is often overlooked.
- Success stories/case studies are important communication tools to share learning and impacts amongst breeders, clients, investors and value chain actors
- Case studies provide a medium for understanding and acting on knowledge gained and lessons learned;
- Case studies provide a lasting record of the breeding team's accomplishments and impact well beyond the completion of a specific breeding project (e.g. Norman Borlaug (wheat) and Gibesa Ejeta (sorghum) effect).

# Case study

## Beans in Ethiopia 2004-2014



# 7. Making the business case for investment in new variety development

## Overview

- Changing perception of breeding as a cost to breeding as an investment that gives a return
- Plant breeding bring benefits to many people -farmers, consumers and others in value chain
- Successful plant breeding brings economic, social and environmental benefits

# Key Messages

- Understanding the value and costs of investing in plant breeding is critical to success for a breeder
- Detailed analysis is required on the merits of each case and the strength and degree of certainty of each assumption
- When the benefits are higher than the costs, it may be worth making the investment in developing a new variety
- Opportunity cost: Also consider alternative variety design, activity option or other breeding program that could be a better investment choice for using the resources available

Beneficiary	Specific benefit	Benefit consequence	Benefit type	Quantification units
Farmers	Greater yield	Farmer income, Shift from subsistence farming to entering markets, Business growth, Can afford education for child	Economic	USD
	Earlier or later cropping (than vs. main season)	Higher prices (as less supply)	Economic	USD
	Improved crop quality	Higher price, more customers	Economic	USD
	Improved plant architecture	Easier harvesting Time saving	Economic	USD
Seed producers	Greater seed yield, Higher productivity per area grown	Farmer income, Unit costs are less. More competitive price to distributors	Economic	USD/person hours
Transporters	Less damage in transit	Cost saving	Economic	USD
Wholesalers	Improved shelf-life	Cost saving	Economic	USD
Food processing companies	Source from local farmers rather than imports	Cost saving Reliable supply	Economic, Logistics	USD
Food retailers/ Supermarkets	Good varieties and sourcing from local smallholders	Freshness and higher prices Differentiation and fair trade brands		
	Improved shelf-life	Loss of wastage and costs		
Consumers	Easier preparation	Time saving	Economic, Social	USD
	Shorter cooking time	Energy saving	Economic Social	USD
Public investors Governments , International dev. agencies)	Deliver their mandate, Support balance of payments, Economic development, Farmer livelihoods	Economic development, Continued funding for plant breeding projects and support for innovation and science	Economic, Social	USD

# Investment Analysis Tool

- Project rationale
- Financial metrics as inputs for analysis
  - E.g. seed market size, projected growth, market share of new variety, gross profit on seed; total breeding costs .
- Outputs: Investment analysis – Performance and investment metrics
- Demonstration on how to use Investment Tool

# Further information

Persley, G J and Anthony, V M (eds) (2017). *The Business of Plant breeding: Market-led approaches to new variety design in Africa*. CABI Wallingford, Oxon. UK. [www.cabi.org](http://www.cabi.org)