Mitigation of Cadmium Bioaccumulation in *Theobroma cacao*

The Cocoa Research Centre,
Trinidad and Tobago

Background

I**ncreasing consumer awareness** of food safety, sustainability issues

Food safety concerns in cocoa

- Ochratoxins/ polyaromatic hydrocarbons/ pesticide residues
- heavy metal contamination particularly **cadmium.** Why?

Cadmium contamination of soils

- naturally in some **volcanic soils**
- **industrial** contaminant (mining, industrial paints, coloured glasses, metal coatings, batteries)
- through **flood waters**
- use of **agricultural** application of contaminated sources of phosphorus or gypsum.

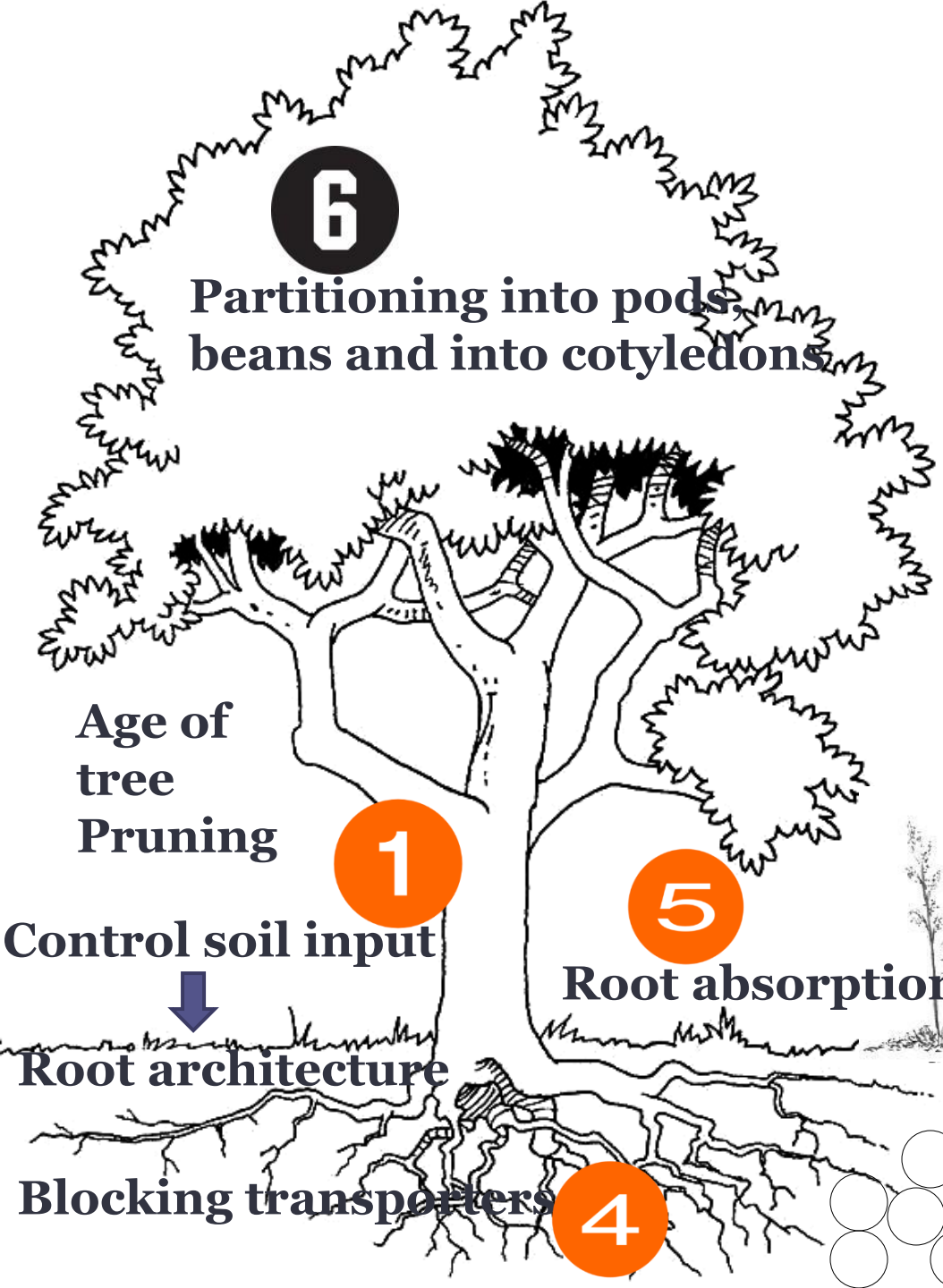
EU regulation

- EU regulation published on May 2014:

  - Milk chocolate with <30% total dry cocoa solids : 0,1 mg/kg
  - Chocolate with <50% total dry cocoa solids : 0,3 mg/kg
  - Milk chocolate with ≥30% total dry cocoa solids : 0,3 mg/kg
  - Chocolate with ≥50% total dry cocoa solids : 0,8 mg/kg
  - Cocoa powder sold to final consumer or as ingredient in sweetened cocoa powder sold to the final consumer (drinking chocolate) : 0,6 mg/kg

  - The levels would be applicable as from **January 1st 2019**

MITIGATION OF CADMIUM



6 Partitioning into pods, beans and into cotyledons

7 Post harvest
- Modification of fermentation
- Removal of husk

Age of tree
Pruning

1 Control soil input

Root architecture

5 Root absorption

3 Phytoremediation
Bioremediation

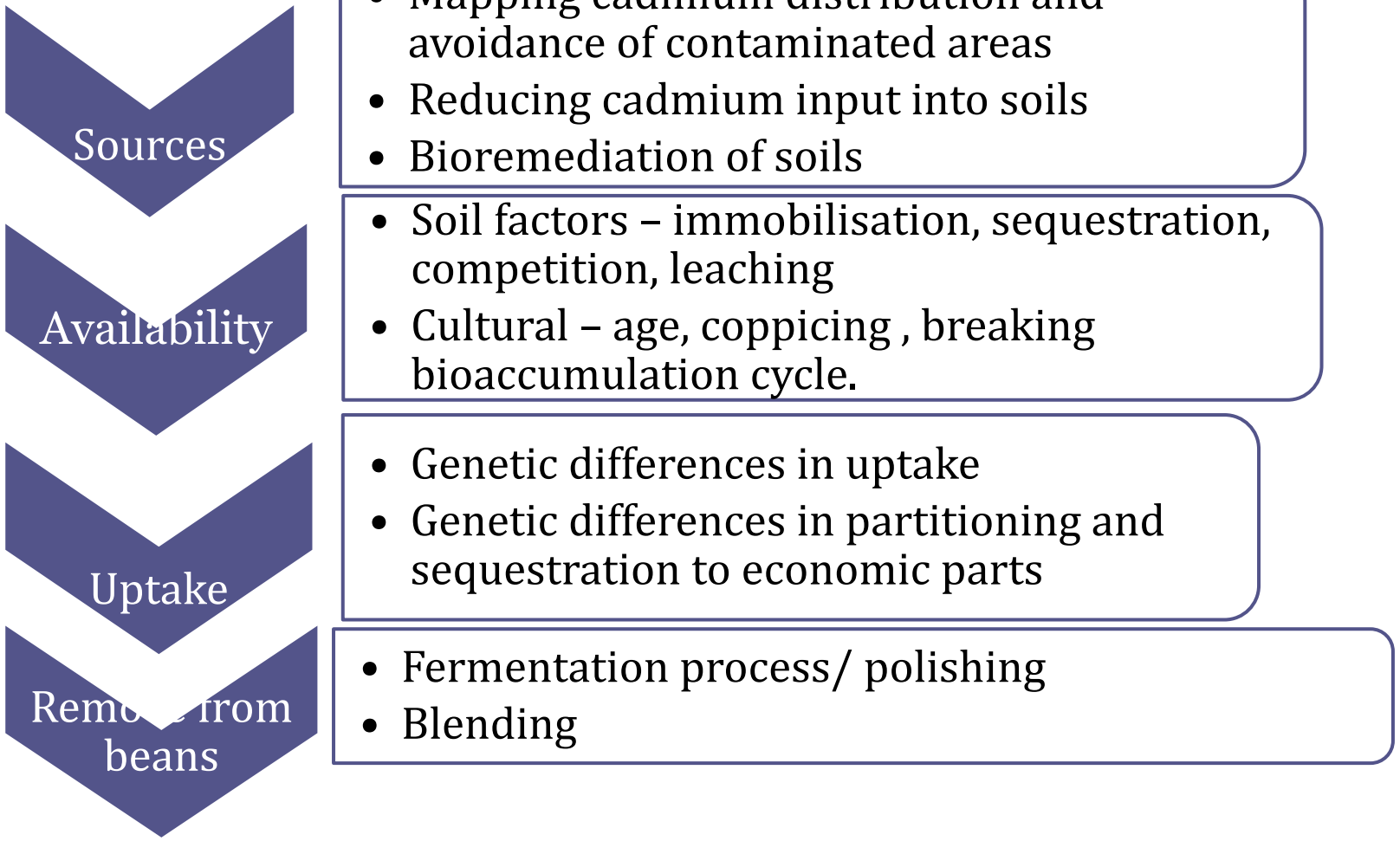
Blocking transporters

4

Soil fixation availability

2 Mycorrhiza

Mitigation of cadmium in cocoa beans



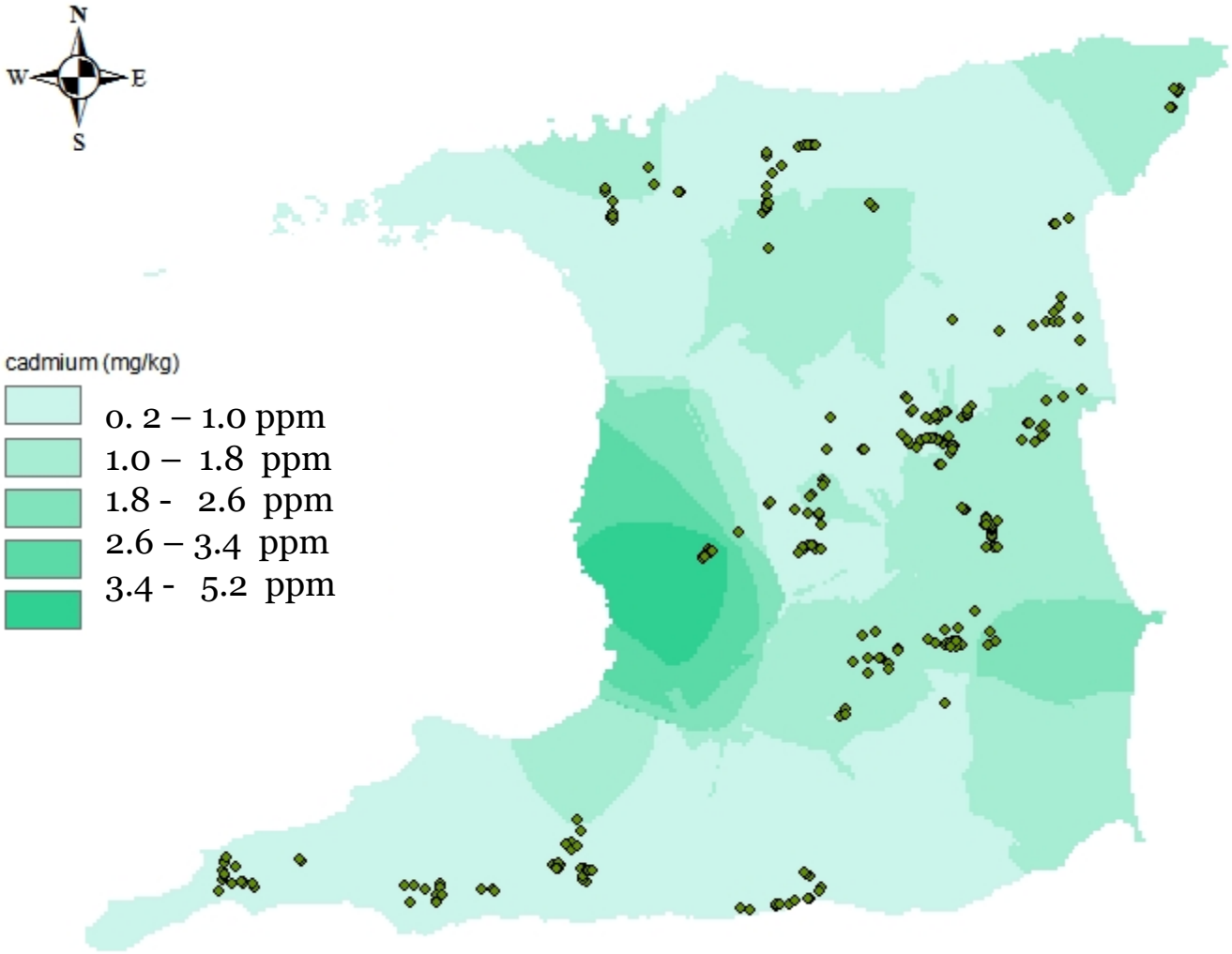
Trinidad and Tobago

1. **Government of the Republic of Trinidad & Tobago (2005-)**
   - Distribution of cadmium in cocoa growing areas
   - Factors affecting availability of cadmium to cocoa
   - Partitioning of cadmium into cocoa

2. **Cocoa Research Centre -ECA/CAOBISCO/FCC (2014-)**
   - Mitigation of cadmium bioaccumulation – genetic, cultural and soil amelioration

Trinidad and Tobago

1. Developing a **validated methodology** for cd determination in soils and cocoa products.
2. Understanding **soil cadmium distribution** in Trinidad and the associated underlying causes.
3. Understanding the **factors affecting availability** of cadmium to cocoa plant – universal and specific factors
4. Understanding the **genetic variation** for cadmium bioaccumulation and partitioning in the genebank.
5. Understanding the **mechanism** of cadmium bioaccumulation and developing a universal screening method.
6. Developing a range of **cultural and soil amelioration** practices to mitigate against cadmium in cocoa beans.
7. Develop **application methodologies** for farms and dissemination


N
W
E
S
cadmium (mg/kg)
0. 2 – 1.0 ppm
1.0 – 1.8 ppm
1.8 - 2.6 ppm
2.6 – 3.4 ppm
3.4 - 5.2 ppm

Take home-I

1. Considerable variation in soil cadmium levels even within a small island – Trinidad.

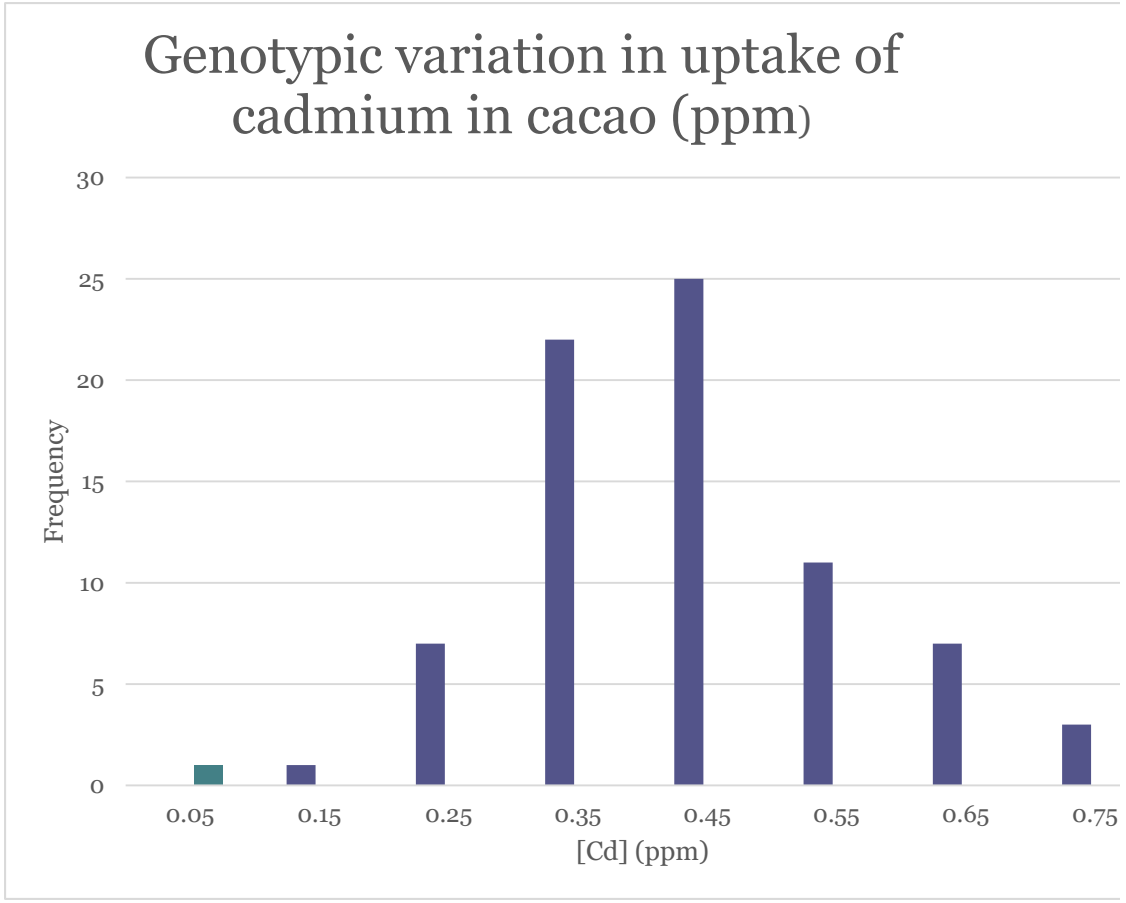
2. Soil cadmium distribution is Trinidad is a function of
   - Areas with volcanic soil
   - Flood plains
   - Anthropogenic effects – sugarcane areas with high phosphorus use.

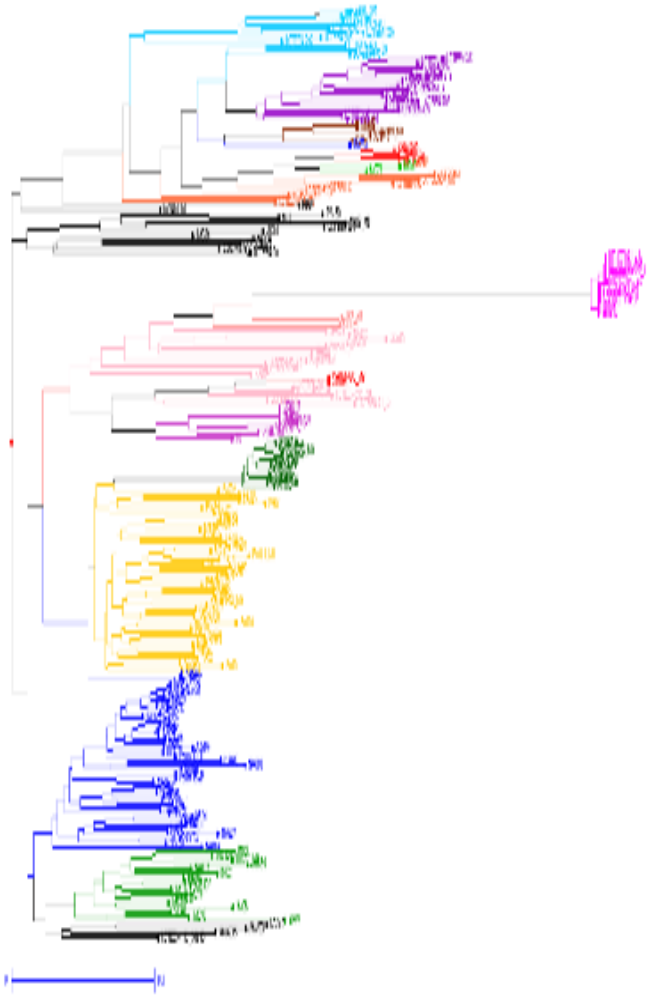
Take home- II

2. Total cadmium in soil is immaterial the available cadmium is more important.
   - Soil organic matter
   - Other competing cations and CEC
   - Soil pH

Soil Cd	TOTAL Cd	AVAILABLE CADMIUM IN LEAVES				
	HNO_3	Mehlich III	DTPA	Aqua Regia	EDTA	Water
Leaf Cd	0.16	0.72***	0.74***	-0.08	-0.26	NA

Take home III





Take home III

1. Considerable genetic variation for cadmium bioaccumulation.
   - Root system – size and morphology
   - Differences in transporters.

2. There is also evidence of differential partitioning

Take home IV – Soil Amelioration

In greenhouse studies

1. Changing pH, sequestration using organic matter or microbes, biochar or use of metal ion competitors have all shown strong effects in our studies and other studies.

2. Combination strategies are more effective than single strategies.

Field studies

Application methodologies need further development.

Where do we go from here?

Consolidation and Validation

Consolidation

Consolidation of the work carried out in different countries and further validation is important.

Cost-benefit analysis

Cost-benefit analysis is required to understand the applicability of the technologies in the short-term and longer term.

Validation - Multi-location trials

Validation of the technologies developed in multiple locations is critical to understand the effectiveness in different soils and environments.

Future

ECA/CAOBISCO/FCC

Regional Meeting – early 2017

- to share results from the various studies towards developing a consolidated strategy for further validation.