African Crop Evolution, Diversity & Adaptation

Adeline Barnaud
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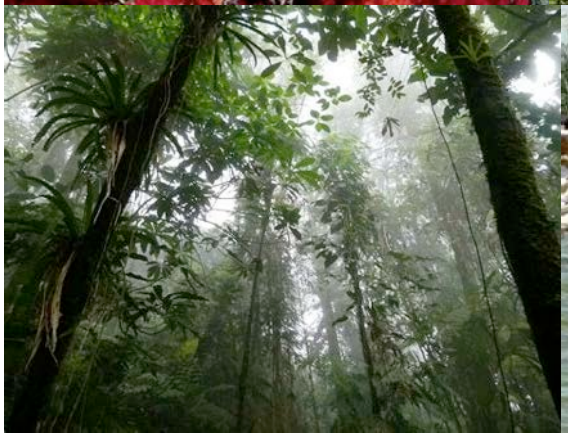
Biodiversity



A. Barnaud©IRD

Agrobiodiversity

Family Farming produces over 80 % of world's food

- improves environmental sustainability of agriculture,
- preserves and restores biodiversity
- preserves ecosystems, traditional and nutritious food,
- contributes to a balanced diet
- contribute to the maintenance of cultural heritage in rural areas

United Nations Decade of FAMILY FARMING 2019-2028

Lack of knowledge and ressources

Of the **7000 plant species** used throughout human history, about 95% of the food energy needs of humans are fulfilled by just 30 species, of which wheat, maize and rice provide the majority of energy supply.

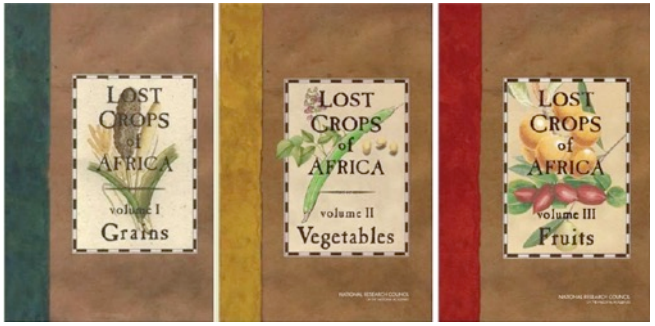
Since the 1900s, some **75 % of plant genetic diversity has been lost** as farmers worldwide have left their landraces for genetically uniform, high-yielding varieties.

Research **has focused on a few major crops** leaving the vast majority of the species qualified as underutilized and neglected crop (NUS)

Lost crops of Africa

Africa contributed to the domestication of many major crops for food security :

- **Sorghum (*Sorghum bicolor*)**,
- African rice (*Oryza glaberrima*)
- **Pearl millet (*Pennisetum glaucum*)**
- Yams (*Dioscorea rotundata*)
- **Fonio (*Digitaria exilis*)**



African crops domestication history

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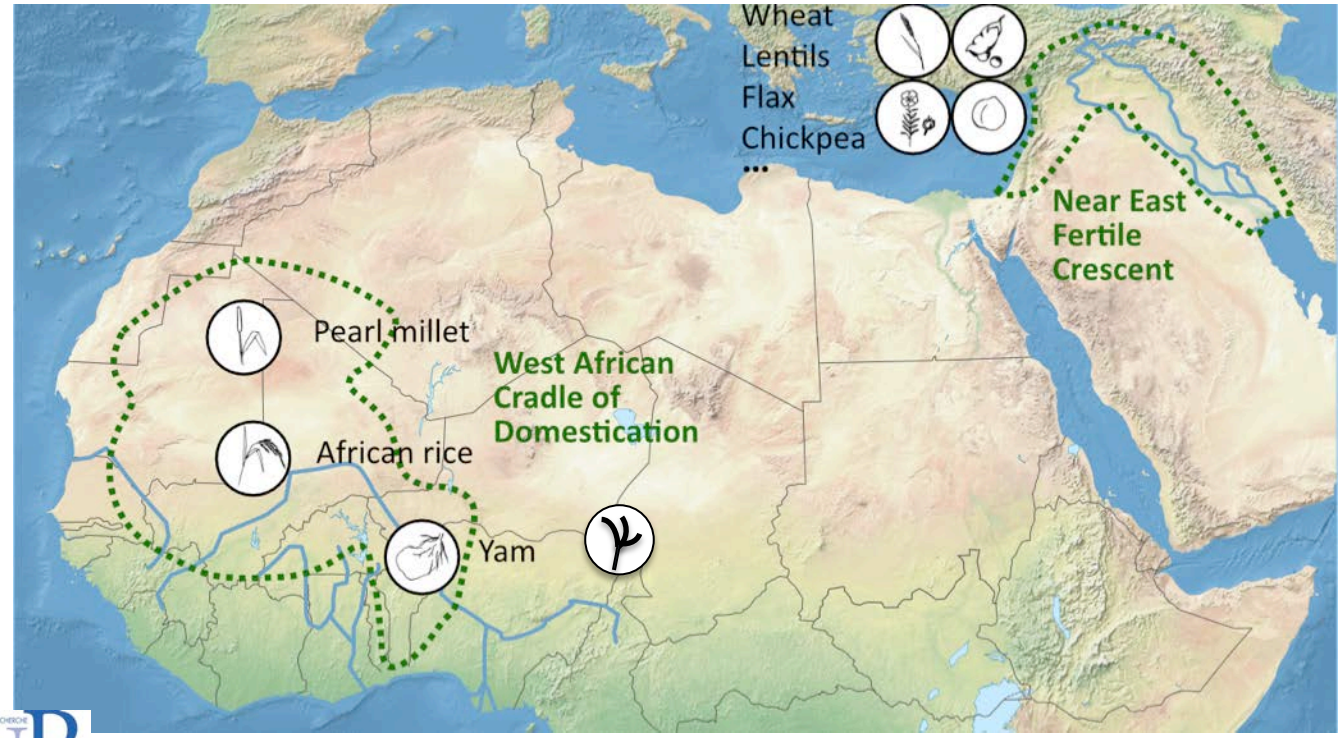


Inference of the geographic origin of the cultivated species with spatial modelling and genomic data

Scarcelli et al 2019
Cubry et al. 2018
Burgarella et al. 2018
Barnaud et al. In prep

African crops genetic diversity

Crop genetic diversity was mainly analyzed with a strong focus on environmental, climatic and agronomical factors

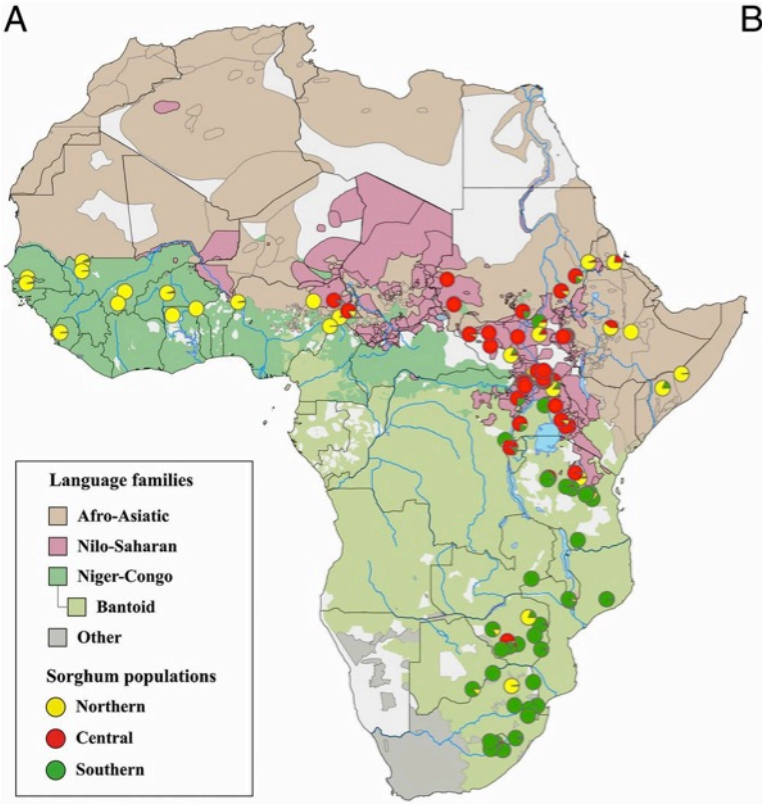
BUT

Crops are biological, cultural and social objects.

Farmers “leave their imprint on the plants; crops show the effect of the cultivator’s eye as well as hand” (Boster, 1985)

Seeds social life

Farming-language co-dispersal hypothesis:
Farming and language families have moved together through population growth and migration (Diamond J & Bellwood P 2003)

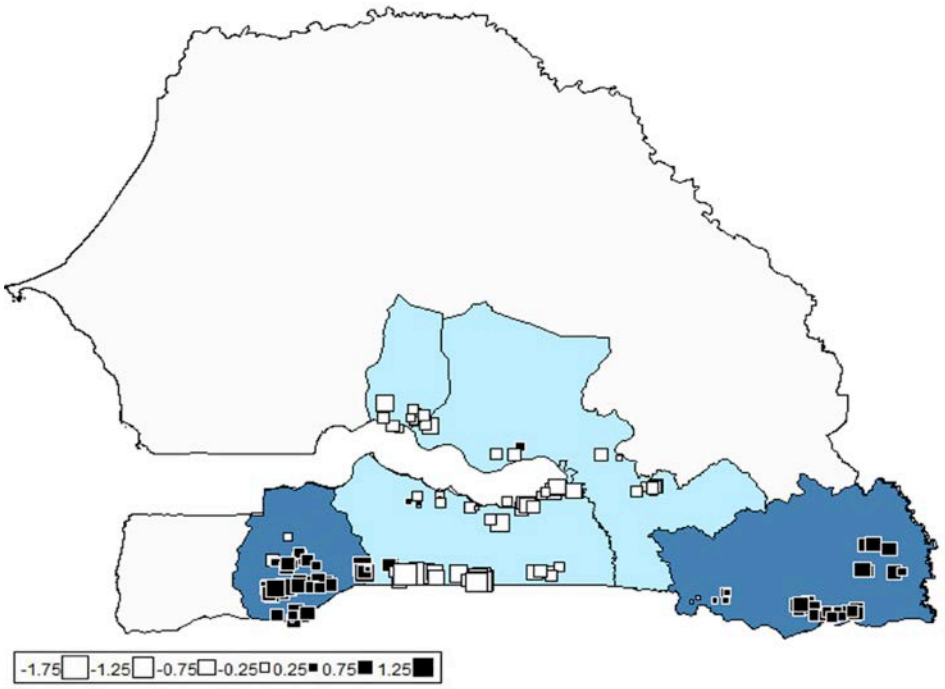


Westengen et al. PNAS 2014

Fonio, *Digitaria exilis*
African quinoa

- **Indigenous staple crop in Western Africa**
- **Valuable source of income**
- **Culture**
  - **few land work**
  - **Abiotic and biotic stress tolerant**
- **Food security**
  - **short growing cycle**
  - **Nutritious, diversifying diets**
- **Great cultural significance**

Farming-language co-dispersal



Etnobotanical surveys and landraces collections :
33 villages ; 155 accessions and 16 SSRs

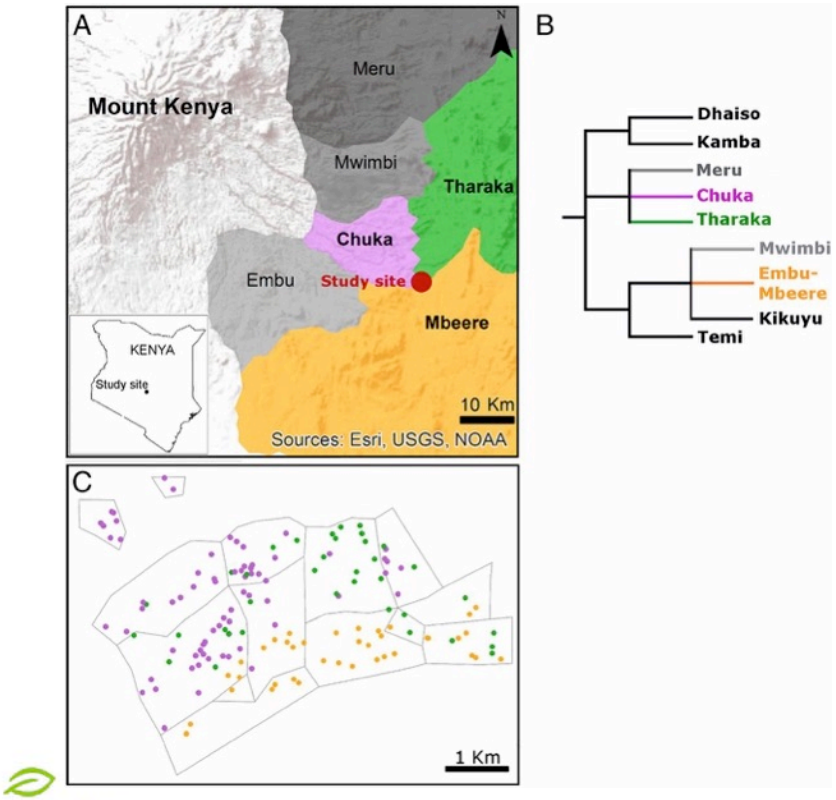
Historical Humans Migration Influenced the Current Spatial Genetic Structure of fonio in Senegal

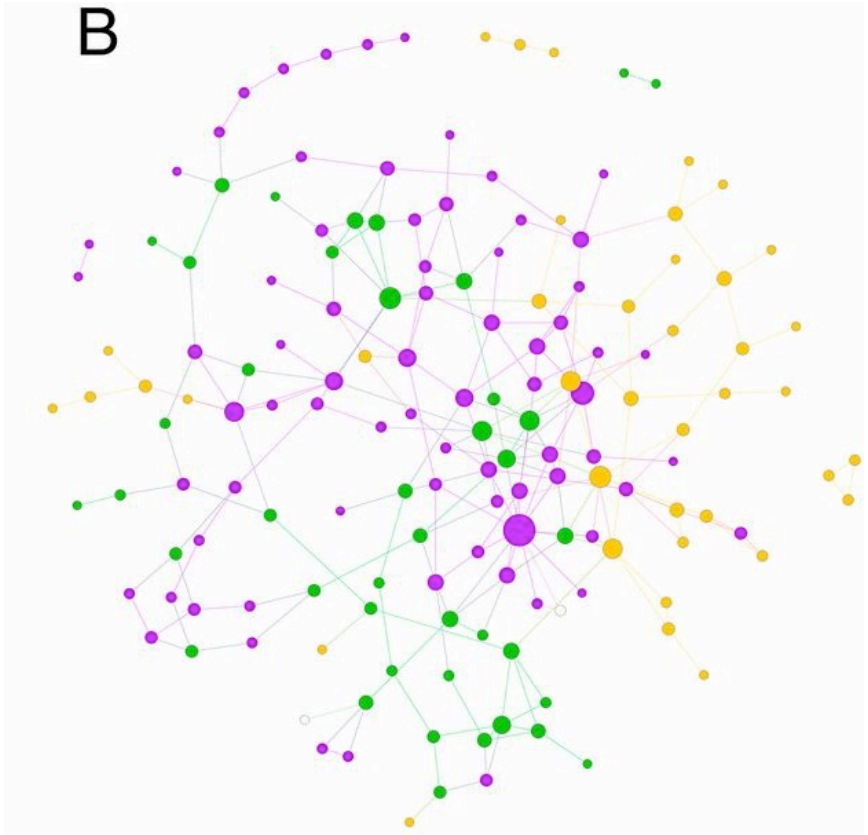
WAAPP / PPAAO

Diop et al. 2018, In prep

Seeds social life

Ethno-linguistic barriers, reflecting cultural differences among human communities (preferential seed exchanges)



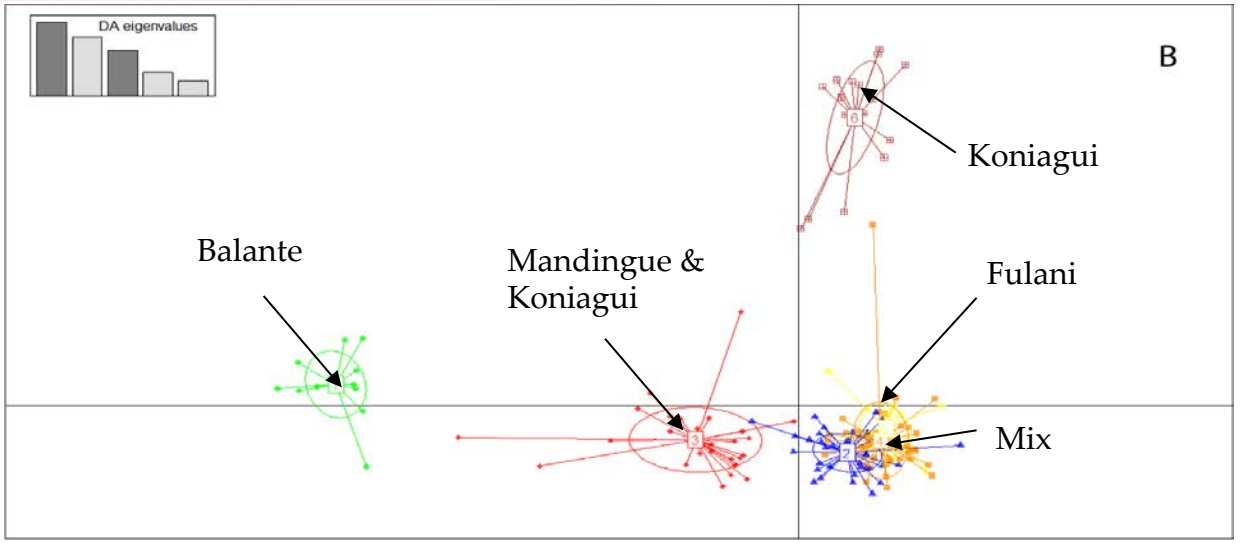


agropolis fondation

Labeyrie et al. 2014, 2016

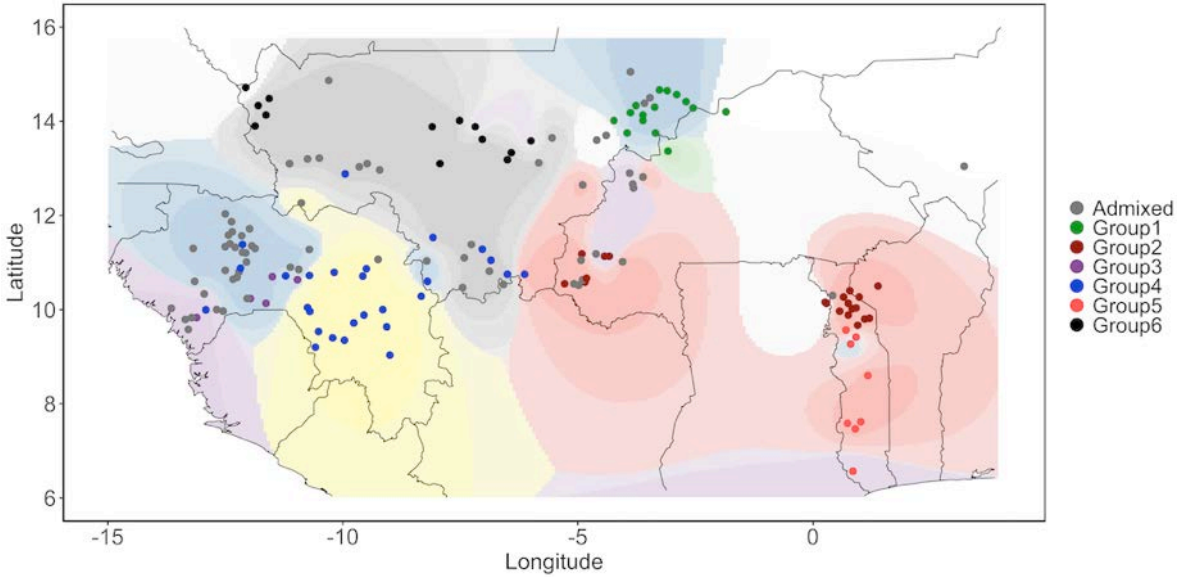
Ethnolinguistic structuring of fonio genetic diversity

SSRs



Diop et al. 2018, In prep

Whole genome sequencing



Abrouk et al. In prep

What is a landrace ?

Duupa Agrosystem in Cameroon

More than 80 edible sp. in the fields

- -About 50 crops
- -About 40 sorghum landraces
- -5 to 18 landraces mixed in fields

Garine et al. 1995
Barnaud et al. 2006

What is a landrace ?

toot zeng naaa

Home sorghum

gbansaa

benga

toot zeng naaa

kubaze kolla

baadangkalia

yeen waaa

gorotta

muskwari

kak banna

bonna

binsaa

tukka

zakpayya

zenzen yeksekka

'angonga

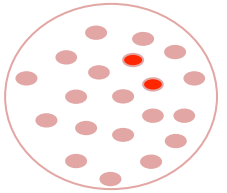
za'toota

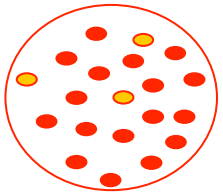
'eeka

yatta

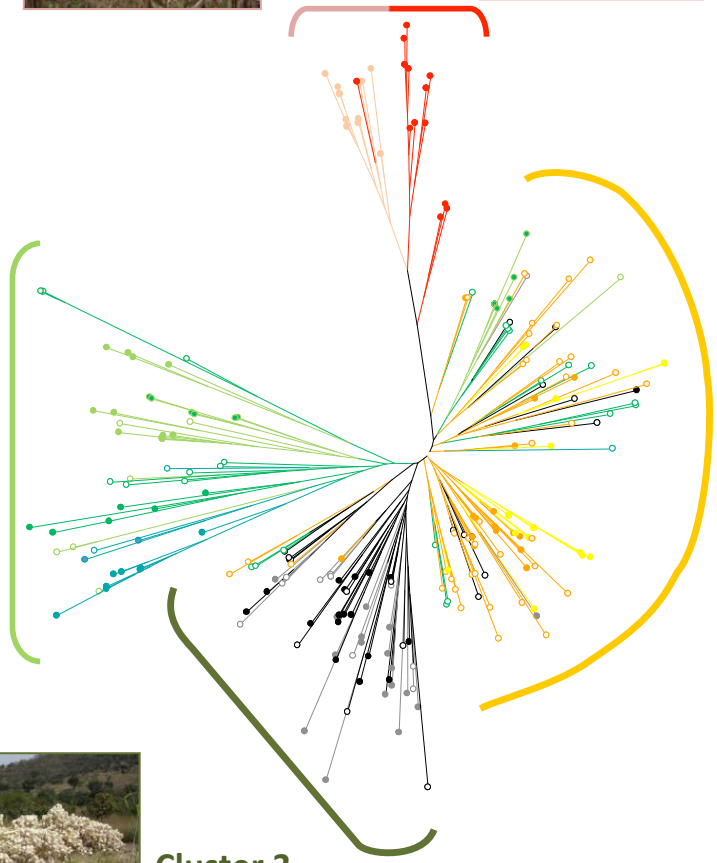
see gooriya

What is a landrace ?

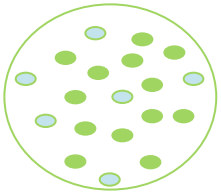




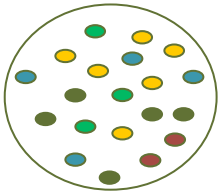
Cluster 1
2 landraces



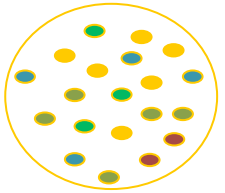
Cluster 4
Several landraces



Cluster 2
several
Landraces



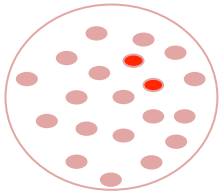
Cluster 3
Plusieurs
variétés



14 SSRs

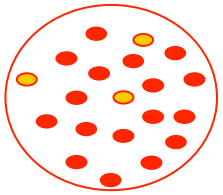
Barnaud et al 2006

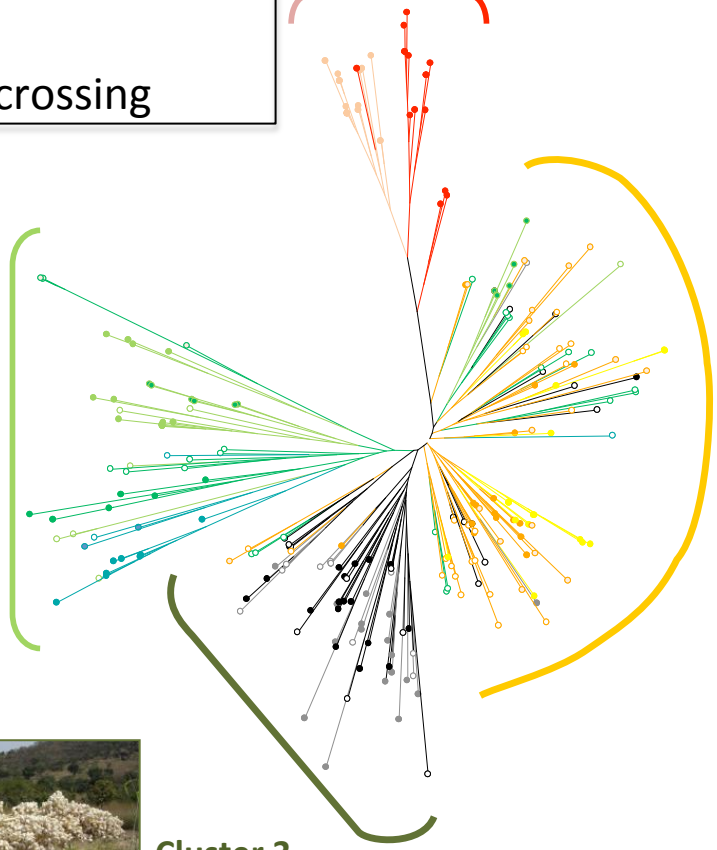
What is a landrace ?



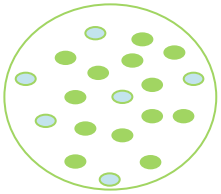
5% of outcrossing

Cluster 1
2 variétés

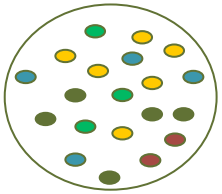




Cluster 4
Plusieurs variétés



Cluster 2
Plusieurs
variétés



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Plusieurs
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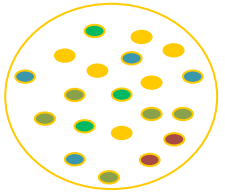
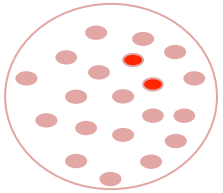
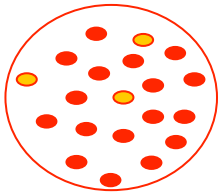


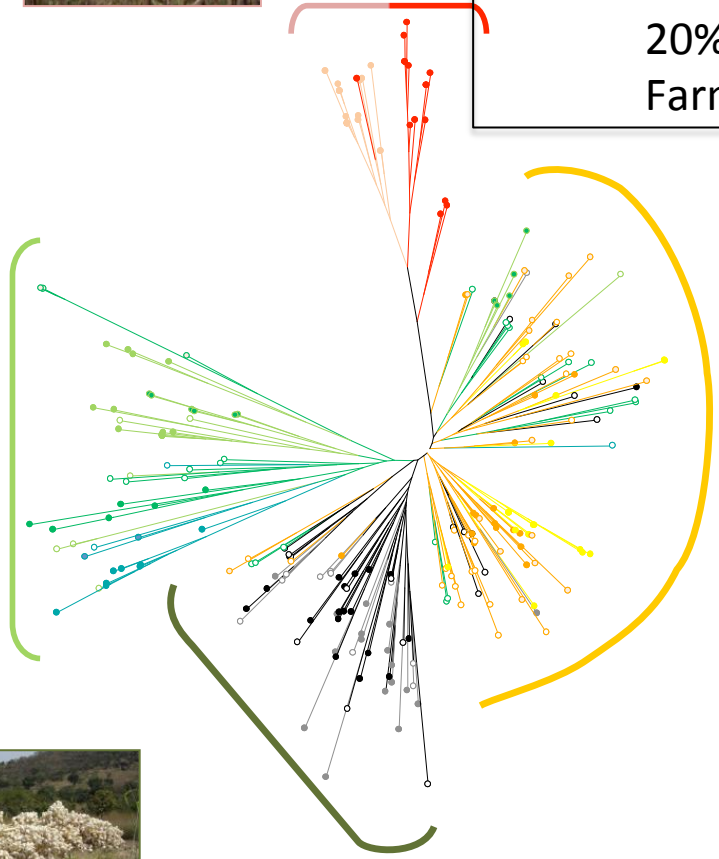
Barnaud et al 2008

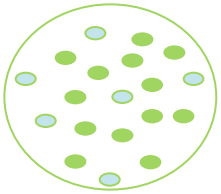
What is a landrace ?

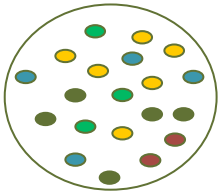


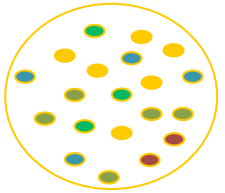


20% of outcrossing
Farmer selection



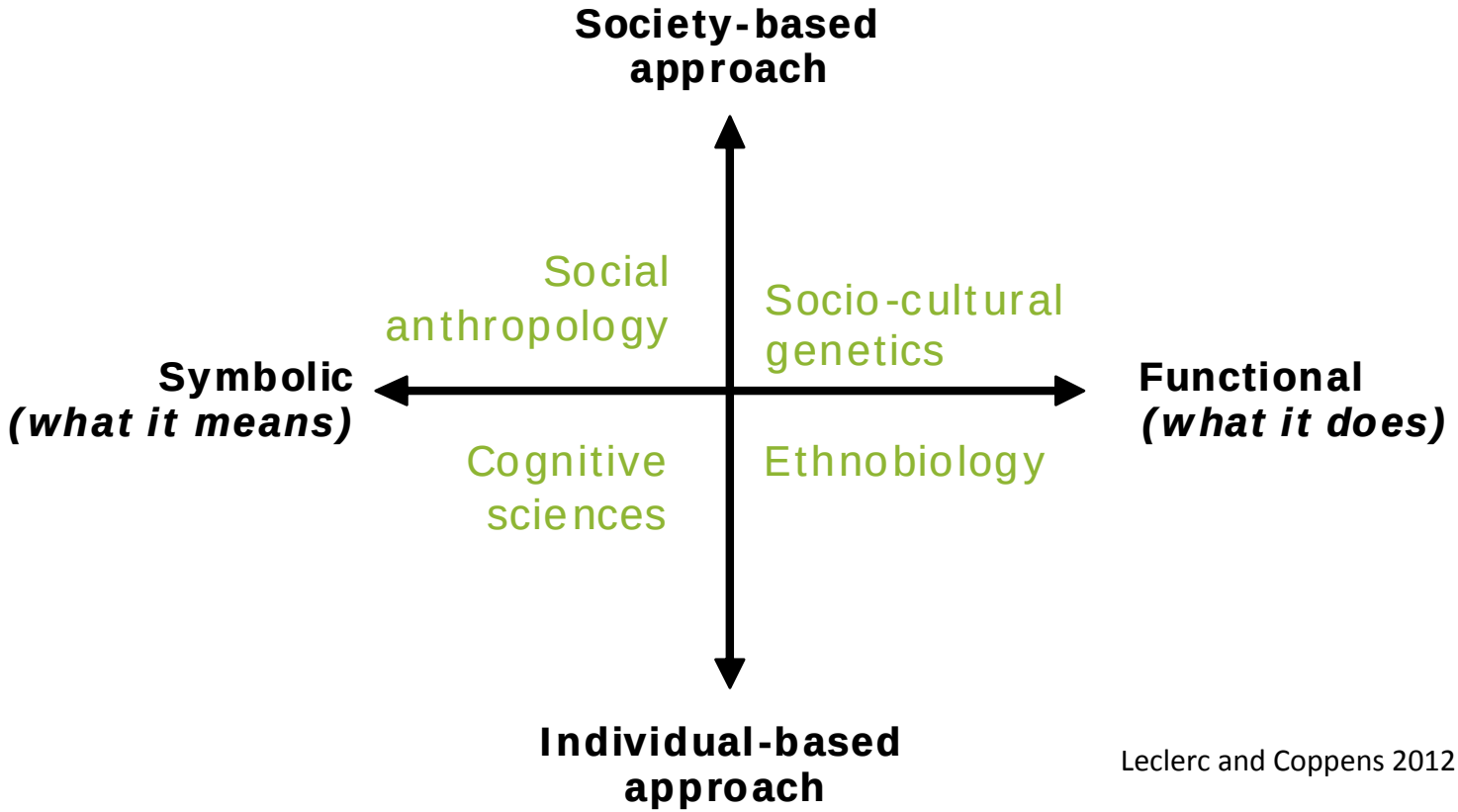






Barnaud et al 2008

A need for interdisciplinary approach



Leclerc and Coppens 2012

New approaches to document crop evolutionary history, genetic diversity to develop sampling strategies, in situ conservation strategies, etc.

Agriculture in Africa faces major challenges

- Climate changes will deeply impact crop productions
- Demand for food would increase by 70% by 2050 (FAO)
- Increasing the food supply and improving its nutritional value (Godfray et al., 2010)

Crop diversity can provide a strategy to cope with climate change and to fulfil the Sustainable Development Goals (SDGs)

Agriculture in Africa faces major challenges

What are the most vulnerable areas of agriculture in Africa under future climate projections ?

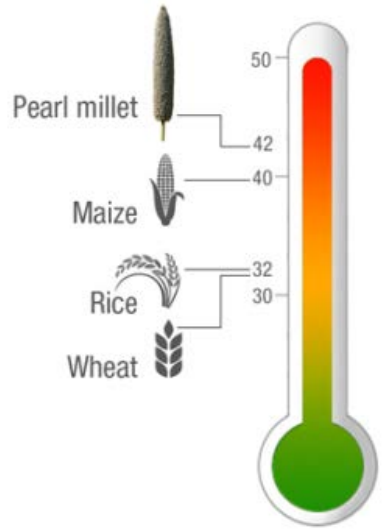
Can we use current crop agro-bio-diversity to mitigate vulnerability to future climate projections ?

How can adaptation and resilience be promoted for the future ?

What are the most vulnerable areas of agriculture in Africa under future climate projections ?

Pearl millet (*Pennisetum glaucum*)

- Staple cereal for 90 million people
- Highly nutritious
- Cultivated in arid and low-fertility soils
- Low productivity

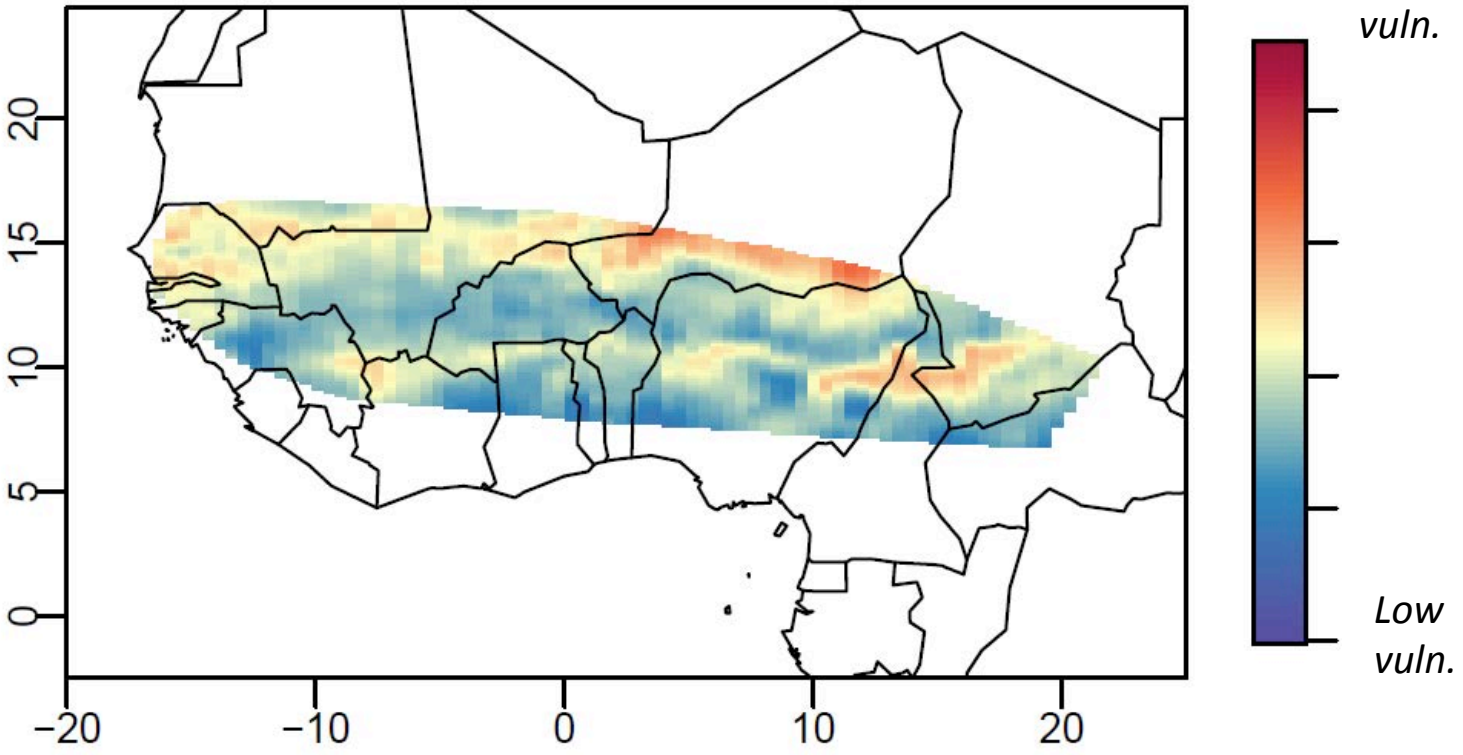


Maximum temperature tolerated by crops

Rhoné et al. Submited

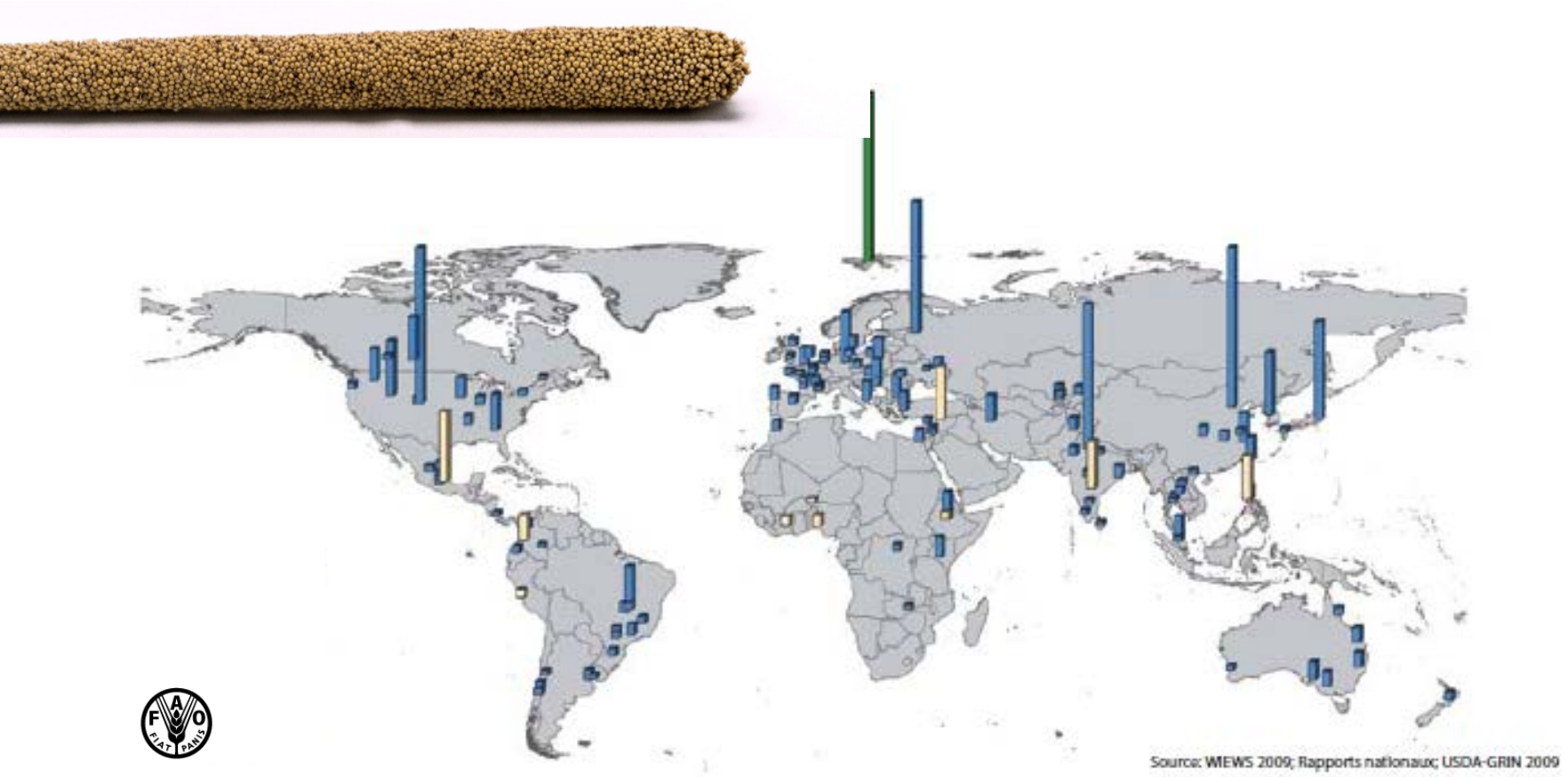
What are the most vulnerable areas of pearl millet cultivation in West Africa under future climate projections ?

2050



Rhoné et al. Submited

How can adaptation and resilience be promoted for the future ?



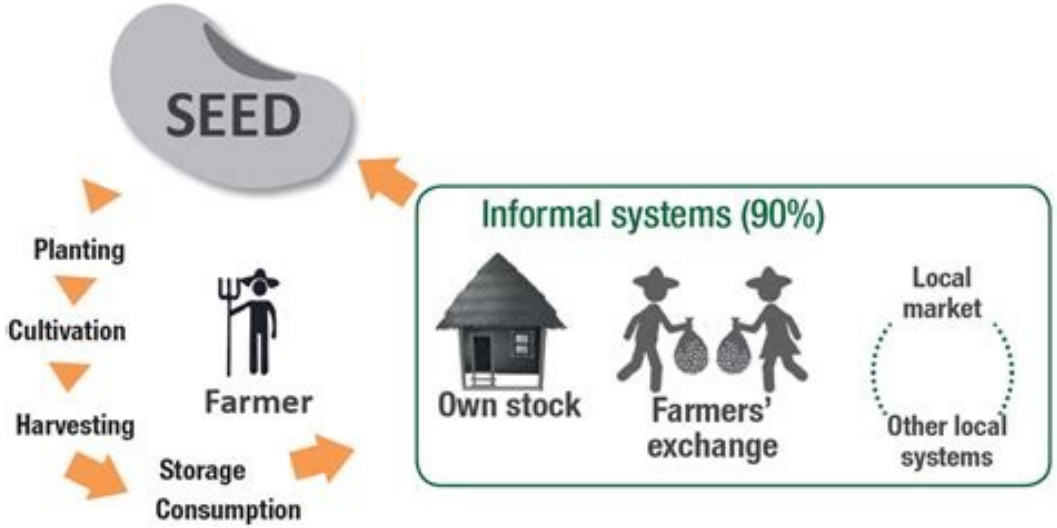
Conservation and new collections are of high priority for African crops and their wild relatives

-Genebank and herbarium

-Traditional ecological knowledge

How can adaptation and resilience be promoted for the future ?

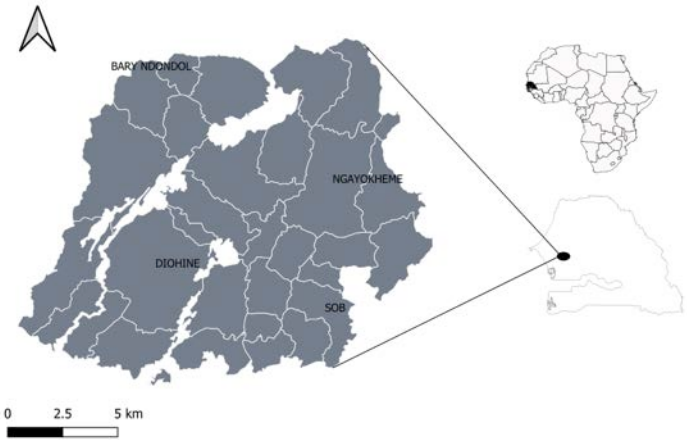
Seed security « households have access to seeds of adapted plant material by sufficient quantity and of adequate quality, in all conditions - good or bad » FAO

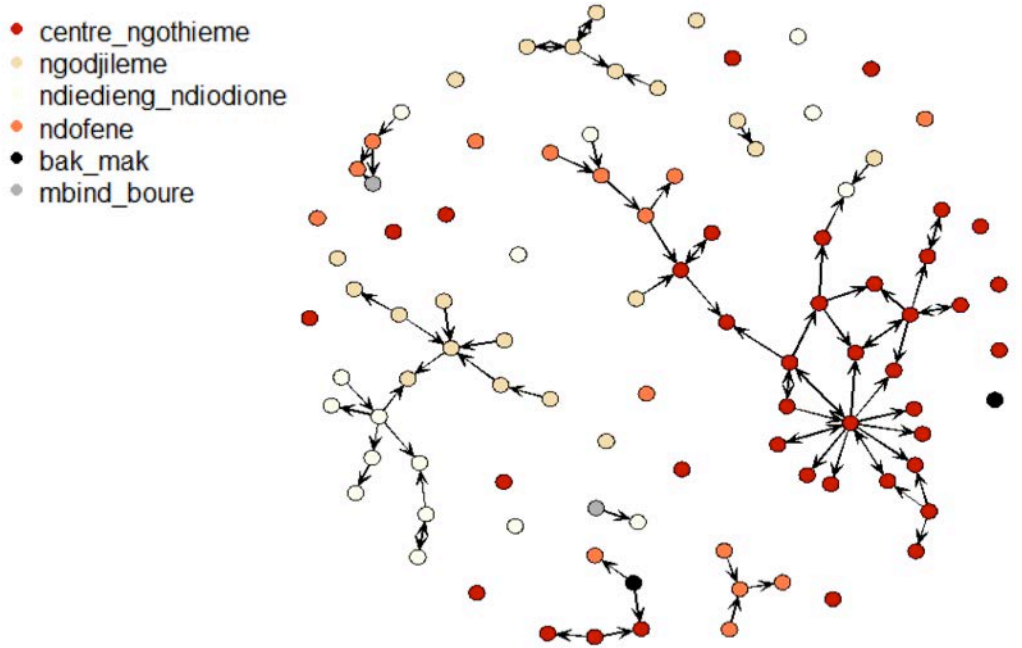


In family farming, crops continuously co-evolves with their environement (ecological, economical, environmental, social and cultural)

How can adaptation and resilience be promoted for the future ?

The return of mil sanio in the Sine : A reasoned adaptation to climate change





Seed network analysis

Local/informal seed networks a key to conserve et access crop diversity

AGENCE NATIONALE DE LA RECHERCHE ANR

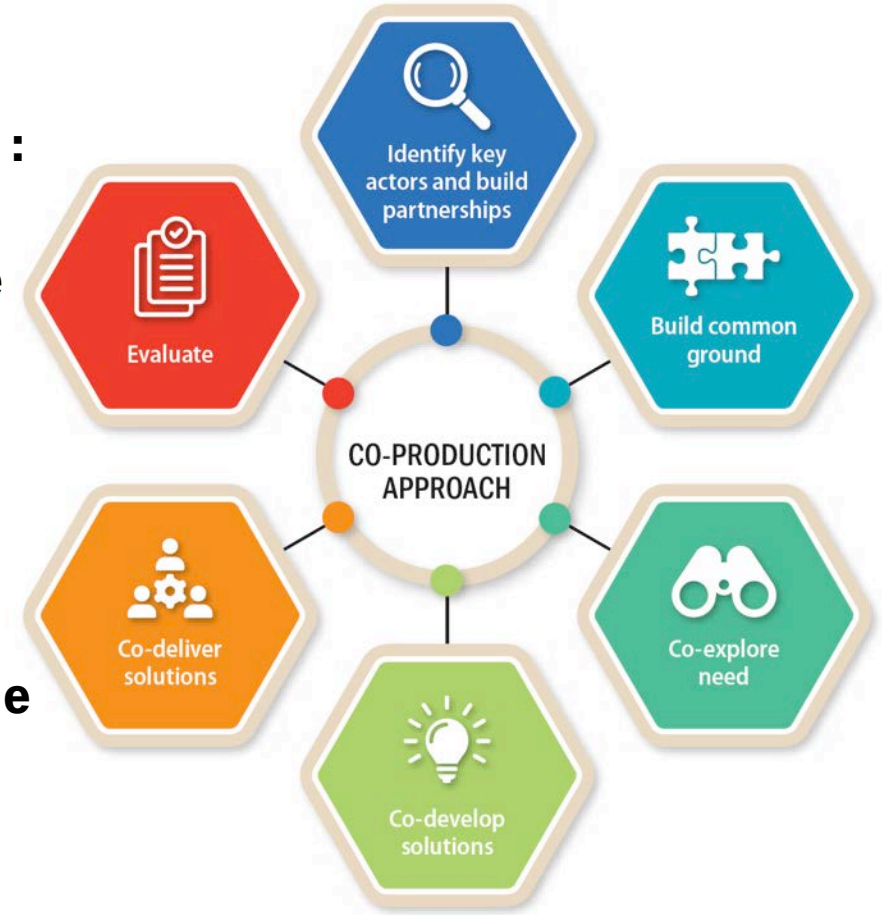
Ledoussal, 2016

Toward transdisciplinary approach: knowledge co-production

From ethnoecology to co-production :

- Understanding how farmers are mobilizing diversity to respond to climate change

-co-constructing Sustainable Agriculture while preserving agrobiodiversity and cultural heritage



Vismann et al. 2019

Toward transdisciplinary approach: knowledge coproduction

Researchers

interaction with society

Decision makers

Actors and Society

KADDU YARAAX

Thanks

Farmers –Student-Postdoc-Collaborators-Funders

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Benedicte Rhoné
Sophie Ledoussal
Benjamin Sultan

CNRS
Delphine Renard
Christine Raimond

WAG Herbarium
Jan Wieringa

CIRAD
Claire Billot
Monique Deu
Christian Leclerc
Frédérique Jankowski
Vanesse Labeyrie
Hélène Joly

IFAN
Mathieu Gueye

ISRA / CERAAS
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Ndjido Kane
Baye Diop
Ablaye Ngom
Katina Olodo
Moussou Cissoko
Aby Cissé

Kaust
Michael Abrouk
Hanin Amhed
Simon Krattinger

Université de Nanterre
Eric Garine

Kings College
Emma Vismann
Camilla Audia

Université Gaston Berger
Saidou Sall

ASPSP

Crop diversification in a changing world
Mobilizing underutilized crop genetic ressources

S. Bottalico©IRD