How to derive meaningful selection indexes for plant breeding targeting smallholder farms?

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Crops genemic- Selection Events

Rabat Morocco Sept. 2016

Objectives

- **to develop selection indexes targeted to small holder farmers**

- What is a selection index:
  - « The selection index refers usually to a linear combination of observations that is used to compute, for each individual available for choice, a criterion for selection » (Hanson and Robinson, 1961).

  - Index selection: a method of artificial selection in which several usefull traits are selected simultaneous

  - "Selection Indexes allow you to make balanced selection decisions. They take the hard work out of knowing how much emphasis to put on each individual trait by ranking animals (*or plants*) on their overall genetic value for a particular production system and value along the entire production chain". (meat and livestock Australia)

Farmer Participatory Variety Selection in South Asia (Ortiz-Ferrara et al. 2001)- Case study in Nepal.

Ranking of farmer-preferred traits based on gender criteria, Bankatti Village, Rupandehi District (Terai), Nepal, 1999-2000.

Women	men
1.Disease resistance	1. Late heat stress tolerance
2. Pest resistance	2. Large white grains
3. Good chapati making	3. Shattening tolerance
4. High yield	4. Disease resistance
5. High tillering	5. Lodging tolerance
6. Medium height	6. Early maturing
7. While bold seed	7. High yield
8. Lodging tolerance	8. Medium heigh
9. Large spikes	9. Good chapati making
11. Shattering resistance	
12. Short awns	

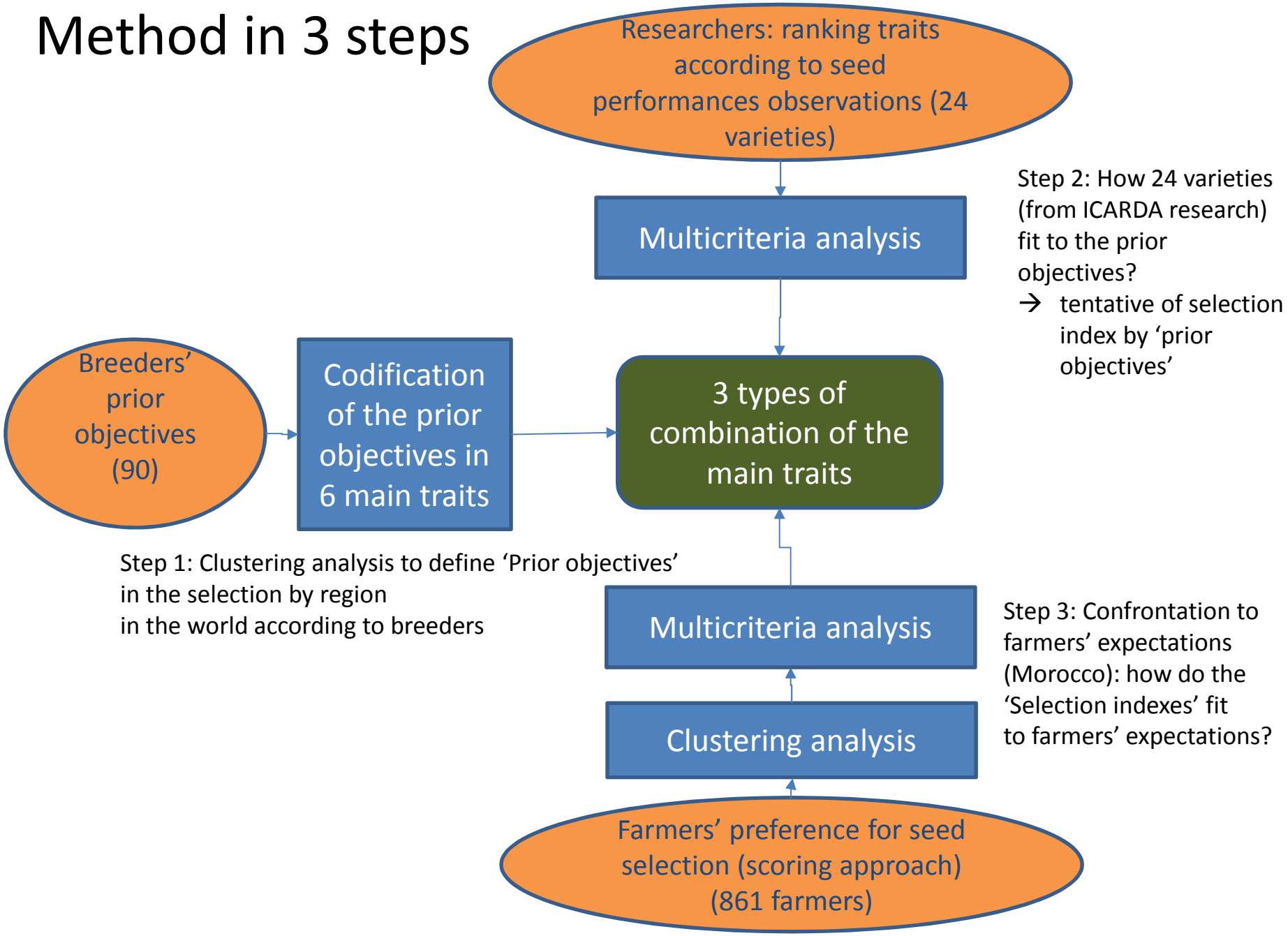
Lantican et al. 2014 CIMMYT Breeders' objectives

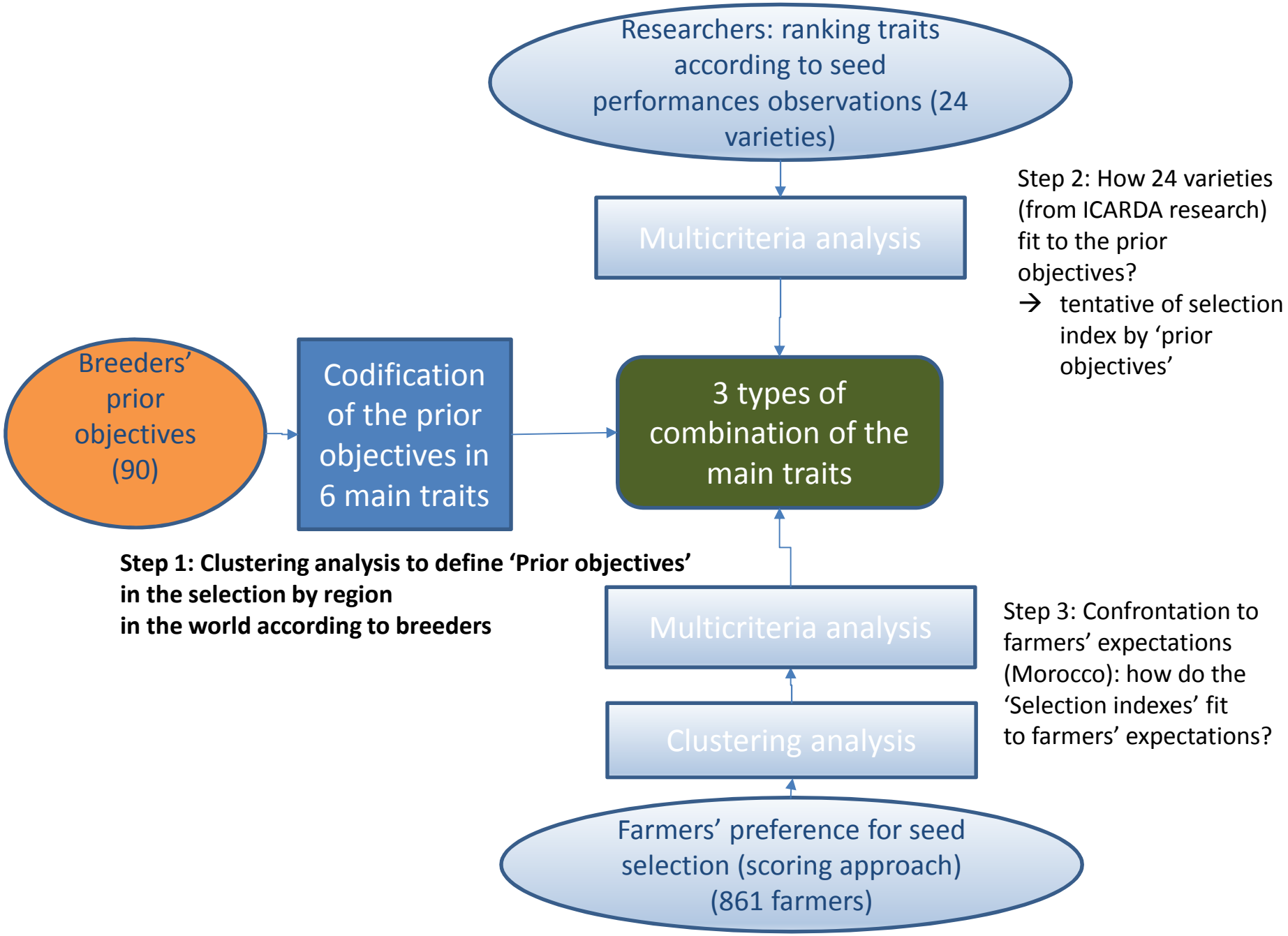
Breeders	Objective 1	Objective 2	Objective 3
59	Yield potential	Resistance breeding for biotic stresses	Resistance breeding for abiotic stresses (drought, heat, sterility)
60	High yielding	Disease & insect resistant	Wide adaptability with better end use quality

Methodology

- Durum Wheat
- Used existing materials from different sources
- Cross different approaches:
  - Descriptive statistics;
  - Factorial & clustering analysis;
  - Multi-criteria analysis based on weighting system;

Method in 3 steps




Researchers: ranking traits according to seed performances observations (24 varieties)
Multicriteria analysis
Step 2: How 24 varieties (from ICARDA research) fit to the prior objectives?
→ tentative of selection index by 'prior objectives'
Breeders' prior objectives (90)
Codification of the prior objectives in 6 main traits
3 types of combination of the main traits
Step 1: Clustering analysis to define 'Prior objectives' in the selection by region in the world according to breeders
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Farmers' preference for seed selection (scoring approach) (861 farmers)

Step 1. Define types based on a combination of the main traits

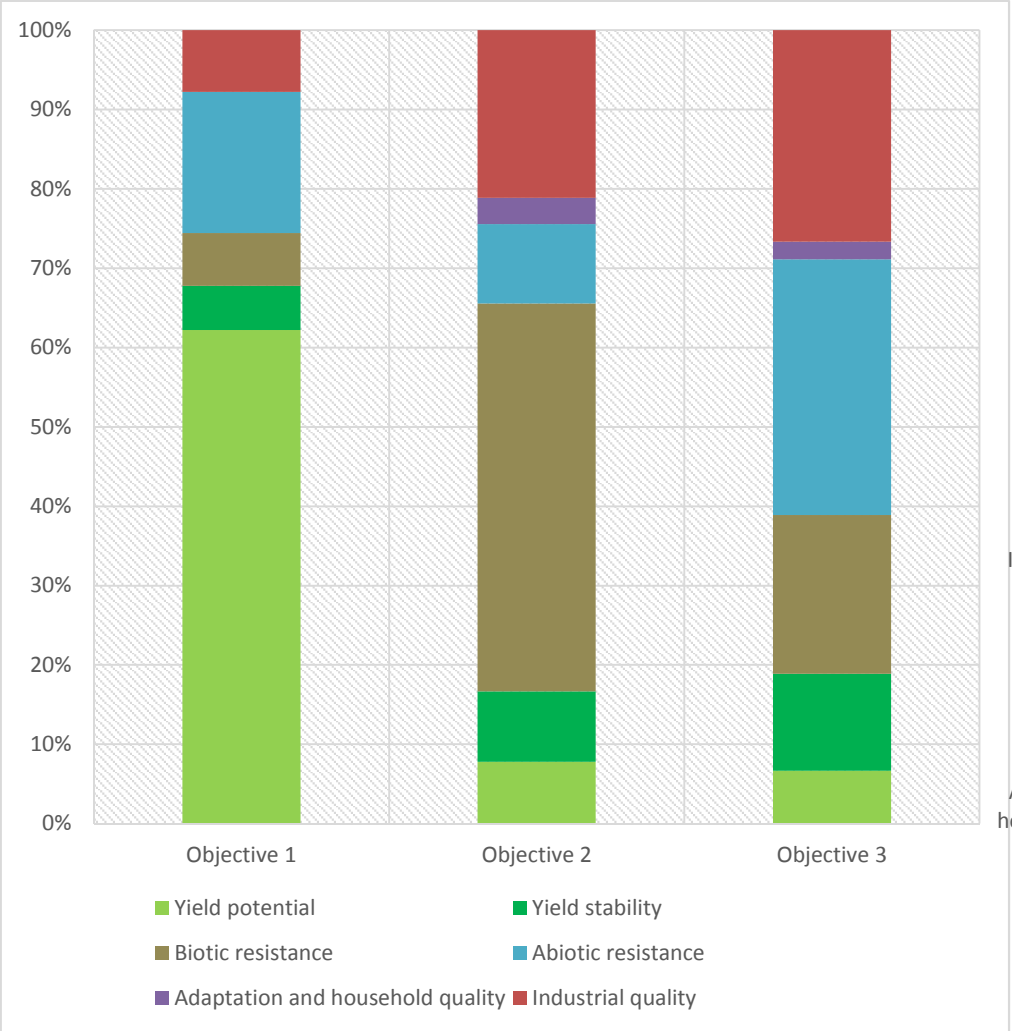
From « Wheat global impacts study 1994-2004”(M. Lantican)

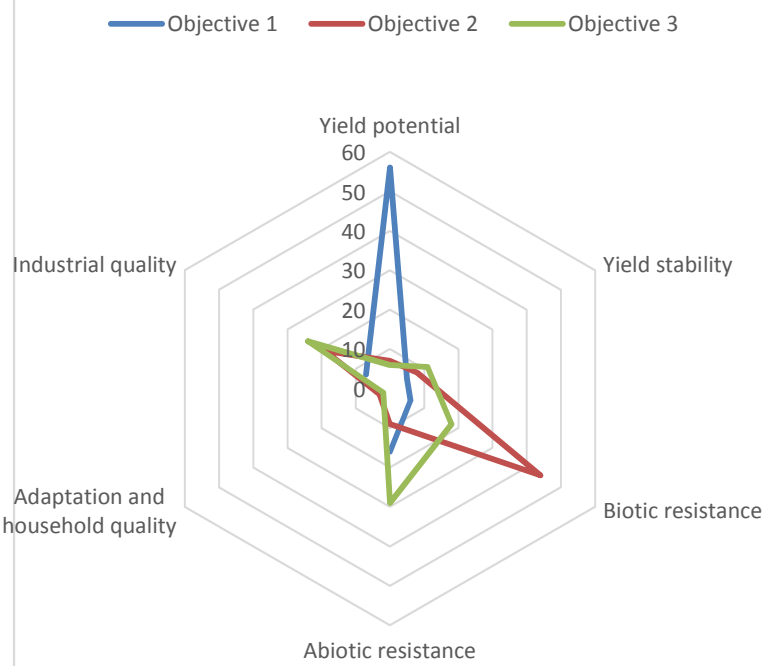
Lantican, M.A., T.S. Payne, K. Sonder, R. Singh, M. van Ginkel, M.Baum, H.J. Braun, and O. Erenstein. In press. Impacts of International Wheat Improvement Research in the World, 1994-2014. Mexico, D.F.: CIMMYT - See more at: https://www.icarda.org/update/impacts-international-wheat-improvement-research-1994-2014#sthash.QlGBSomw.dpuf

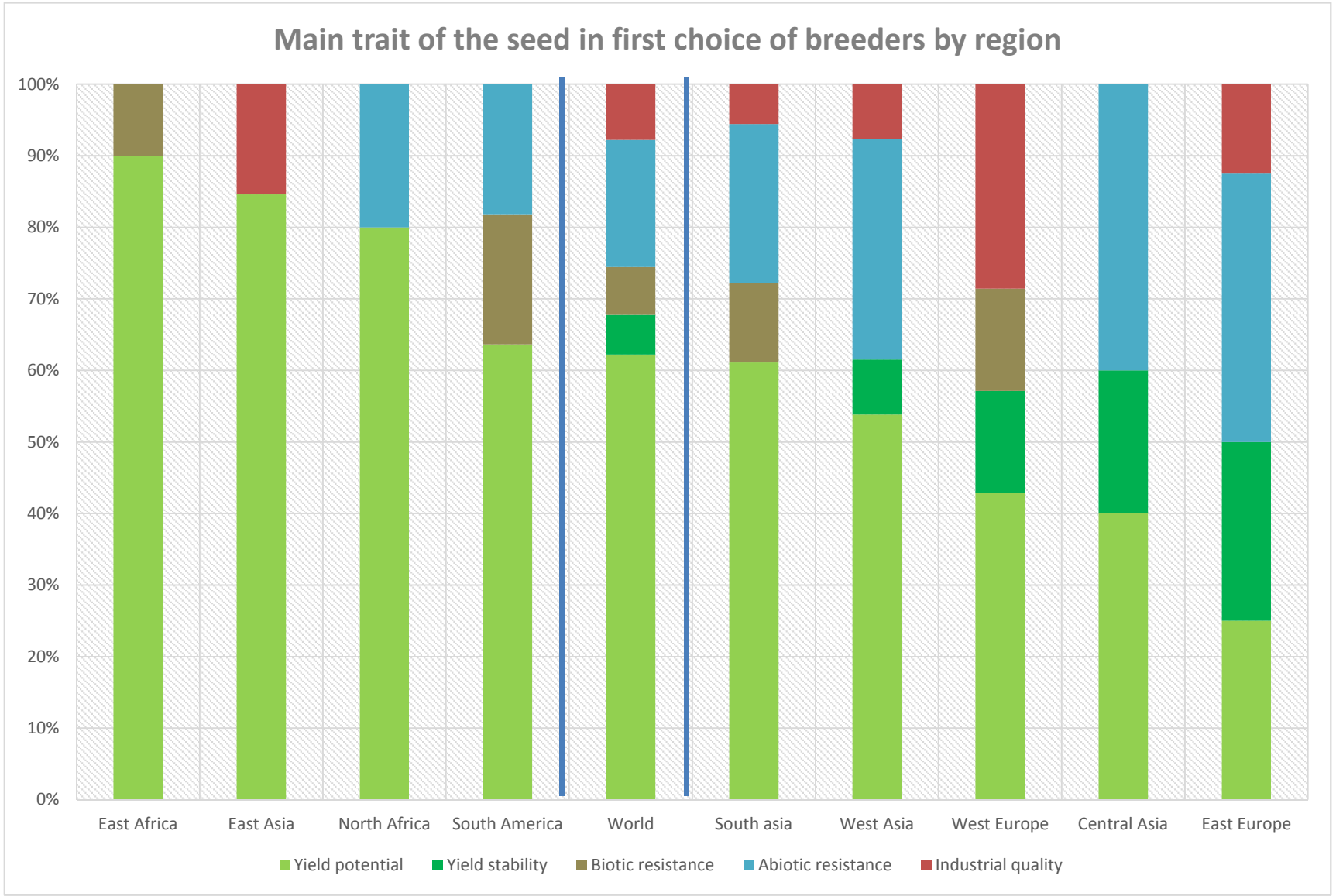
- List of 6 main traits categorized in 3 ranked objectives
- Sample (90)
- Countries (50)

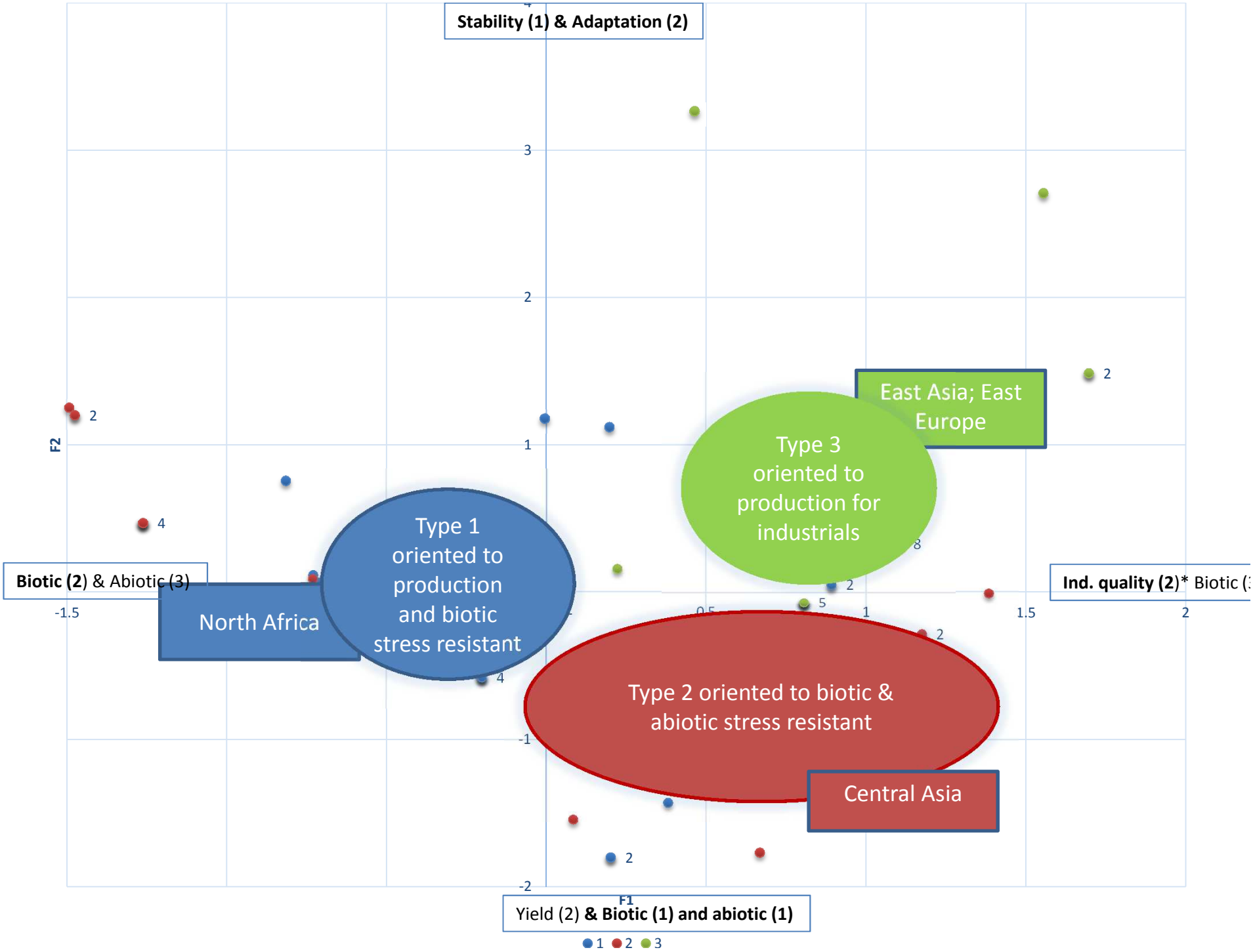
List	Main traits	Descriptive
1	Yield potential	All yield traits without additions
2	Yield stability	Indicating stability or GxE
3	Biotic resistance	All diseases and insects
4	Abiotic resistance	Mainly heat and drought, but also others such as salinity or frost
5	Adaptation and household quality	Straw, storability, grain size, taste, conversion to flour -occasionally grain color
6	Industrial quality	Bread making, yellow pigment, semolina yield, gluten strength, extensibility

From yield > Biotic stress resistant > abiotic stress resistant






Main trait of the seed in first choice of breeders by region
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
East Africa
East Asia
North Africa
South America
World
South asia
West Asia
West Europe
Central Asia
East Europe
Yield potential
Yield stability
Biotic resistance
Abiotic resistance
Industrial quality

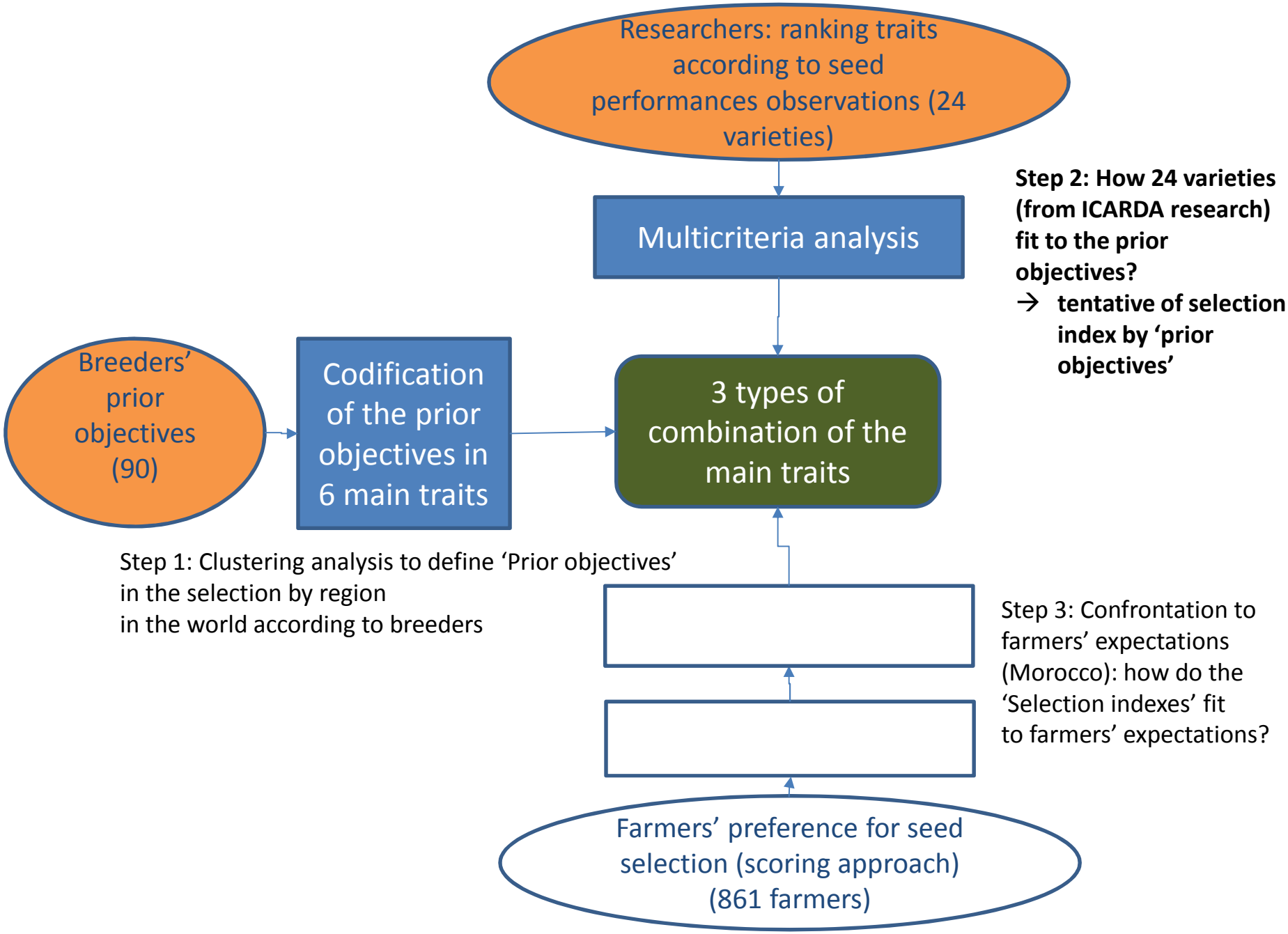

Stability (1) & Adaptation (2)
Biotic (2) & Abiotic (3)
Ind. quality (2)* Biotic (
Yield (2) & Biotic (1) and abiotic (1)
F1
F2
East Asia; East Europe
Type 3 oriented to production for industrials
Type 1 oriented to production and biotic stress resistant
North Africa
Type 2 oriented to biotic & abiotic stress resistant
Central Asia
1 2 3

Clustering analysis: combination of the main traits

Classe	Charac	Obj1	Obj2	Obj3	Region	NENA Countries	Other countries
1 (60)	Type 1 oriented to production and biotic stress resistant	Yield potential (82%)	Biotic (71%)	Industrial quality (47%)	**North Africa; East Africa**; **South America**; **South** & West & East Asia; East &**West Europe**	Morocco; Algeria; Tunisia; Egypt; Sudan; Syria; Jordan; Turkey;	Ehiopia; china;Mexico;Argentina; Afghanistan; Italy;Spain
2 (39)	Type 2 oriented to biotic & abiotic stress resistant	Abiotic (50%)	Biotic (40%)	Abiotic (35%)	**Central Asia;** South & East Asia; West Europe	Lebanon	Hungary;Romania; Iran; India;Switzerland; Italy;
3 (13)	Type 3 oriented to production for industrials	Yield potential (74%)	Industrial quality (89%)	Biotic (58%)	**Central & West Asia**; **East** & West Europe**;**	Turkey	Kazakhstan;China;Czech; Brasil;Ecuador; Italy;

3 types

	Type 1 oriented to production and biotic stress resistant	Type 2 oriented to biotic & abiotic stress resistant	Type 3 oriented to production for industrials	Global profile
Yield potential	43%	10%	38%	35%
Yield stability	5%	7%	16%	8%
Biotic resistance	24%	25%	14%	22%
Abiotic resistance	17%	38%	2%	18%
Adaptation and household quality	1%	0%	3%	1%
Industrial quality	9%	21%	27%	16%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Step 2. Ranking index for 24 varieties

Traits used to calculate ranking

Weights	Yield potential	Yield stability	Biotic resistance	Abiotic tolerance	Household use	Industrial quality
0,35	b'	perf. Index	LR	GY FAN	BY	SDS
0,30	BLUP GY	WAI	HF	GY min	spike.m2	YP
0,25	GY Sids	r2	TS	GFP	HI	GPC
0,10	GY rank to max	GY rank median	ST	.	Victories	.
					TKW	
	max: G+GxE	G			TestW	
					TKW TER	
					TKW MCH	

Coefficients used to estimate the distance between the « prior objectives » types of a selection system and the varieties (50% obj1;30% obj2; 20% obj 3)

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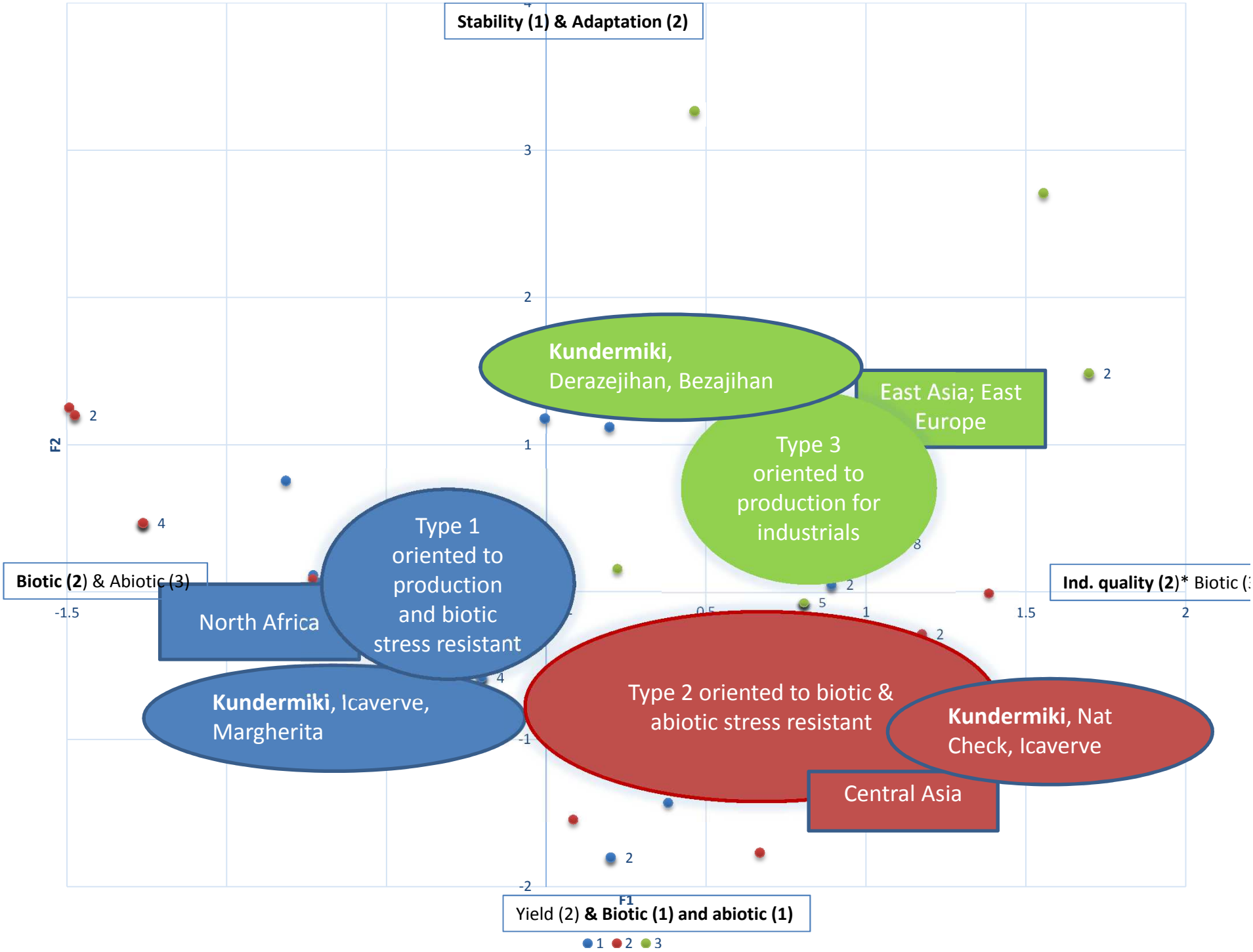
Matrix of ranking for varieties

no	Var name	Yield potential	Yield stability	Biotic resistance	Abiotic tolerance	Household use	Industrial quality
1	Aghramatlas	4	2	10	2	2	14
2	Azeghar2	11	3	10	1	22	22
3	Bezaghras	2	6	1	4	7	9
4	Bezajihan	18	22	1	19	14	24
5	Derazejihan	22	23	18	9	20	13
6	Icacube	6	19	1	5	15	1
7	Icadezful	14	16	1	8	19	19
8	Icaghram	21	17	18	12	4	15
9	Icambel	8	9	12	6	11	16
10	Icamoram7	13	15	12	23	5	11
11	Icarasha2	10	5	6	22	16	6
12	Icarukus	5	13	10	14	23	5
13	Icavert	9	4	18	16	10	12
14	Icaverve	23	20	24	18	17	7
15	Kundermiki	20	24	18	17	12	21
16	Margherita	24	12	18	20	13	2
17	Miki3	17	7	12	3	24	10
18	Nat Check	7	10	24	21	21	20
19	Omrabi5	1	1	1	15	1	23
20	Ouassara1	16	8	1	7	6	8
21	Ouassara3	19	11	3	13	9	4
22	Secondroue	3	18	1	11	3	3
23	Waha	15	14	10	10	8	17
24	Zagharin2	12	21	1	24	18	18

Link varieties and types

no	Var name	Type 1	Type 2	Type 3	types
15	Kundermiki	98%	100%	97%	Type 1,2,3
14	Icaverve	81%	59%	46%	Type 1,2,3
16	Margherita	75%	52%	27%	Type 1,2,3
5	Derazejihan	73%	42%	71%	Type 1,2,3
8	Icaghram	71%	42%	65%	Type 1,2,3
4	Bezajihan	50%	51%	69%	Type 1,2,3
21	Ouassara3	34%	-11%	11%	Type 1
17	Miki3	22%	-35%	23%	Type 1,3
13	Icavert	19%	18%	-2%	Type 1,2
10	Icamoram7	16%	38%	-1%	Type 2
18	Nat Check	8%	74%	8%	Type 2
23	Waha	8%	21%	24%	Type 2,3
24	Zagharin2	8%	41%	34%	Type 2,3
11	Icarasha2	3%	10%	-41%	Type 2
2	Azeghar2	-12%	-24%	12%	Type 3
7	Icadezful	-31%	-42%	14%	Type 3
12	Icarukus	-51%	-31%	-62%	no
20	Ouassara1	-56%	-91%	-62%	no
9	Icambel	-60%	-48%	-40%	no
19	Omrabi5	-64%	-21%	-44%	no
1	Aghramatlas	-66%	-55%	-59%	no
22	Secondroue	-72%	-49%	-66%	no
6	Icacube	-88%	-87%	-65%	no
3	Bezaghras	-90%	-80%	-73%	no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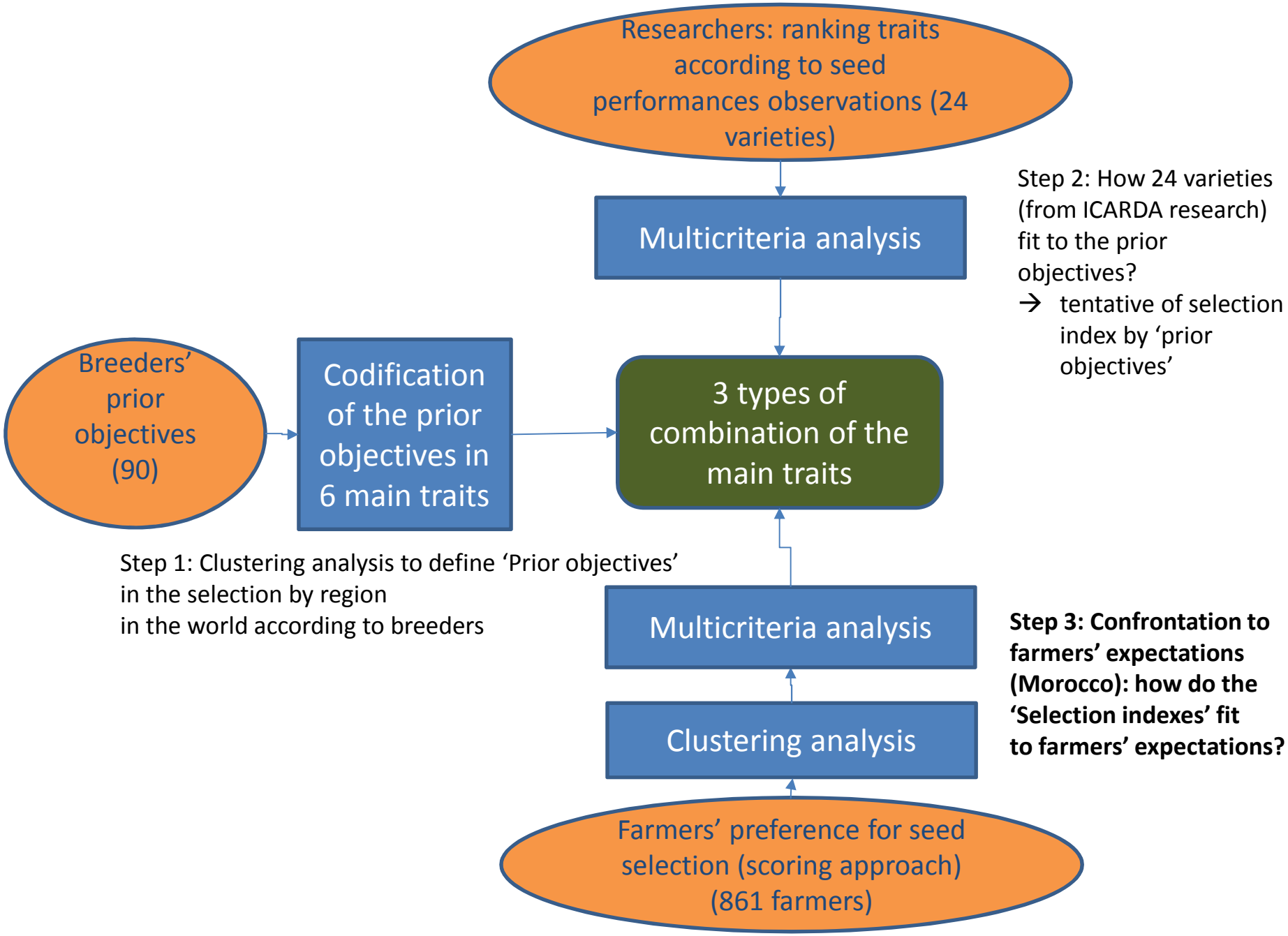
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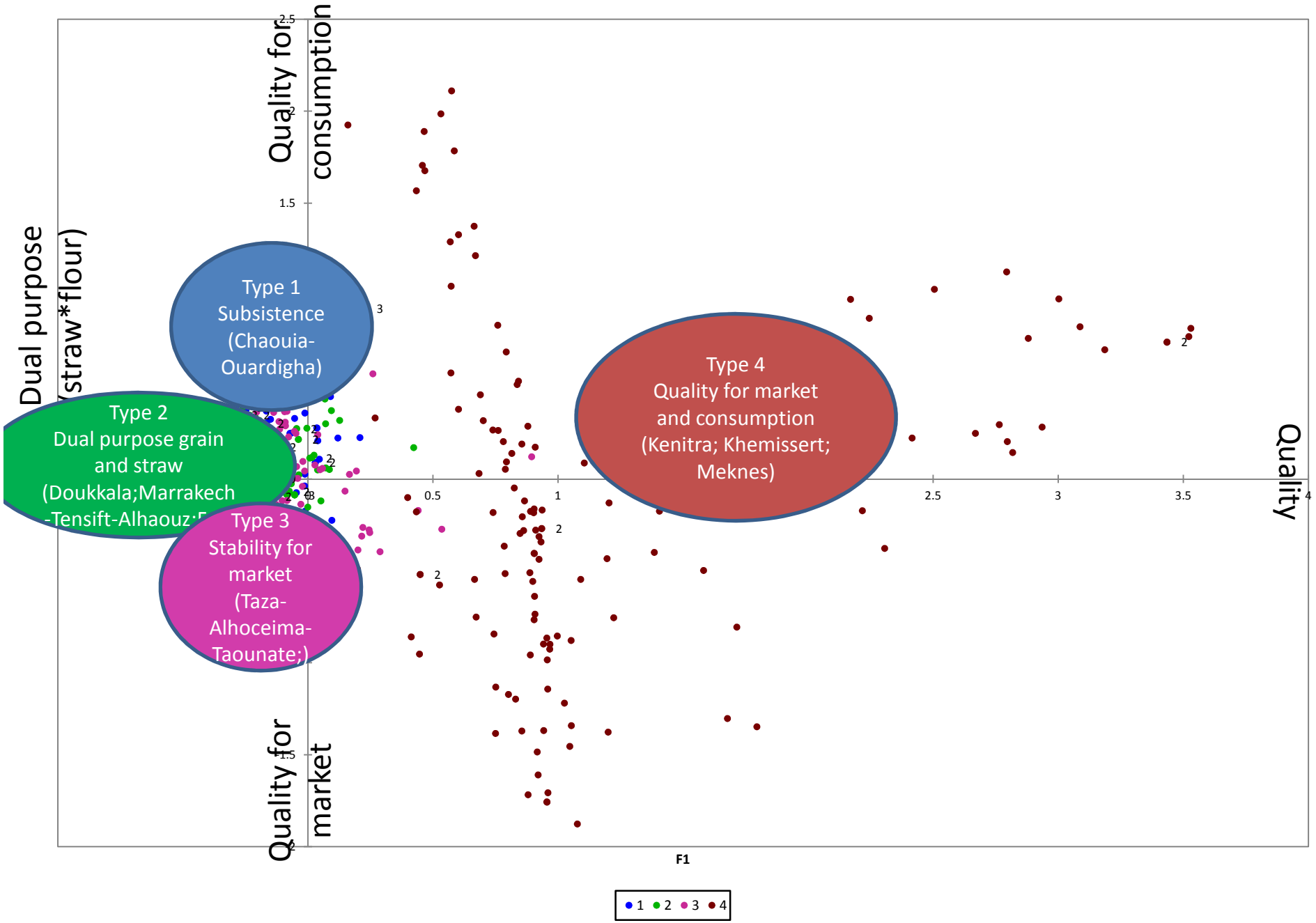
Step 3. Confrontation to farmers' selection system

- Sample: 861 farmers in Morocco
- Source: Yigezu,
- Questionnaire: score 1..10] to each criteria

no	Trait	N	Minimum	Maximum	Mean	Std. Deviation
1	Grain yield	832	1	10	8,94	1,404
2	Grain yield stability	340	1	10	7,84	1,759
3	Grain color	345	1	10	7,52	1,690
4	Guaranteed minimum yield	347	1	10	7,37	2,005
5	Grain size	276	1	10	7,19	2,034
6	Marketability (demand)	531	1	10	7,16	1,977
7	Taste for different dishes	208	1	10	7,15	2,072
8	Storability	133	1	10	6,92	2,190
9	Straw yield	556	1	10	6,91	1,852
10	Baking quality	210	1	10	6,86	2,554
11	Grain shape	217	1	10	6,82	2,313
12	Early maturity	230	1	10	6,70	2,018
13	Flour making quality	523	1	10	6,67	2,368
14	Drought tolerance	414	1	10	6,66	2,015
15	Tillering ability (wheat)	293	1	10	6,65	2,320
16	Less inputs demand (fertilizer)	72	1	10	6,60	1,969
17	Shattering tolerance	135	1	10	6,56	2,118
18	Bread making quality	304	1	10	6,55	2,216
19	Better grain price (MD/unit)	268	1	10	6,49	2,216
20	Palatability of straw	258	1	10	6,44	1,964
21	Cooking time (faba bean)	132	1	10	6,30	2,641
22	Water-logging tolerance	164	1	10	6,15	1,890
23	Disease tolerance	374	1	10	6,07	1,940
24	Other food making quality	134	1	10	6,03	2,849
25	Insect tolerance	153	1	10	6,03	1,930
26	Frost tolerance	146	1	10	5,71	1,876
27	Labor demand (for which ope	59	1	8	5,69	1,578
28	Threshability	88	1	10	4,68	2,087


Quality for consumption
Dual purpose (straw*flour)
Quality for market
Quality
F1
Type 1 Subsistence (Chaouia-Ouardigha)
Type 2 Dual purpose grain and straw (Doukkala;Marrakech -Tensift-Alhaouz;
Type 3 Stability for market (Taza-Alhoceima-Taounate;)
Type 4 Quality for market and consumption (Kenitra; Khemissert; Meknes)
1 2 3 4

Type	Subsistence system	Dual purpose grain and straw	Stability for market strategies	Mixed market-consumption obj.	Typo
Classe	Cluster 1 (198)	Cluster 2 (236)	Cluster 3 (291)	Cluster 4 (136)	Criteria
Region	Chaouia-Ouardigha;	Doukkala-Abda;Marrakech-Tensift-Alhaouz;Fes-Boulemane	Taza-Alhoceima-Taounate;Tadla-Azilal	Meknès-Tafilalet	
Seed	Karim; Markaz	Karim; Markaz; Crioca	Karim; Markaz; Saidi; Crioca	Karim; Markaz	
Minimum yield	6,909	1,742	1,278	6,757	Yield
Capacity	2,722	2,178	1,739	7,029	Yield
Grain yield	8,460	8,288	9,124	8,699	Yield
Maturity	1,732	1,483	2,017	6,551	Stability
Stability	5,338	2,064	2,162	7,463	Stability
Price	3,333	1,258	2,557	4,640	Quality
Shape	1,545	1,746	1,701	6,699	Quality
Marketing	4,465	1,508	6,656	7,037	Quality
Size	1,955	3,364	1,278	7,471	Quality
Color	1,182	3,720	3,162	7,926	Quality
Disease resistance	3,636	2,225	2,402	5,993	Biotic
Palatability	1,707	2,750	1,488	6,206	Adaptation
Bread making quality	1,798	3,267	1,938	6,294	Adaptation
Straw yield	3,747	5,250	4,069	7,235	Adaptation
Taste	1,015	1,614	1,859	7,485	Adaptation
Cooking quality	1,207	1,301	1,811	7,493	Adaptation
Flour quality	2,465	4,038	4,632	7,618	Adaptation
Drought tolerance	3,025	1,733	4,845	5,787	Abiotic

Confrontation of farmers' expectations and main 'breeders' types

Mean of farm rating for each main traits							Type 1 oriented to production and biotic stress resistant
Farmers cluster	Abiotic	Adaptation	Biotic	Quality	Stability	Yield	
Subsistence system	3	2	4	2	4	6	47
Dual purpose grain and straw	2	3	2	2	2	4	-17
Stability for market strategies	5	3	2	3	2	4	0
Quality for market-consumption obj.	6	7	6	7	7	7	99

This questions the system

- High variations of the weight in the selection index according to stakeholders (with different objectives/strategies)+ for farmers : high sensibility according to type of interviews

- The Breeders ' prior objectives related to seed traits varies according to the agro-climatic conditions of each zone but also the national objectives in terms of food self-sufficiency and agro-industrial capacity;

- The farmers' expectations about seed traits varies according to the farming systems and family asset→ quality criteria for market or self consumption, criteria of adaptation (dual purpose), etc..

- How to consider the diversity of demand? The clustering approach can help to analyze the diversity…

Some parameters to go further…

- Who are these smallholder farmers? (size)
- What are their main strategies? Family food security (yield*baking quality); market sale (industrial quality); by products grazing?
- What are the main biotic and abiotic stresses? (frequency; intensity; trend…/ agro-climatic zone)
- What the main demand and policies orientation for this product? → future change

Main challenges/ compromises:

- Ag policies: Between agriculture (for production) and food security (availability & quality & accessibility)
- Development: Between 'food system' at territorial level and 'value chain' at national level
- Global changes: Multi-functionality of agriculture (adaptation) and environmental changes (stability)