Drought impacts in small-scale farming community: Opinion from Global and Local contexts

Management of Disaster Risk and Societal Resilience (MADIS)

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Introduction

- Management of Disaster Risk and Societal Resilience (**MADIS**) → internationally-funded project through **Belmont Forum** and **EPSRC.**
- The UK team is headed by Professor Nazmiye Ozkan at **Cranfield University.** Our project partners are at **Pennsylvania State University** (Prof Mike Jacobson & Prof Abdullah Konak), the **University of Sao Paulo** (Professor Adelaide Nardocci)
- Local collaborators in **Morocco**, **South Africa**, and **Turkey**.

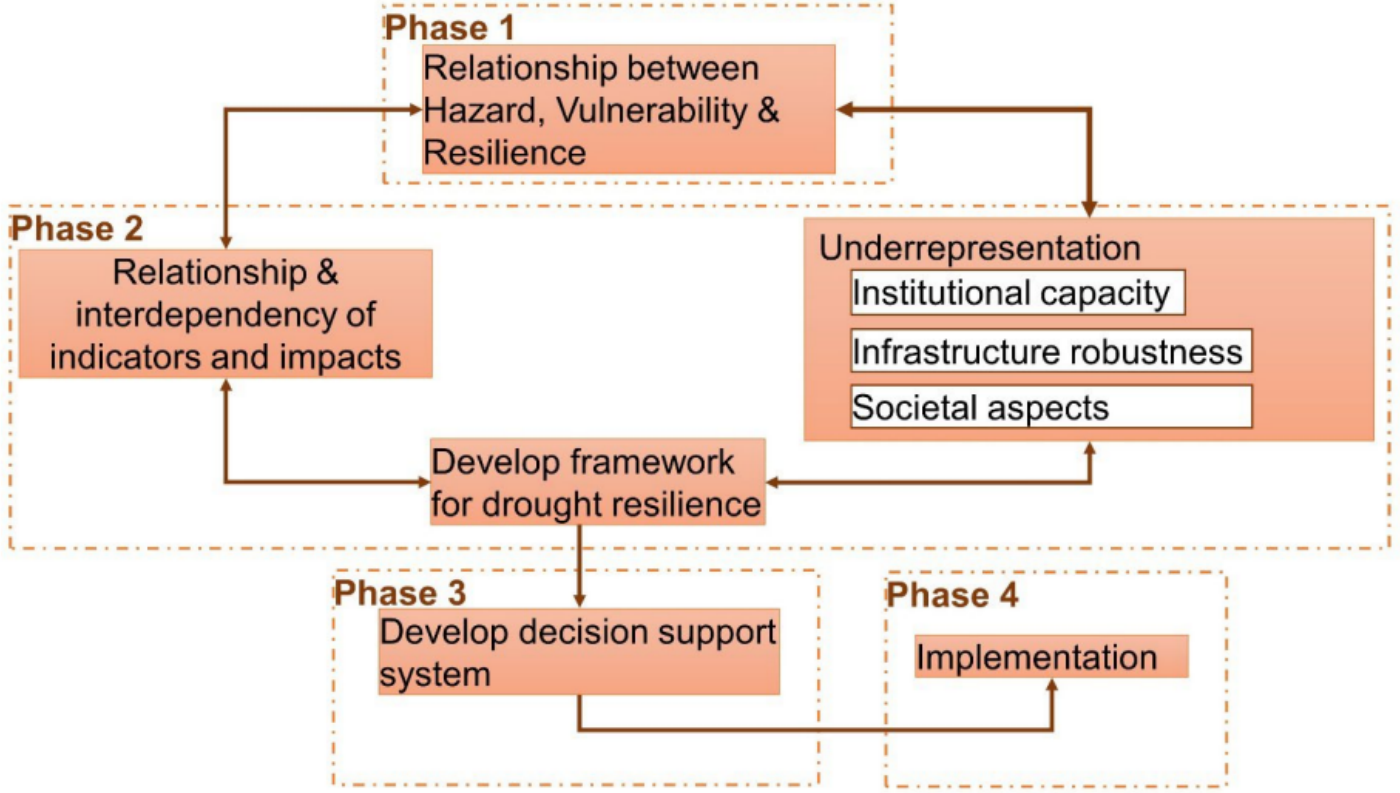
Aim and Objectives of MADIS

Aim: To improve insights into the interaction and interdependencies between→

←different risk, resilience, and vulnerability indices→

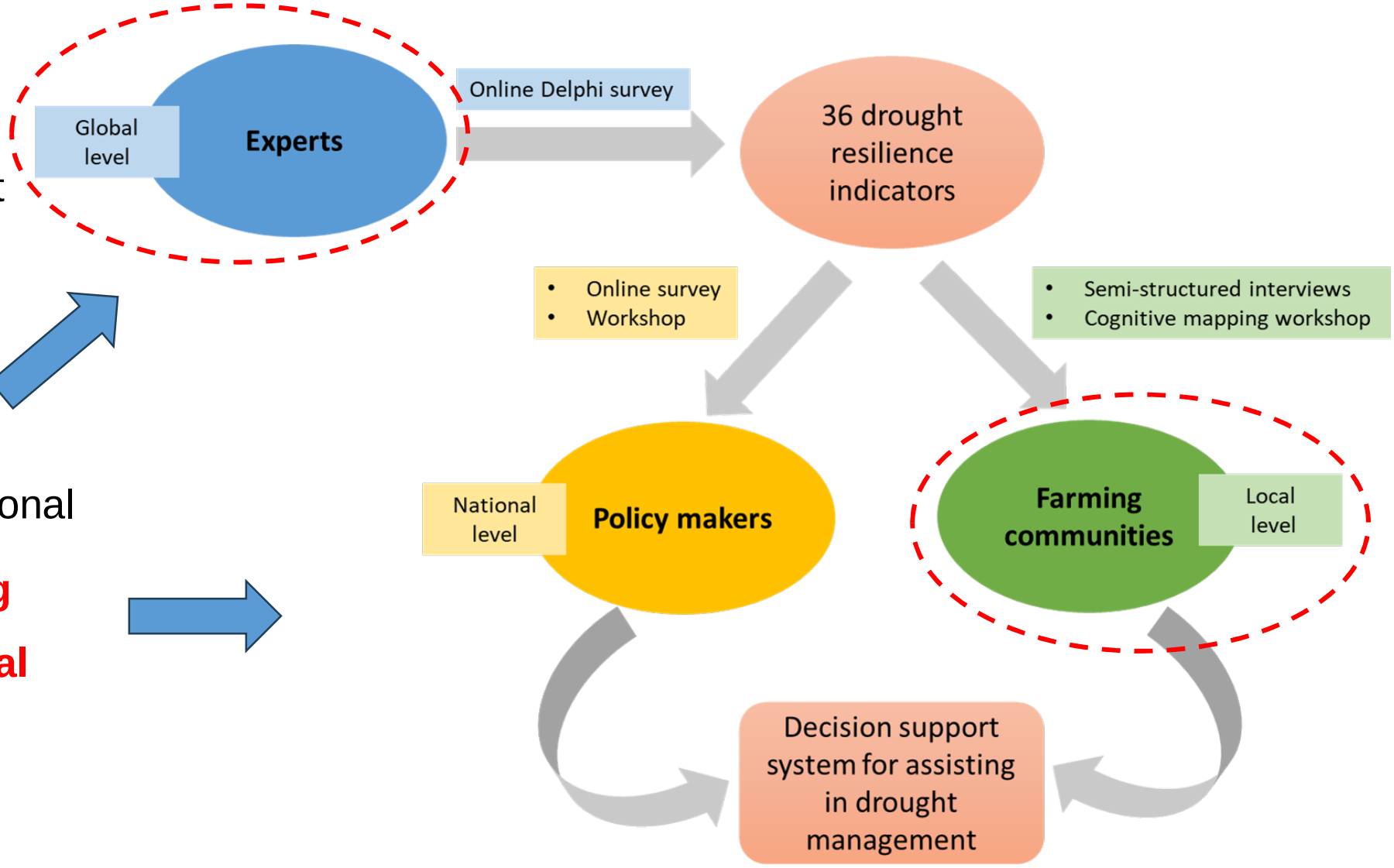
←relationship to the impacts of droughts and evolution of infrastructure systems.

- Relationship between **drought hazard**, **vulnerability**, and **resilience**
- Role of **institutional**, **infrastructural**, and **societal** dimensions to improve drought resilience
- Linkage between droughts **indicators** and the impacts
- Drought management using **socio-technical tools** for decision making



MADIS Activities

- MADIS looks at drought indicators from different perspectives.
  - **Experts—Global**
  - Policy makers—National
  - **Small scale farming communities—Local**



Part A

Relevance of agricultural drought vulnerability and resilience indicators for small farms—*Experts' POV*

Background

- Drought is often referred to as a “creeping hazard”
- Frequency and severity of drought events are also increasing
- Looking towards→ drought resilience, a multidimensional framework
- Gap in understanding the specific drought vulnerability and resilience indicators

Rationale

- Indicators → measurable quantities that guide decision-making process
- Existing literature → myriad of indicators
- Differing opinion→ based on ‘perspective’, ‘lens’ or ’categories’
- No answer to question: “Which indicators are important for indicator-based decision-making from different lenses?”
- might be crucial for decoding the importance attached to individual indicators→ Experts’ POV

“The burden of choice”

Methodology

Step 1

- 36 indicators chosen for Delphi survey

Category	Responses received	Final responses considered
Relevancy	326	134
Understanding	326	125
Accessibility	326	115
Objectivity	326	117
Temporal	326	100

Step 2

- All indicators assessed from the lens of 5 categories

- Relevancy
- Understanding
- Accessibility
- Objectivity
- Temporal

Step 3

- Principal Component Analysis (PCA)— identify underlying constructs

- Which indicator associate with what constructs?
- Which indicator did not belong with any construct?

Global Online Delphi Survey with Experts

- Delphi survey in two parts—this work is from the first part.
- Each indicator → evaluated in terms of **‘’categories”** :relevancy, easy of understanding, data accessibility, data objectively, data consistency over time.

- Scale: low, medium, high, and don’t know.

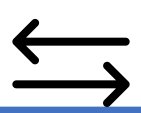
Resilience

Type	Indicators
Agricultural (crop)	Cultivation of drought-resistant crops (%)
Agricultural (crop)	Farmers use different crop varieties (%)
Agricultural (land)	Land rights clearly defined (yes/no)
Government & policy	Existence of drought management policies
Government & policy	Technical assistance from local entities
Government & policy	Farmers with crop, livestock or drought insurance (%)
Government & policy	Water use rights clearly defined
Infrastructure & Technology	Availability of drought prediction and warning systems or climatic predictions
Infrastructure & Technology	Transportation network
Infrastructure & Technology	Access to electricity (Acess to energy)
Socioeconomic	Food source reliability and diversity
Social	Public participation in local policy
Social	Participation in farming cooperatives or associations
Socioeconomic	Access to financing and credit
Water/stream	Integrated land and water management policies
Water/stream	Percentage of retained renewable water
Water/stream	Total dam capacity

Vulnerability

Type	Indicators
Agricultural (crop)	Percentage of participation of crop and livestock production in the income of smallholder farming
Agricultural (crop)	Crop Damage & Sensitivity (Crop Loss)
Agricultural (general)	Area protected and designated for the conservation of biodiversity (%)
Agricultural (general)	Use of Insecticides and pesticides (Use of agricultural inputs)
Agricultural (general)	Crop water use efficiency (WUE)*
Agricultural (land)	Degree of land degradation and desertification*
Social	Prevalence of conflict/insecurity
Social	Population without access to (improved) sanitation (%)
Social	Gender inequality (categorical)
Social	Rural population (% of total population)
Socioeconomic	Unemployment rate (and/or proportion of formal work)
Social	Population ages 15-64 (% of total population)
Social	Percentage of population displaced internally or transboundary
Social	Presence of drivers of migration and displacement
Socioeconomic	Poverty Rate
Socioeconomic	% of the population employed in small farms
Water/stream	Baseline water stress (ratio of withdrawals to renewable supply)
Water/stream	Water quality
Water/stream	Groundwater level/sources

Questionnaire “categories”



Relevancy

- **LOW:** The indicator is not clearly connected to a policy objective.
- **MEDIUM:** The indicator is understood by most decision-makers with some clarification.
- **HIGH:** The indicator conveys useful, relevant information for decision-makers on a specific policy objective.

Ease of Understanding

- **LOW:** The indicator may be interpreted differently by various decision-makers.
- **MEDIUM:** The indicator is understood by most decision-makers with some clarification.
- **HIGH:** The indicator is readily understood by decision-makers.

Data Accessibility

- **LOW:** Collecting and processing the data requires significant time and effort.
- **MEDIUM:** The indicator data is mostly available, but processing the data requires some effort.
- **HIGH:** The indicator data is publicly accessible and readily available. Processing the data requires minimal effort.

Objectivity

- **LOW:** May require expert judgment to evaluate the indicator.
- **MEDIUM:** Requires some degree of expert judgment to interpret quantitative or qualitative data.
- **HIGH:** An objective measure is based on quantifiable, impartial, and recorded data.

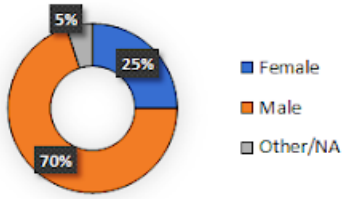
Temporal Availability

- **LOW:** The indicator data is collected in an ad-hoc manner, limiting the ability to monitor the indicator over different temporal scales.
- **MEDIUM:** The indicator data is collected periodically but not frequently enough for comparing the indicator in different temporal scales.
- **HIGH:** The indicator data is available over different time scales.

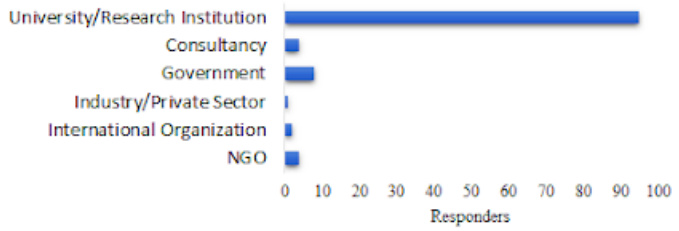
Demographical Overview

Primary information

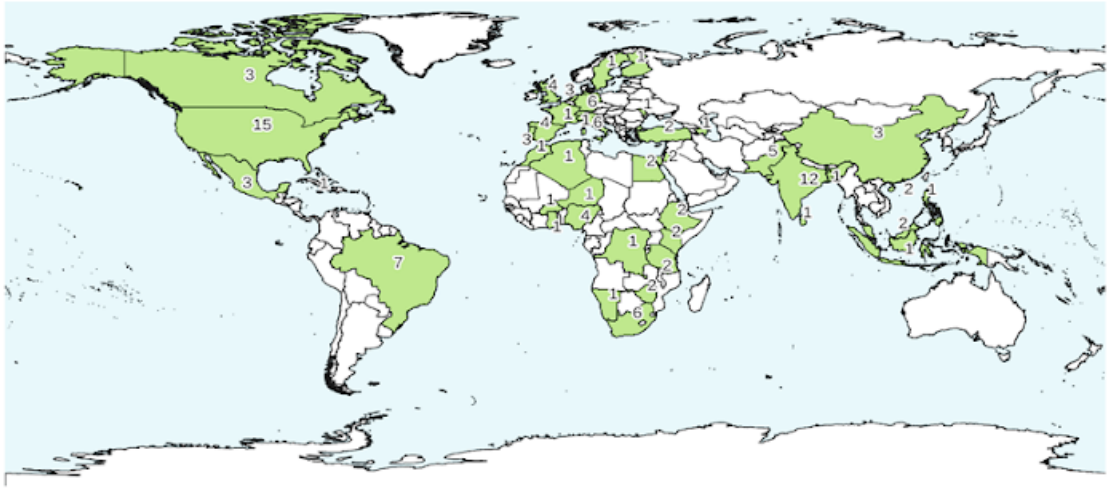
Gender



Institution of (primarily) work

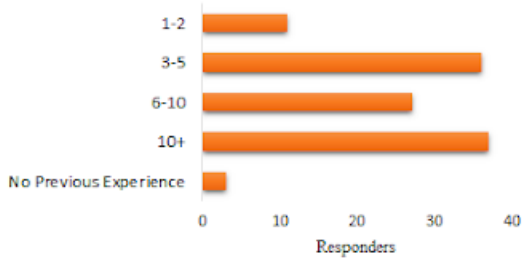


Location

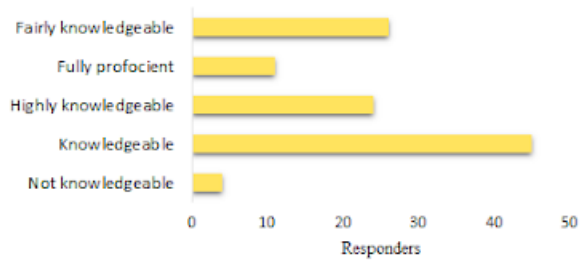


Expertise in drought

Years of experience working on drought

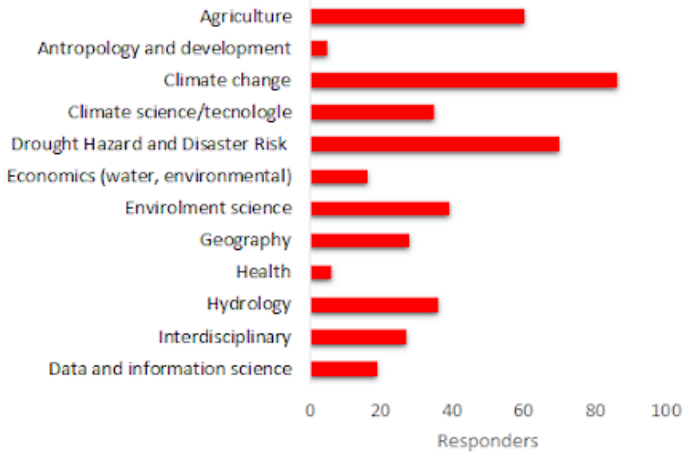


Level of expertise in disaster risk/resilience

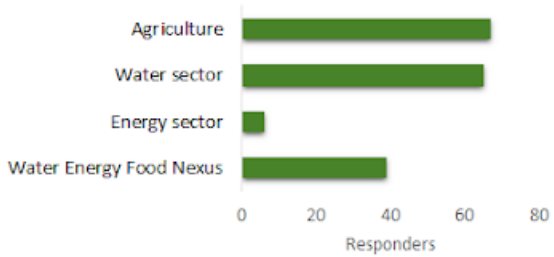


Areas and sectors of expertise

Area of expertise

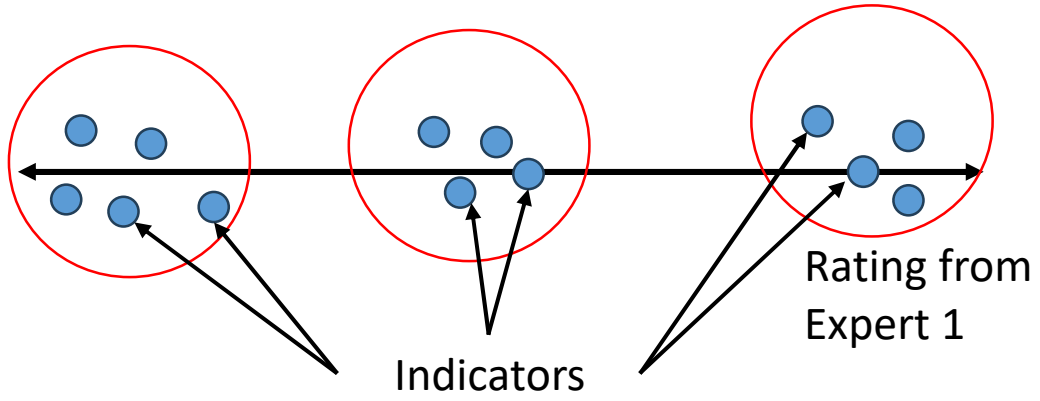


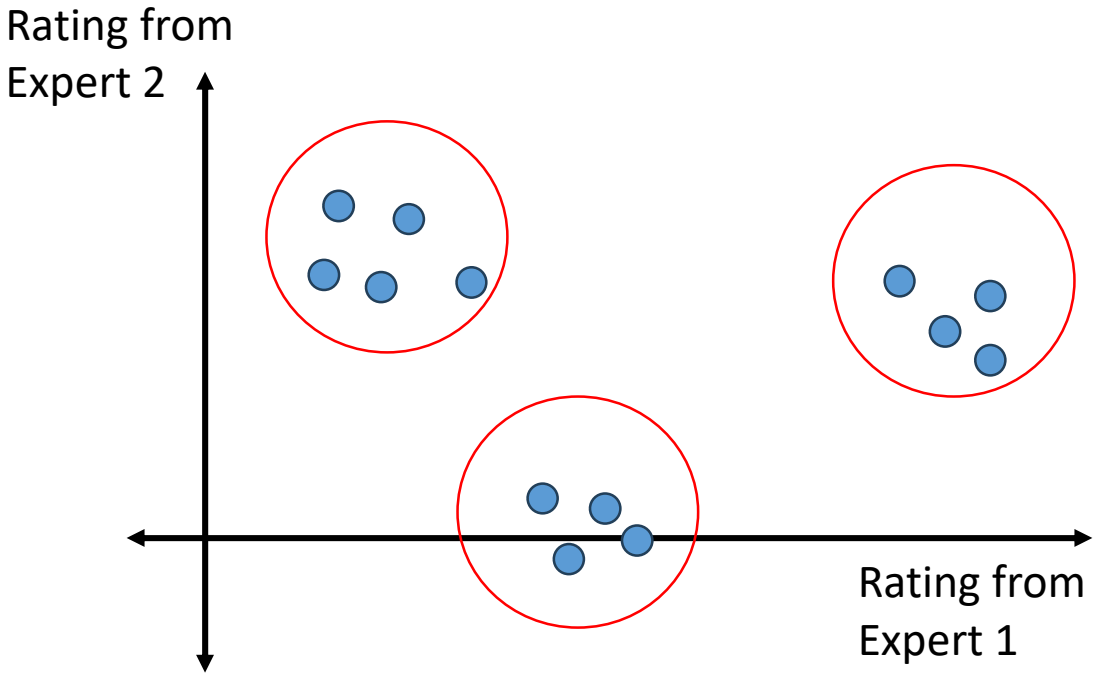
Sector of expertise



Principal Component Analysis (PCA)

- Before jumping to PCA → how can we reduce variable without any technique?
- Our case → Variables = 36 indicator, measurement for grouping = rating from experts
- For one expert → possible to group similar ratings
- For two & three experts → graphically possible to group





Principal component analysis (PCA)

- But not possible for >3 experts—graphically
- PCA: Technique for reducing/ consolidating variables in a dataset
- Basis to reduce/ consolidate→ correlation among indicators
- Transforms original variables into new variables (PC)→ As many PC as indicators but no correlation among themselves
- Overall strength of each PC = “Eigen Value”
- Strength of each indicator in one PC = “Loading”

PC = a1*X1 + a2*X2 + ……. (rating for indicator #36)

Correlations among responses – ‘Relevancy’ category

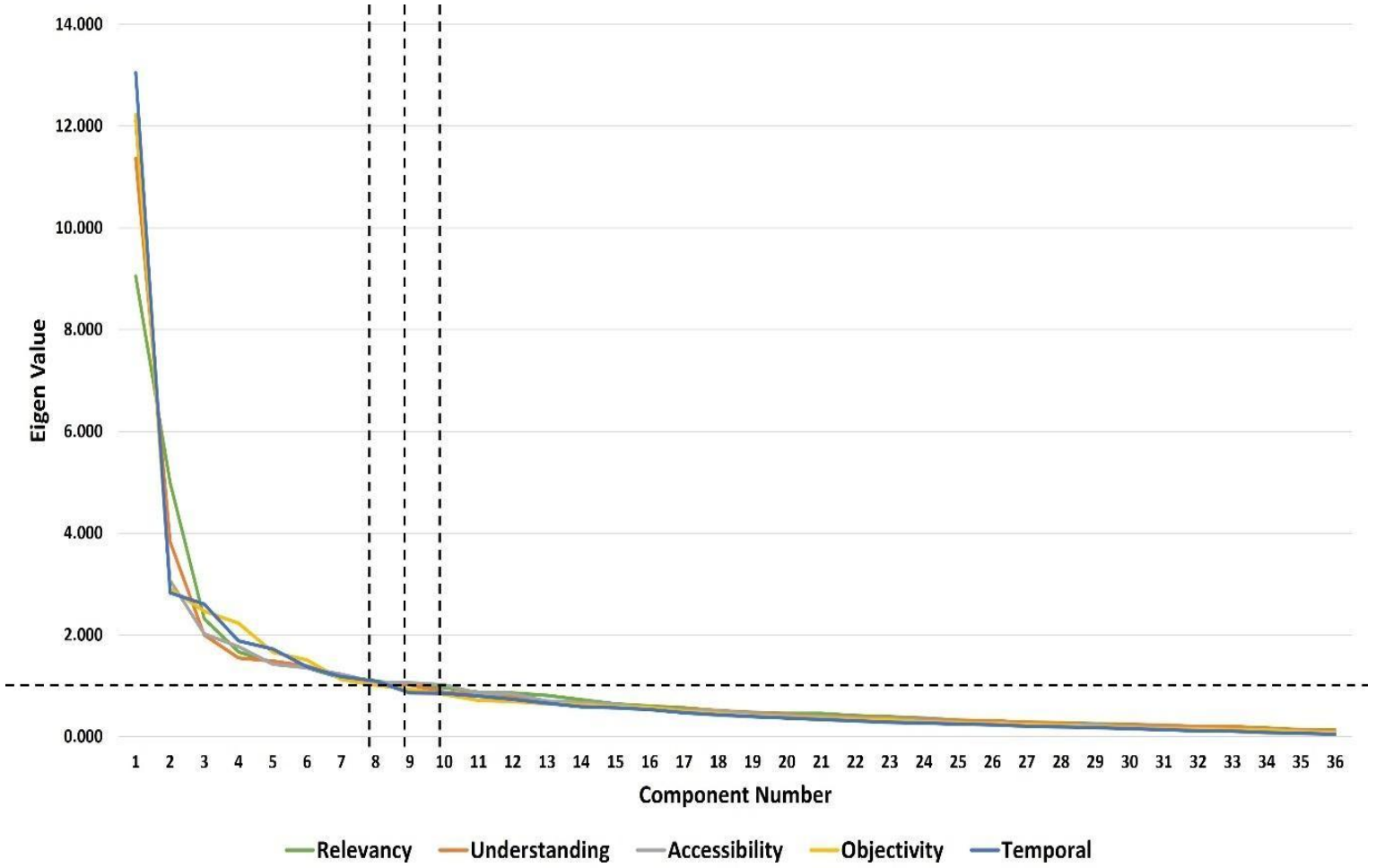
- Certain indicator pairs were moderately (and positively) correlated across all indicator categories
- The correlation values of these indicator pairs ranged between 0.468 to 0.711 with a majority of this pair having a value more than 0.6 across all categories

Lowest correlation – Percentage of the rural population vs. Unemployment rate = 0.468

Highest correlation – Integrated land and water management policies & Percentage of retained renewable water = 0.711

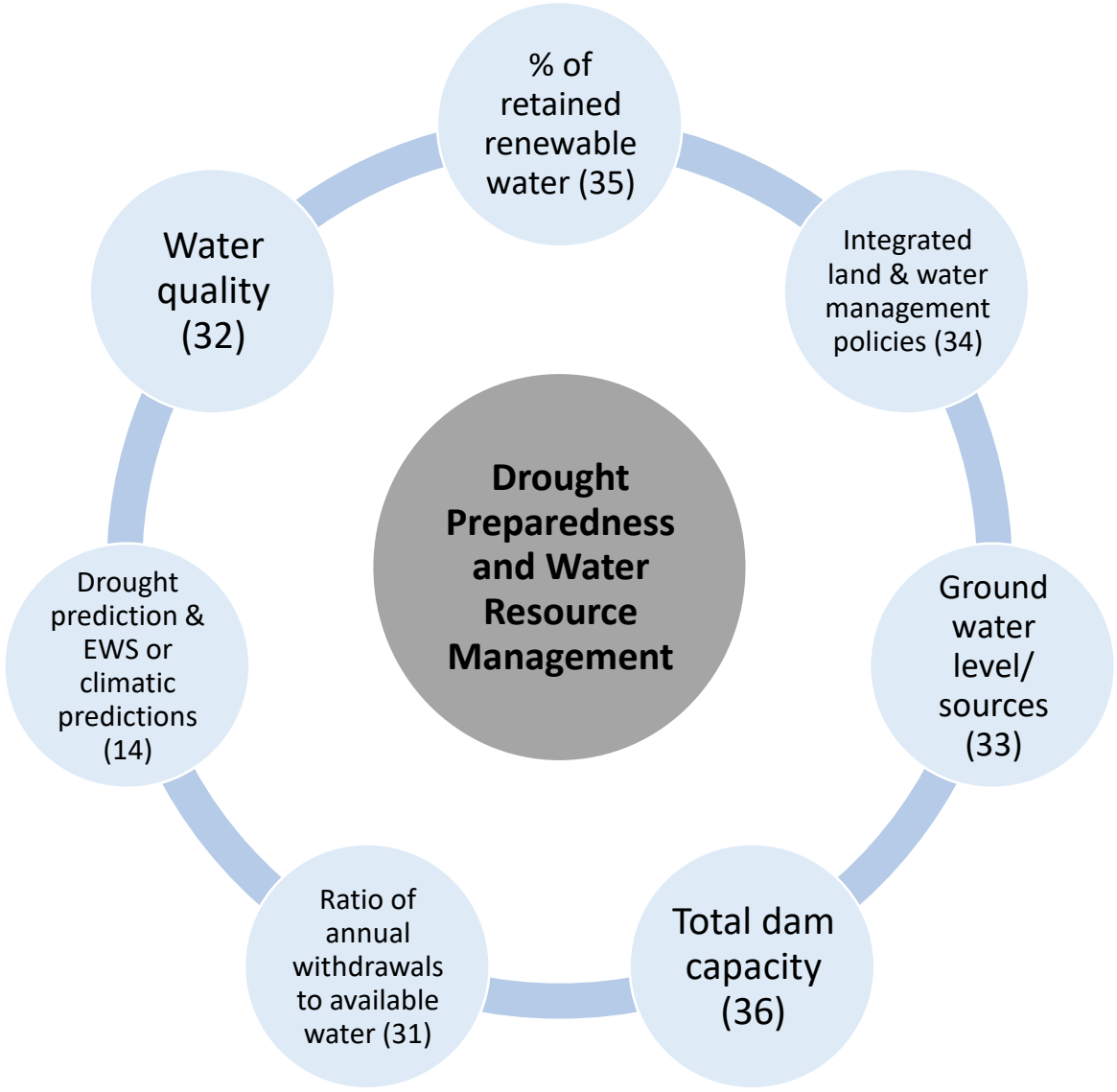
Study Results – Principal components derived

- To identify number of principal components ‘scree plot’ is used → all PC eigen values > 1 are retained
- 8 PCs for ‘Objectivity’ & ‘Temporal’
- 9 PCs for ‘Relevancy’ and ‘Understanding’
- 10 PCs for ‘Accesssibility’
- Each PC were associated with certain indicators → Each component can therefore be given a common ‘name’ associated with the indicators



Study Results – Principal component naming

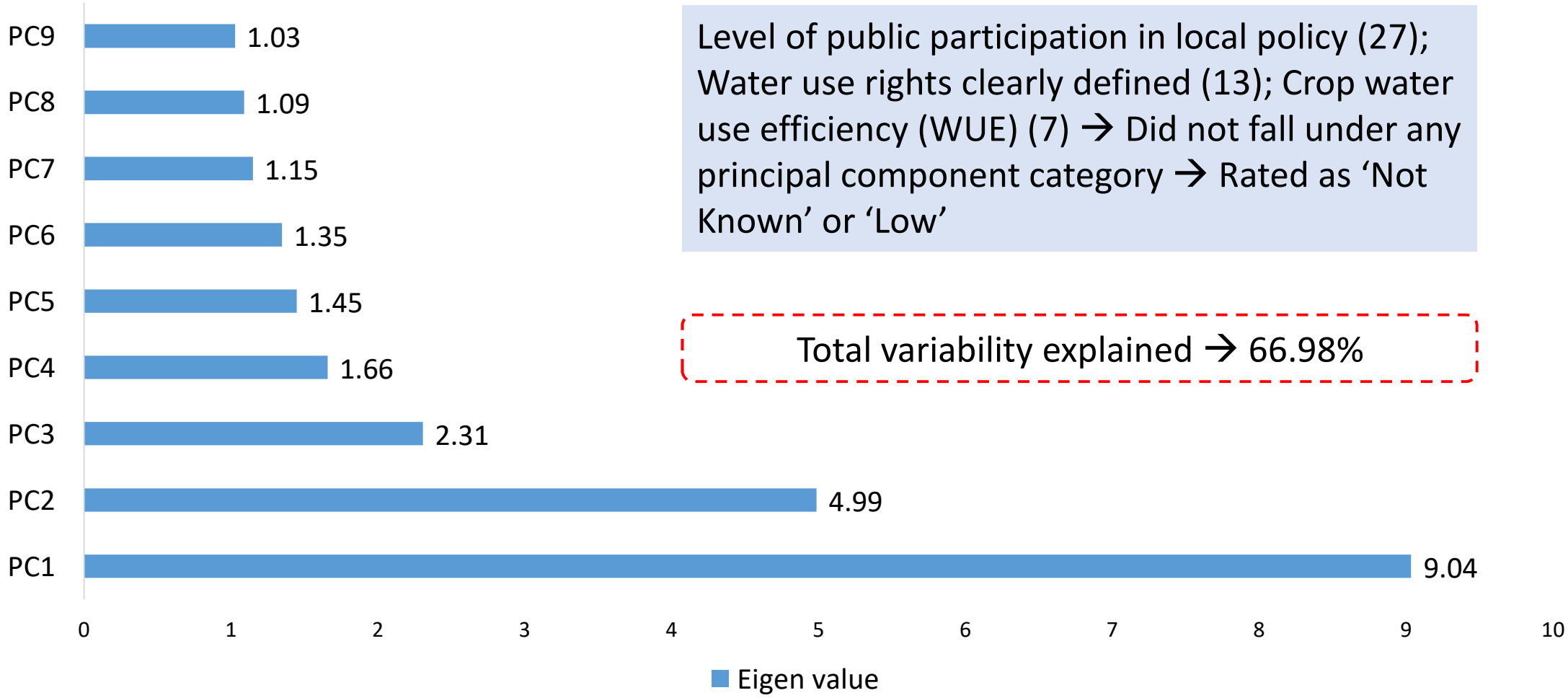
- Example→ **‘Relevancy’ PC1**
- Eigen Value= 9.04
- Name: **Drought Preparedness and Water Resource Management**
- No. of indicators: 7
- Benefit → Individual indicators become viewed within the component (water-cycle management) as a whole rather than in isolation



Study Results – Principal component naming

- Example→ **‘Relevancy’ PC2**
- Eigen Value= 4.99
- Name: **Socioeconomic and Agricultural Development**
- No. of indicators: 4

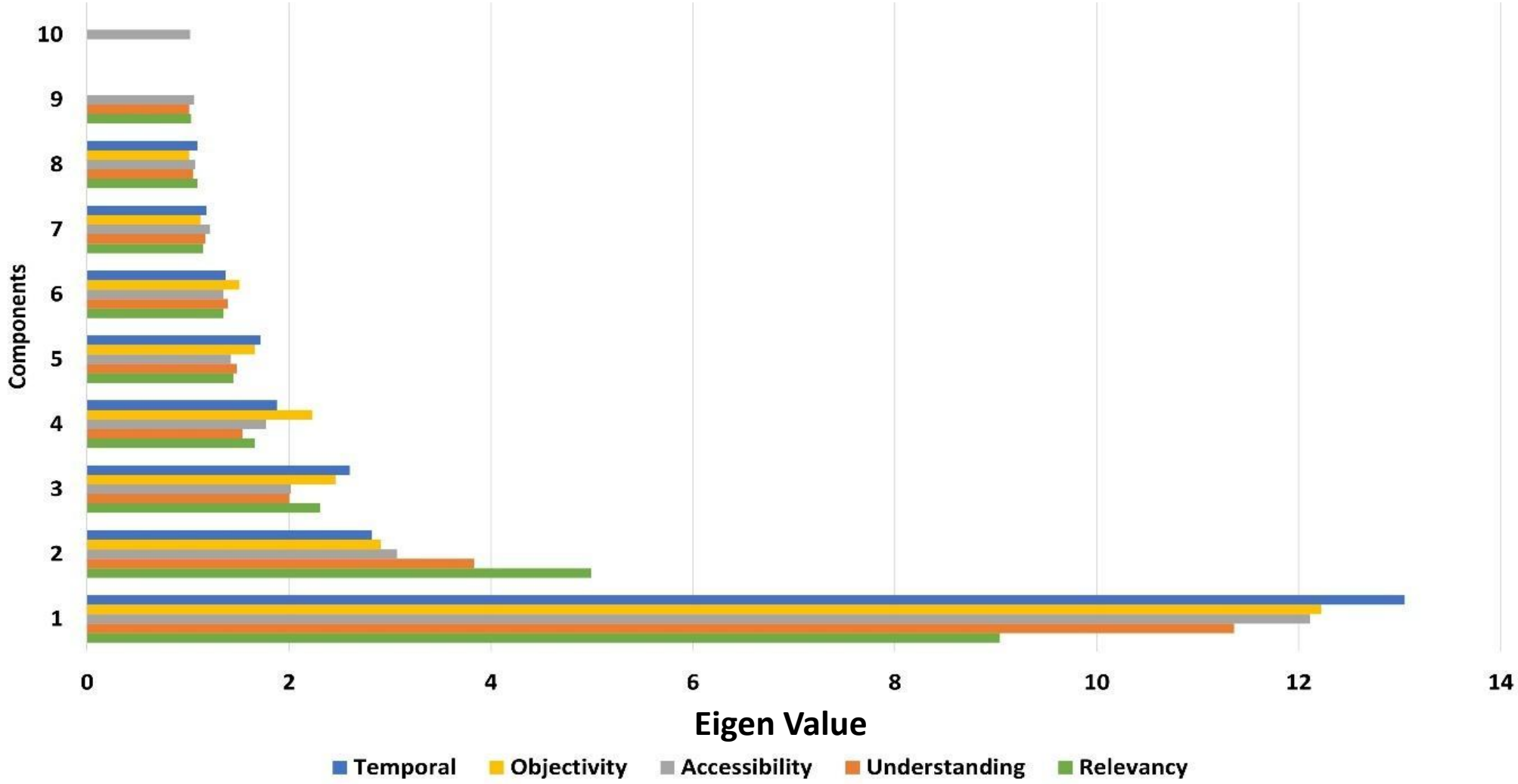
Study Results – Other principal components



Level of public participation in local policy (27); Water use rights clearly defined (13); Crop water use efficiency (WUE) (7) → Did not fall under any principal component category → Rated as 'Not Known' or 'Low'

Total variability explained → 66.98%

Study Results – All categories



Discussion – Indicators common across PCs

Principal Component 1 across all categories

Comp.	Indicators	R	U	A	O	T
Integrated water management	Crop water use efficiency (WUE) (7)					
	Degree of land degradation and desertification (8)					
	Availability of drought prediction and warning systems or climatic predictions (14)					
	Participation in farming cooperatives or associations (28)					
1 ✓	**Ratio of annual withdrawals to available water (31)**					
✓	**Water quality (32)**					
✓	**Groundwater level/sources (33)**					
	Integrated land and water management policies (34)					
✓	**Percentage of retained renewable water (35)**					
	Total dam capacity (36)					

- Most relates to water
- 4 most influential indicators—"must-haves"
- Intuitive

Indicator appearing across all 5 categories
Indicator appearing across any 4 categories
Indicator appearing across any 3 categories
Indicator appearing across any 2 categories

Discussion – Indicators common across PCs

- As eigen value decrease→ common indicators also decrease
- 3 indicators across ‘accessibility’, ‘objectivity’, ‘temporal’
- Data is available, historically as well as easily quantifiable—”planning and policy levers”

Principal Component 2 across all categories

Comp.	Indicators	R	U	A	O	T
	Percentage of the contribution of crop and livestock production in the income of smallholder farming (1)					
	Crop loss (2)					
✓	**Percentage of drought-resistance crop varieties cultivated (3)**					
✓	**Percentage of farmers who use different types of crops (4)**					
	Percentage of area protected and designated for the conservation of biodiversity (5)					
✓	**Use of agricultural inputs (e.g., insecticides, pesticides, fertilizer, machinery) (6)**					
2	Existence of drought management policies (mitigation/adaptation/prevention/preparedness) (10)					
sustainable agricultural development	Percentage of farmers with crop, livestock, or drought insurance (12)					
	Water use rights clearly defined (13)					
	Poverty Rate (25)					
	Food source reliability and diversity (26)					
	Level of public participation in local policy (27)					
	Participation in farming cooperatives or associations (28)					
	Access to financing and credit (30)					

Discussion – Indicators common across PCs

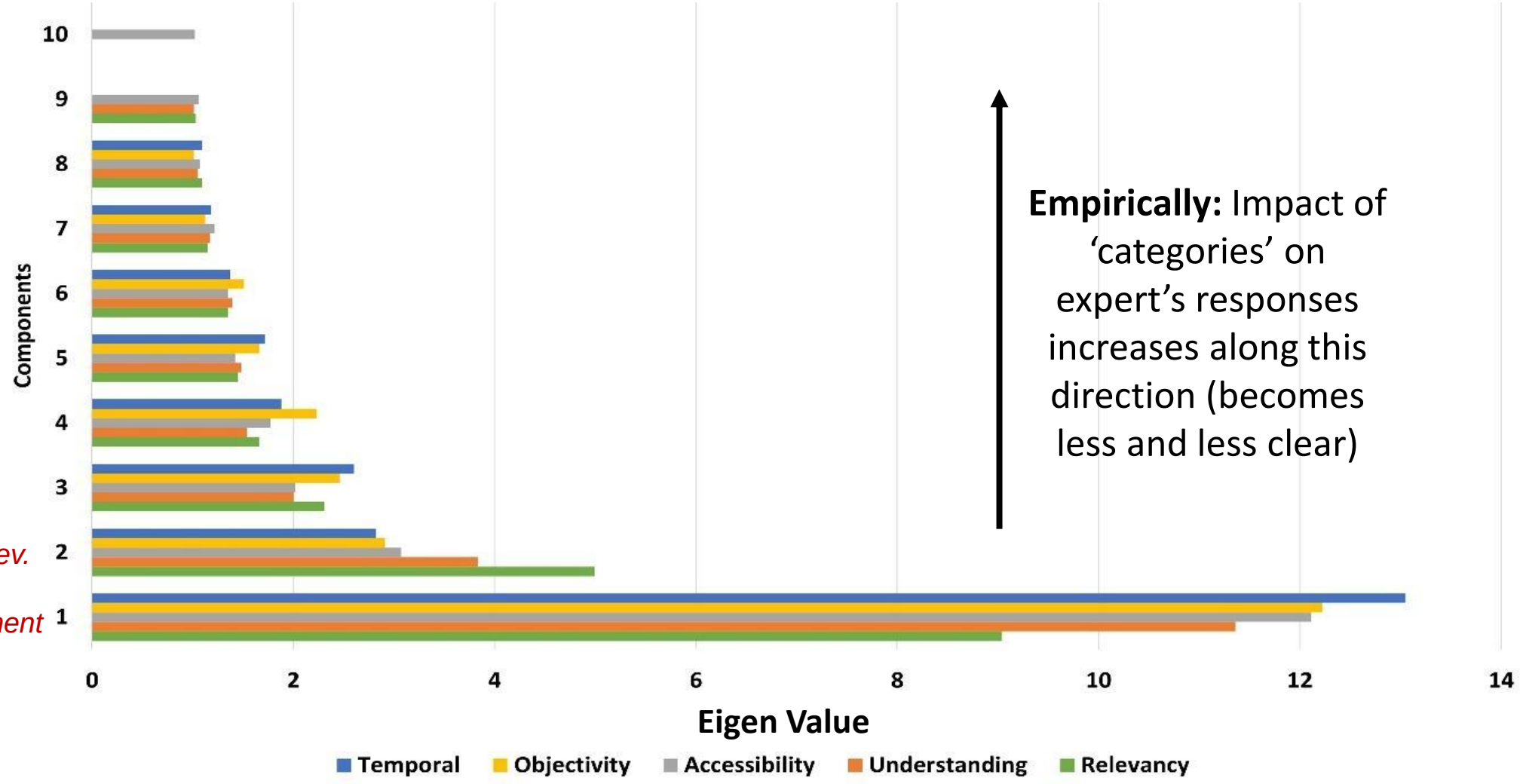
Different and non-overlapping themes

Economic opportunities

Rural governance

Sustainable agricultural dev.

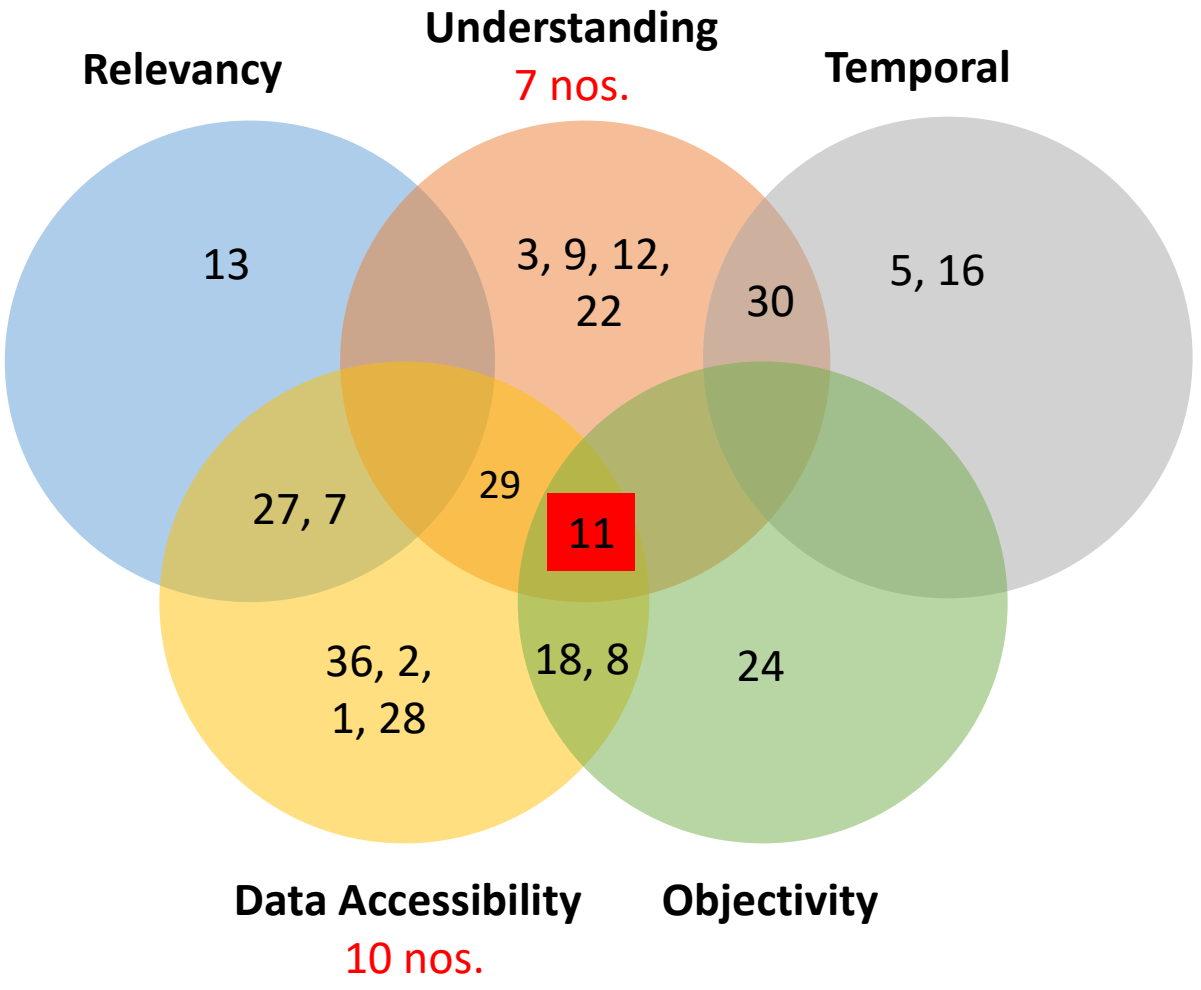
Integrated water management



Empirically: Impact of 'categories' on expert's responses increases along this direction (becomes less and less clear)

Discussion – Indicators that do not relate to any PC

- ‘Understanding’ and ‘accessibility’ → max. no. of indicators that did not include any PC
  - Because → indicators interpreted differently by experts
  - Indicator data not easily accessible or available, as best known by the experts
- Technical assistance from local entities (e.g., cooperatives/NGO/government) (11) → does not fall under any of the three categories
  - Because → data on the provision of technical assistance from local entities is qualitative, less understandable, if the data exists it is not accessible to all
  - But → indicator is relevant and can be collected at different temporal scales



Conclusion

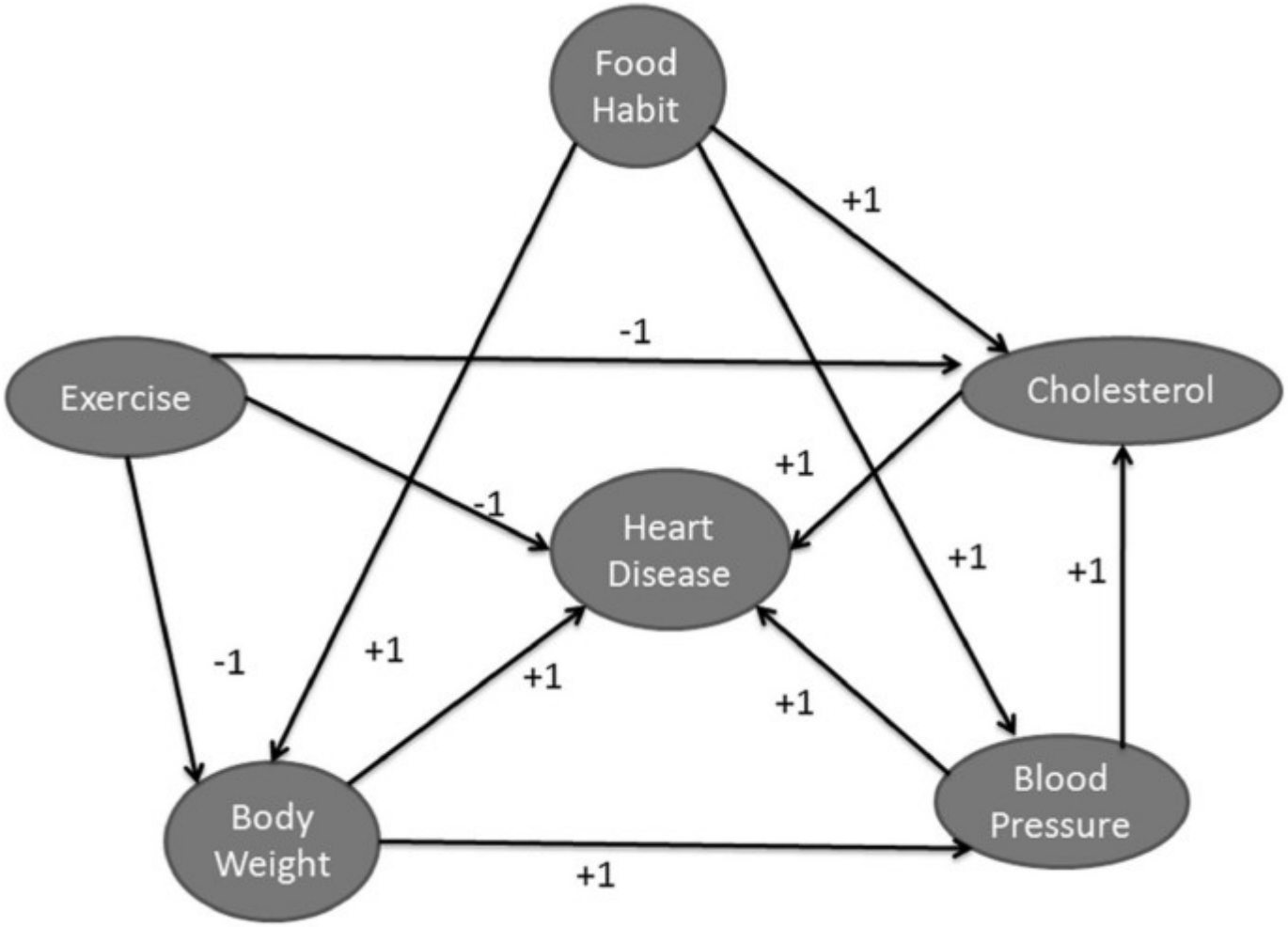
- **Not all indicators** are influential and usable for the policy makers
- **“Must-have”** indicators (influential and usable across all ‘categories’):
  - Ratio of annual withdrawals to available water (31)
  - Water quality (32)
  - Groundwater level/sources (33)
  - Percentage of retained renewable water (35)
- **“planning and policy levers”** indicators—highly objective, accessible and temporally available
  - Percentage of drought-resistance crop varieties cultivated (3)
  - Percentage of farmers who use different types of crops (4)
  - Use of agricultural inputs (e.g., insecticides, pesticides, fertilizer, machinery) (6)
- Impact of ‘categories’ increases on experts’ responses→ less number of common indicators in each category→ In other words, indicators associated with low Eigen value are less influential and usable
- Indicators that did not relate with any PC across many category can be removed from use→ E.g. Technical assistance from local entities (e.g., cooperatives/NGO/government) (11)

Part B

Learnings from small scale farmers in Morocco

Introduction to Fuzzy Cognitive Mapping (FCM)

- What is Fuzzy Cognitive Mapping?
- A type of mental modelling → translated to pen and paper
- Example →
- Captures cause-effect relationships and dynamic interactions through ‘maps’
- Useful in capturing complex systems, people’s perception, and where data is limited



FCM in Morocco

- Conducted in Morocco, South Africa, Turkey
- Used to capture views on the connectivity between indicators showcasing → impacts of drought and adaptation to drought
- Most important and most linked indicators → views from male and female groups → separately

Indicators

Impacts

Indicators
• Loss of crops
• Reduce levels of groundwater
• Sale of livestock
• Soil degradation
• Reduced availability of nutritious food
• Reduced water quality
• Reduced investment possible in fertilisers, seeds, machinery
• Migration away from the area
• Increased poverty and unemployment
• Increased gender inequality
• Change in energy needs (more or less?)

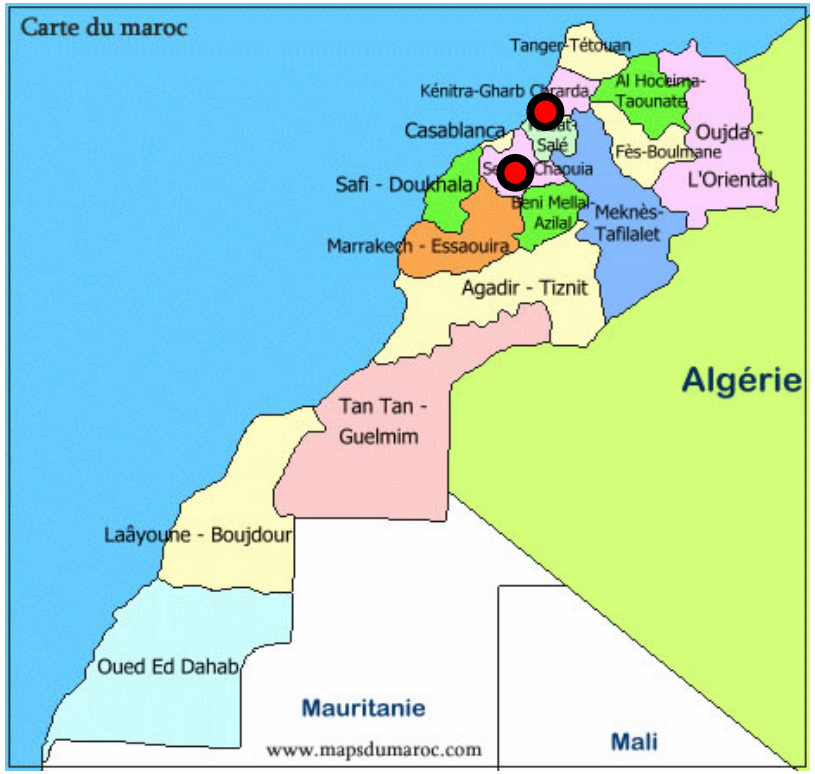
Adaptation

Indicators
• Government policies on drought for small farmers
• Drought prediction and early warning systems
• Advice and coaching on new techniques and technology
• More water re-use or more efficient irrigation
• Higher % of drought resistant crops cultivated
• Access to insurance, finance or credit
• Access to fertilisers or machinery
• Access to (more) energy
• Participation in local farming co-operatives
• More local land set aside for conservation and biodiversity
• Improved produce storage and transportation capacity

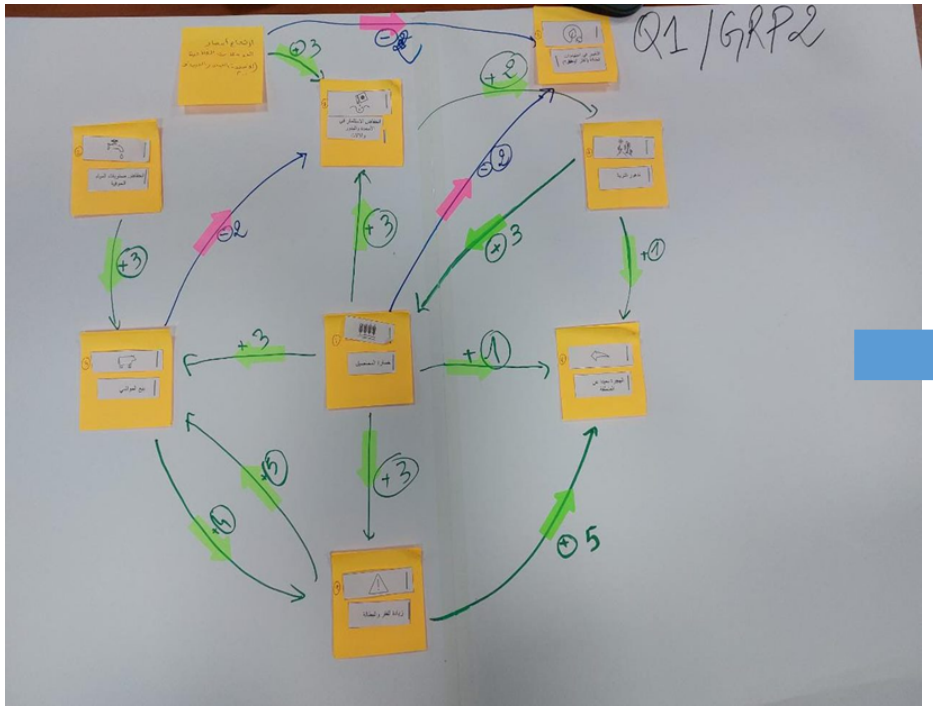
Participants

- Teams from CU and UM6P
- Workshop conducted in two locations of Morocco
- Members from Al Moutmir, an NGO supporting farmers, also present as facilitators

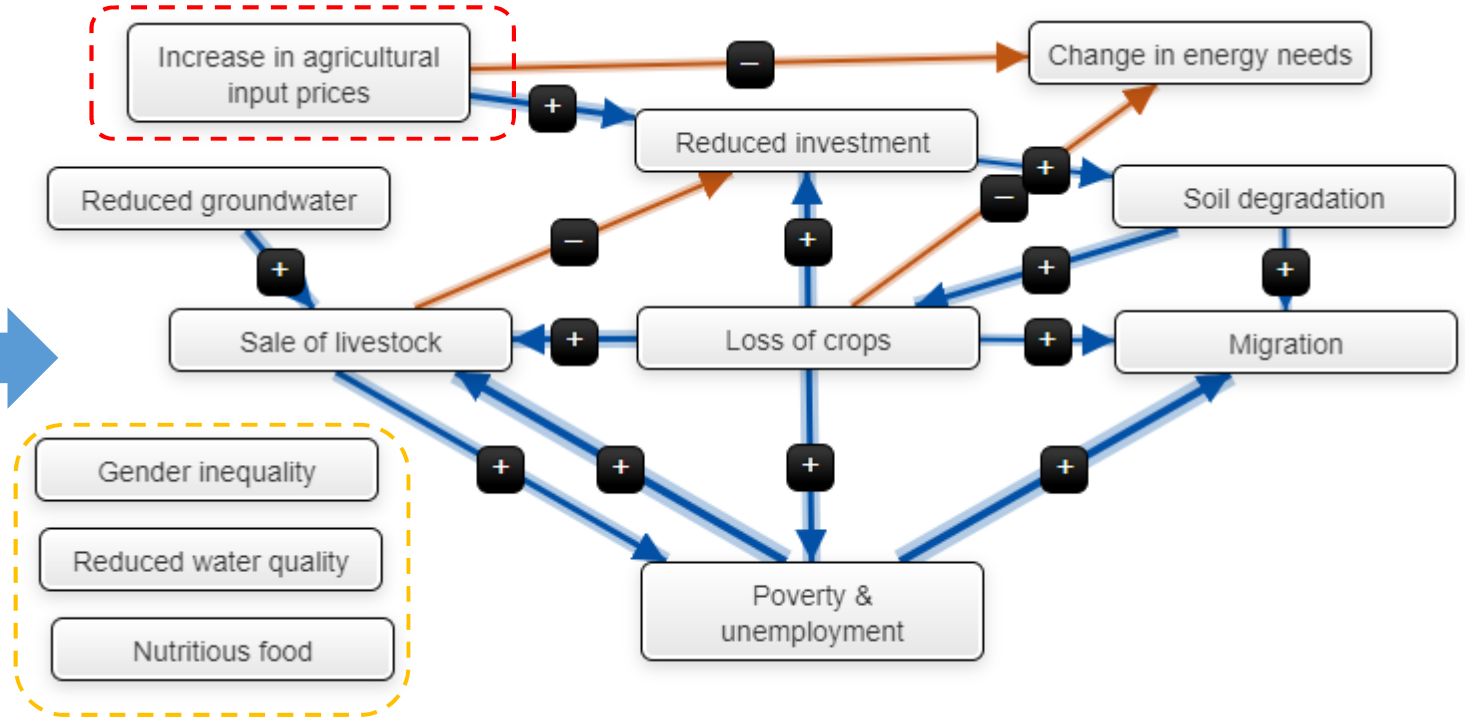
Settat (n=10)	**El Jadida (n=16)**
Male = 4 + 4	Male = 6 + 6
Female = 2	Female = 4



Mapping Responses

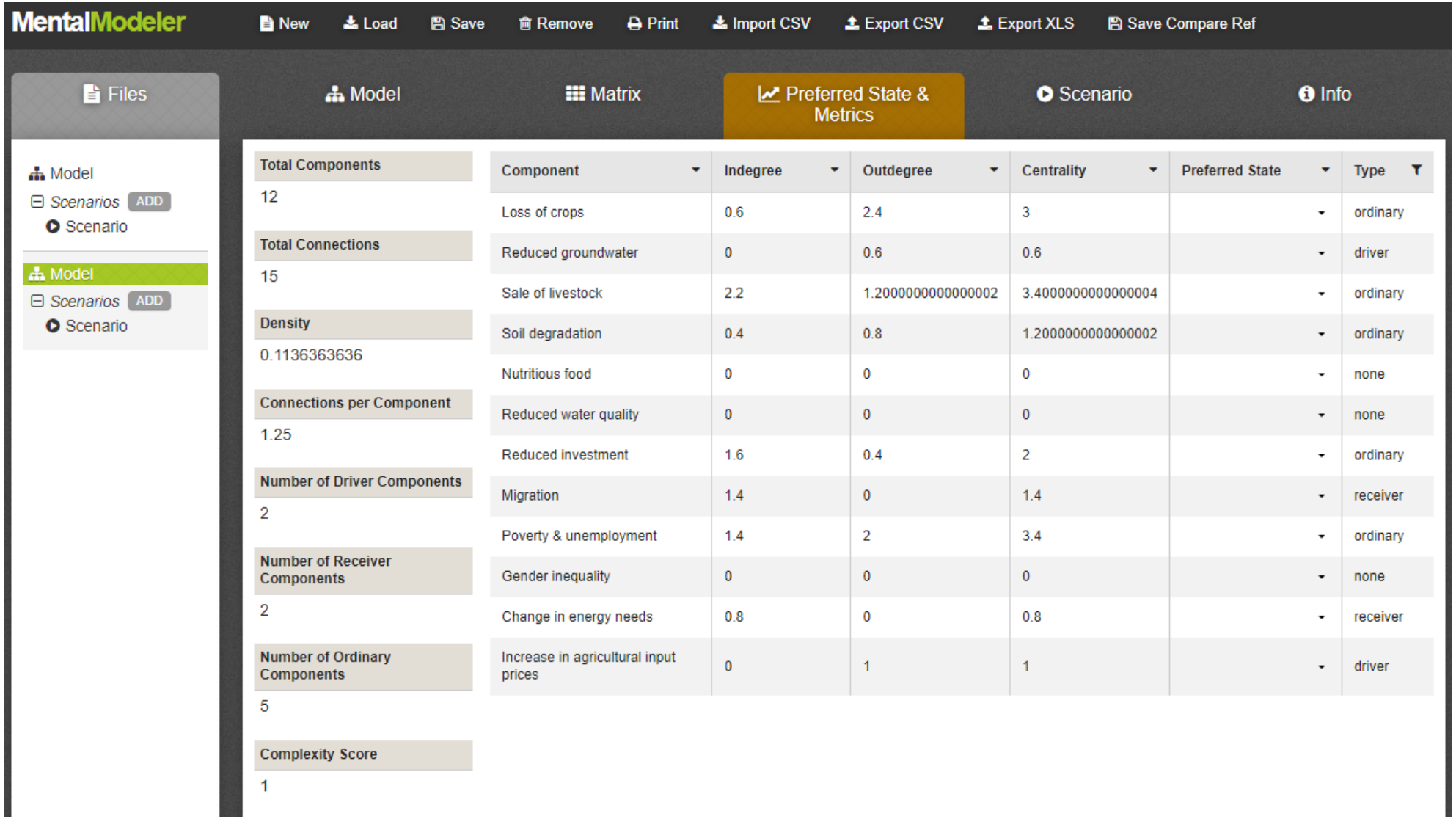


Responses from farmers using sticky notes and white paper



Cognitive map developed using Mental Modeler

Data Gathered



Component	Indegree	Outdegree	Centrality	Preferred State	Type
Loss of crops	0.6	2.4	3		ordinary
Reduced groundwater	0	0.6	0.6		driver
Sale of livestock	2.2	1.2000000000000002	3.4000000000000004		ordinary
Soil degradation	0.4	0.8	1.2000000000000002		ordinary
Nutritious food	0	0	0		none
Reduced water quality	0	0	0		none
Reduced investment	1.6	0.4	2		ordinary
Migration	1.4	0	1.4		receiver
Poverty & unemployment	1.4	2	3.4		ordinary
Gender inequality	0	0	0		none
Change in energy needs	0.8	0	0.8		receiver
Increase in agricultural input prices	0	1	1		driver

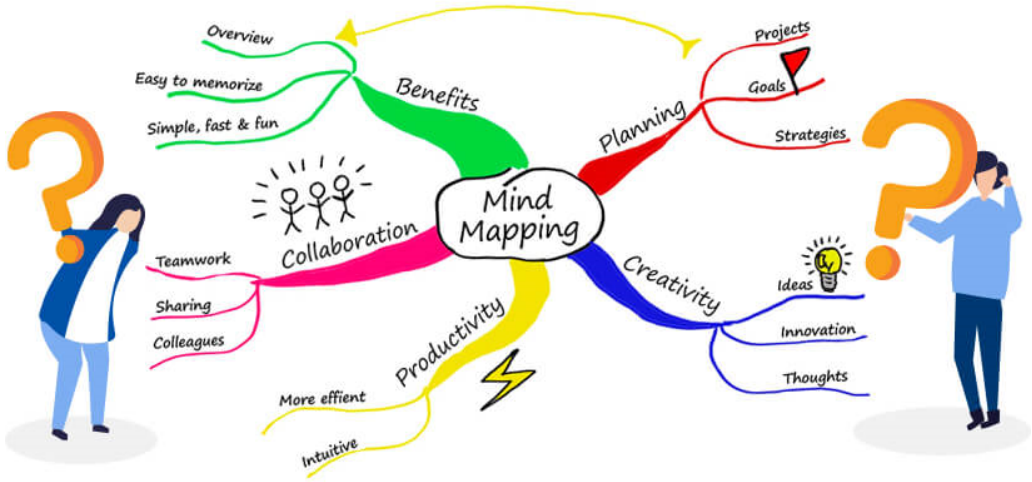
Findings in Morocco

	Top central indicators Settat			Top central indicators El Jadida		
	Male 1	**Male 2**	**Female**	**Male 1**	**Male 2**	**Female**
Q1 Impacts	Loss of crops Low groundwater	Loss of crops Sale of livestock	Low groundwater Sale of livestock	Low groundwater Low water quality	Sale of livestock Low investment	Low groundwater Low water quality
Q2 Adaptation	Govt. policies New tech.	Drought resistant crops New tech.	Farming cooperative New tech.	New tech. Desalination unit	Govt. policies Drought resistant crops	Farming cooperative Fertilizers & machinery

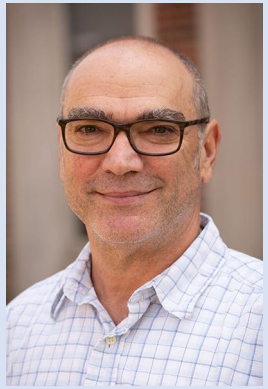
- New indicators added by farmers:
  - Increase in agricultural input prices
  - Sale of farms
  - Lack of precipitation
  - Participation in agricultural cooperatives
  - Helping small farmers to dig wells and access solar energy
  - Loan accumulation
  - Increase of cost of living
  - And so on….

Summary – Based on cognitive mapping workshops

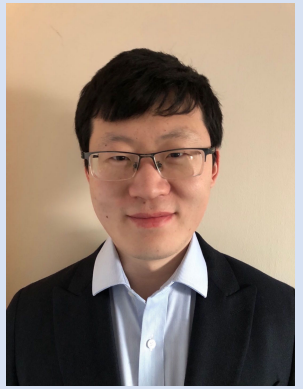
- Used as a participatory method → explore experiences of drought and measures that support adaptation
- Additional indicators → shows importance of farmers perspective in decision making
- Allows → exploration of how indicators link together
- Sheds light on → important indicators. Maps help us to find influence points.
- Significant similarities and differences noted → location, gender, type of crops → useful in formulating context specific policies



MADIS Team



Penn State University, USA

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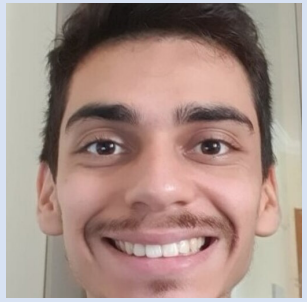

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