NASA IDS: Seasonal Prediction of Hydro-Climatic Extremes in the Greater Horn of Africa (GHA)

The First Participatory Research and Project Meeting

August 11 - 12, 2014

Sheraton Hotel, Addis Ababa, Ethiopia

Central University of Technology, Free State

Integrating Modern and Indigenous Drought Forecasting Approaches

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Our Research Units

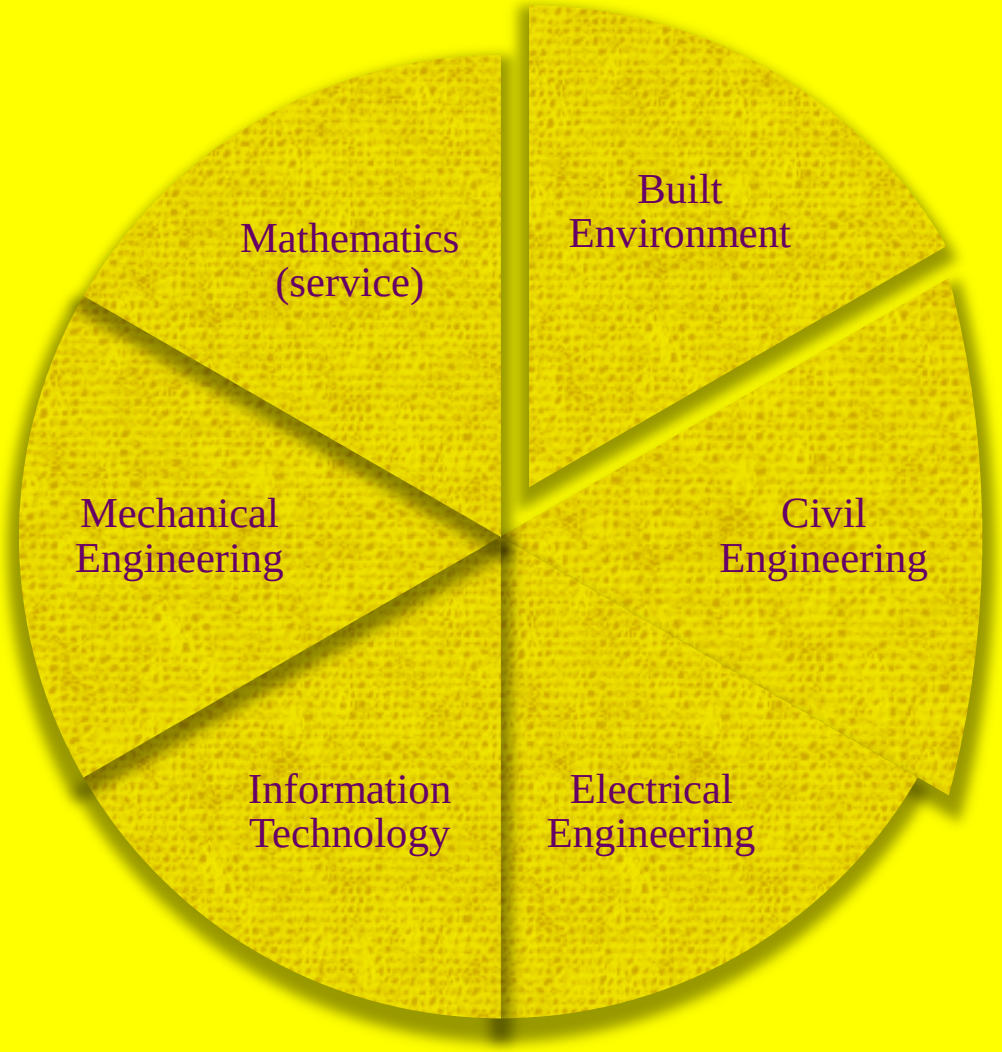
CUT's Faculty of Engineering and IT (FEIT)

Department of Information Technology

Africa Centre for Research on Informatics of Droughts

Central University of Technology, Free State

FEIT's Departments



Guiding Quotes

- Throughout human history, departures from the seasonal rhythms of climate often provided the difference between wealth and poverty, feast and famine, health and disease, and even life and death. [Stern and Easterling, 1999]

- Disasters are first and foremost a "local" phenomenon. Local communities are on the frontlines of both the immediate impact of a disaster and the initial, emergency response, which, experience has shown, is crucial for saving the most lives. (UN-ISDR, 2007)

Guiding Quotes

- … the onset and the end of a drought are difficult to determine, the impacts of a drought increase slowly, often accumulate over a considerable period and may linger for years after termination. Therefore, a drought is often referred to as a creeping disaster(Mishra and Singh, 2010).

- *"The economic case of most African countries is agriculture. Agricultural production and weather are so highly interrelated that a good rainy season means a healthy economy, and failure of the rains…means famine and death"*[An African economic planning Minister during Climate Variability, Water Resources and Agricultural Productivity: Food Security Issues in Tropical Sub-Saharan Africa, 1997, *(Virji et al, 1997)]*

Background Information

- Droughts are Chronic in Africa; Africa contributed 56% of droughts that occurred between 2003 and 2012; they affected 26% of her population. Mostly in SSA and especially the GHA
- The Seasonal Climate Forecasts (SCFs), the most commonly used form of forecast are too 'course' and supply-driven; dissemination format & channels are ineffective

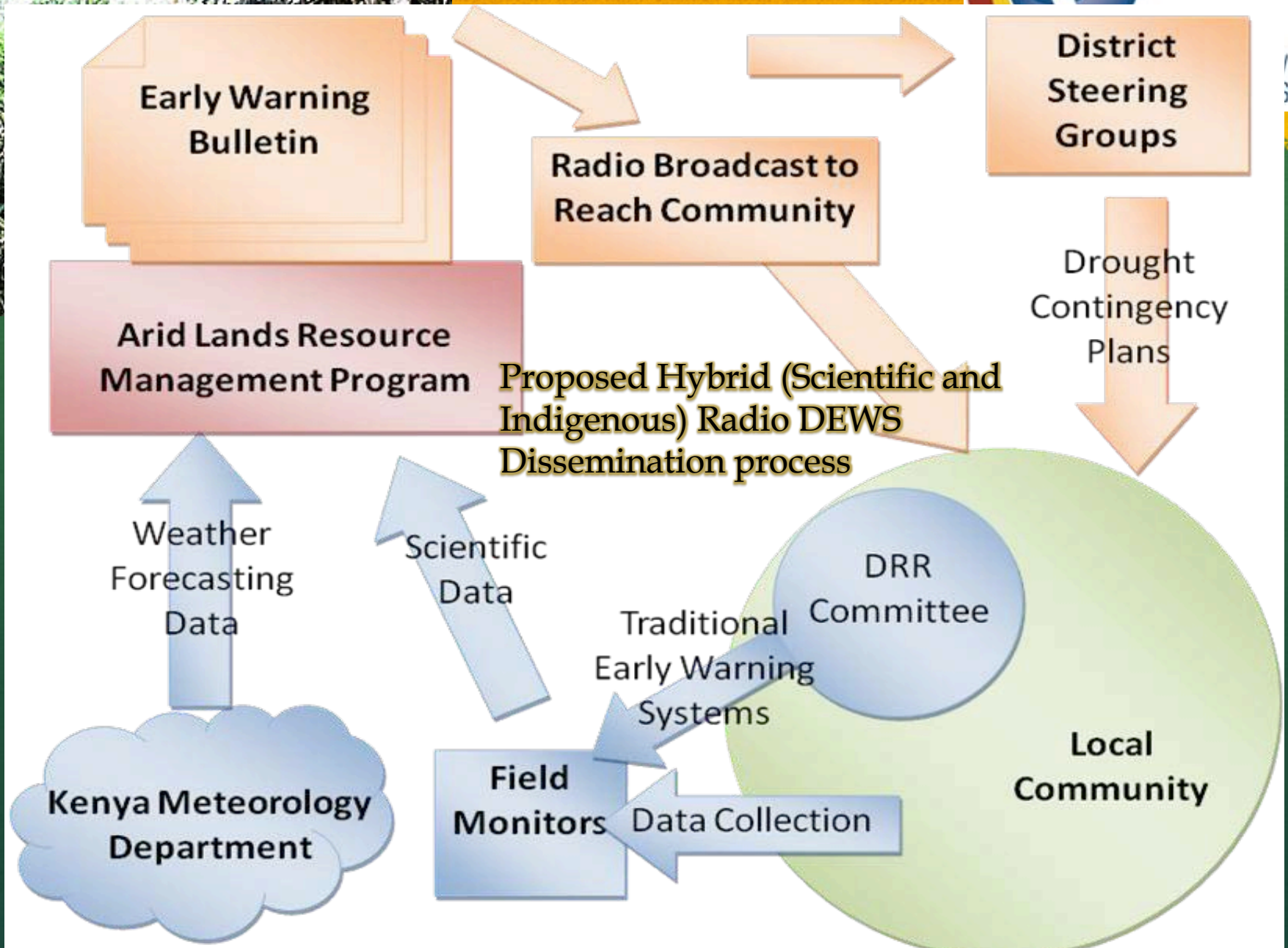
Background Information

- Farmers continue to consult their indigenous Knowledge Forecasts (IKFs)
- *"Of the ten countries with the highest levels of hunger, and of the ten whose scores have actually increased since 1990, nine are in Sub-Saharan Africa in both cases".* [**International Food Policy Research Institute, 2009**]
- Very sparse network of weather stations

Solution - ITIKI

- **ITIKI** - **I**nformation **T**echnology and **I**ndigenous **K**nowledge with **I**ntelligence
- A generic solution designed around 3 ICTs (Wireless Sensor Networks, Mobile Phones and Artificial Intelligence) to tackle the challenges (of scaling-up and scaling-down) facing the IKFs and SCFs integration initiatives.

Related Initiatives



Methodology

- Research Approaches

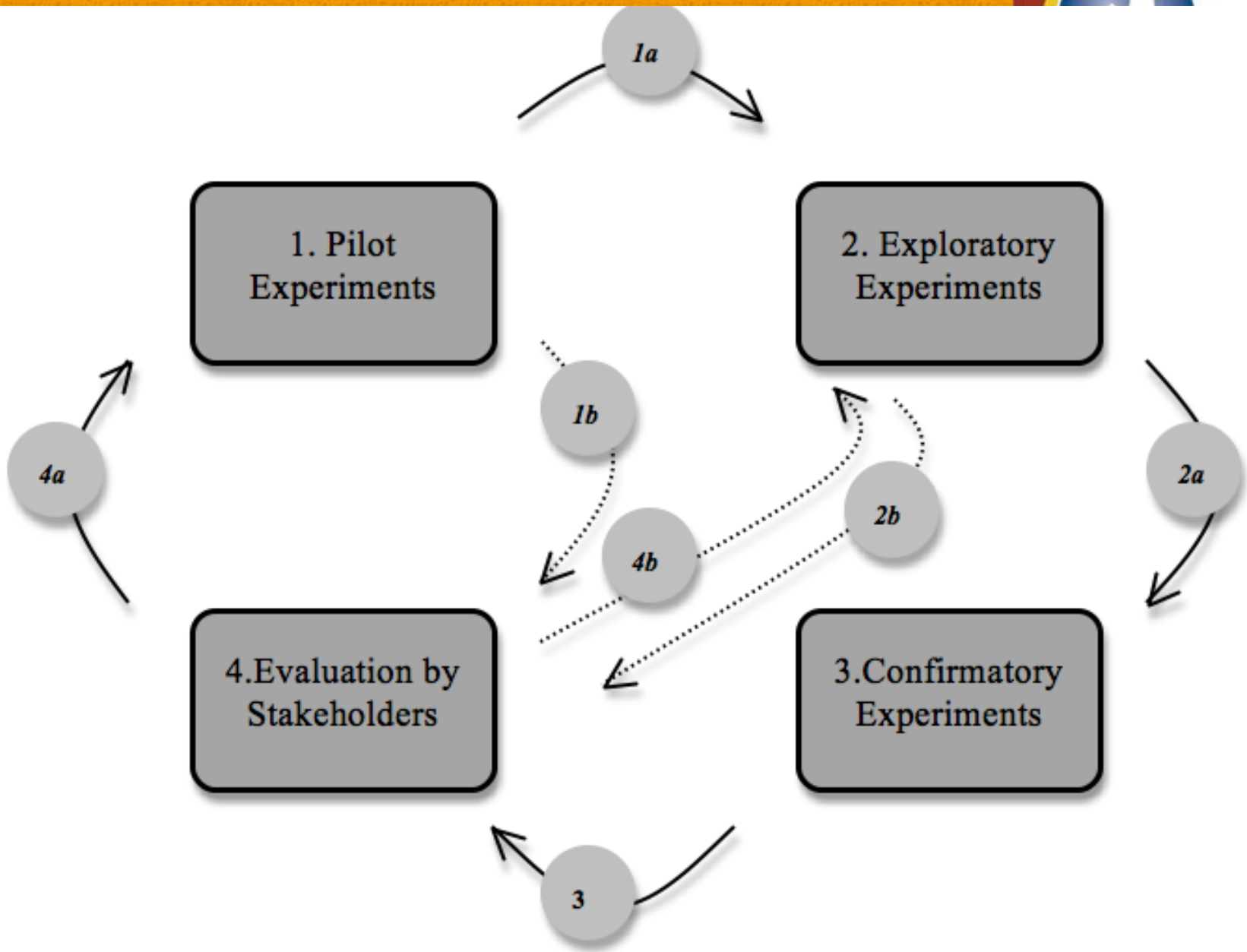
Research Application	Research Objectives	Research Inquiry Mode
1. Applied ->	descriptive ->	structured
2. Applied ->	correlational ->	structured
3. Applied ->	exploratory ->	unstructured

Methodology

- Research Design:
  1. Experimental Design – to calibrate sensors
  2. Case Study Design – to test assumptions on EDI, ANNs and OND Vs MAM seasons
  3. Longitudinal research Design – in future to test the rest of the hypotheses

Methodology

- Experimental Design:
- Recursive Participatory Experiments of 3 types:
  - That is, running a series of **Pi**lot, **E**xploratory and **C**onfirmatory **E**xperiments (**PiECEs**) recursively

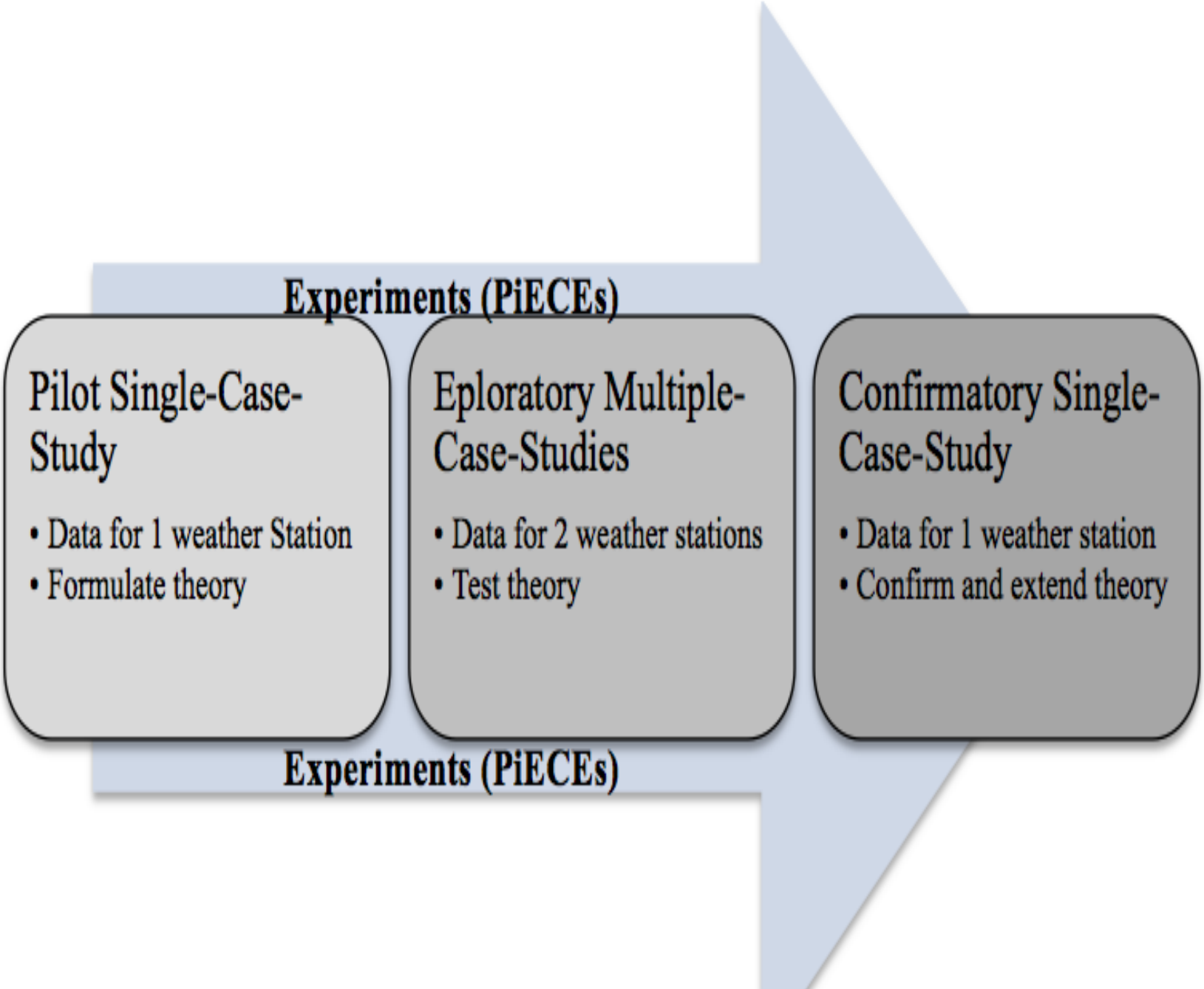

1a
1. Pilot Experiments
2. Exploratory Experiments
1b
2a
4a
2b
4b
4.Evaluation by Stakeholders
3.Confirmatory Experiments
3

Methodology

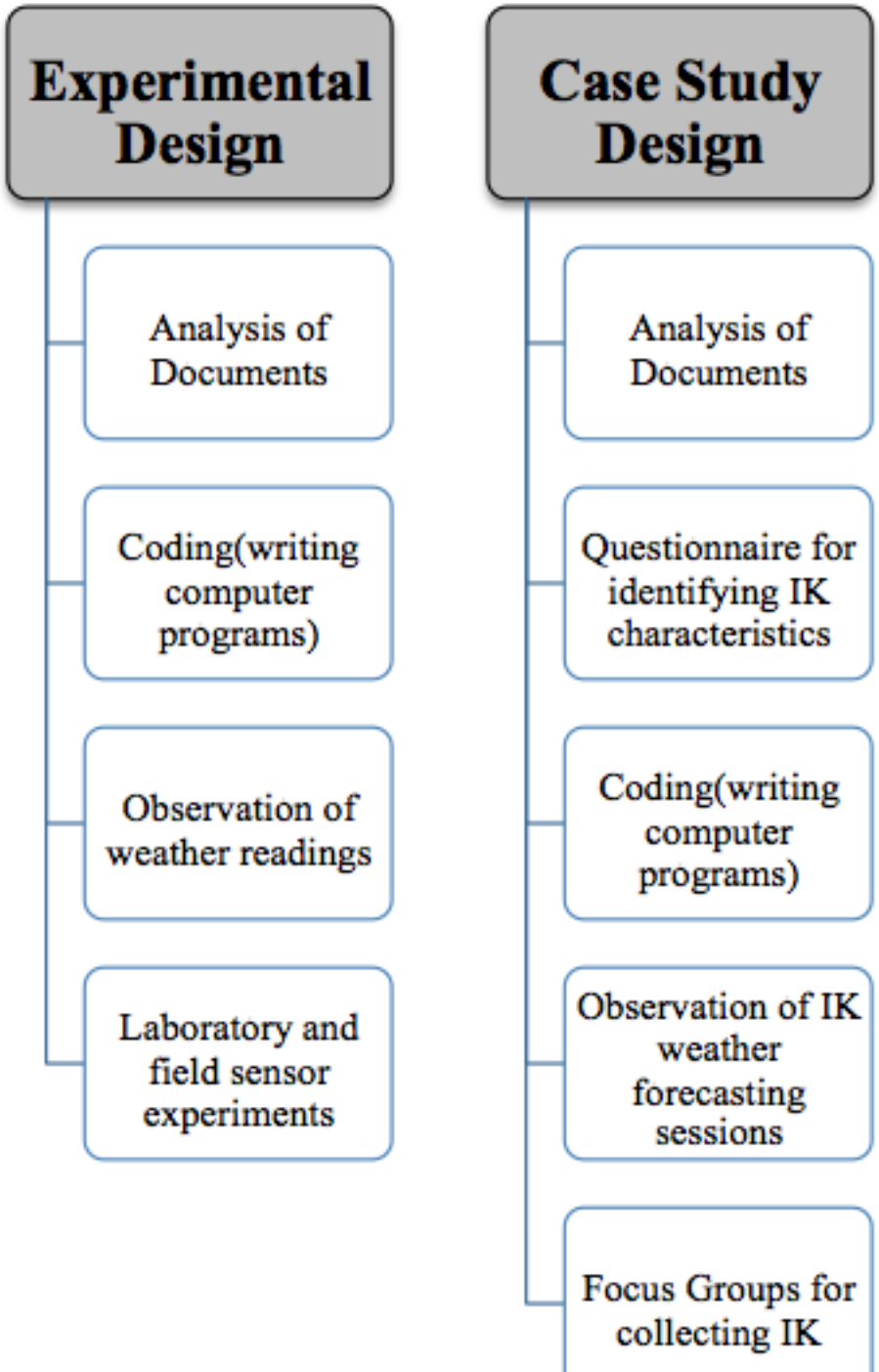
- Exploratory Experiments Cycles
  - Needed to explore:
    1. WSNs for weather monitoring
    2. IK – the myths and beliefs
    3. Use of Mobile phones as a computing device

Methodology

- Case Study Design
  - Used in both EDI and ANNs
  - Both single multiple case studies used
  - Descriptive case studies of IK from 2 communities in Kenya


Experiments (PiECEs)
Pilot Single-Case-Study
• Data for 1 weather Station
• Formulate theory
Eploratory Multiple-Case-Studies
• Data for 2 weather stations
• Test theory
Confirmatory Single-Case-Study
• Data for 1 weather station
• Confirm and extend theory
Experiments (PiECEs)

Methodology



- Data Collection Methods

Methodology

- Data and Error Analysis Methods
  - Calibrating for Uncertainty of Meteorological Measurements
    - Systematic Errors in Sensors; ME, MAPE and RMSE
    - Sensor inherent errors; board temp, lag errors and similarity tests
  - ANNs Models Performance: R, MSE, RMSE and %RMSE

ITIKI's Characteristics

- Takes the form an Integrated Droughts Early Warning System

1. Risk Knowledge
   - *Systematically collect data and undertake risk assessments*

2. Monitoring and Warning Service
   - *Develop hazard monitoring and early warning services*

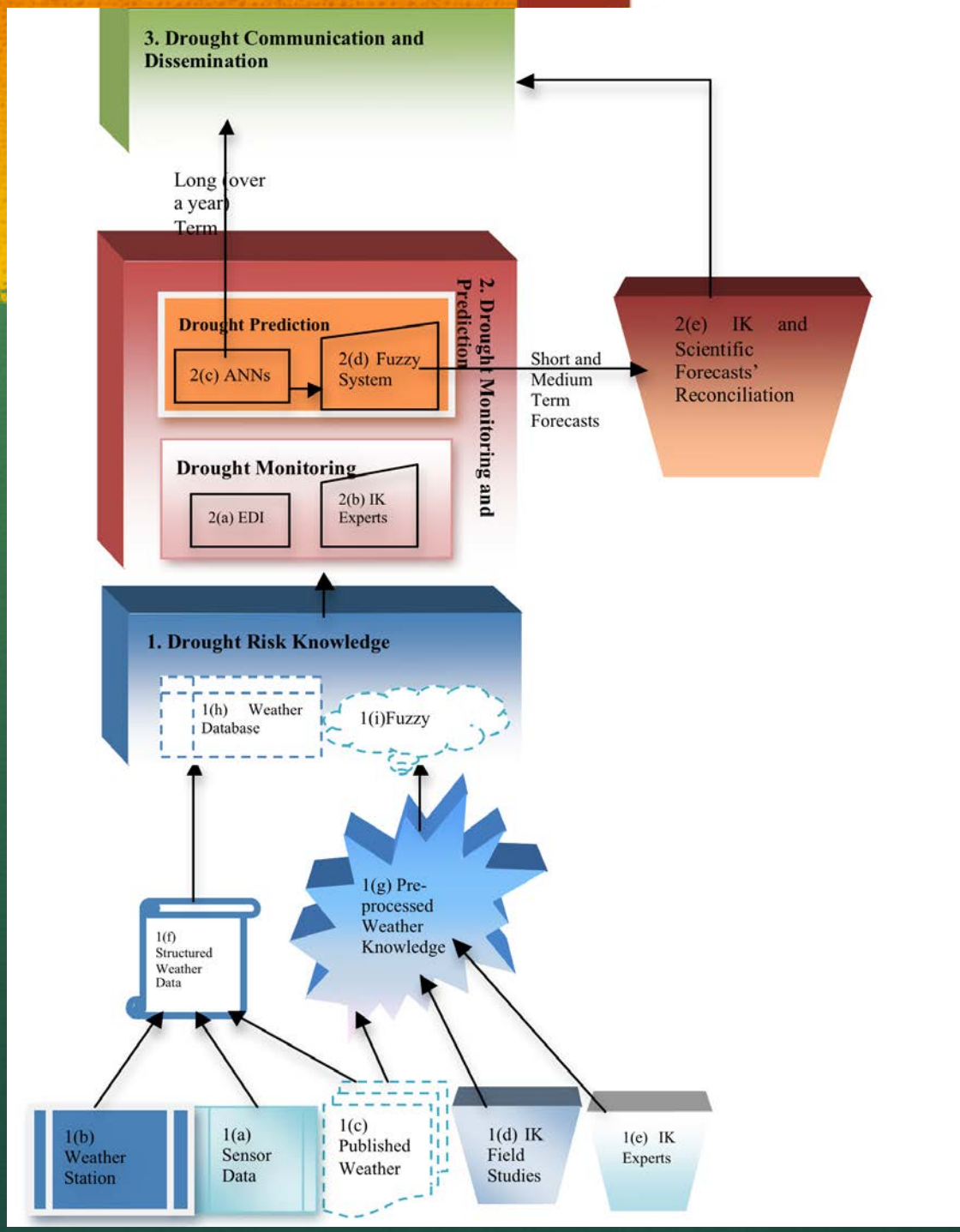
3. Dissemination and Communication
   - *Communicate risk information and early warnings*

4. Response Capability
   - *Build national and community response capabilities*

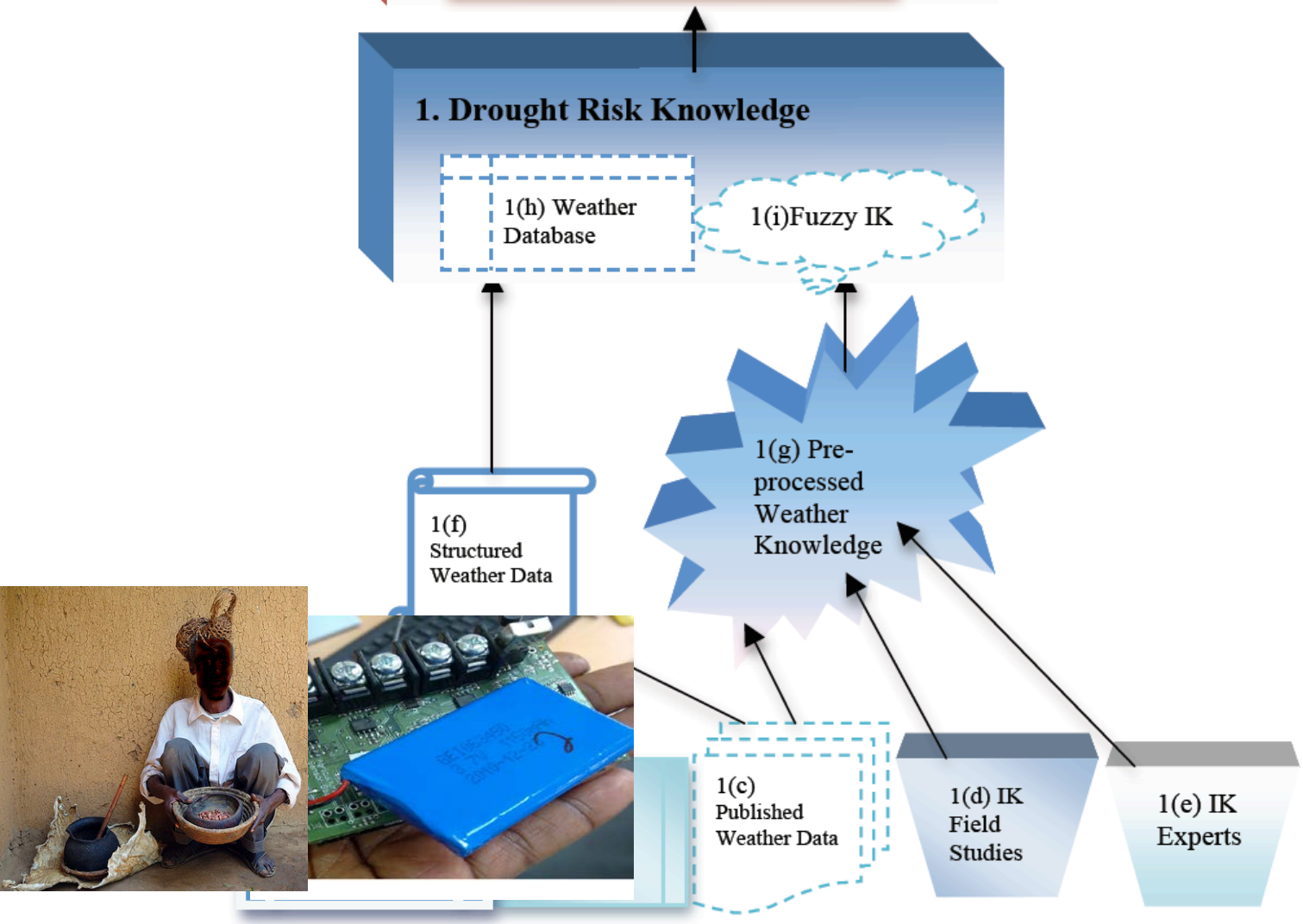
ITIKI's Characteristics

- Relevant, affordable, sustainable, integrated, resilient, useable, effective, generic, and micro-level; through:
  1. Indigenous Knowledge
  2. Effective Drought Index (EDI)
  3. Wireless Sensor Networks
  4. Mobile Phones
  5. ANNs and Agents

The Architecture

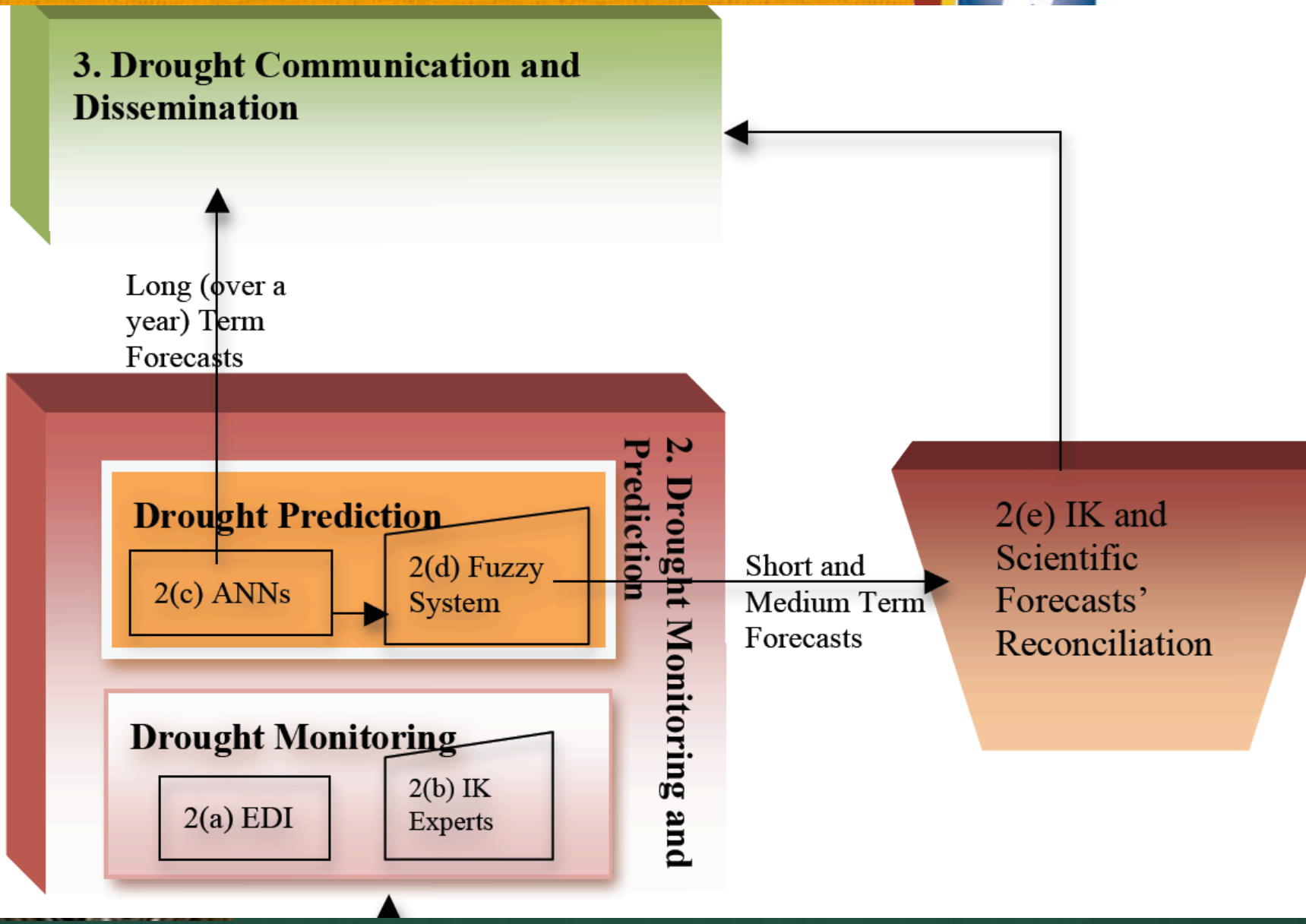


The Architecture

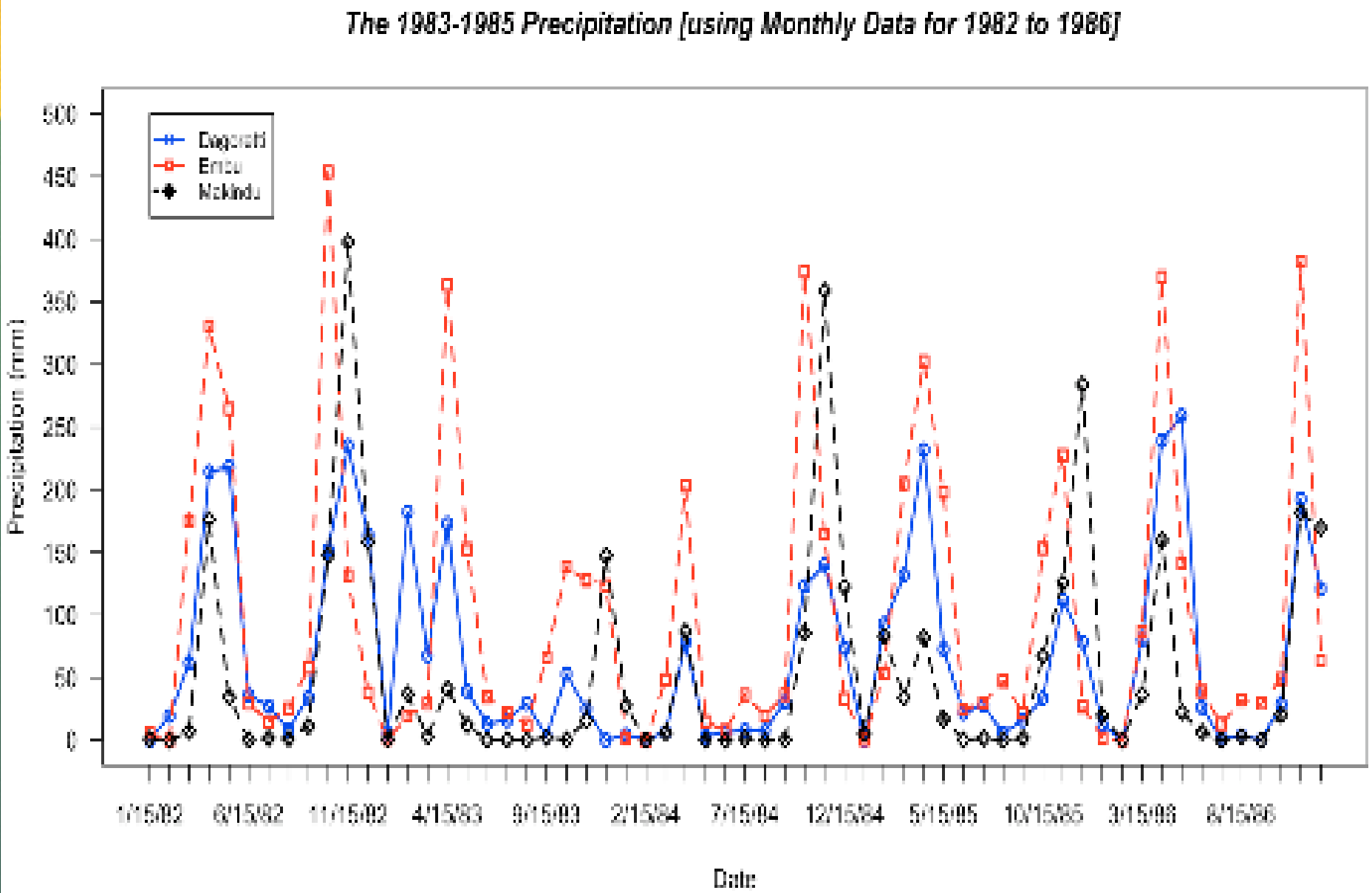


Drought Knowledge

The Architecture



Drought Monitoring



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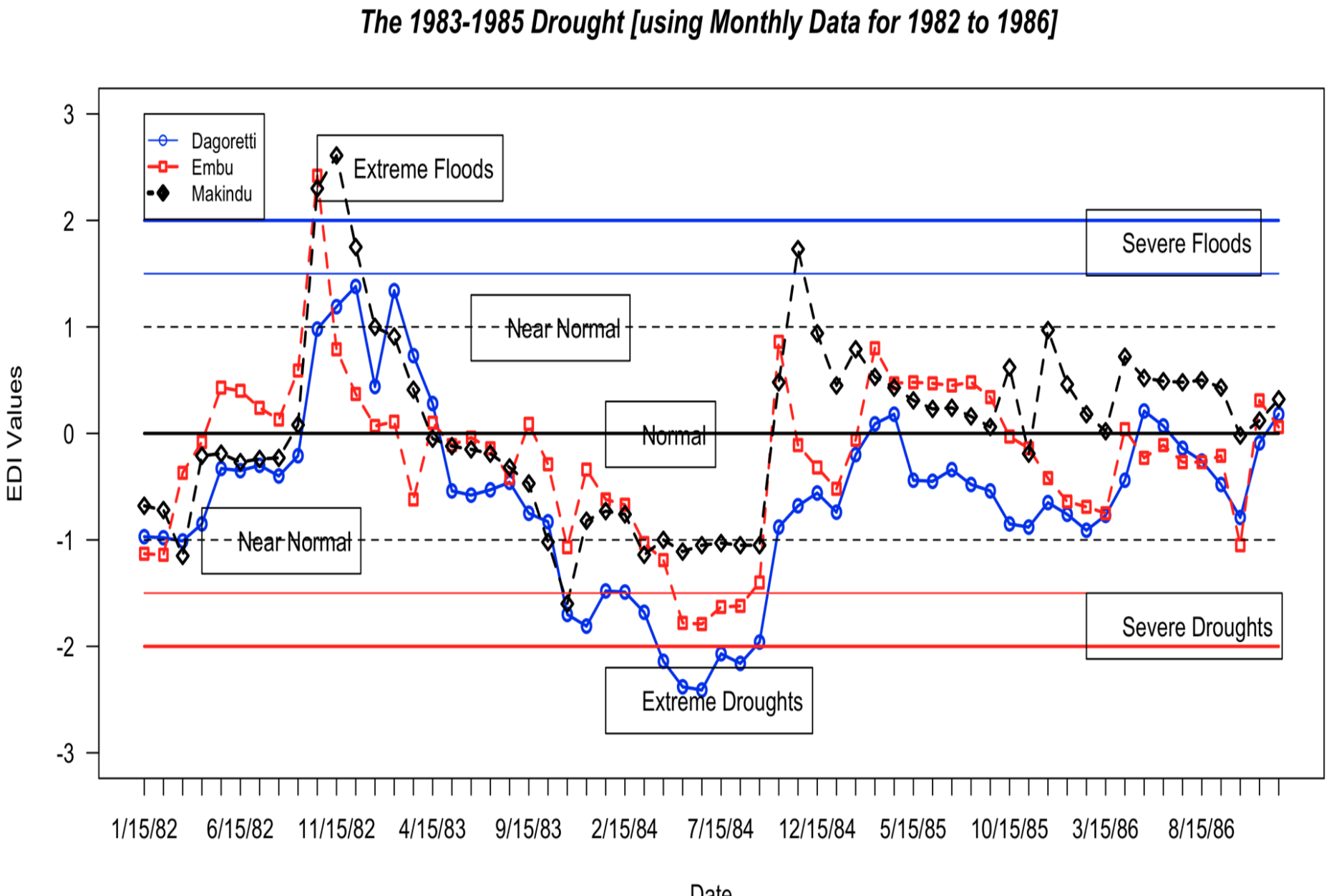

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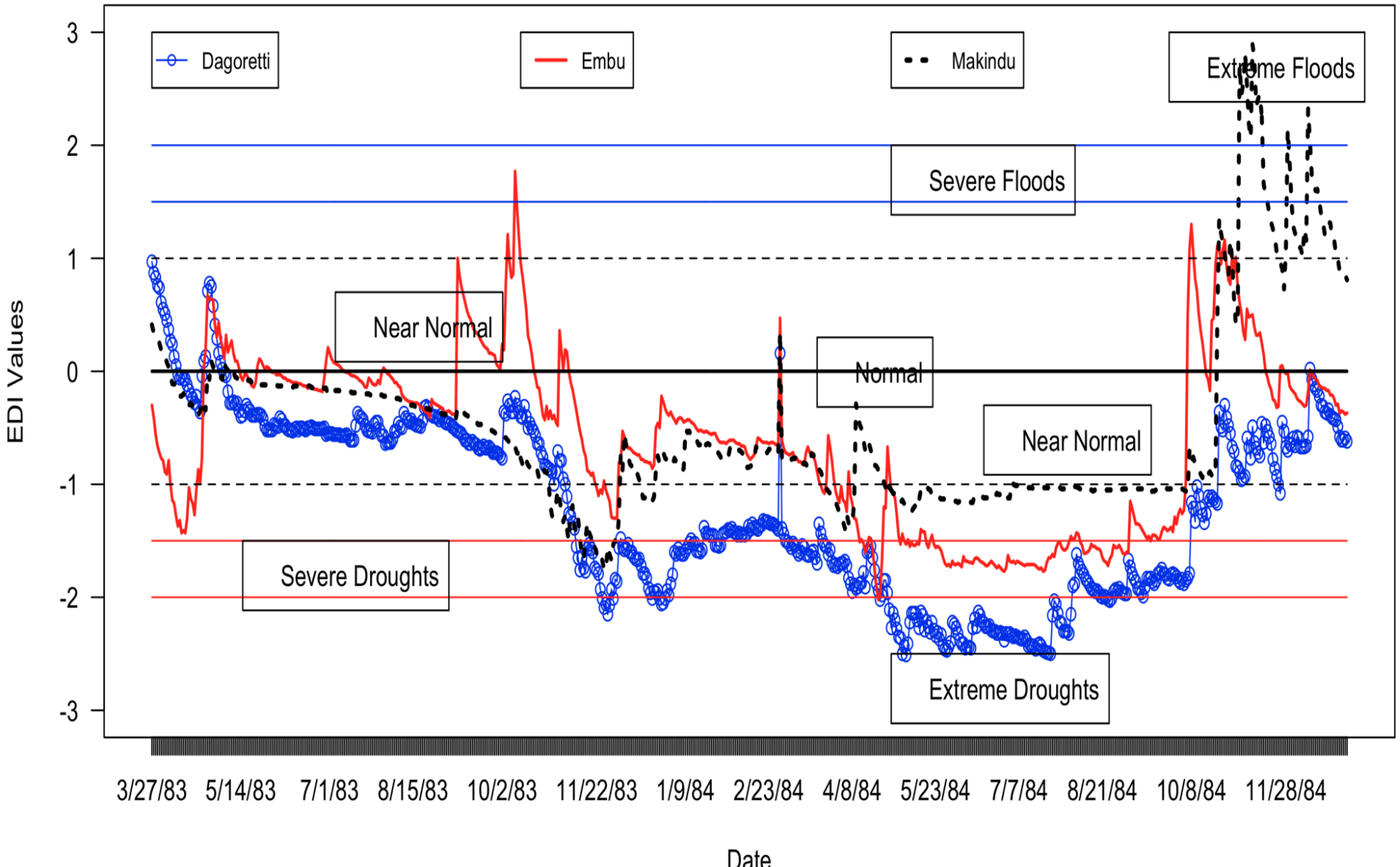
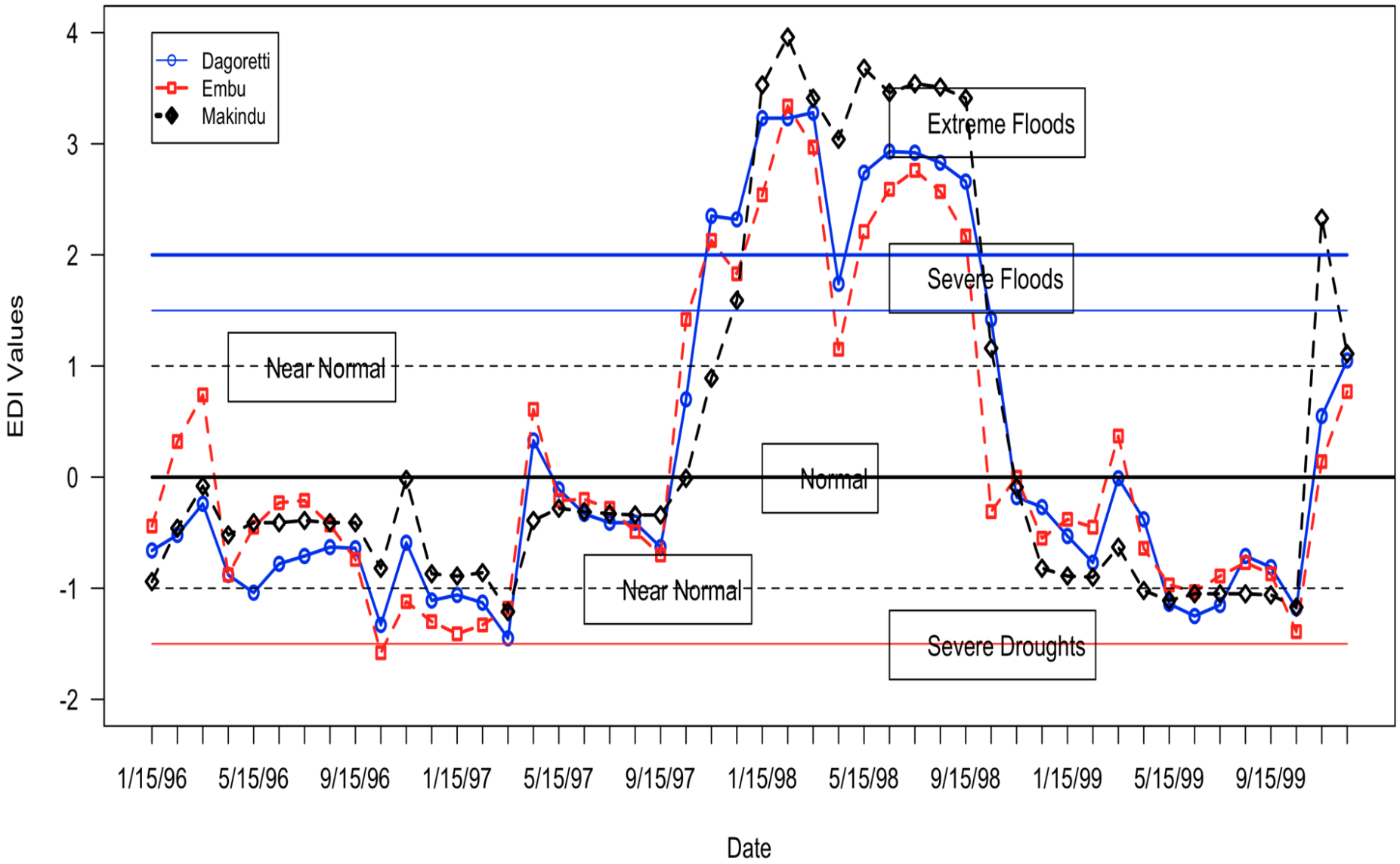
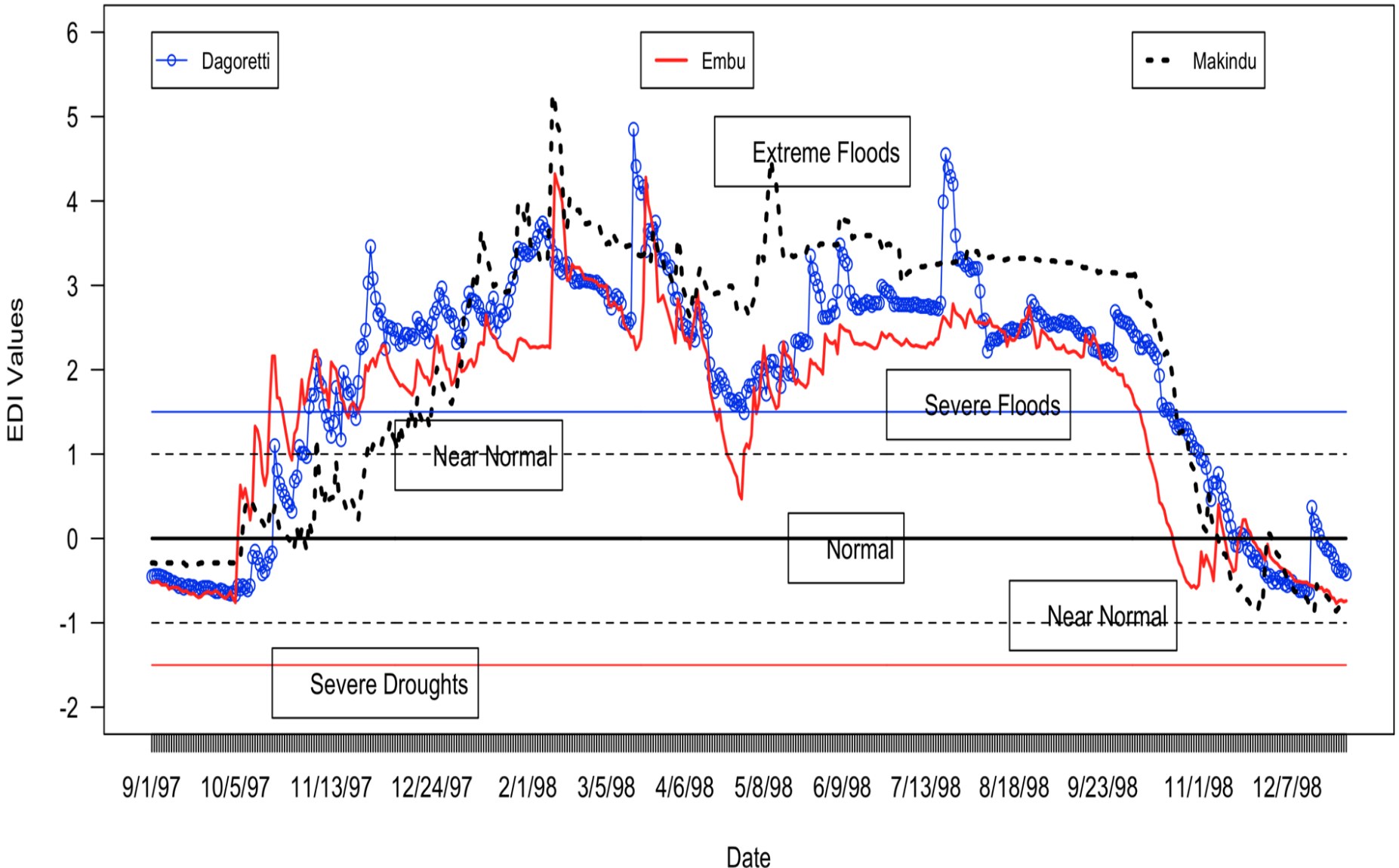


Drought Monitoring



Drought Monitoring



Drought Monitoring

Home | About the Project | Weather Monitoring | Drought Monitoring | Past Droughts | Related Links | Related Publications

Browse This Site

- Home
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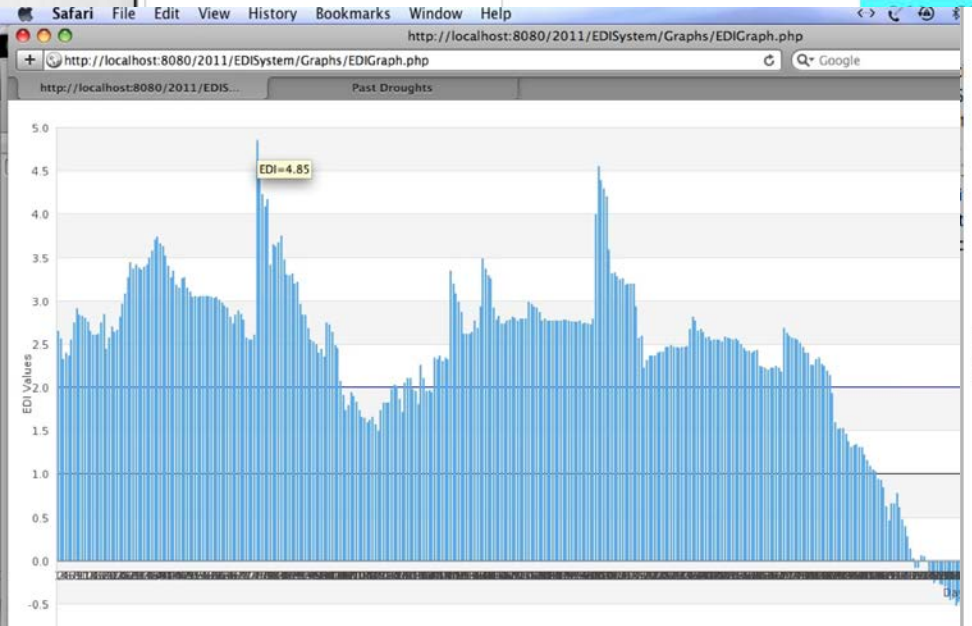
- Weather Monitoring
- Drought Monitoring
- **Past Droughts**
- Related Links

Weather Readings for Makindu [May, 2009]

Date	Precipitation	AWRI	EDI	EDI Class
1-May-2009	0	43.1	-1.59	Severe Drought
2-May-2009	11	53.1	-1.37	Moderate Drought
3-May-2009	0	50.6	-1.44	Moderate Drought
4-May-2009	0	49.1	-1.52	Severe Drought
5-May-2009	0	47.8	-1.51	Severe Drought
6-May-2009	2.1	48.9	-1.51	Severe Drought
7-May-2009	0	47.6	-1.54	Severe Drought
8-May-2009	0	46.6	-1.55	Severe Drought

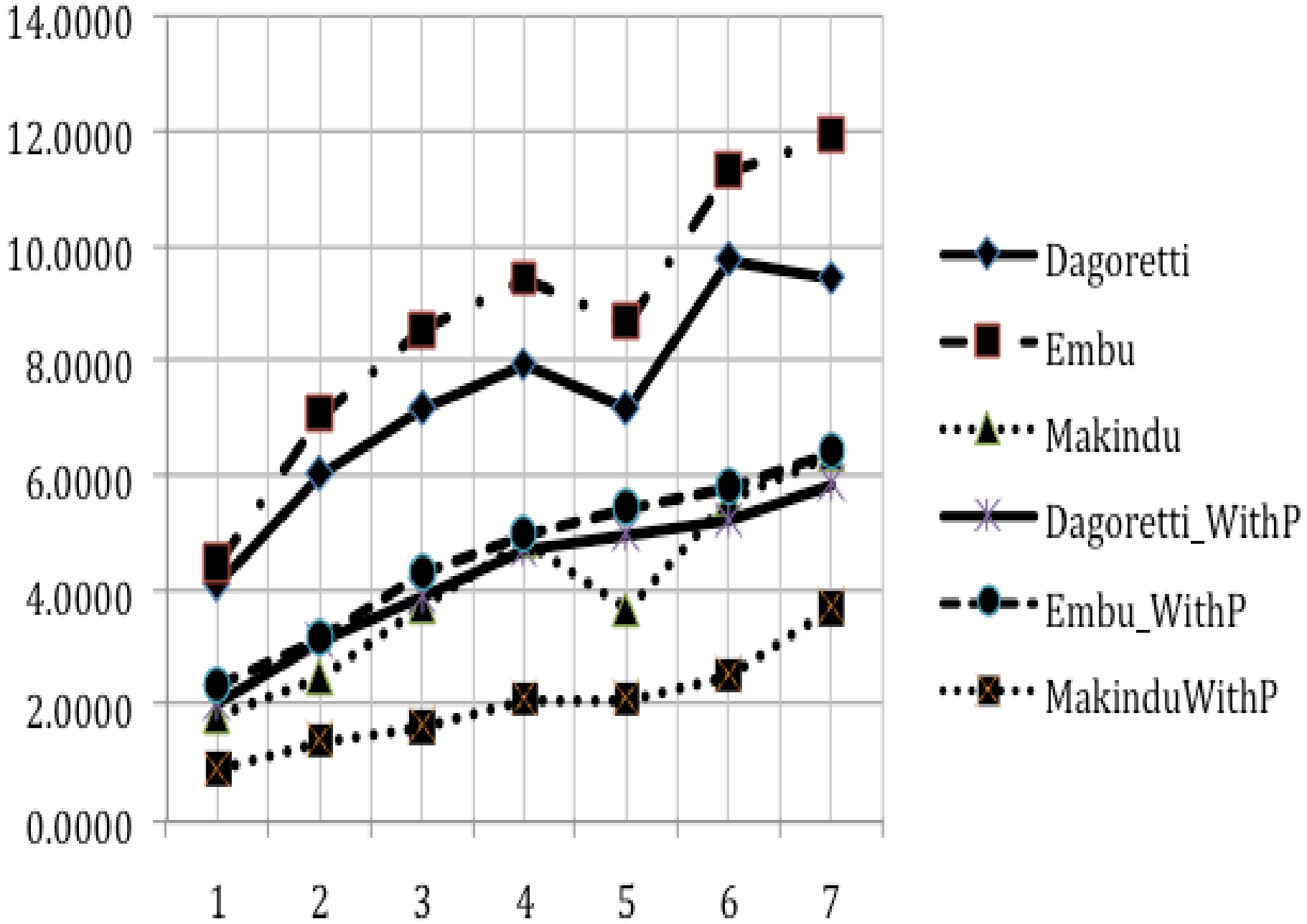


Drought Forecasting

- **Artificial Neural Networks (ANNs)**
- EDI (and other drought Indices) only detects droughts already happening; ANNs were adopted to forecast
- Combining ANNs and EDI addressed the drawback of El Nino–Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO)
- ANNs implemented in MATLAB

Drought Forecasting

- ANNs
  - Network Forecasting Models:
    - D-Days Lead Time – 75 – 96% accuracy and correlation coefficient of over 0.9
    - D-Days Lead Time with Precipitation - – 94– 99% accuracy and correlation coefficient of over 0.99
    - M-Months Lead Time: – poor performance as low as 20%
    - Y-Years Lead Time: – 75 – 82% accuracy and correlation coefficient of over 0.9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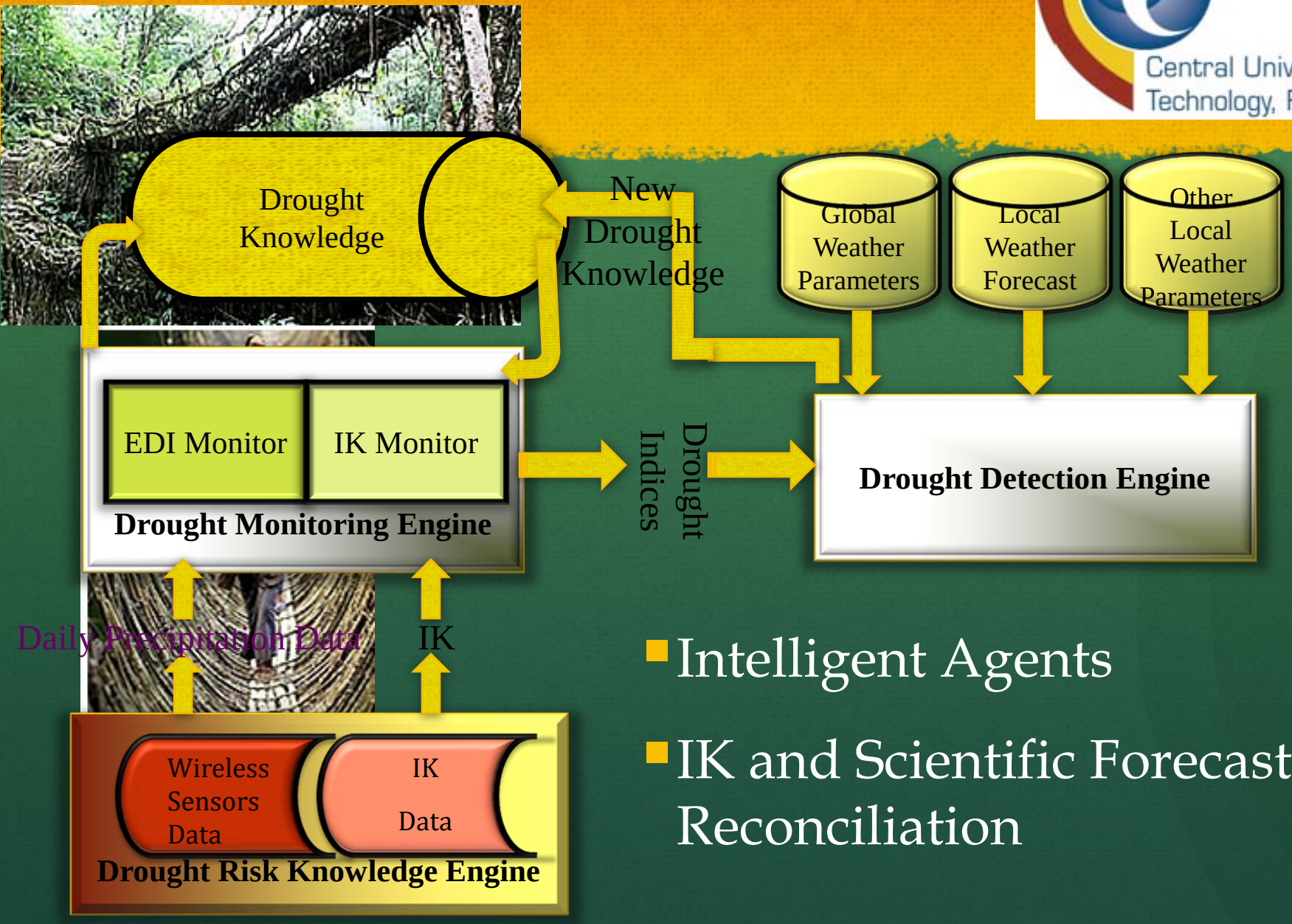
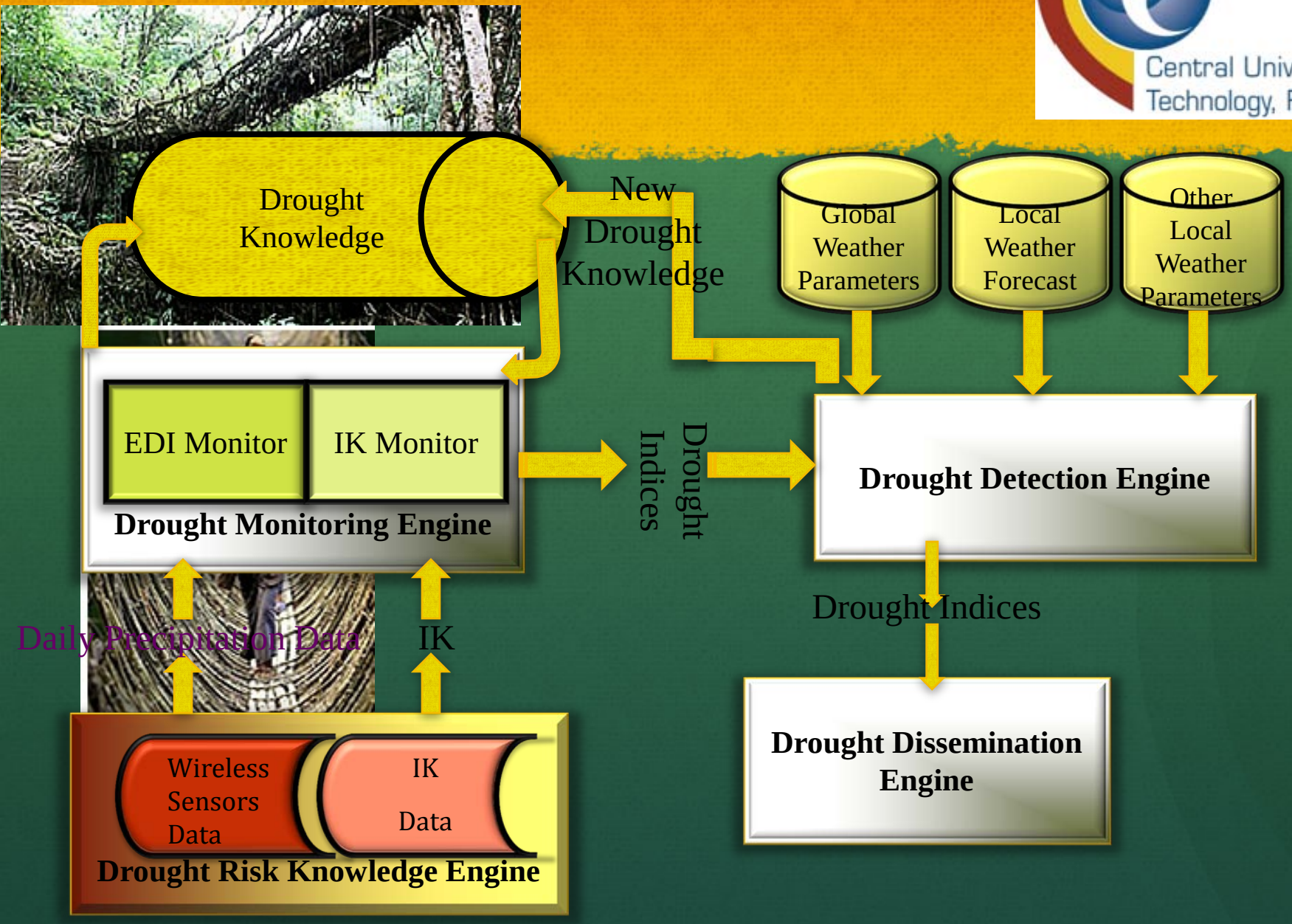
Integrated Drought Detection

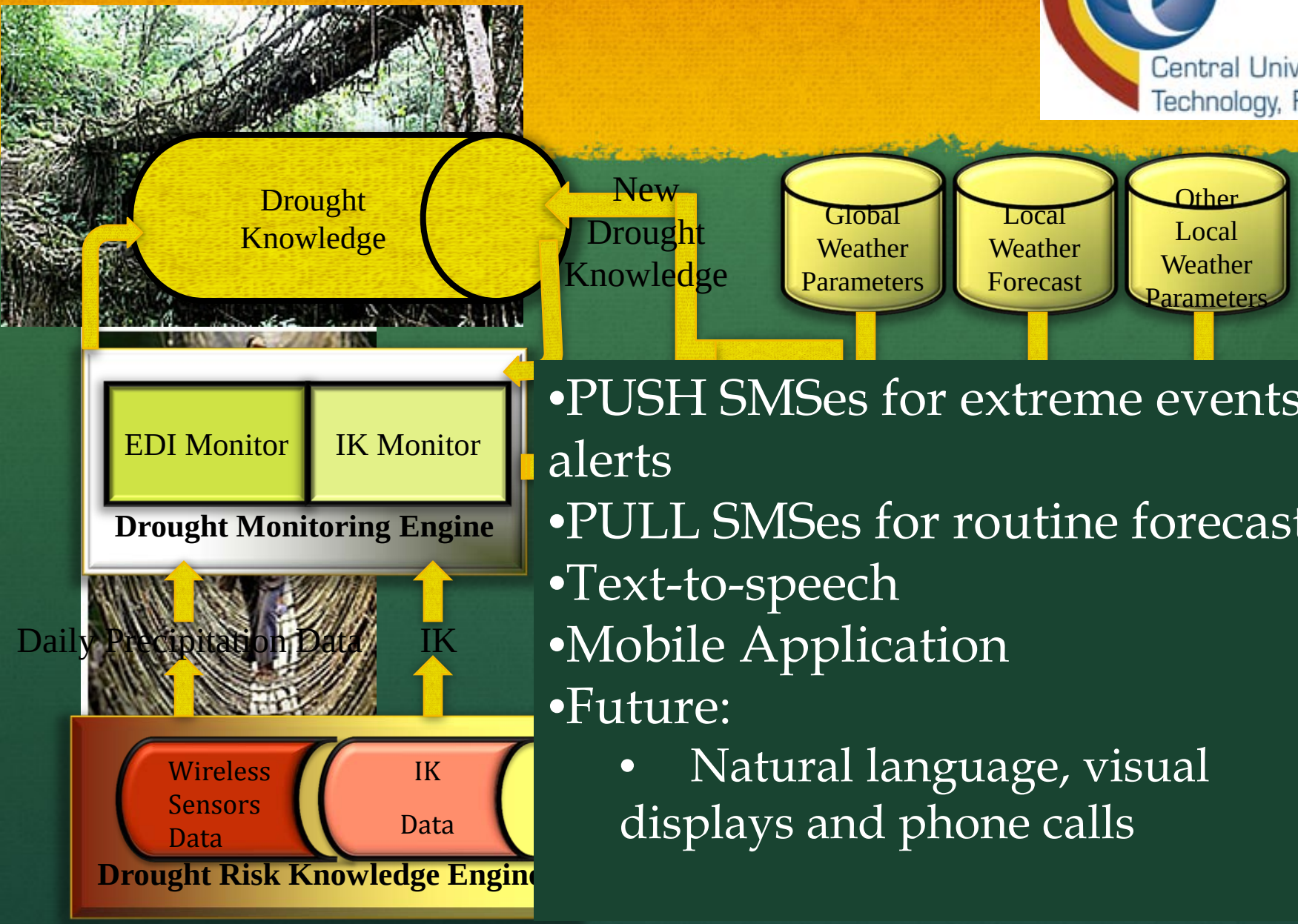


- Intelligent Agents
- IK and Scientific Forecasts' Reconciliation

Forecast Dissemination

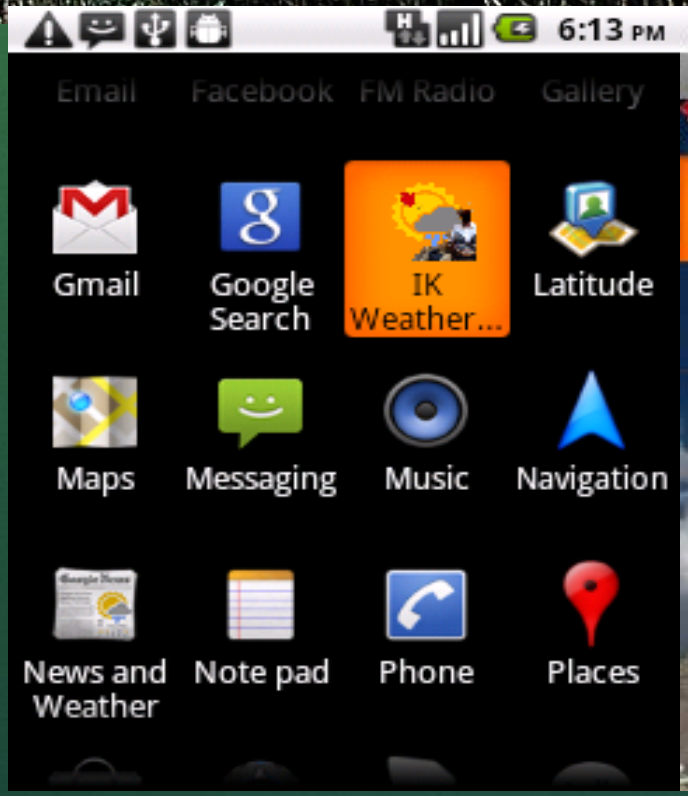


Forecasts Dissemination



- PUSH SMSes for extreme events alerts
- PULL SMSes for routine forecasts
- Text-to-speech
- Mobile Application
- Future:
  - Natural language, visual displays and phone calls

Forecasts Dissemination



Central University of Technology, Free State

The East Africa Drought Monitor
eastafricaweather@gmail.com

To: muthonimasinde@gmail.com 1:14

Drought Forecast for: 2012-8 in Embu will be: Moderate Drought and Current IK Forecast is: Rains wil...

EaDrought Monitor <073-225-0851>

Me: Df;HKEM;2;2

Sent: 1:12PM

EaDrought Monitor: Drought Forecast for: 2012-8 in Embu will be: Moderate Drought and Current IK Forecast is: Rains will fall in two weeks

Sent: 1:14PM

Conclusion and Future/Current Work

- Though forecasting droughts alone cannot eradicate droughts in SSA, relevant, accurate and timely forecasts can be used to mitigate effects of the droughts
- System still a prototype;
  - can be used to conserve IK
  - Completion/enhancement of some components
  - Needs to anchored within a relevant institution

Thank you

"But while witches, priests, and chiefs developed taller and taller hats, scientists worked out a method for determining the validity of their experimental results: They learned to ask, Are they Reproducible? --- That is, would anyone, using the same materials and methods arrive at the same results?" (Scherr, 1983, p. ix)

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