Impact of climate change on water resources in upper Tana River Basin, Kenya

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Outline of presentation

- Introduction
- Drought challenge on water resources
- Objective of the study
- Methodological Approach
- Results
- Conclusions and recommendation

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Introduction

- Hydrological drought
- Impact of drought Globally, Regionally and locally
- Episodes of droughts in Kenya
- Need for developing mechanism to manage drought
- Case study: upper Tana River Basin
- Absolute Stream flow Drought Index (SDI)
- Use of modified Gumbel method to determine frequency of drought

Hydrological drought

- Many models for forecasting and projecting drought occurrence have been developed
- Use of Artificial Neural Networks (ANNs) in conjunction with drought indices have made it possible to forecast drought for short, mid and long-terms scenarios
- Choice of drought indices depends on the type of drought of interest

Focus on Hydrological drought

- ➢ Hydrological drought refers to a persistently low discharge and/or volume of water in streams and reservoirs, lasting months or years
- ➢ This inadequacy is usually caused by an unfavourable performance of the factors which drive the climate system over the affected region:
  - ✓ Sunspot activity
  - ✓ El Niño/La Niña Southern Oscillation phenomenon
  - ✓ Wind patterns at the top of the atmosphere
- ➢ Hydrological droughts are usually related to meteorological droughts, and their intervals of recurrence vary accordingly

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Impact of drought on Water Resources

- Droughts are classified according to their effects:
  - Meteorological
  - Agricultural
  - Hydrological
  - Socio-Economic
- Globally, droughts have become more frequent and severe due to climate change/ variability
- Some regions experience droughts at varying scales and times -more impact on ASALs
- According to IPCC (2014), droughts have either direct or indirect impacts on river basins and human lives

Reduced stream flows

Reduced water supply

Reduced reservoirs levels

Total Crop failure

Massive loss of livestock

Episodes of Hydrological Droughts in Kenya

- Kenya has experienced approximately 30 major droughts in the last 100 years
- The severity and frequency of droughts in Kenya have been increasing over the Years
- Some of the recognizable droughts include:
  - ✓ 1952-1955
  - ✓ 1973- 1974
  - ✓ 1983-1984
  - ✓ 1992-1993
  - ✓ 1999-2000
  - ✓ 2009-2011
  - ✓ 2016-2017
  - ➢ Huge resources which would have otherwise been used for other socio-economic projects are normally diverted to cater for food insecurity crises and water scarcity during the drought periods

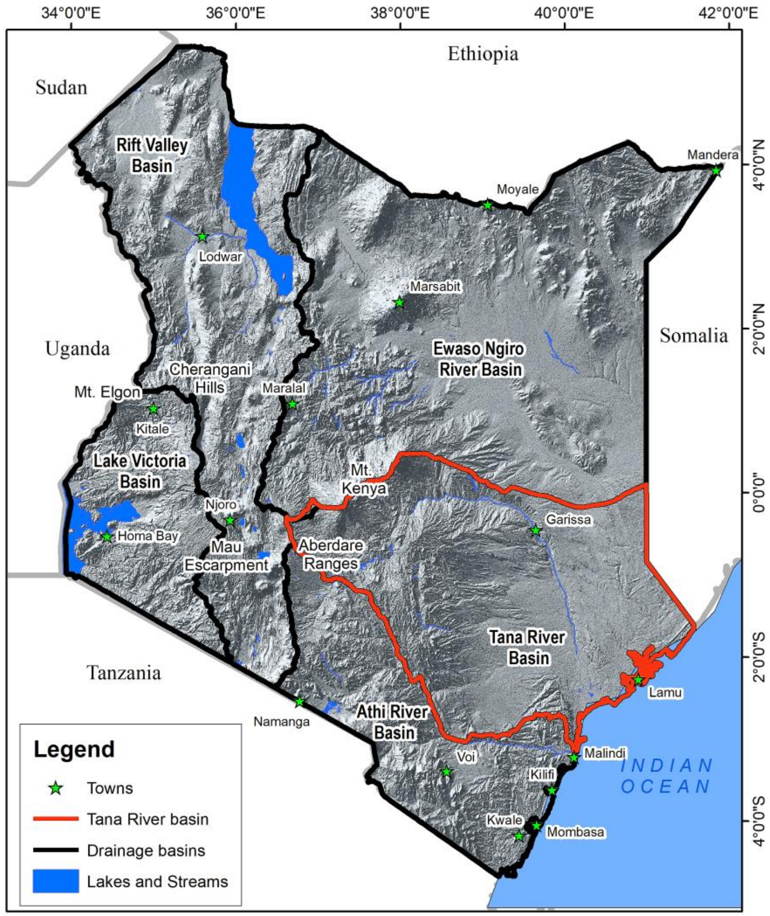
Need for managing drought

- **Due to the continued negative impact of drought on water resources in the Upper Tana River Basin, it became imperative to develop drought mitigation and copying mechanisms (Wambua *et al*., 2014)**

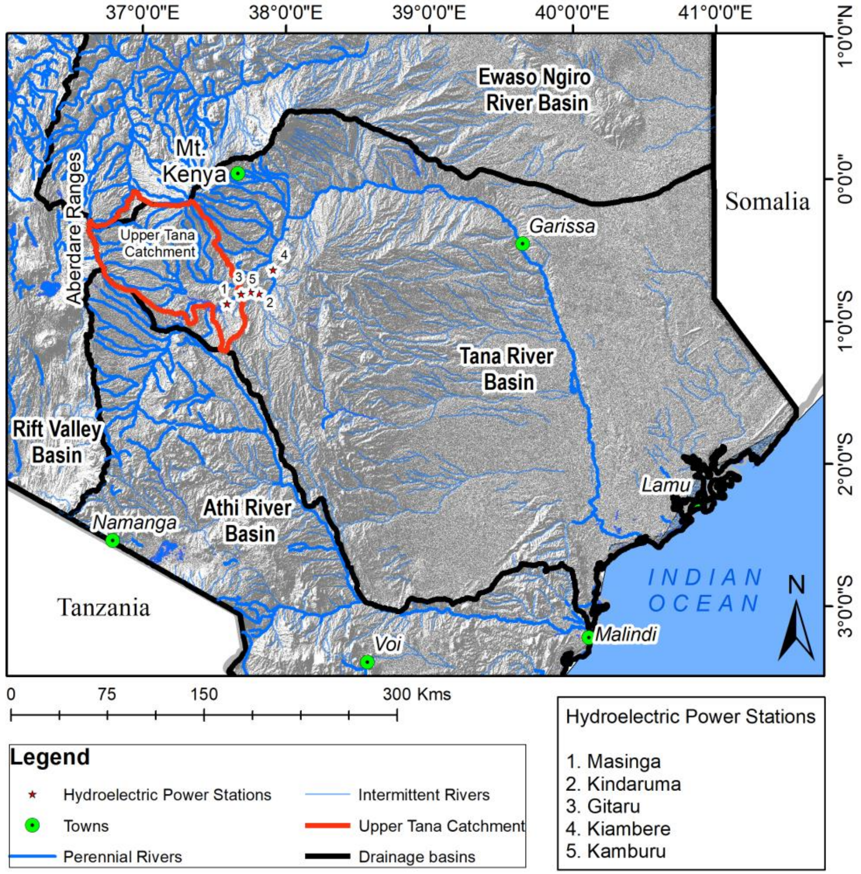
- **One of the key parameter is determination of the frequency of drought event of a defined severity for a particular return period**

- **Frequency of drought is fundamental in planning, designing, operating and managing water resources systems within a basin**

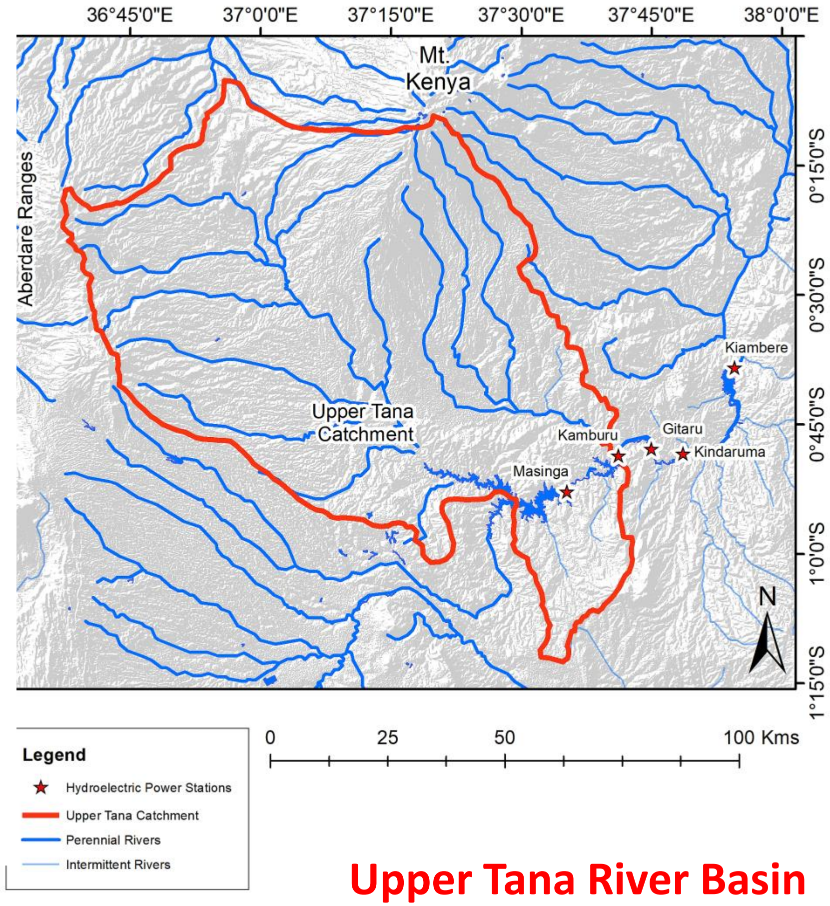
Study area: Upper Tana River Basin



Map of Kenya- Entire Tana River Basin



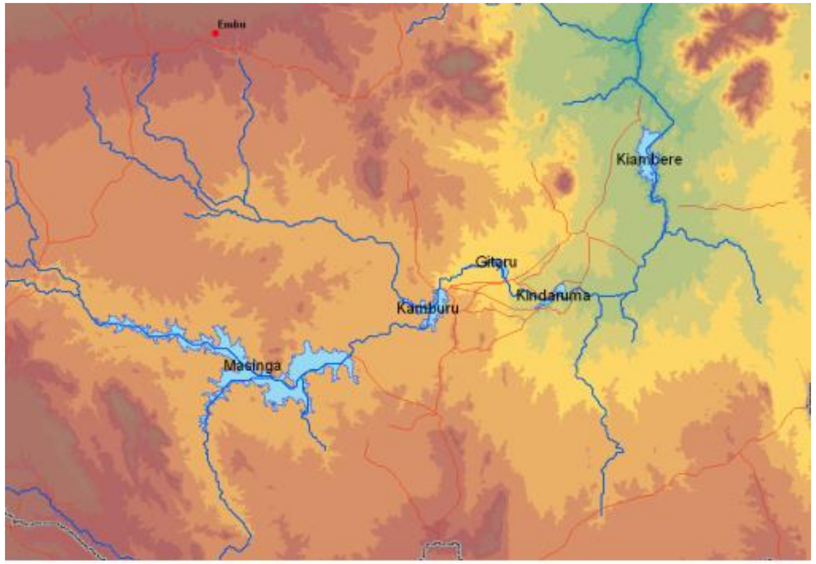
Tana River Basin

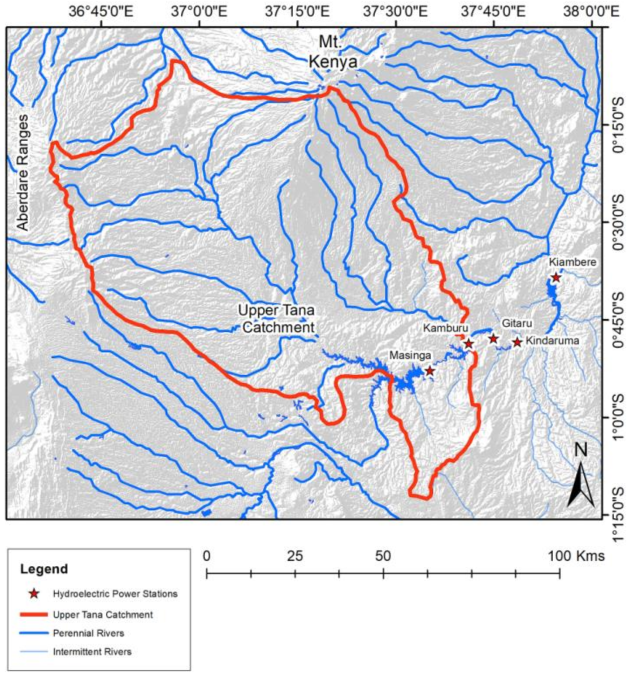


Upper Tana River Basin

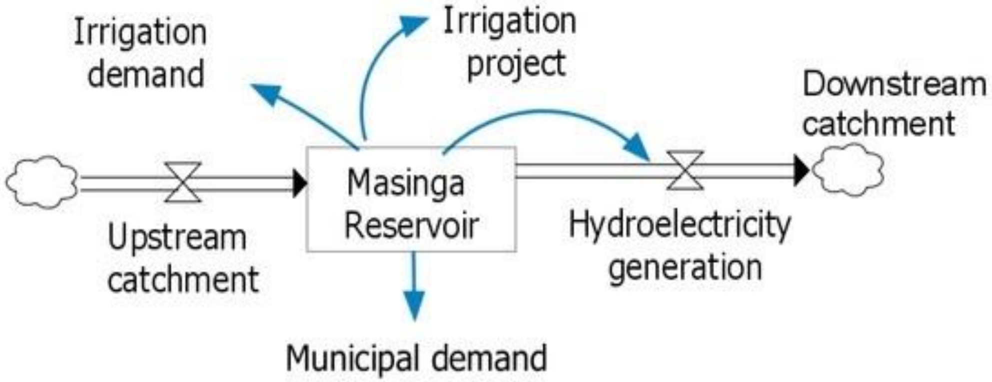
Important of Upper Tana River Basin

- The basin plays a critical role in **regulating the hydrology** of the entire basin (IFAD, Upper Tana River Basin 2012)
- Basin **controls the hydro-electric power** generation within the Seven-Folk dams downstream of the Tana River
- The basin is very critical in Kenya as it **drives the socio-economic development** through water supply and agricultural production





Cascade of reservoirs in Upper Tana River Basin



Socio-economic activities within Upper Tana River basin

Methodology

- Several methods are used to analyse the frequency of drought
- This paper presents an analysis of the hydrological drought frequency for the upper Tana River Basin in Kenya
- The study employs use of absolute Stream flow Drought Index (SDI) and modified Gumbel technique
- **A 41-year (1970-2010) stream flow data and hydrological droughts of 2, 5, 10, 20, 50, 100, 200, 500 and 1000-year return periods were evaluated based on the stream flows**
- **The study focused on key parameters of droughts:**
  - ✓ **drought's magnitude (duration + intensity)**
  - ✓ **spatial extent**
  - ✓ **probability of occurrence**
  - ✓ **Impacts**
- **Information of longest duration and largest severity for a**

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Gumbel's extreme value (EV1) method

Gumbel's extreme value (EV1) method

- Although the Gumbel's method was originally developed for flood estimation, it was adopted in this study to estimate the hydrological drought using the relation:

$$Q_T = \overline{Q}(1 + KC_v)$$

Where; Q_T= probable hydrological drought discharge with a return period of T years

C_v = coefficient of variation,

$\overline{Q}$ = Mean hydrological drought discharge (m^3/s)

and K= frequency factor

- The frequency factor and the coefficient of variation are determined from the relation

$$K = \frac{(y_T - y_n)}{\sigma_n} \qquad C_v = \frac{\sigma}{\overline{Q}} \qquad y_T = -\ln\ln\left(\frac{T}{T-1}\right)$$

Where;

y_n, =expected mean

σ_n =standard deviation of reduced drought extremes estimated from Gumbel's Table

Stream flow drought index

The *SDI* for each gauged station was determined using the relation:

$$SDI_i = \frac{\left(Q_i - \overline{Q_k}\right)}{\sigma_k}$$

Where;

SDI_i= stream flow drought index for i^{th} hydrological month

Q_i = stream flow for the i^{th} hydrological month

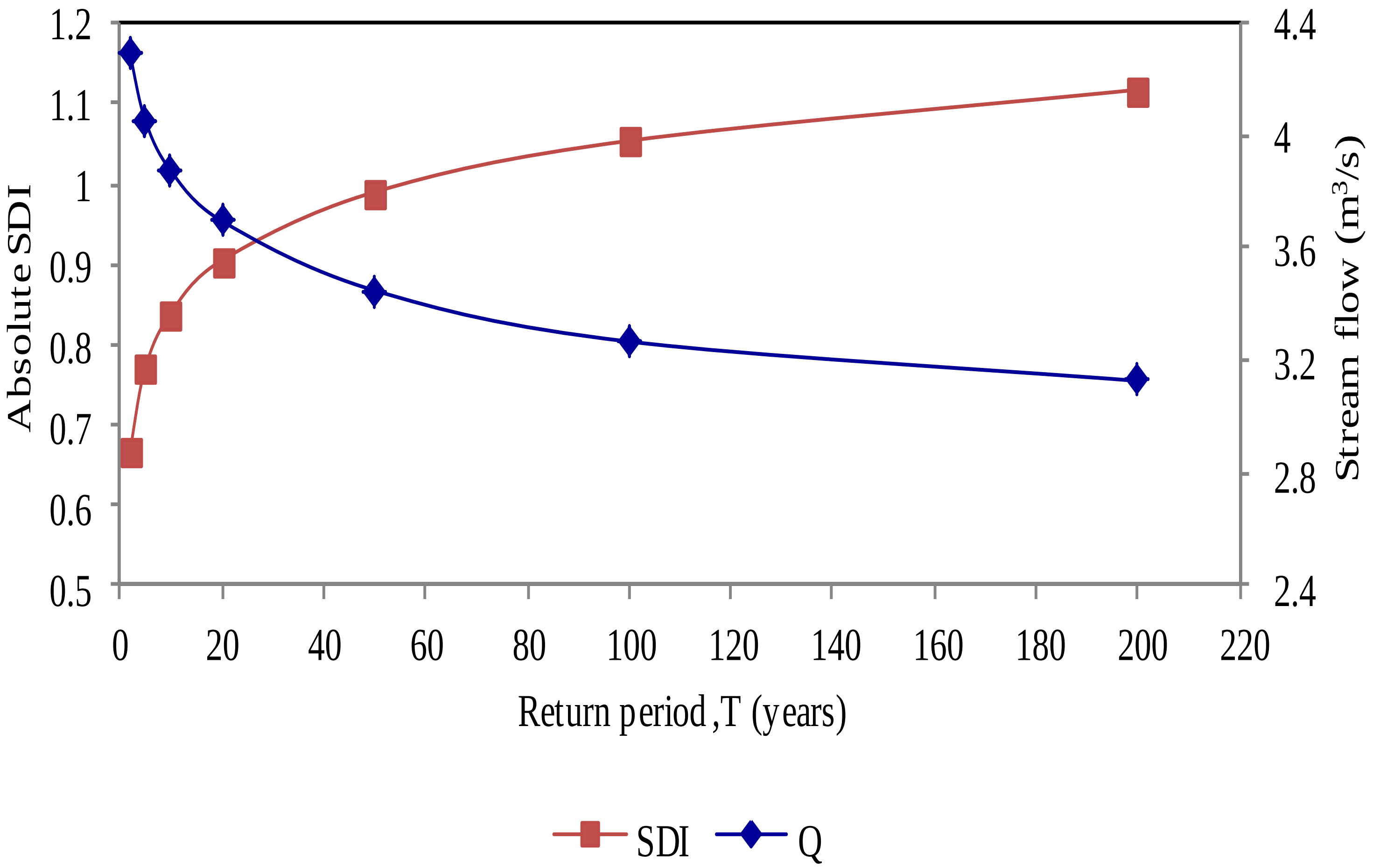
K = length of period of data record/reference period

σ_k= the standard deviation of the cumulative stream flow volumes for k^{th} reference period

Results

Drought categories based on SDI

Drought description	Criterion
Non drought	$SDI \geq 0.0$
Mild drought	$-1.0 \leq SDI < 0.0$
Moderate drought	$-1.5 \leq SDI < -1.0$
Severity drought	$-2.0 \leq SDI < 1.5$
Extreme drought	$SDI < -2.0$



➢**The results of the fitted curves show that the absolute SDI increases with the return period whereas the streamflow reduces with increase in return periods**

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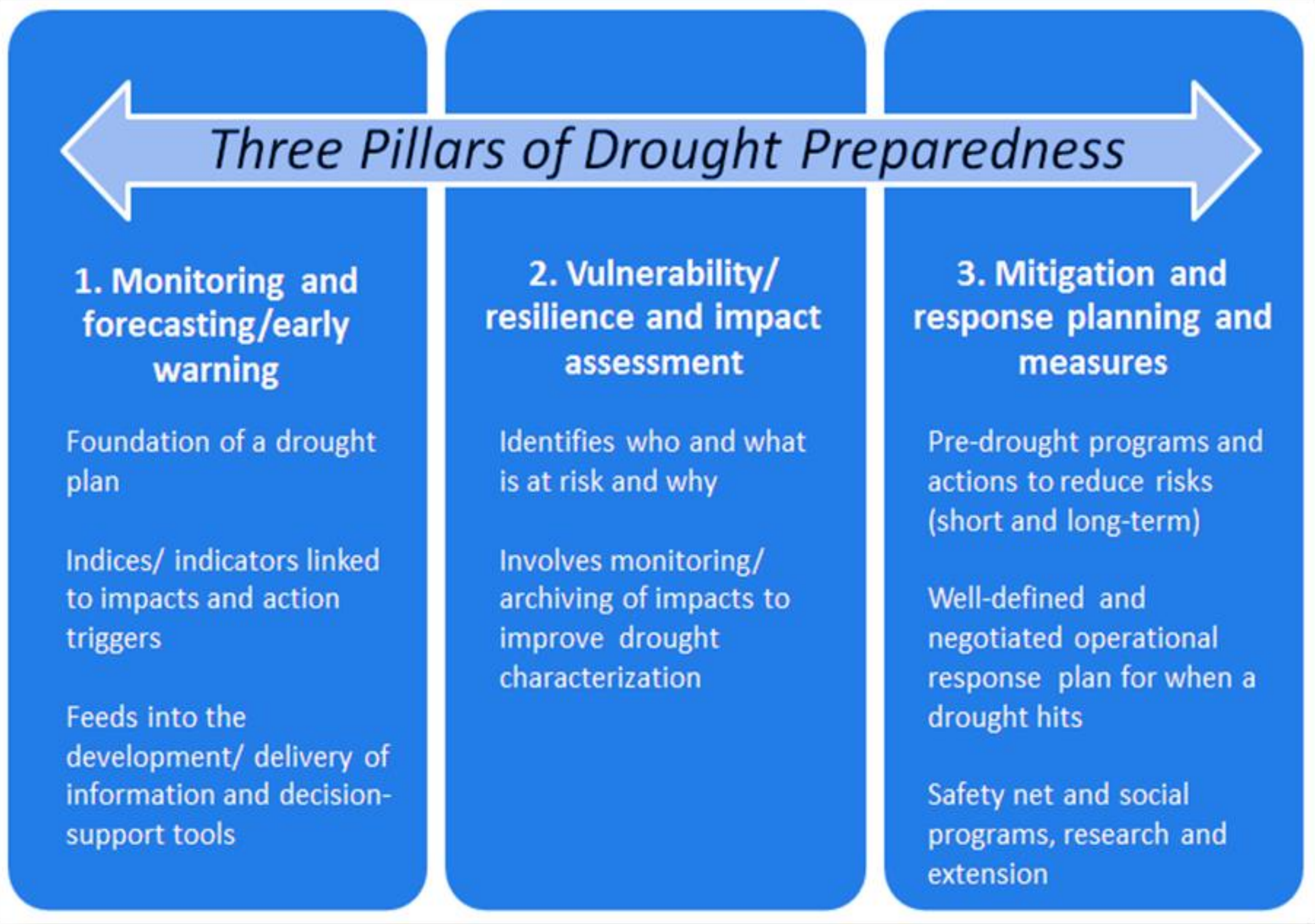
What are the major challenges, gaps and opportunities for building drought resilience?

- ➢With regard to drought resilience, countries need to make better decisions in managing drought
- ➢Need to have early warning systems
- ➢Need to be strategically prepared for drought occurrences



Conclusions

- Stream flows have been explored and their corresponding return periods estimated
- A simplified mathematical model for estimating hydrological drought was developed for different return periods in the Upper Tana River Basin
- The model will be useful to water resources managers within the basin in planning, designing, operating and managing the water resources systems
- Developed curves relating SDI, stream flow and return periods will make it easier in managing the water systems within the basin

Recommendation

- Dealing with climate change and/or variability therefore requires efforts from a wide range of stakeholders and policy makers working together towards climate change mitigation and building resilience on climatic conditions
- Need to have decision support tools to deal with drought impact

End

Thank you for your attention