Technology
Arts Sciences
TH Köln

Institute for Technology and Resources Management
in the Tropics and Subtropics

Drought Assessment and Management

Lars Ribbe (presenter)
Alexandra Nauditt

Drought Assessment and Management

1. Understanding drought:
   - Defining drought
   - Monitoring drought
   - Setting thresholds

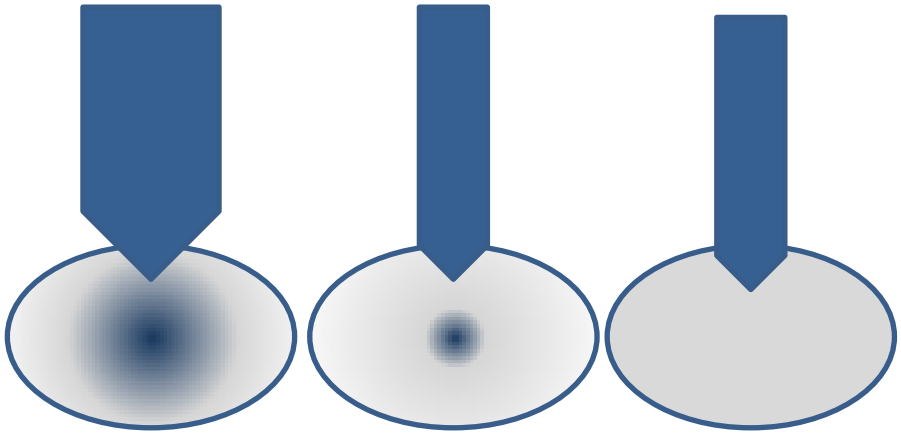
2. Coping with Drought
   - Basin Wide Measures
   - Information Systems

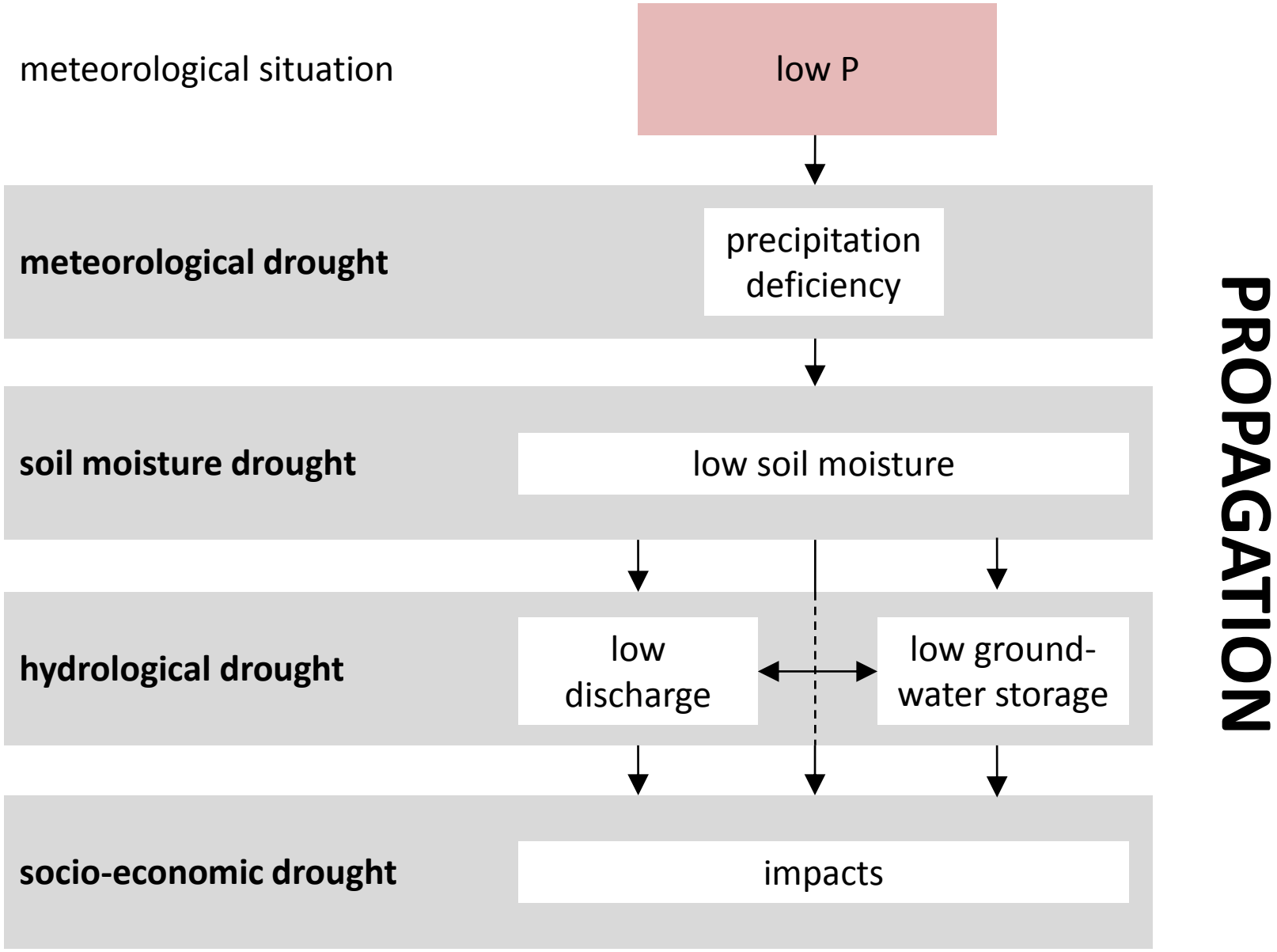
Drought Assessment

Definition of drought

A drought is a period when
water demand (for humans or environment)
is exceeding water supply

Drought risk =
drought hazard +
drought vulnerability





Van Loon et al., 2012

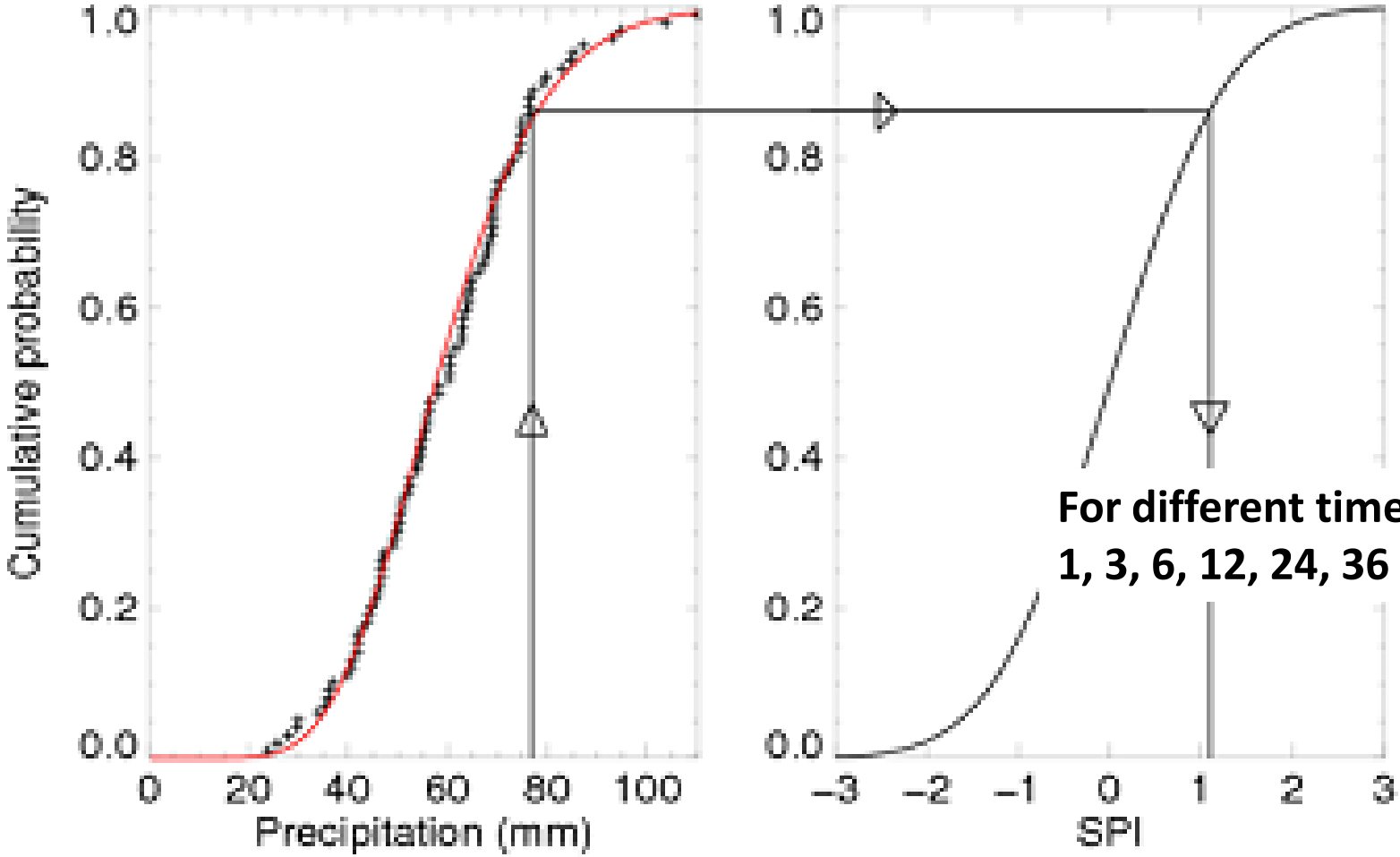
Precipitation, vegetation or soil moisture based indices used for historical drought analyses and forecasting

- **SPI – Standardized Precipitation index** (McKee, 1984)
- **PDSI - The Palmer Drought Severity Index** (Palmer, 1965):
- **Deciles method** (Gibbs and Maher 1967; Coughlan, 1987), Australia
- **NDVI,** monthly MODIS normalized difference vegetation index
- **fAPAR,** Fraction of Absorbed Photosynthetically-Active Radiation, derived from MERIS

⇒Standardized approaches

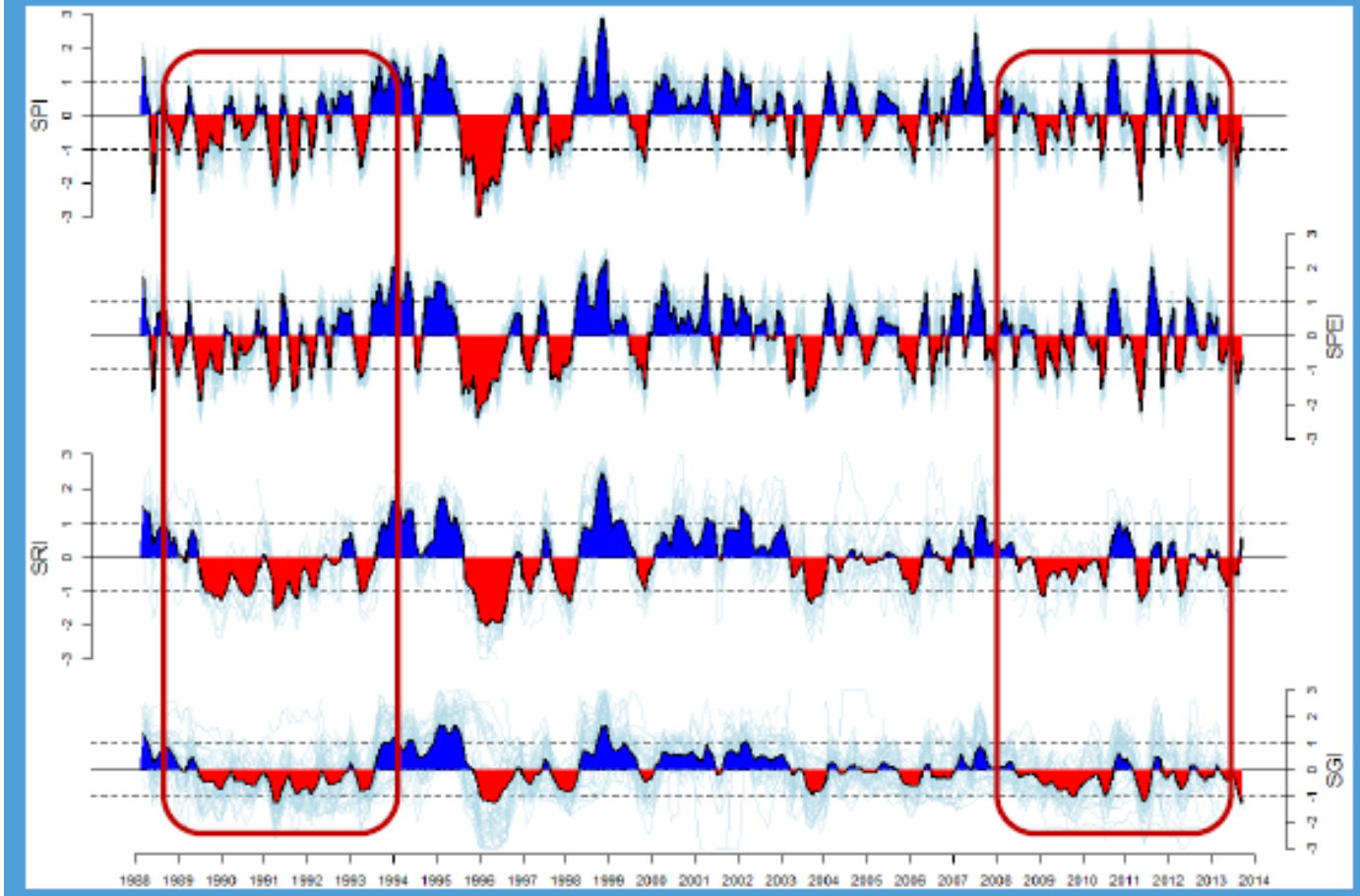
→ are they useful?

How is SPI calculated?



For different time periods:
1, 3, 6, 12, 24, 36 months

Standardised approaches

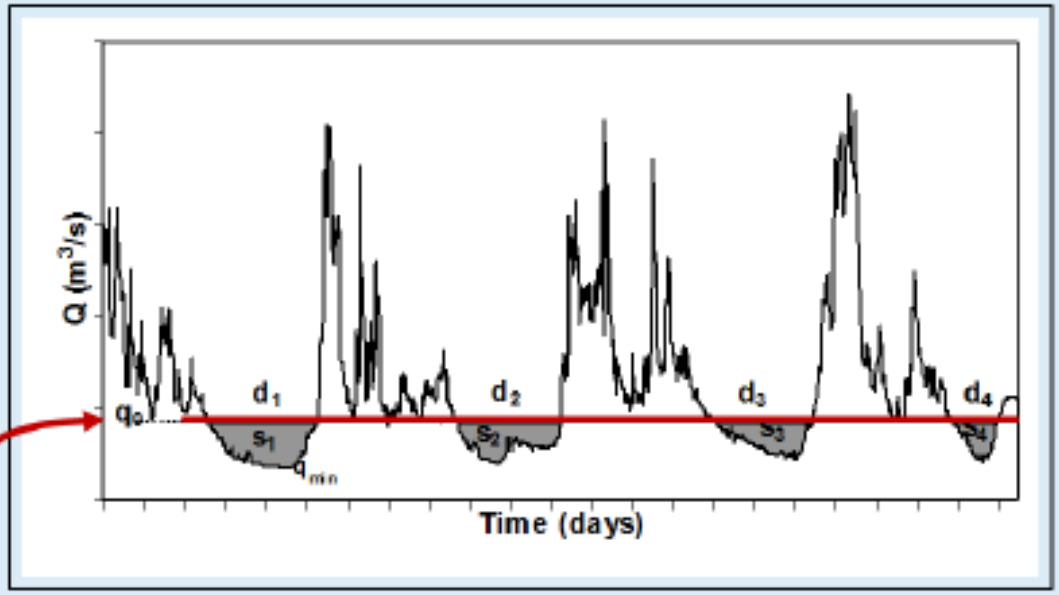


Ten Broek et al., (DROUGHT-R&SPI TR 15, 2014)

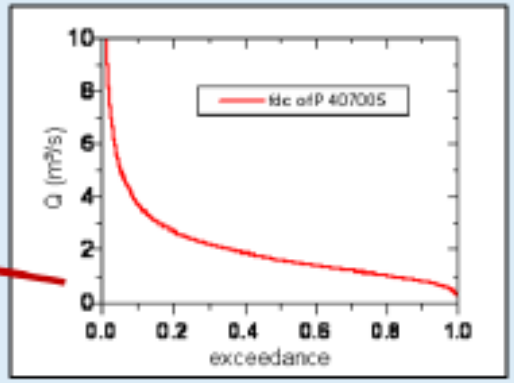
Site appropiate drought assessment, monitoring and forecasting

Need to consider: scale, topography, demand side and other site specific drought relevant indicators:

- Rainfed agriculture: SPI and Vegetation based indices
- Irrigated agriculture: threshold methods
- Storage in reservoirs and groundwater: threshold methods
- Snowmelt driven systems
- …..



Threshold approach
(FIXED)



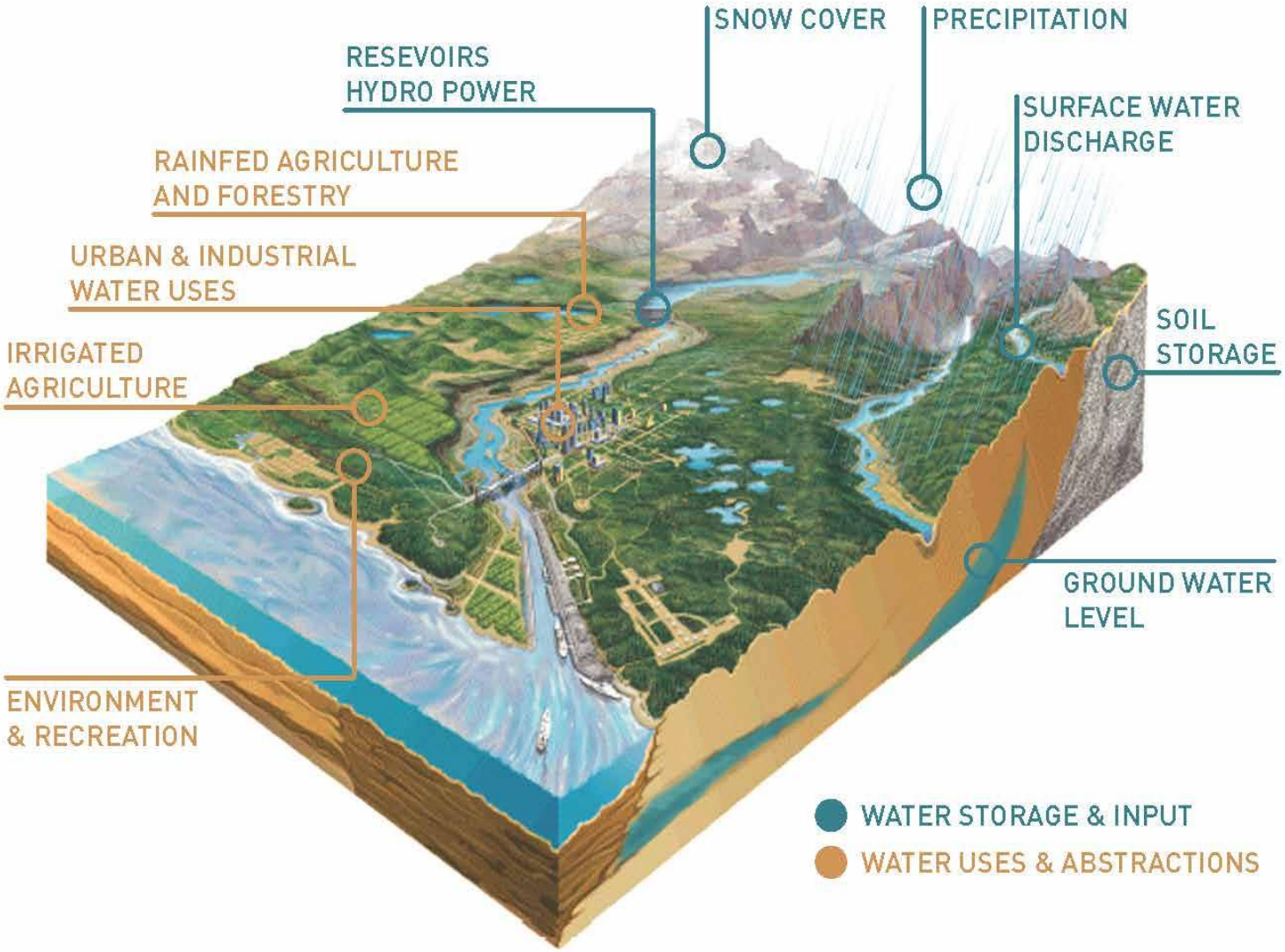
Each drought has:
- **onset**
- **duration**
- **severity (deficit)**
- **intensity**

Hisdal et al. (2004)

Hydrological drought cannot be explained by precipitation and vegetation based indices alone

- Role of evapotranspiration
- Effect of temperature (and snow)
- Non-linear transformation in the subsurface
- Storage (groundwater and reservoirs)
- Human abstractions

Water storage and uses as crucial information for drought assessment!



VuGia ThuBon, Vietnam: hydropower development, irrigated agriculture, extended dry season, salt water intrusion

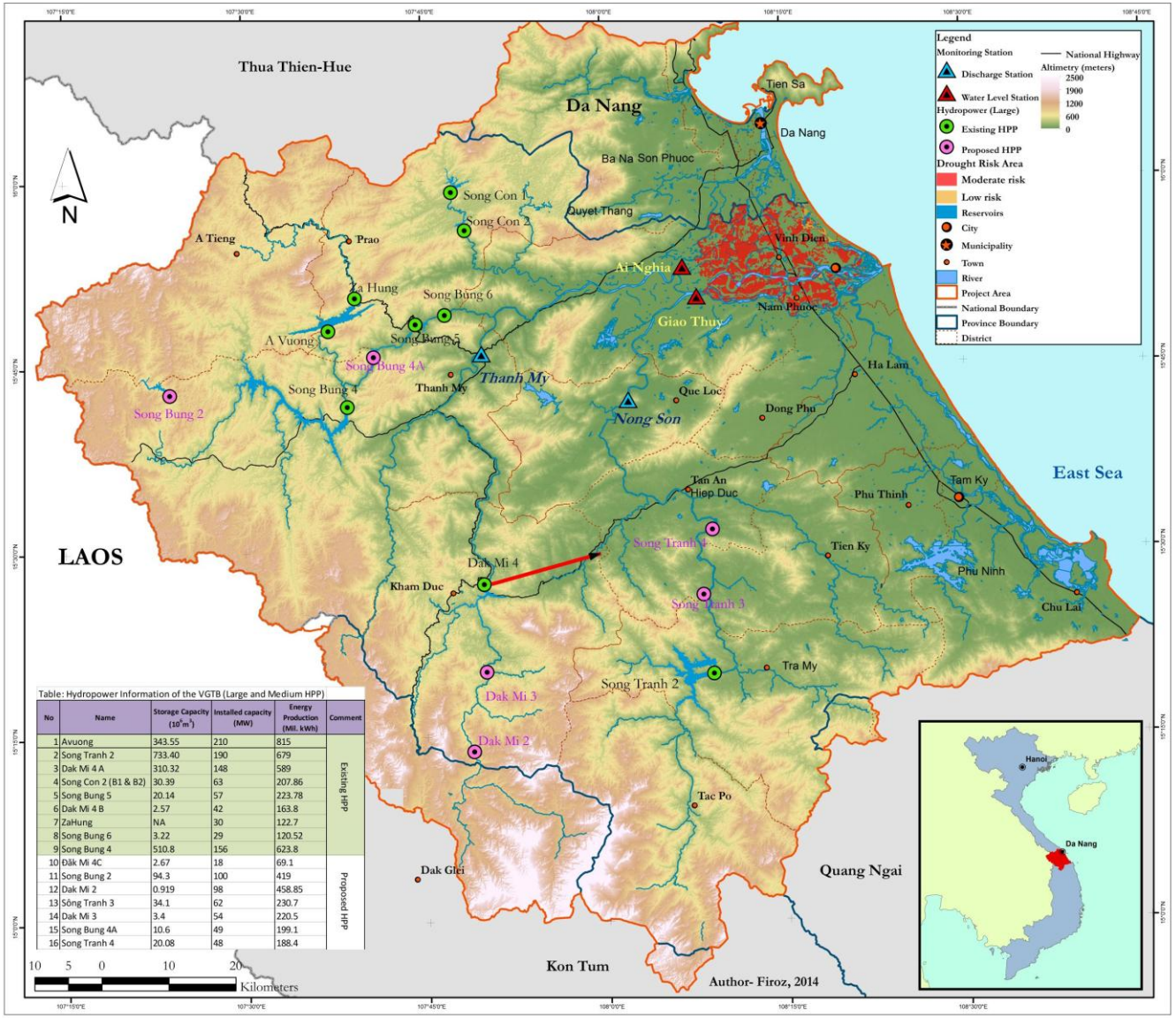


Table: Hydropower Information of the VGTB (Large and Medium HPP)

No	Name	Storage Capacity ($10^6 m^3$)	Installed capacity (MW)	Energy Production (Mil. kWh)	Comment
1	Avuong	343.55	210	815	Existing HPP
2	Song Tranh 2	733.40	190	679	
3	Dak Mi 4 A	310.32	148	589	
4	Song Con 2 (B1 & B2)	30.39	63	207.86	
5	Song Bung 5	20.14	57	223.78	
6	Dak Mi 4 B	2.57	42	163.8	
7	ZaHung	NA	30	122.7	
8	Song Bung 6	3.22	29	120.52	
9	Song Bung 4	510.8	156	623.8	
10	Đăk Mi 4C	2.67	18	69.1	Proposed HPP
11	Song Bung 2	94.3	100	419	
12	Dak Mi 2	0.919	98	458.85	
13	Sông Tranh 3	34.1	62	230.7	
14	Dak Mi 3	3.4	54	220.5	
15	Song Bung 4A	10.6	49	199.1	
16	Song Tranh 4	20.08	48	188.4	

Dry season and drought in the VGTB

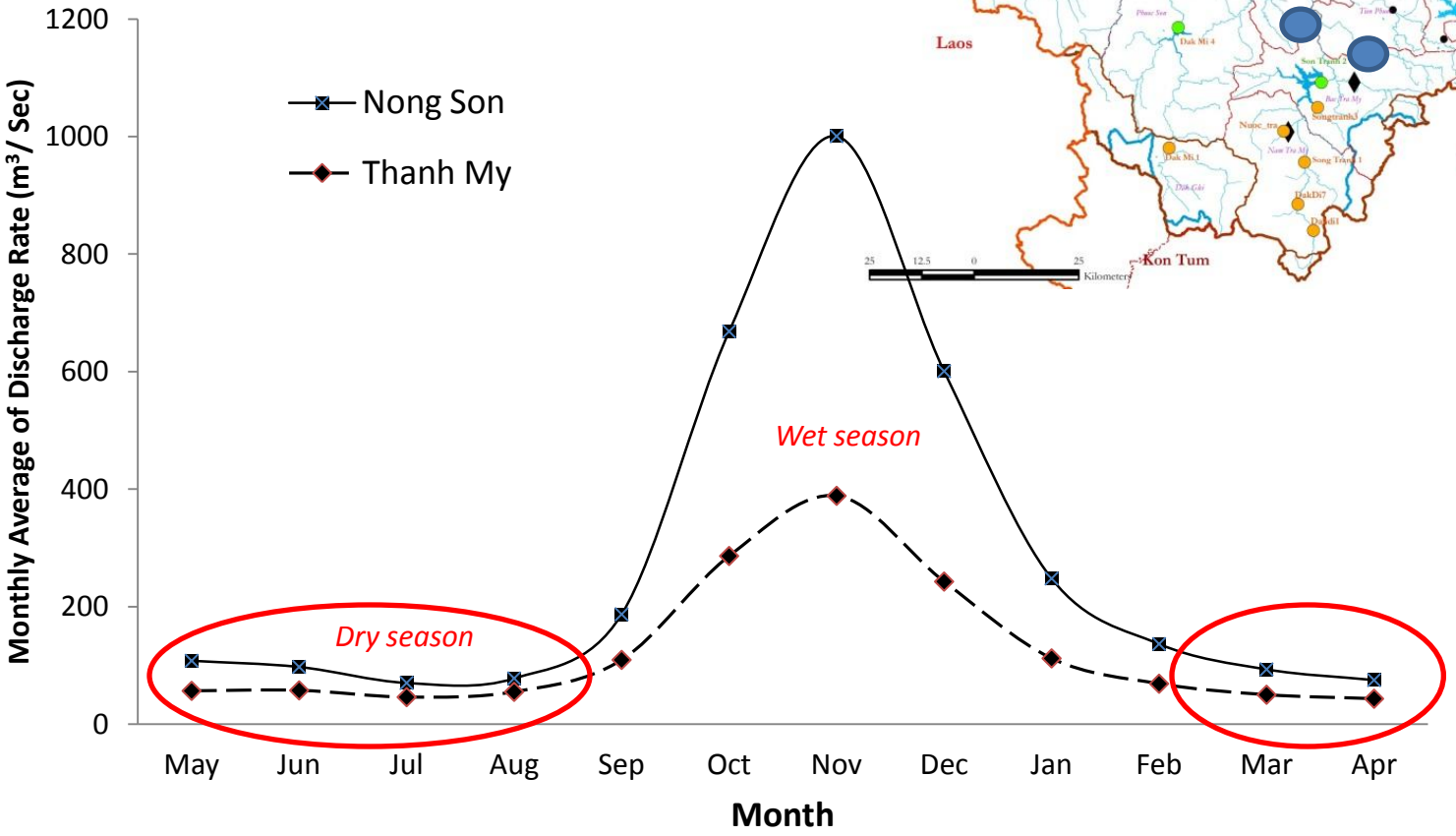


Fig. : Monthly average discharge (m^3/s) at Nong Son & Thanh My (1976-2011)

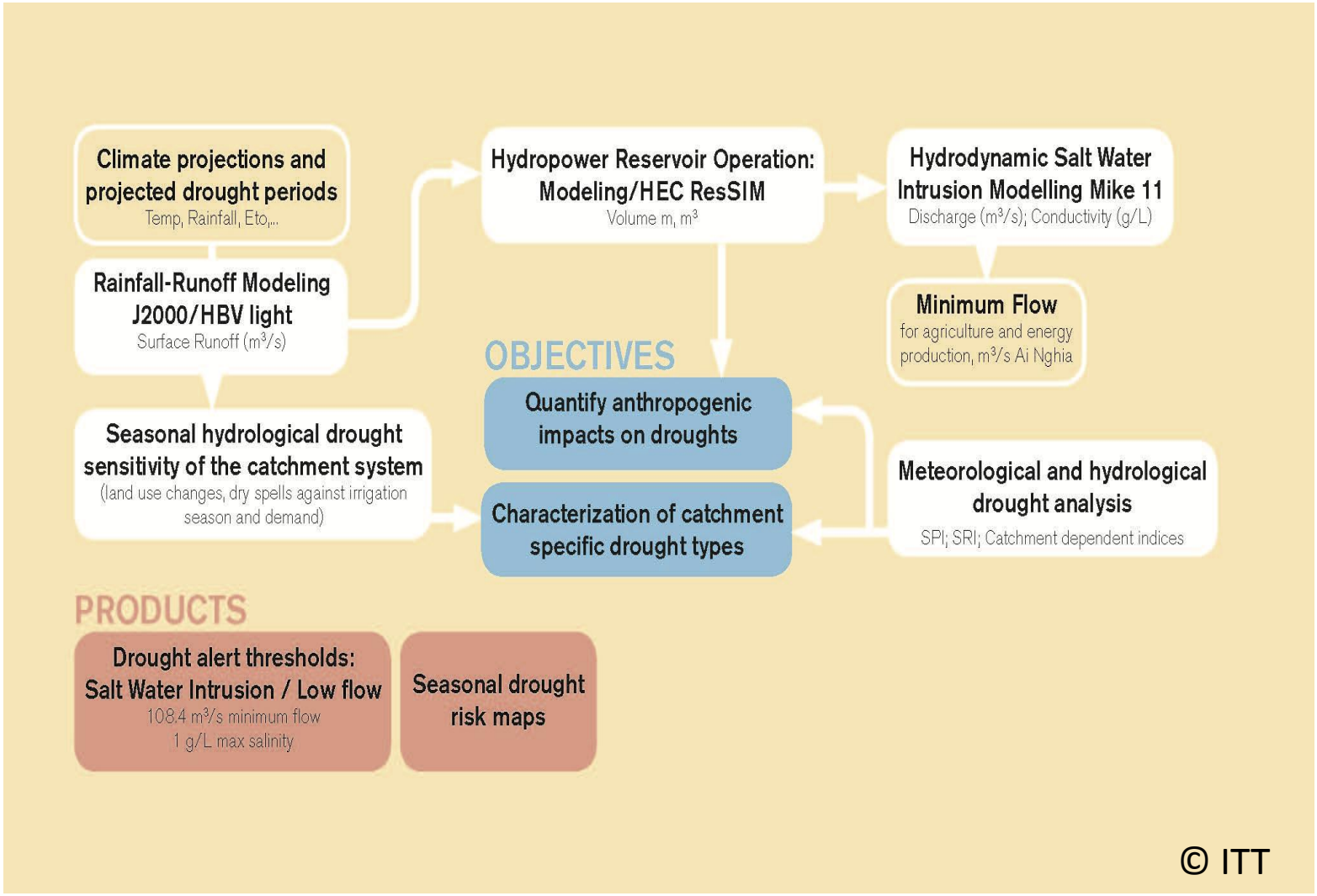


Figure: Catchment specific drought assessment methodology for the Vu Gia Thu Bon River Basin, Central Vietnam

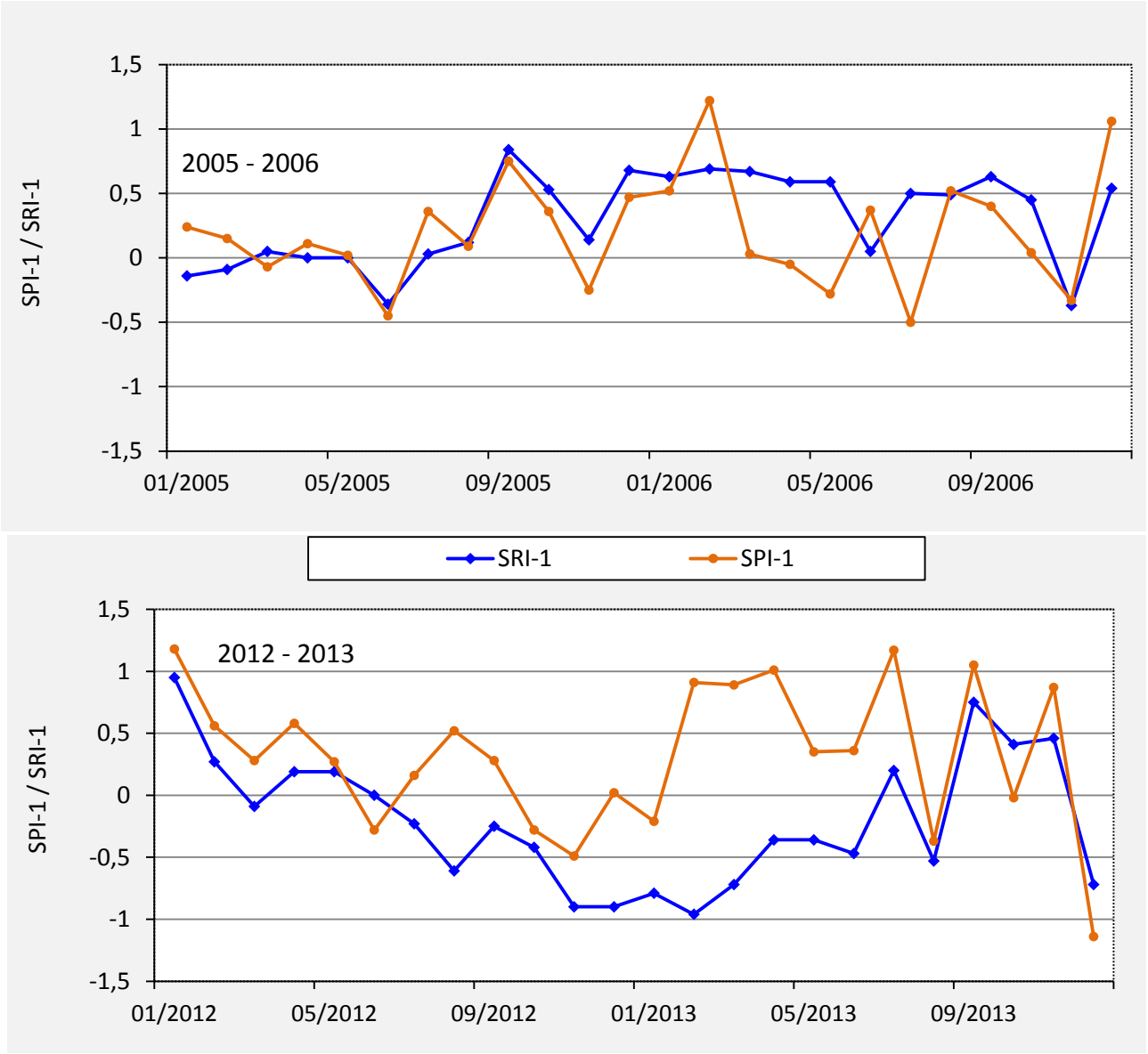


Figure: *Relationship between SPI and SRI in the Vu Gia River basin, values below o indicate meteorological (SPI) or hydrological drought conditions (SRI)*

Sensitivity analysis of discharge against catchment characteristics, here: Land Use change

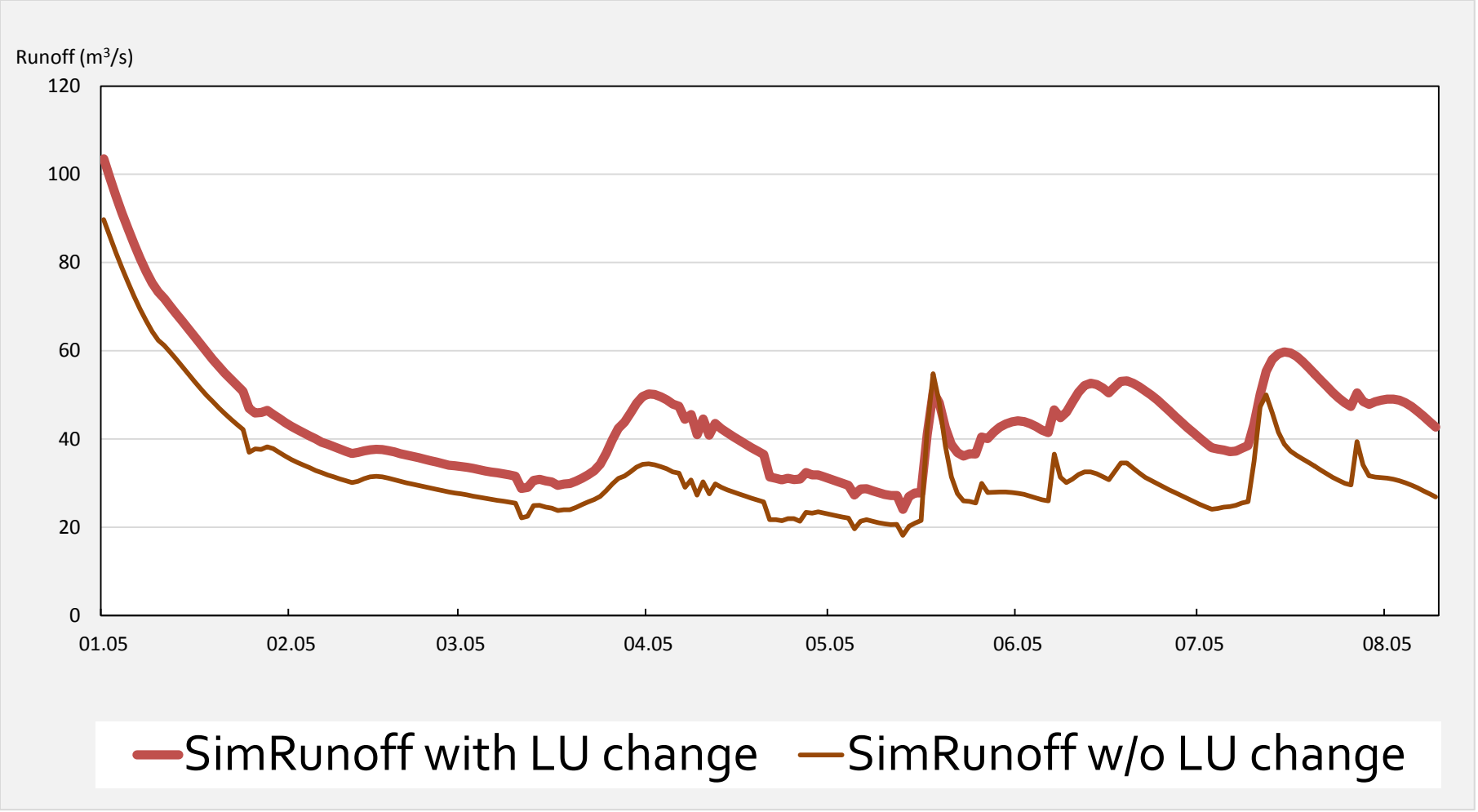
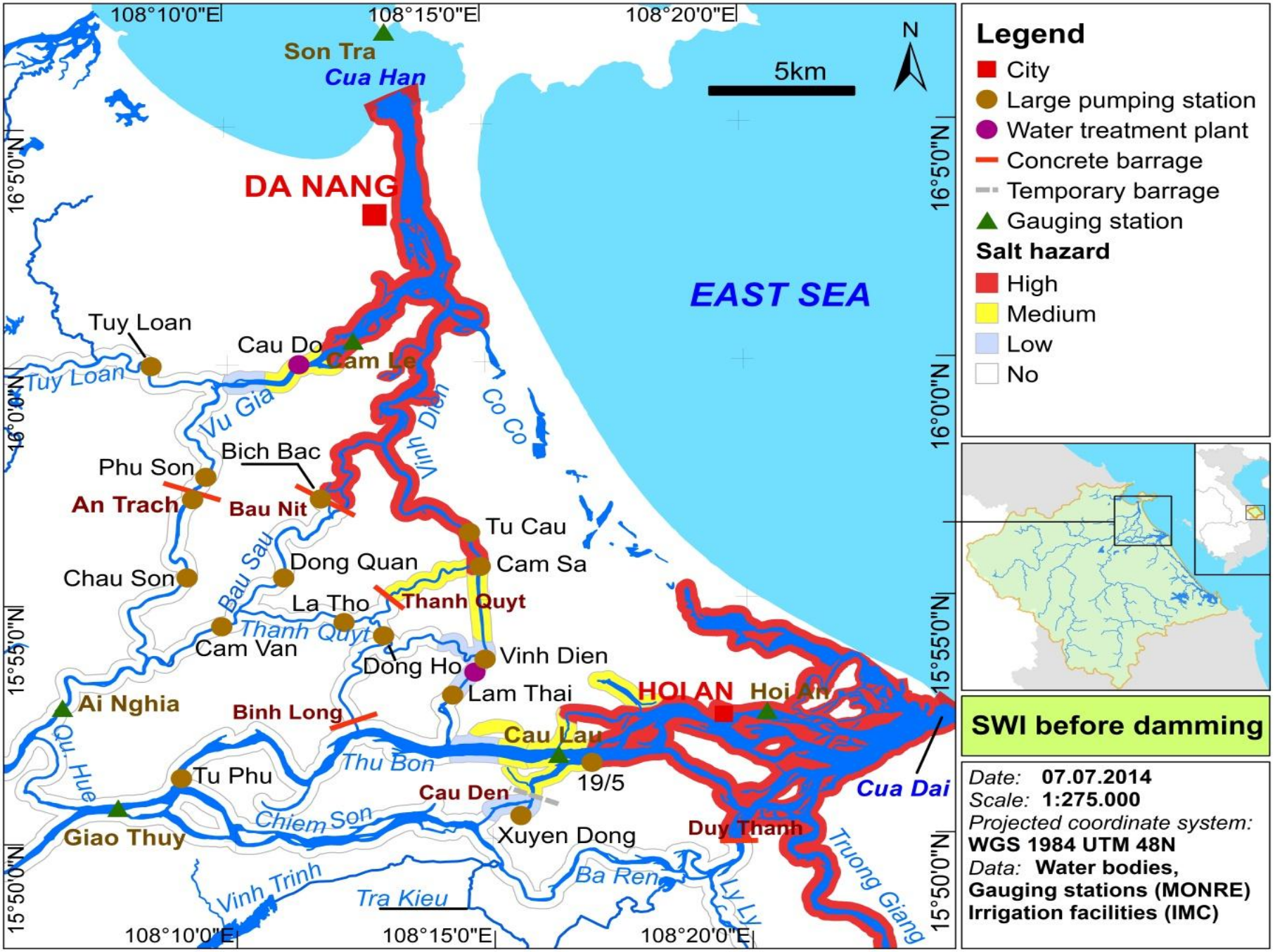


Figure: *J2000 model performance for Vu Gia catchment and simulation testing discharge sensitivity against land use changes at Thanh My station (Fink, 2015)*

Simulation of Salt water intrusion

Hydrodynamic modelling with Mike 11 based on

- input from rainfall runoff model J2000
- reservoir modelling (HEC Resim) and
- water management model Mike Basin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15°55'0"N
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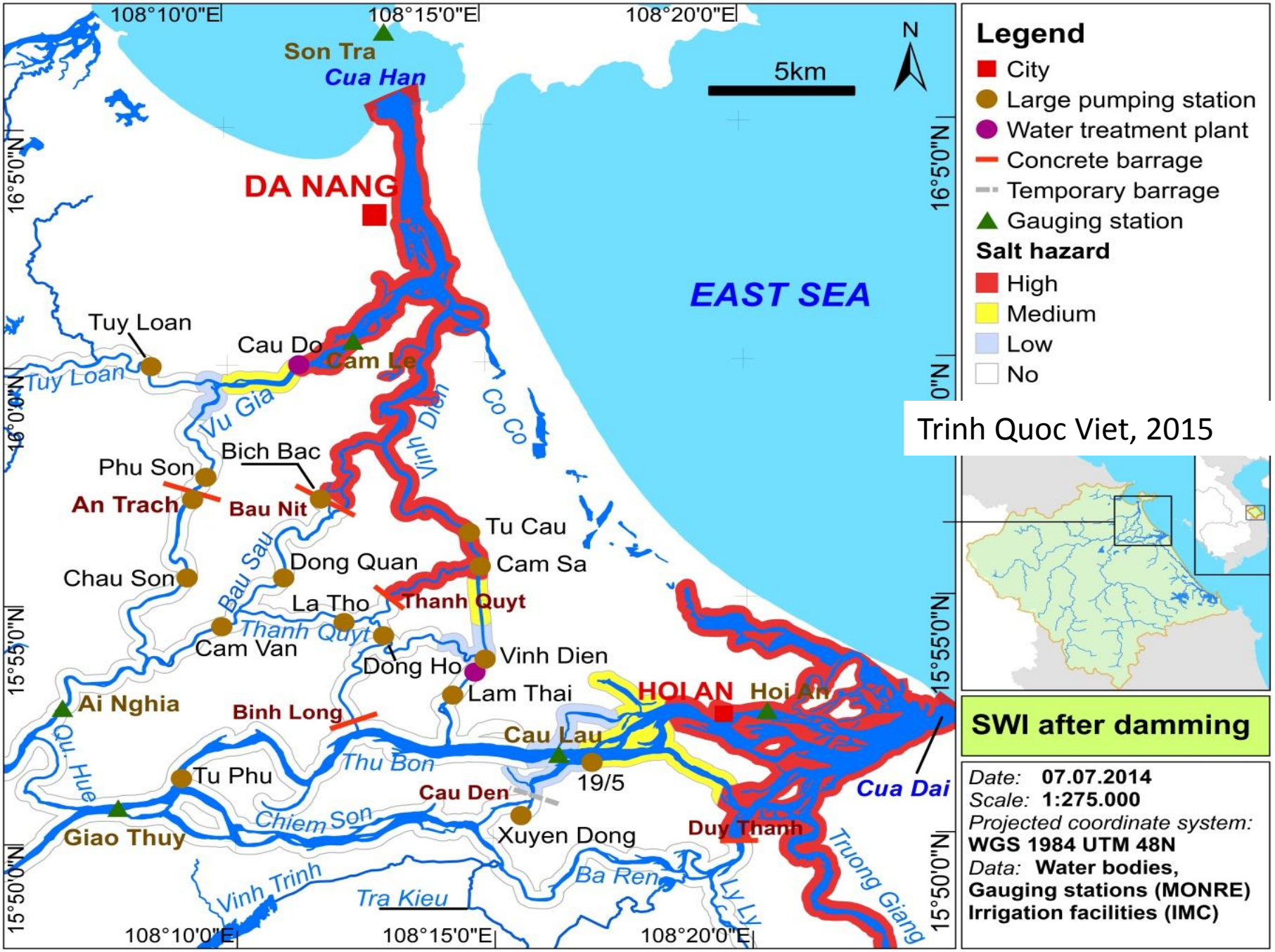
N
5km
Son Tra
Cua Han
DA NANG
EAST SEA
Tuy Loan
Cau Do
Cam Le
Tuy Loan
Vu Gia
Vinh Dien
Co Co
Phu Son
Bich Bac
An Trach
Bau Nit
Tu Cau
Bau Sau
Dong Quan
Cam Sa
Chau Son
La Tho
Thanh Quyt
Thanh Quyt
Cam Van
Dong Ho
Vinh Dien
Lam Thai
HOI AN
Hoi An
Ai Nghia
Binh Long
Cau Lau
Thu Bon
Tu Phu
Cau Den
19/5
Cua Dai
Qu. Hue
Chiem Son
Giao Thuy
Xuyen Dong
Duy Thanh
Vinh Trinh
Tra Kieu
Ba Ren
Ly Ly
Truong Giang
Legend
City
Large pumping station
Water treatment plant
Concrete barrage
Temporary barrage
Gauging station
Salt hazard
High
Medium
Low
No
SWI before damming
Date: 07.07.2014
Scale: 1:275.000
Projected coordinate system:
WGS 1984 UTM 48N
Data: Water bodies,
Gauging stations (MONRE)
Irrigation facilities (IMC)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Vinh Dien
Co Co
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An Trach
Bau Nit
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Chau Son
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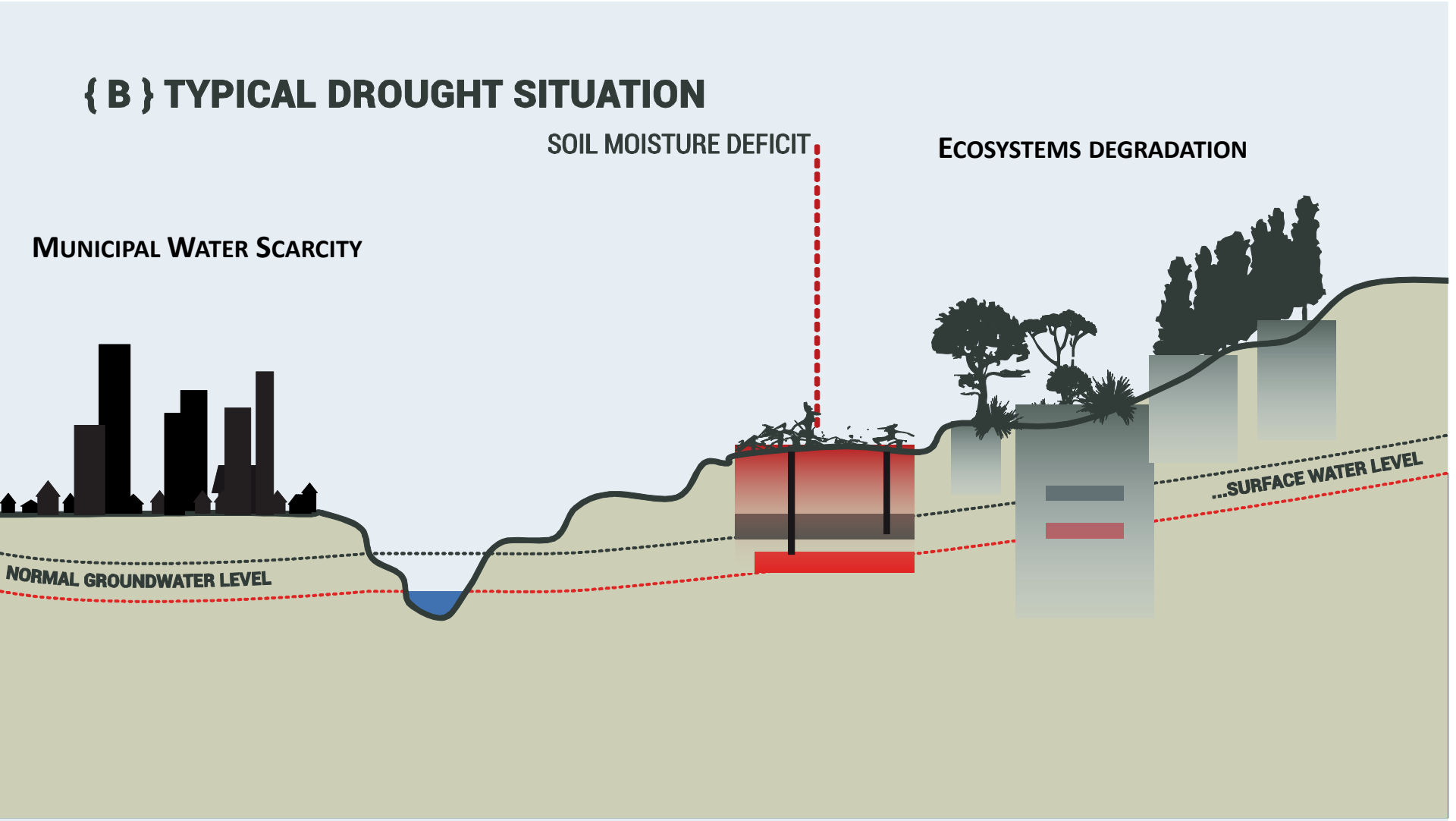
Trinh Quoc Viet, 2015
SWI after damming
Date: 07.07.2014
Scale: 1:275.000
Projected coordinate system:
WGS 1984 UTM 48N
Data: Water bodies,
Gauging stations (MONRE)
Irrigation facilities (IMC)

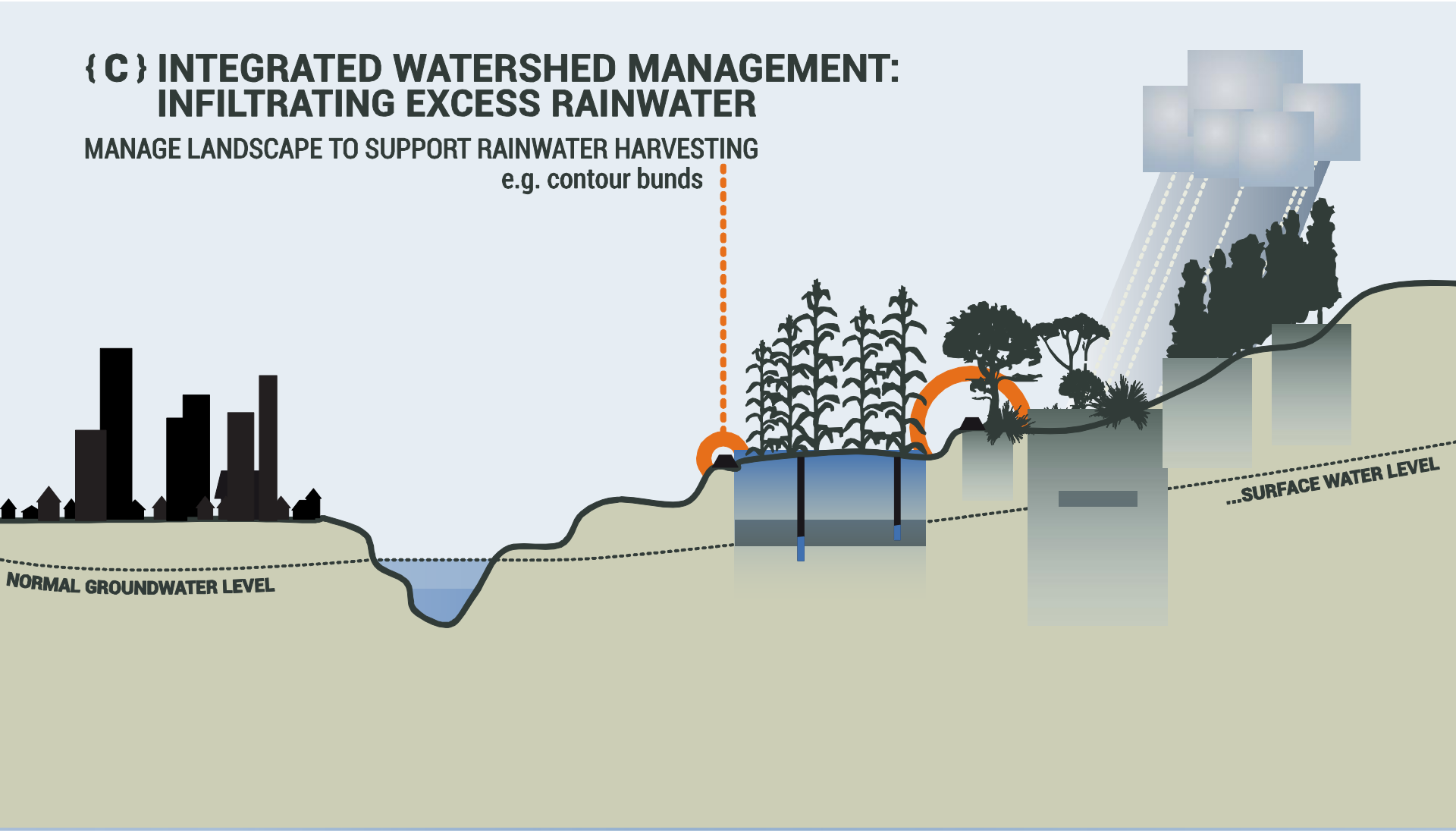
2. Coping with drought

Strategies to cope with droughts

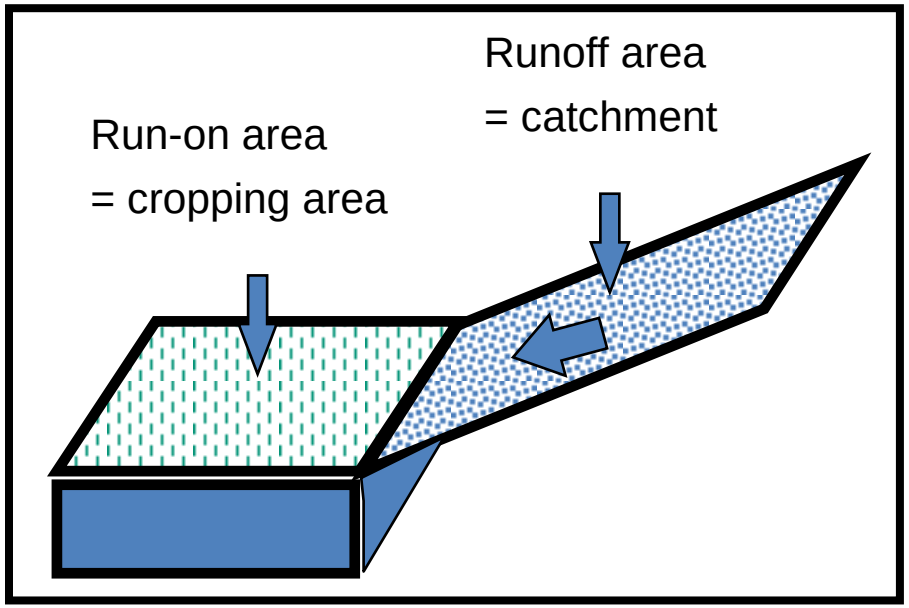
1. Store Water / make it available when needed

2. Inform users about status of drought and possible action


{ B } TYPICAL DROUGHT SITUATION
SOIL MOISTURE DEFICIT
ECOSYSTEMS DEGRADATION
MUNICIPAL WATER SCARCITY
SURFACE WATER LEVEL
NORMAL GROUNDWATER LEVEL

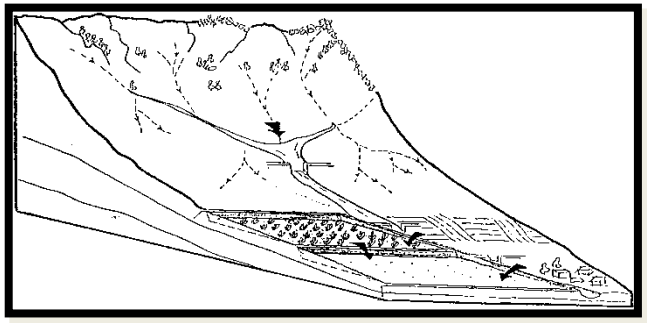

{ C } INTEGRATED WATERSHED MANAGEMENT:
INFILTRATING EXCESS RAINWATER
MANAGE LANDSCAPE TO SUPPORT RAINWATER HARVESTING
e.g. contour bunds
NORMAL GROUNDWATER LEVEL
SURFACE WATER LEVEL

Rainwater Harvesting

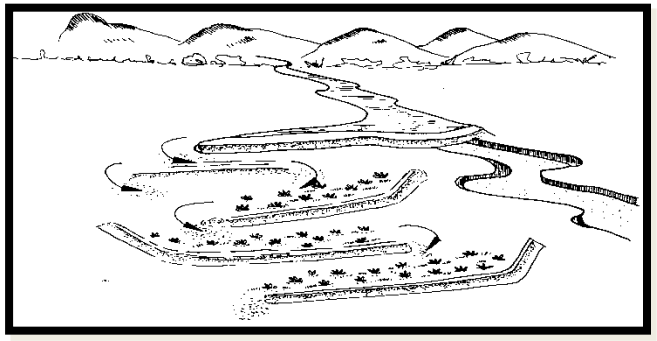


Source: Prinz

Microcatchments

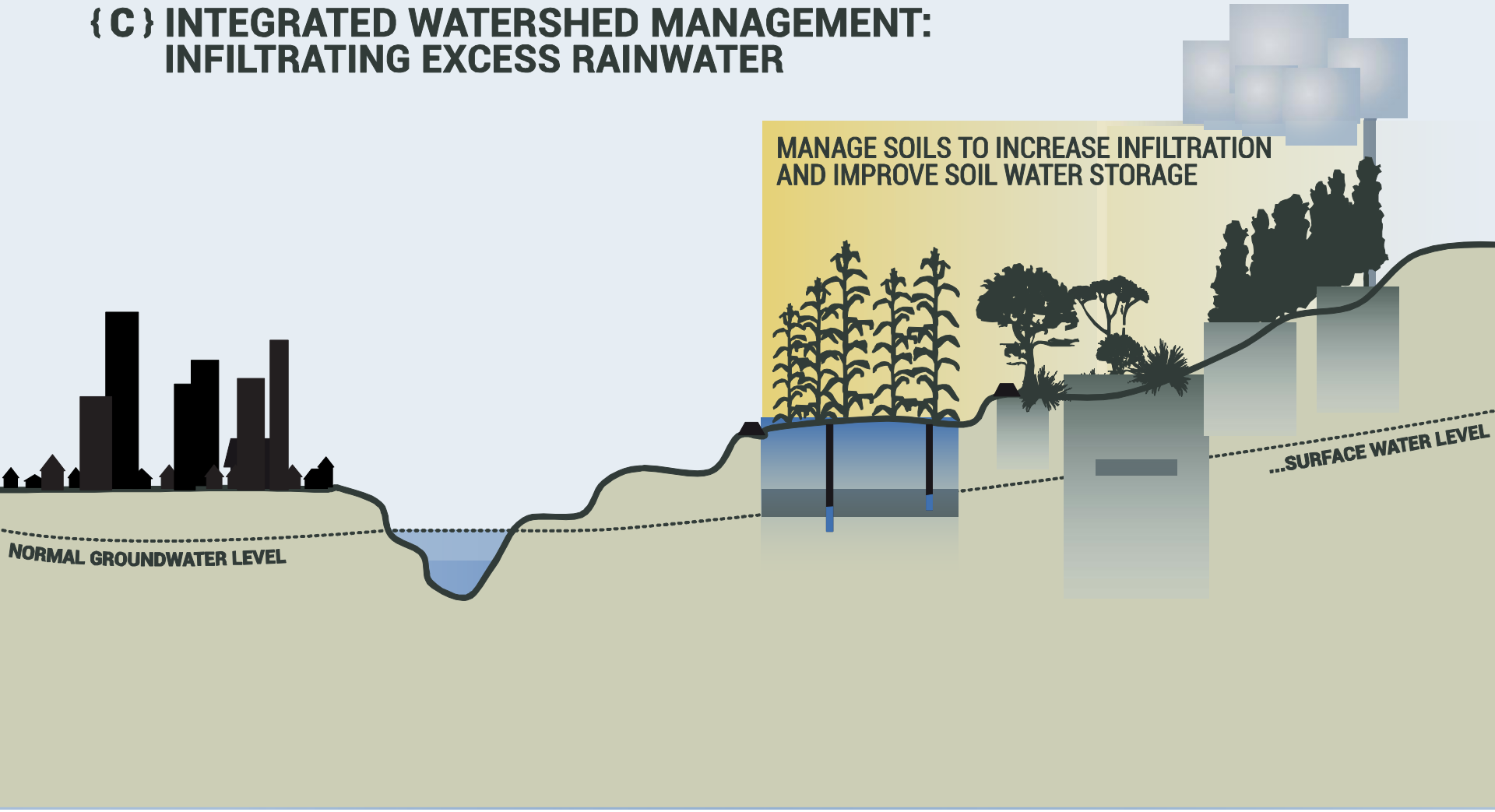


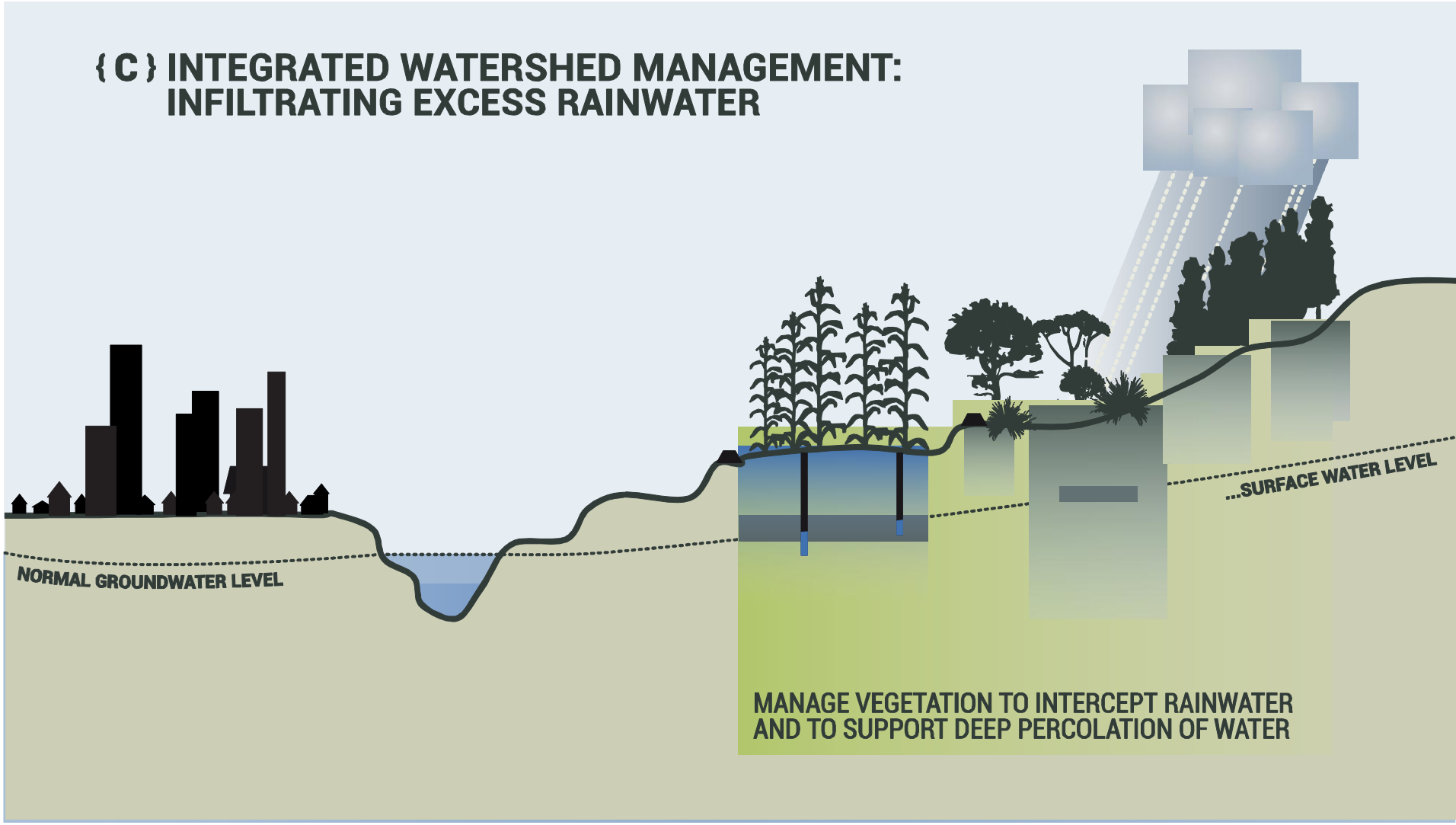
Macrocatchment

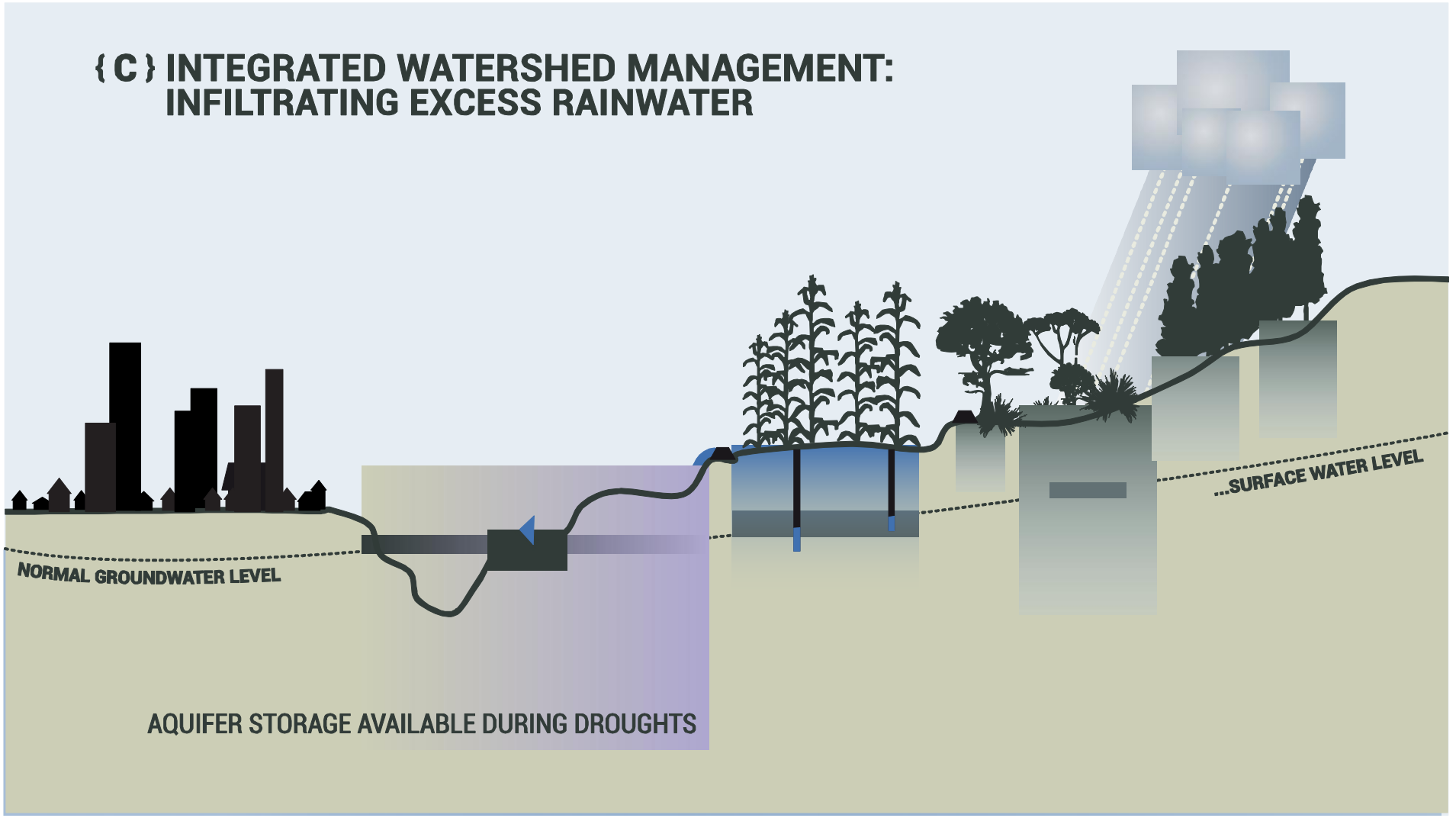


Floodwater harvesting

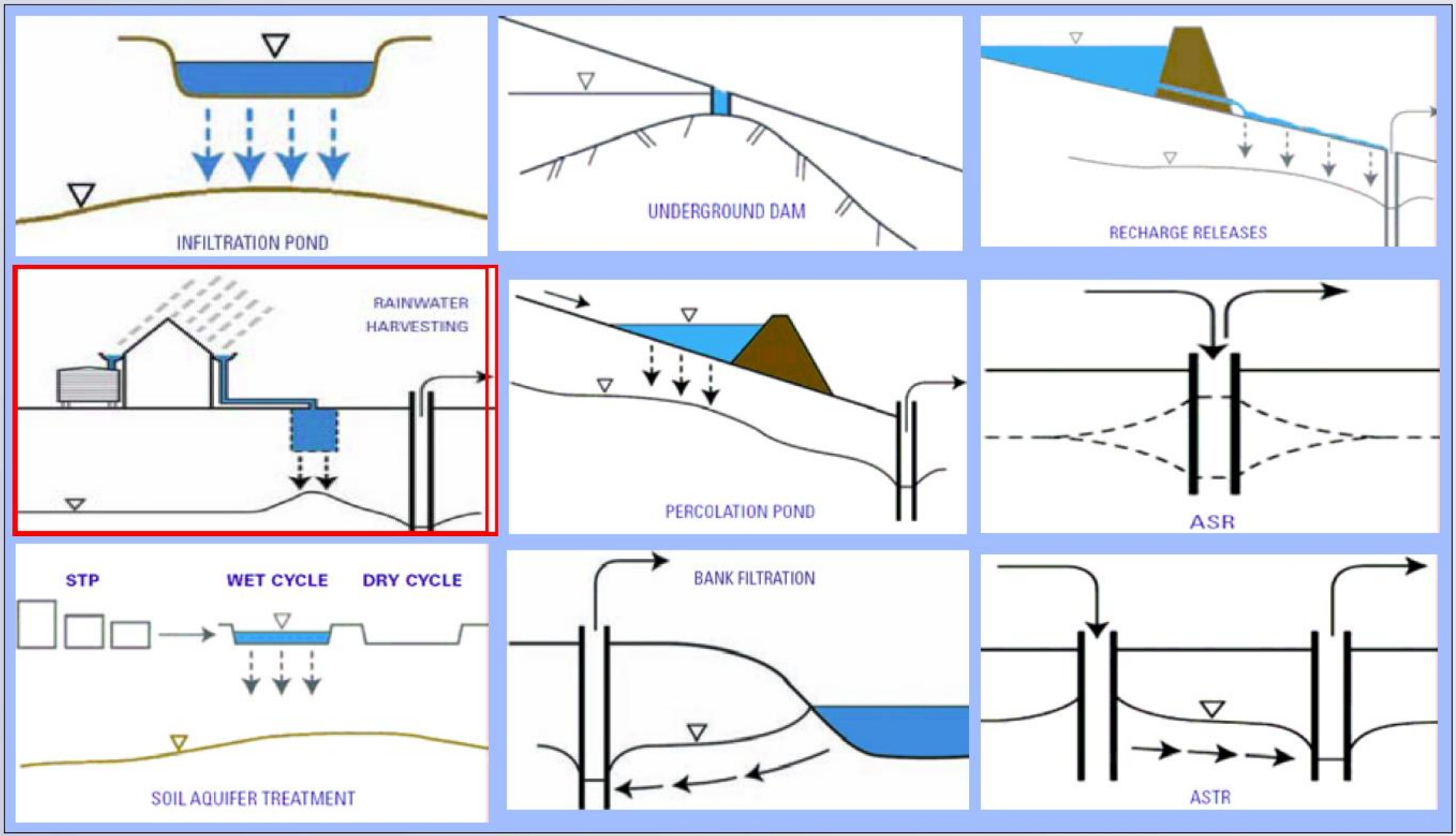
{ C } INTEGRATED WATERSHED MANAGEMENT: INFILTRATING EXCESS RAINWATER




{ C } INTEGRATED WATERSHED MANAGEMENT:
INFILTRATING EXCESS RAINWATER
NORMAL GROUNDWATER LEVEL
SURFACE WATER LEVEL
MANAGE VEGETATION TO INTERCEPT RAINWATER
AND TO SUPPORT DEEP PERCOLATION OF WATER

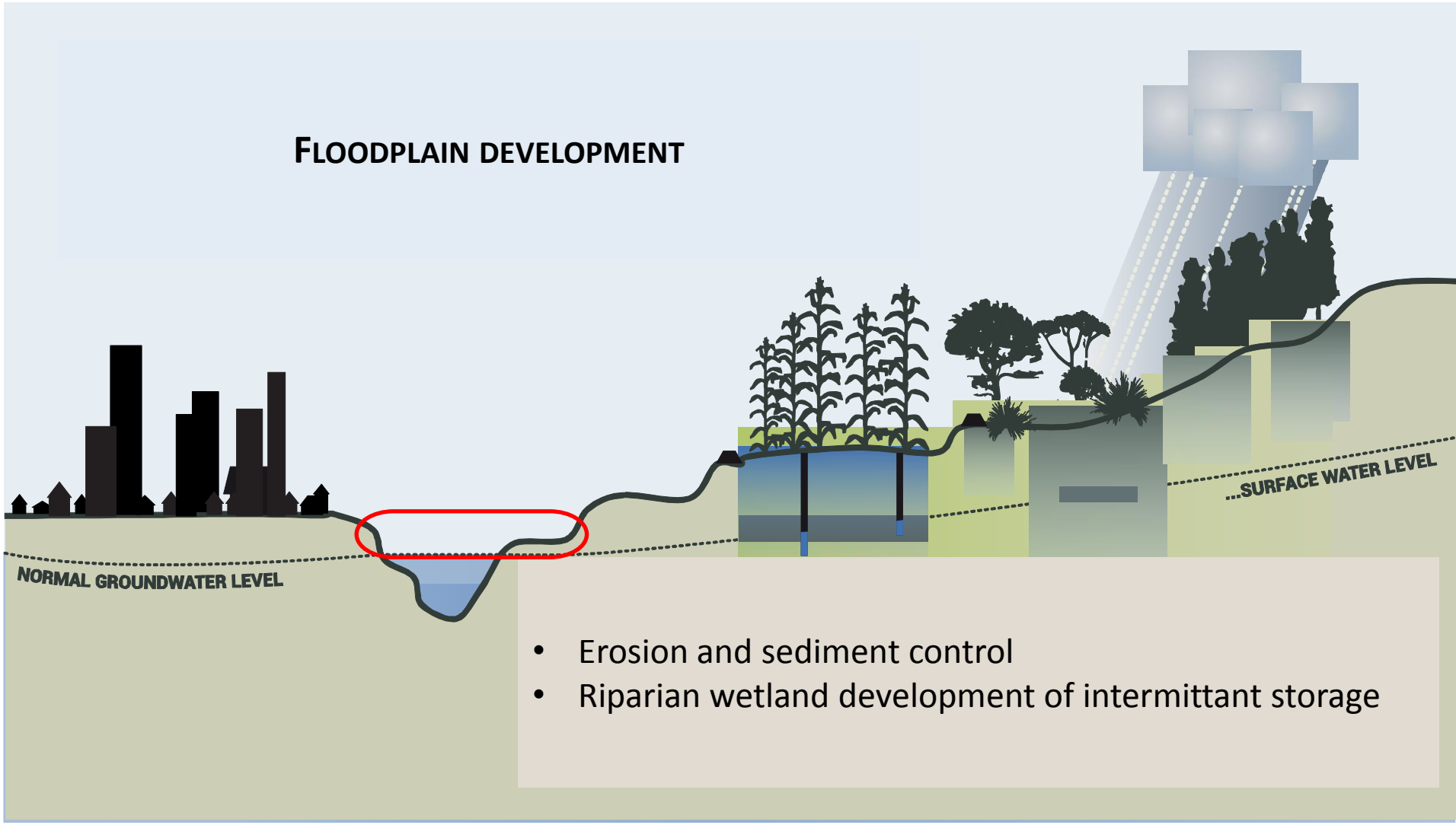

{ C } INTEGRATED WATERSHED MANAGEMENT:
INFILTRATING EXCESS RAINWATER
NORMAL GROUNDWATER LEVEL
SURFACE WATER LEVEL
AQUIFER STORAGE AVAILABLE DURING DROUGHTS

Some MAR techniques

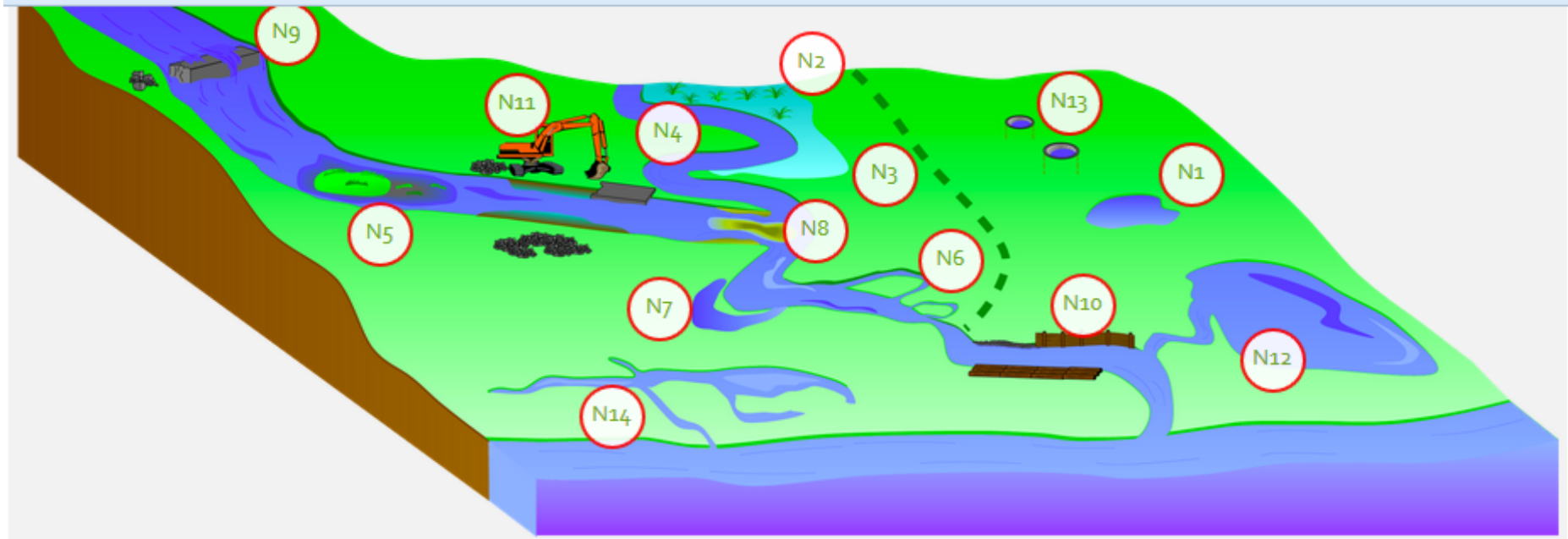


(Source: Gale, 2005)

FLOODPLAIN DEVELOPMENT



- Erosion and sediment control
- Riparian wetland development of intermittant storage



N01	Basins and ponds
N02	Wetland restoration and management
N03	Floodplain restoration and management
N04	Re-meandering
N05	Stream bed re-naturalization
N06	Restoration and reconnection of seasonal streams
N07	Reconnection of oxbow lakes and similar features
N08	Riverbed material renaturalization
N09	Removal of dams and other longitudinal barriers
N10	Natural bank stabilisation
N11	Elimination of riverbank protection
N12	Lake restoration
N13	Restoration of natural infiltration to groundwater
N14	Re-naturalisation of polder areas

Living Weir

Worldwaterlife.com

Natural Water Retention Measures

www.nwrm.eu

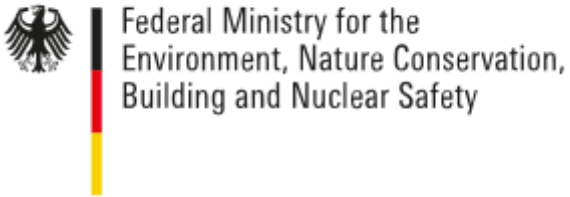
Bringing EbA into practice

"Improved Management of Extreme Events through Eco-system-based Adaption in Watersheds (ECOSWat)"

GIZ

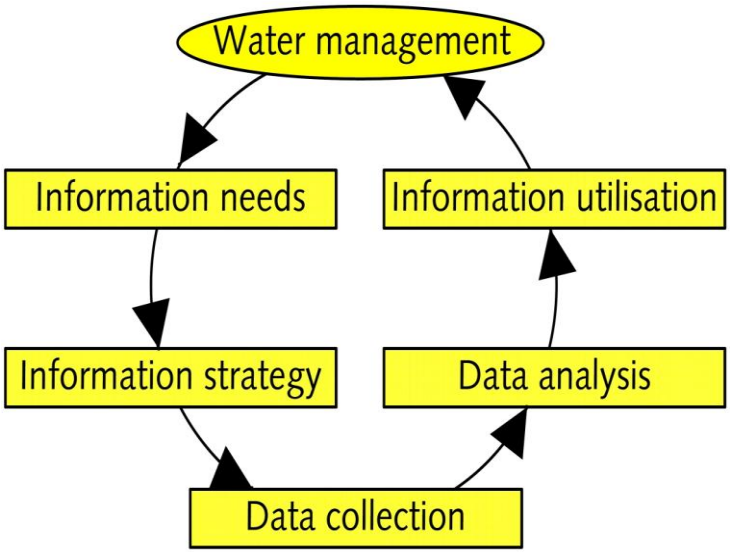
Funded by

International Climate Initiative



Decisioin making process determines information needs

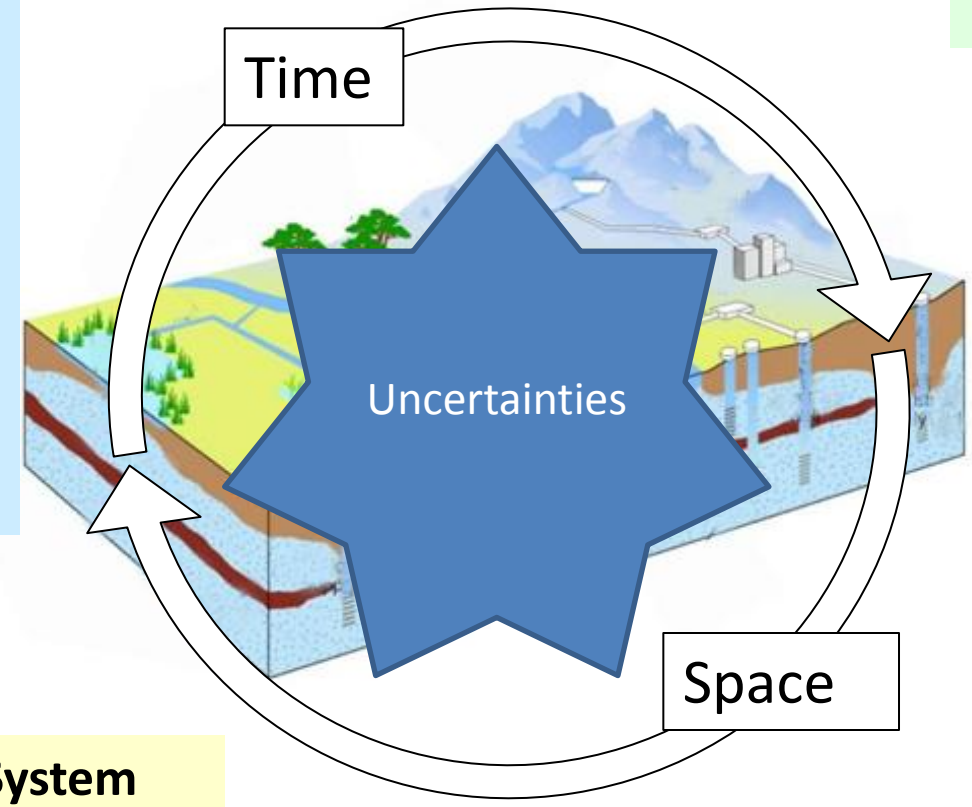
Figure 2.5. Stakeholders involved in river basin planning and management, each having different goals and information needs (*Engineering News Record*, 20 September 1993, with permission).



Information Elements and Levels of (data) Integration

Socio-economic System

Farming
Forestry
Recreation
Urban
Industrial
Commercial
Water &
Waste Treatment
…



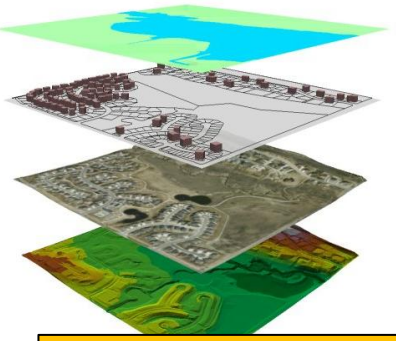
Natural System

Precipitation
Interception
Evaporation
Evapotranspiration
Infiltration
Percolation
Runoff
Storage
Topography
Geology
Soils
Vegetation
Climate
…

Institutional System

Institutions, governments, civil society, educational, private & public sectors, policies, laws, rights, licences, regulations, standards…

Who generates data... and who needs it?



3. Management and Planning

1.Monitoring

Hydromet services

Hydropower company

Irrigation association

Flood protection centre

River basin authority

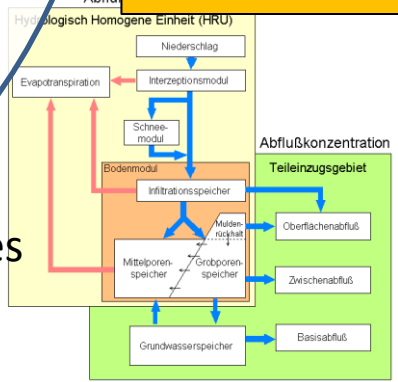
Agricultural services

Office of statistics

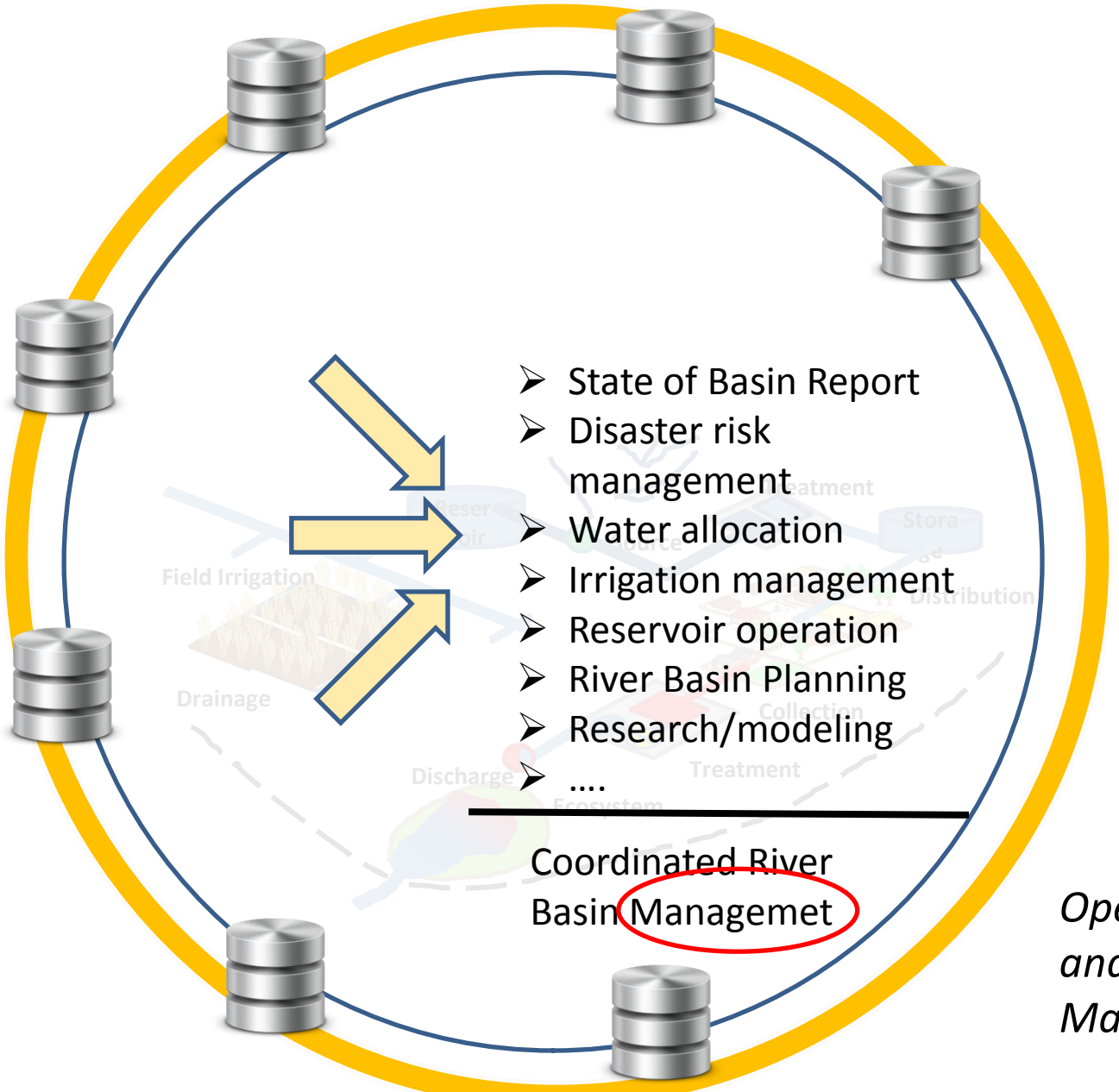
municipalities

...

2. System Modeling

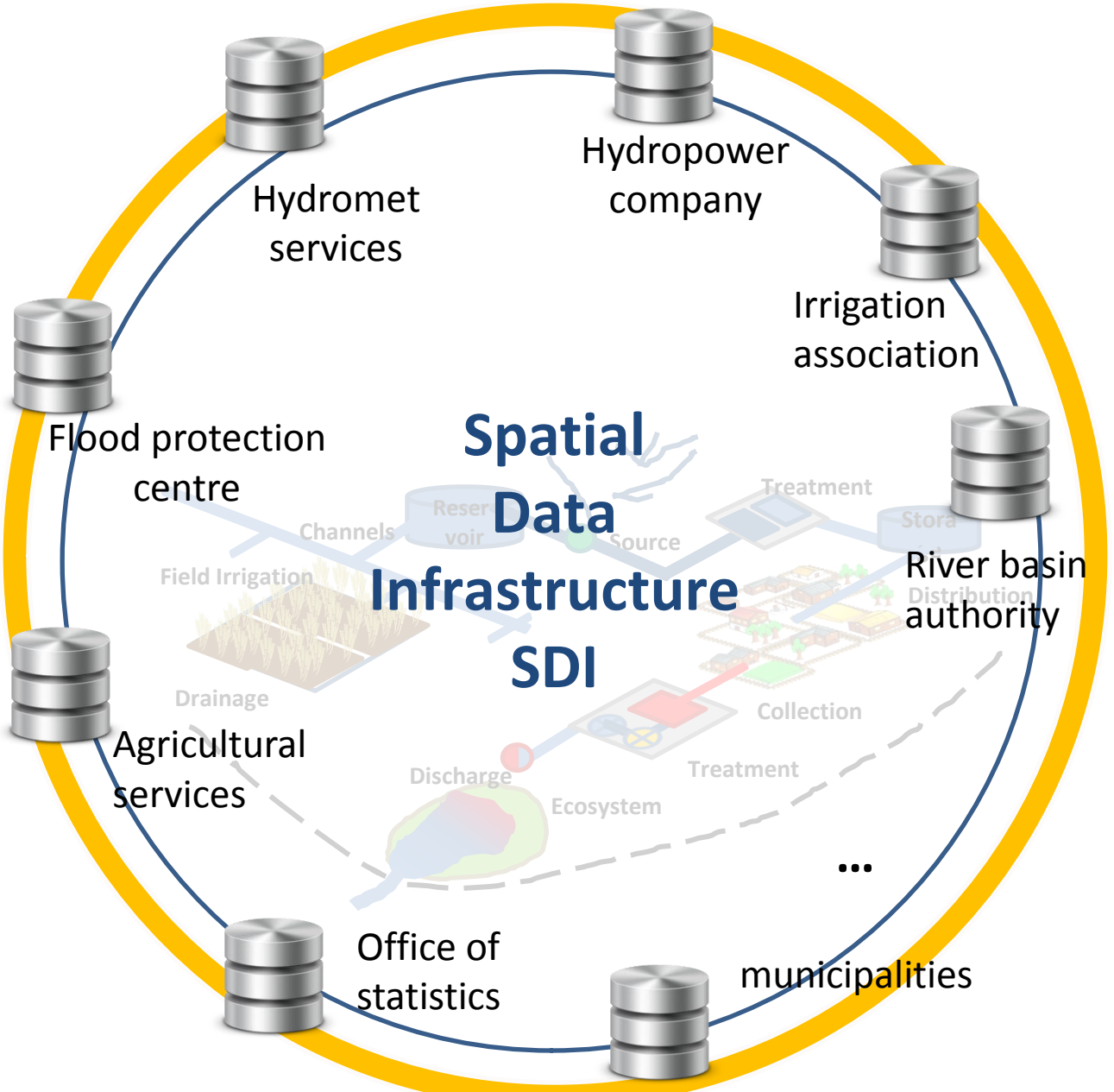


…and for which tasks is information needed?

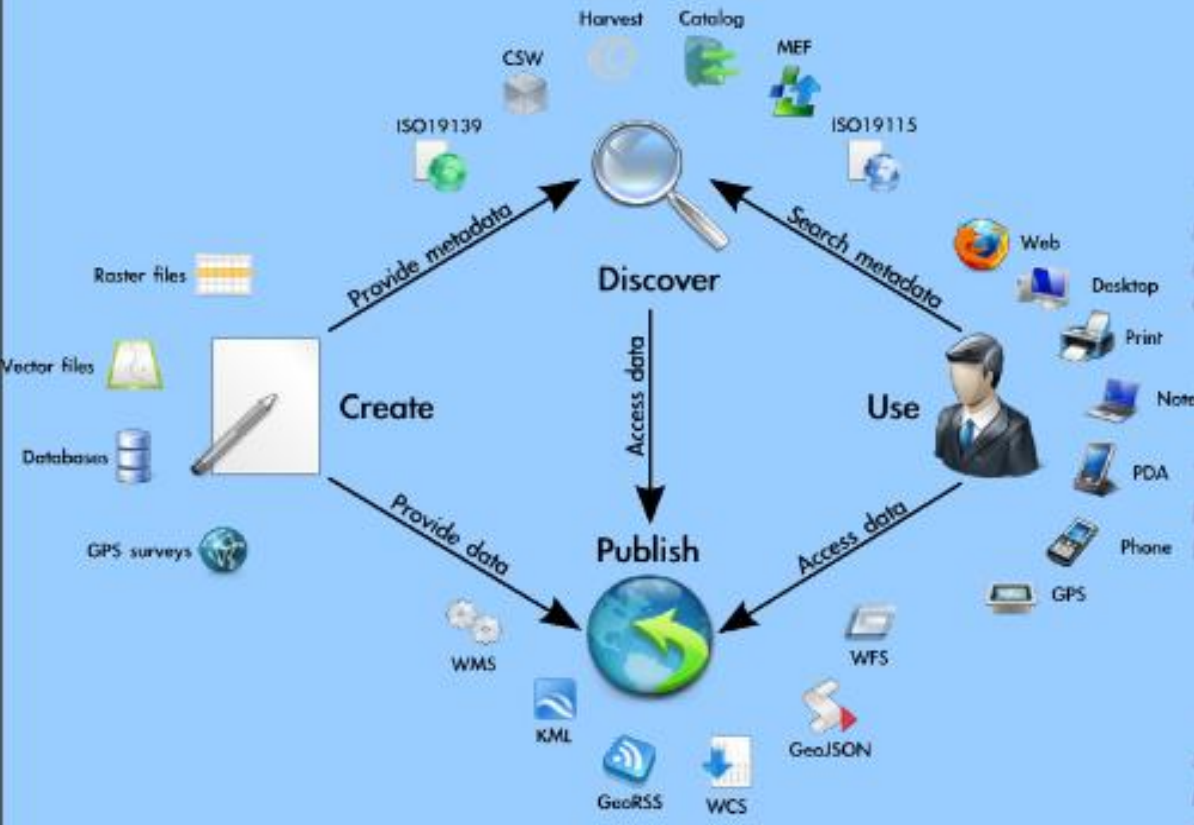


Operational and Strategic Management

Need for coordination…of stakeholders…via information



Spatial Data Infrastructure (SDI)



" the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilisation of geospatial data".

OR

"a system where the general community can expect the geo-spatial data to be available and accessible transparently with networking technology."

OR

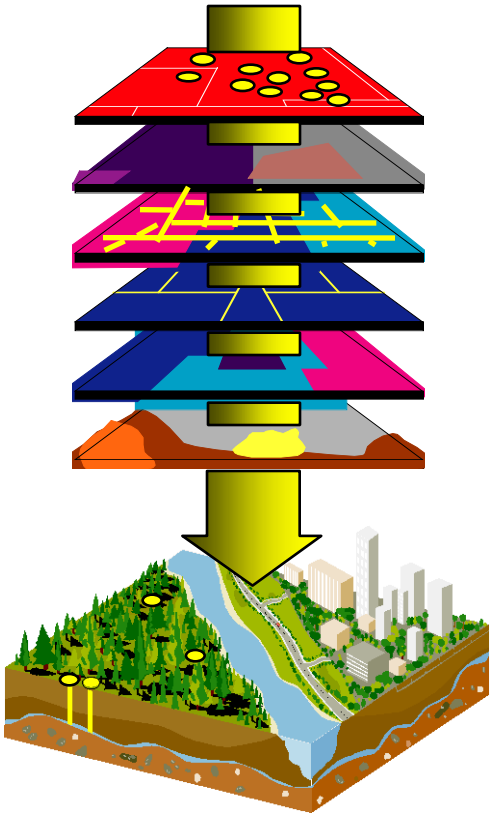
" the data sources, systems, linkages, processes, standards and institutional arrangements involved in delivering spatially-related information (both commercially and publicly held) to the widest possible group of potential users"

Components of a Spatial Data Infrastructure (SDI)

- Policies & Institutional Arrangements (governance, data privacy & security, data sharing, cost recovery)
- People (training, professional development, cooperation, outreach)
- Data (digital base map, thematic, statistical, place names)
- Technology (hardware, software, networks, databases, technical implementation plans)

Why to build an SDI?

- Build data once and use it many times for many applications
- Integrate distributed providers of data: “Cooperative governance”, Interoperability
- Share costs of data creation and maintenance
- Support sustainable economic, social, and environmental development



…and geospatial information is essential in driving competiveness and facilitating effective decision-making

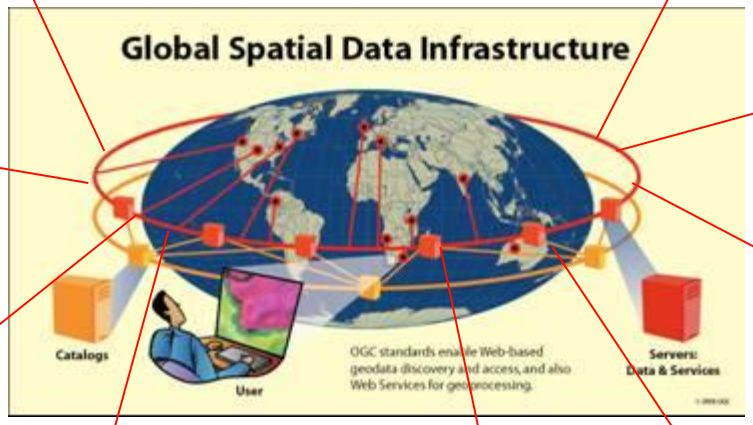
Enabling Spatial Data Infrastructure

Education & Research

Sustainable Development

Utilities

Health



E -Government

Emergency Services

Agriculture

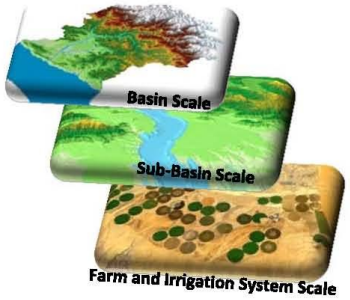
Energy

Water

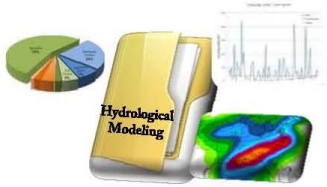
...assuring Interoperability!

Initiatives (examples)

Information Management concept , Limari basin, Chile:



Climate, Hydrology, Water User Analysis
Spatial Information:
- Land Use Mapping
- Imagery and Remote Sensing Based Surveys
- GIS



River Basin assessment
Hydrological Modeling: Water Availability Forecasting (rain-runoff), Water Demand and Allocation Modeling

Water use efficiency and Management of water related risks

KNOWLEDGE

Warning messages

Isotope and Geochemical tracer analysis

Ground Water level and quality monitoring

Discharge and Runoff monitoring

Water level monitoring

Field Measurements Offline Data, Laboratory Data, etc.

MONITORING

Water Ressource Information and Irrigation Water management for mobile devices

Data Transfer

Warning messages

Web-Based Water Information System via Sensor Web Enablement-Standards of OGC

Data Transfer

Water Information and Management System

SOFTWARE

Stakeholders, Water Users and Institutions in the agricultural and urban sector

Collecting Information

Information Transfer of Water Policy

Decision Support, Management and Training

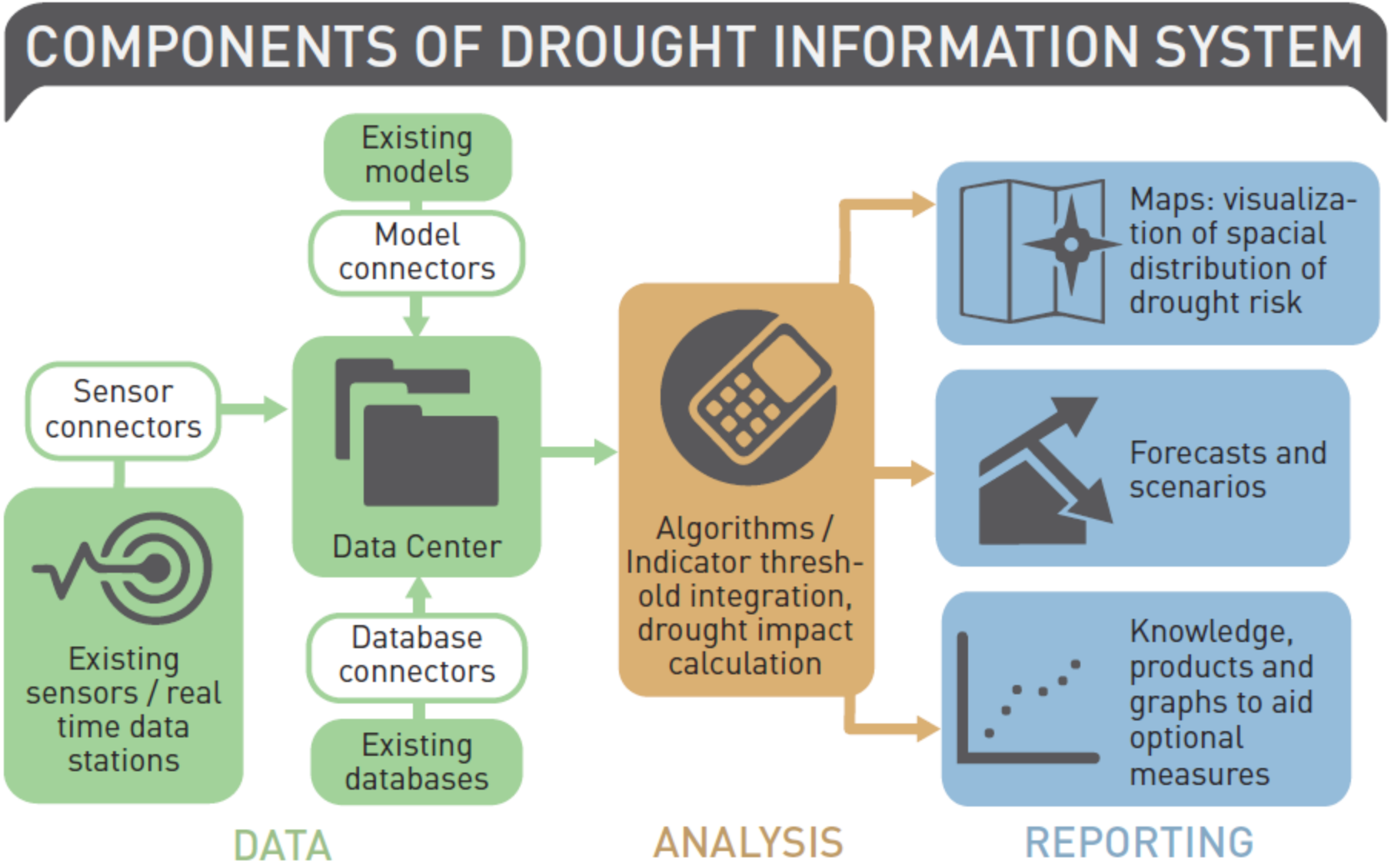
Collecting Information

STAKEHOLDERS

Drought Early Warning systems
-key elements-

- Indicators which make sense in the context of environmental and socioeconomic context
- Efficient monitoring
- Data storage and availability
- Communication with stakeholders using adequate interfaces
- Feedback and collaboration

Information is crucial for drought management!



Contact us:

Institute for Technology and Resources Management
in the Tropics and Subtropics (ITT)
Technology Arts and Sciences TH Köln
Betzdorfer Straße 2
50679 Cologne
Germany

Phone: +49 221 8275-2774
Fax: +49 221 8275-2736
http://www.tt.fh-koeln.de

Contact:
lars.ribbe@fh-koeln.de
alexandra.nauditt@fh-koeln.de

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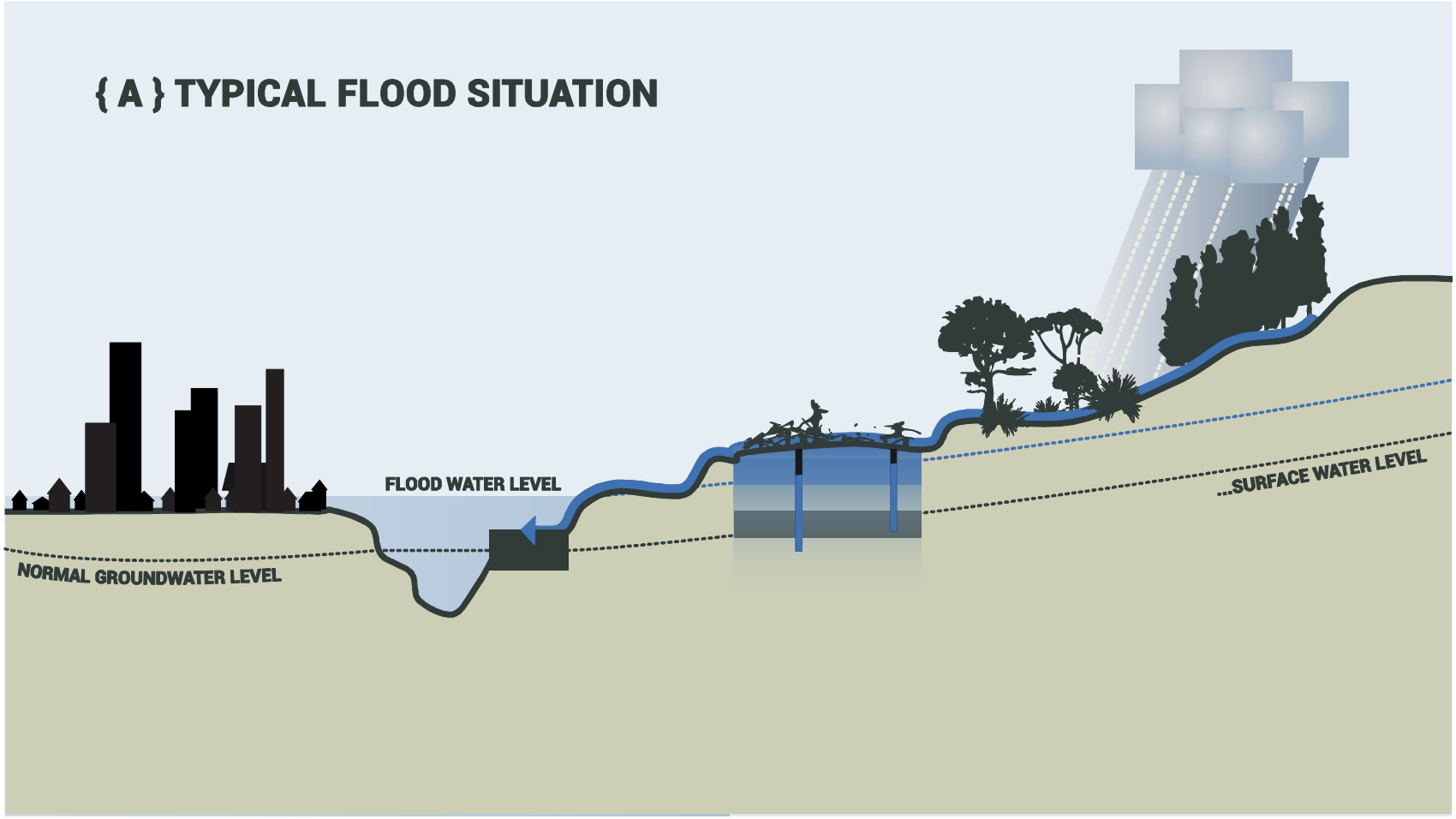
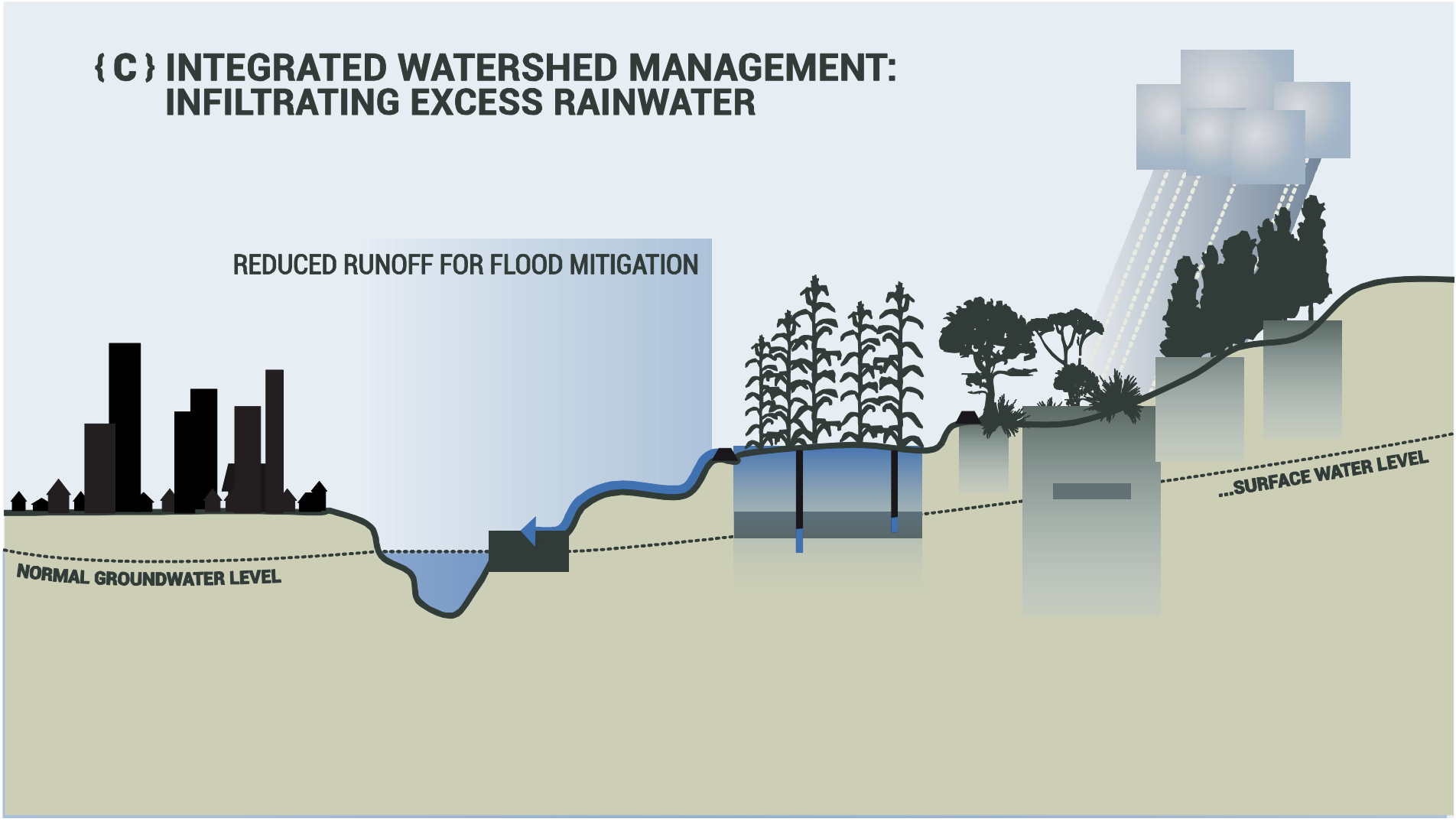

{ A } TYPICAL FLOOD SITUATION
FLOOD WATER LEVEL
SURFACE WATER LEVEL
NORMAL GROUNDWATER LEVEL


{ C } INTEGRATED WATERSHED MANAGEMENT:
INFILTRATING EXCESS RAINWATER
REDUCED RUNOFF FOR FLOOD MITIGATION
NORMAL GROUNDWATER LEVEL
SURFACE WATER LEVEL