SOUTH ASIA DROUGHT MONITORING SYSTEM (SADMS)

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IWMI, Colombo, Sri Lanka

Photo: Samurdhi Ranasinghe / IWMI

International Water Management Institute

World Meteorological Organization Weather • Climate • Water

Global Water Partnership

CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

CGIAR RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security CCAFS

MAFF Ministry of Agriculture, Forestry and Fisheries 農林水産省

भाकृअनुप ICAR

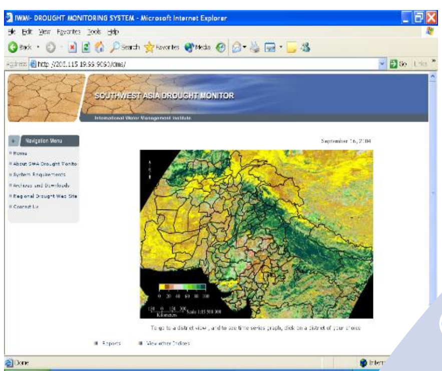
Content

1. Problem Statement and History of SADMS
2. Drought and Remote Sensing
3. SADMS Project Approach
4. Case Studies, Applications, Portal
5. Experimental drought forecast, SM drought indices
6. New proposal, Synergies & Interlinkages

History of drought programme implemented by IWMI

Drought Management Plans and Policy guidelines

INDIA



2005

South West Asia Drought Monitor

US State Department Regional Environment Office

2014

South Asia Drought Monitor (SADMS) –

IDMP(WMO/GWP), CGIAR CCAFS, WLE, Japan's MAFF

Late 2016 - Present

Moving from monitoring to management including contingency plans and insurance application

CGIAR WLE, Japan's MAFF and ICAR-GOI

SOUTH ASIA DROUGHT MONITORING SYSTEM (DMS): OVERVIEW

- Goal - build climate resilience, reduce economic and social losses, and alleviate poverty in drought - affected regions in SA through an integrated approach to drought management

- SADMS Integrates remote sensing and ground truth data (vegetation indices, rainfall data, soil information, hydrological data)

- SADMS supports regionally coordinated drought mitigation efforts that can be further tailored to national level

- SADMS is a partnership initiative of IWMI, IDMP (WMO / GWP), CGIAR CRP's (CCAFS / WLE), Japan's MAFF and Governments in SA.

SADMS Process and Implementation

April 2014

SADMS Concept

South Asia Climate Outlook Forum (SACOF-5) Pune, India

April 2015

Prototype SADMS for pilot countries, Validation with DoM, DMC, ID

SACOF-6

Dhaka, Bangladesh

2016

Operational implementation of SADMS, Portal, Outlook issues, experimental drought forecasting

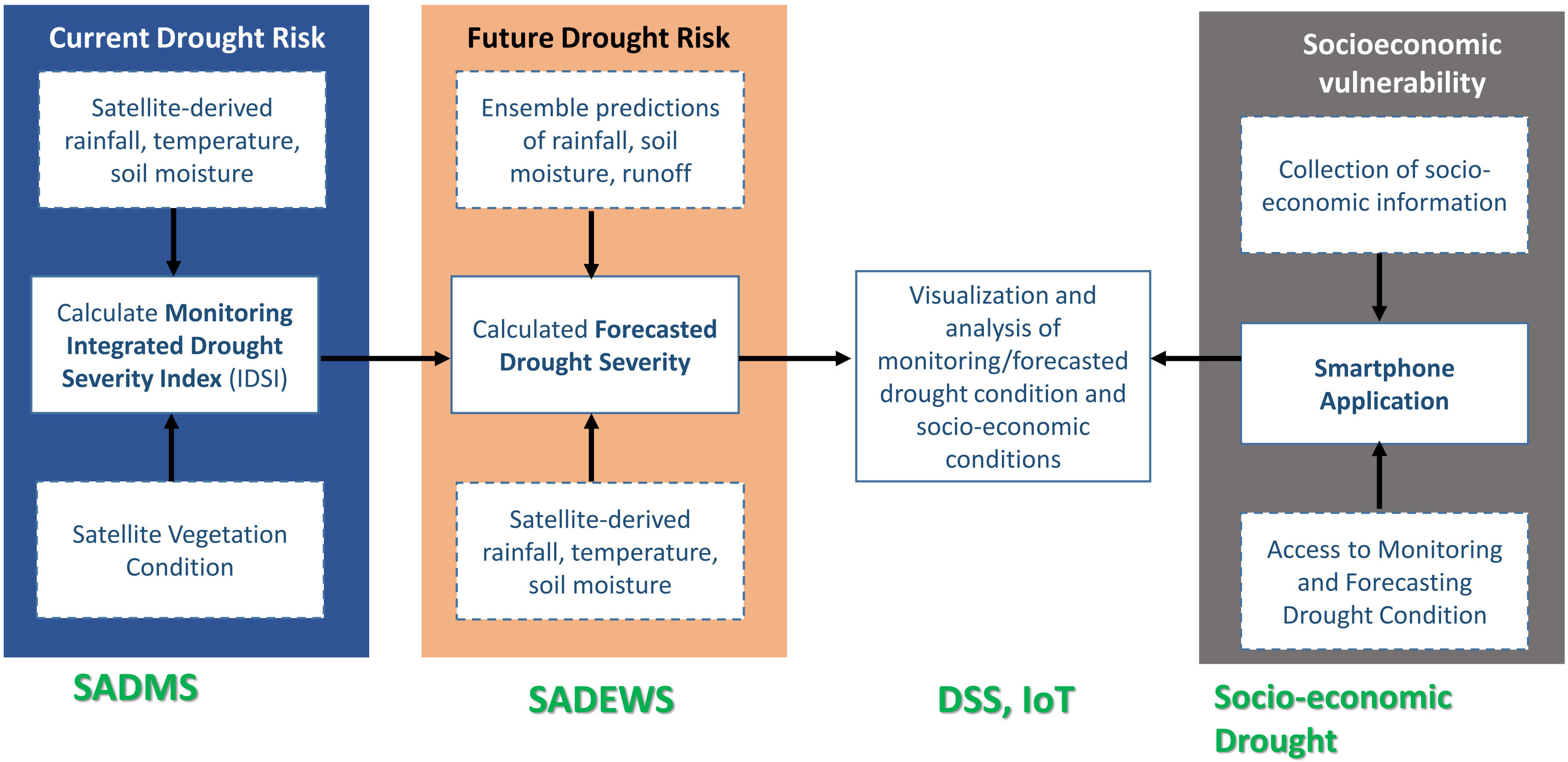
SACOF-7, Colombo, Sri Lanka & IDMP, Geneva

2017

Regional consultative workshop with SA partners; Pilot drought issues with GOI/ICAR; Linking drought contingency plans, CSA and policy guidelines

SADMS support from SA Partners and ICAR-GOI Special project;

IWMI's Drought Monitoring Framework



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We would like to acknowledge: WMO, GWP-CWP, DoM, DoA, MoDM, IARI, MNCFC, NDMC, IDMP for continued support and cooperation.

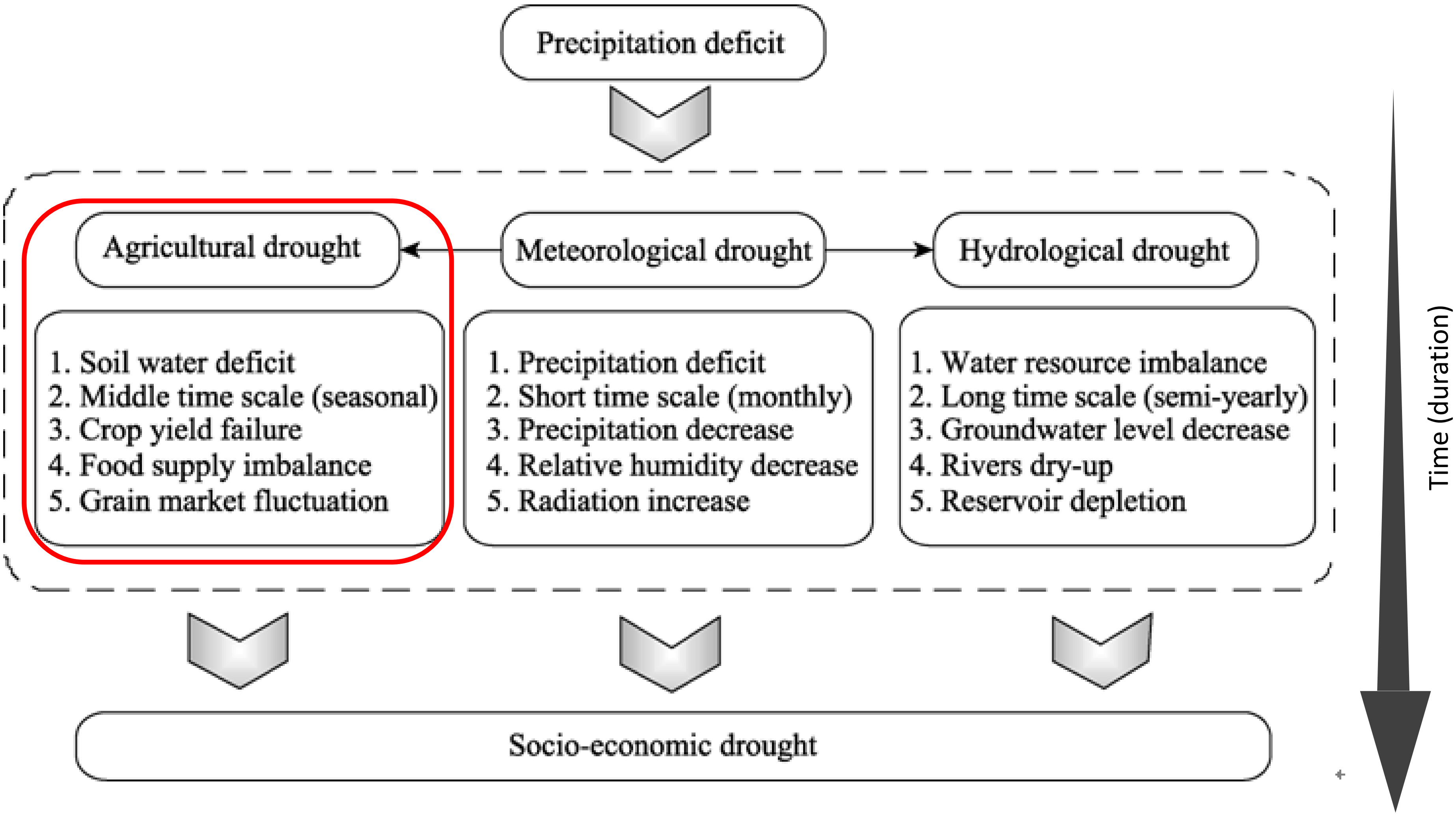
1. Problem Statement

I. Drought

- Deficient precipitation compared to statistical multi-year average conditions (NDMC, 2008)
- significant economic, environmental and social impacts – direct and indirect
- among the most costly of all natural disasters
- ranks first in degree of severity, length of event, total areal extent and social effect when compared to other hazards (Wilhite, 2000, p. 6)
- Since 1980 more than 2.2 billion people were affected by more than 561 drought events accounting 150billion economic damages (EM-DAT, 2017)
- *Four types of droughts*
    - ***Metorological***
    - ***Agricultural***
    - *Hydrological*
    - *Socio-economic*

Photo: Samurdhi Ranasinghe / IWMI

Definition of drought: Four different types



Drought risk assessment

Hazard: Characterization of drought

- Spatial extent
- Magnitude / severity
- Frequency
- Intensity
- Duration
- ...

Photo: Hamish John Appelby / IWMI

Vulnerability: Characterization of drought effects

→ The **characteristics** and circumstances of a **community**, **system** or **asset** that make it susceptible to the damaging effects of a hazard.

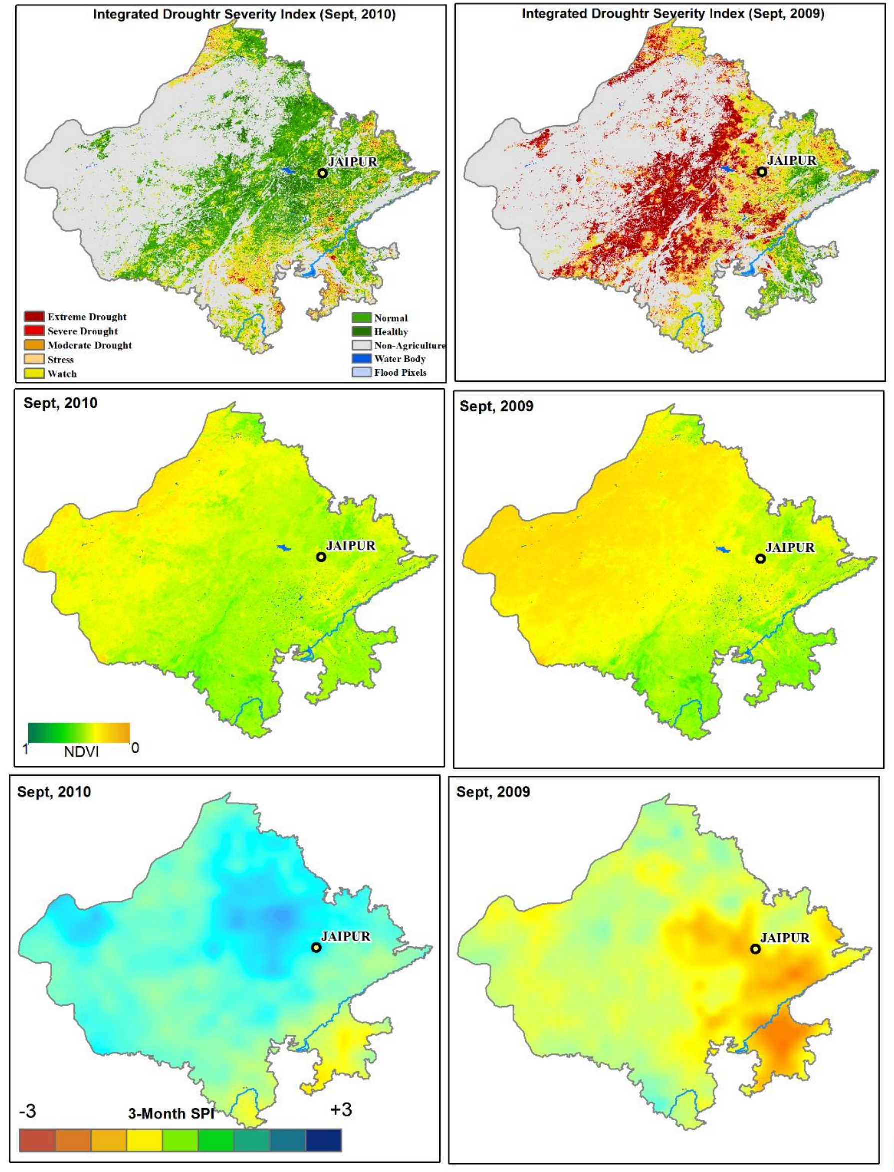
Source: UN/ISDR http://www.unisdr.org/eng/library/lib-terminology-eng.htm

2. Drought Monitor using remote sensing

II. Drought Indicators and Remote Sensing

Drought Hazard vs. Drought Risk

- Drought Hazard: meteorological parameters (Prec., Temp., PET, SM)
  - Palmer Drought Severity Index (PDSI, Palmer 1965)
  - Standardized Precipitation Index (SPI; Guttermann, 1998)
  - Crop Moisture Index (CMI; Palmer 1968)
  - Surface Water Supply Index (Shafer and Dezmann, 1982)



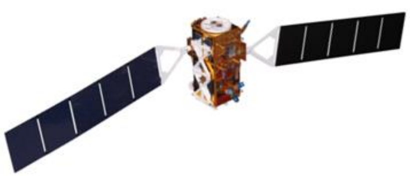
II. Remote Sensing Data

SPOT © DLR

LANDSAT 8 © USGS

Sentinel 2A © ESA

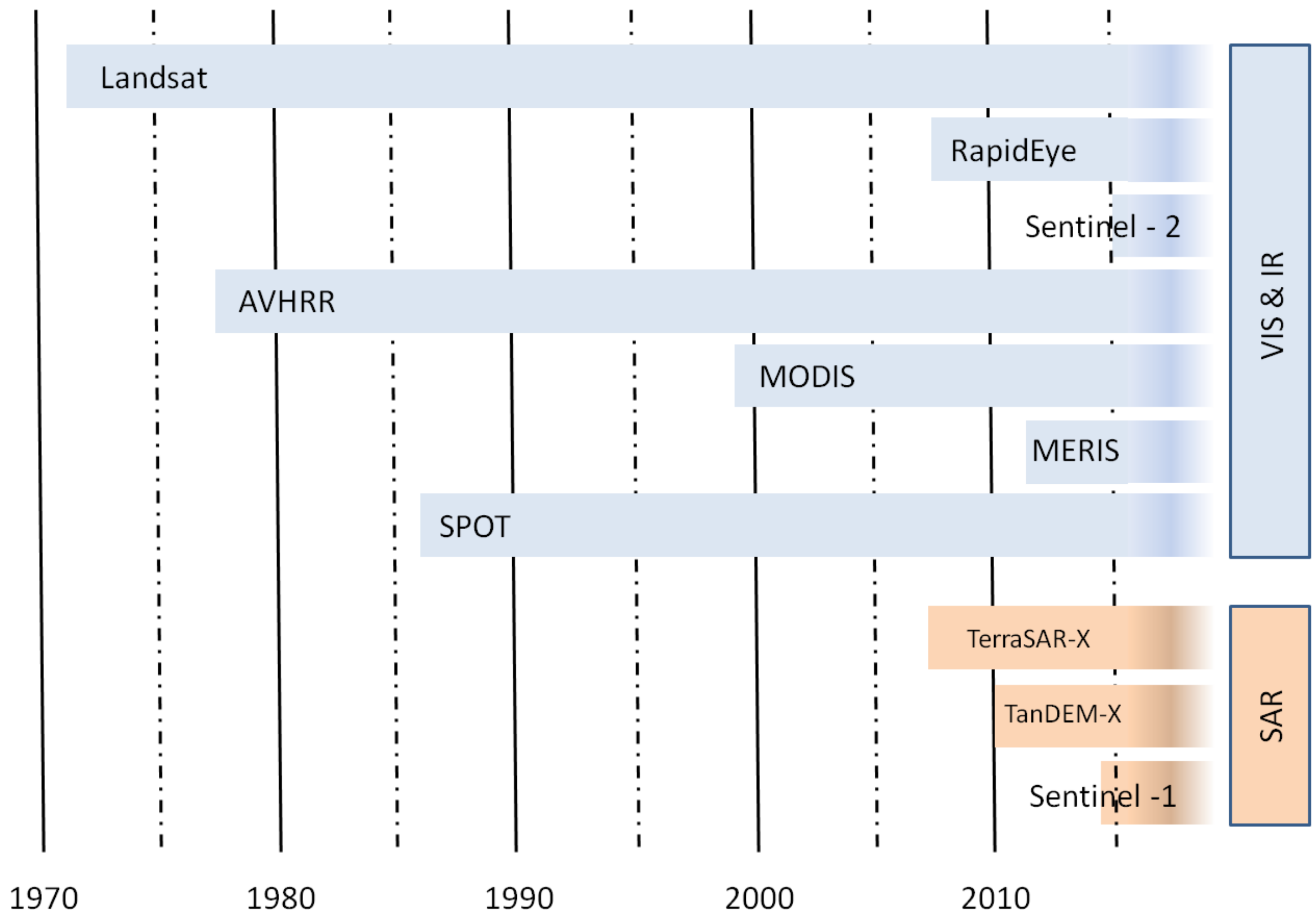
Sensor	Launch date	Spectra	Spatial resolution	Temporal resolution
Landsat	1972	VIS, IR	15 - 60 m	16 days
RapidEye	2008	VIS, IR	5 x 5 m	1 day
Sentinel – 2	2015	VIS, IR	10 – 60 m	10 days (solo), 5 days (dual)
AVHRR	1978	VIS, IR	1100 x 1100 m	14 times each day
MODIS	1999	VIS, IR	500 – 1000 m	1 day
MERIS	2012	VIS, IR	300 – 1200 m	3 days
SPOT	1986	VIS, IR	1,5 – 6 m	2 – 3 days
Sentinel – 1	2014	SAR	5 x 5 m	10 days (solo), 5 days (dual)
TerraSAR – X	2007	SAR	1 – 18 m	2,5 days
TanDEM – X	2010	SAR	1 – 16 m	1 day



Sentinel 1A © ESA

TerraSAR-X © DLR

II. Remote Sensing Data



Own illustration. Based on data of DLR, ESA, NASA, Planet Labs, USGS (2016).

II.Drought Indicators and Remote Sensing

Example: Agricultural Stress Index System (ASIS): Global and Country Analysis

Agricultural Stress Index System is based on the Vegetation Health Index (VHI) (Kogan et al. 1995)

Vegetation condition index (VCI)

$$VCI_i = \frac{NDVI_i - NDVI_{\min}}{NDVI_{max} - NDVI_{min}}$$

Temperature condition index (TCI)

$$TCI_i = \frac{BT_{max} - BT_{\mathrm{i}}}{BT_{max} - BT_{min}}$$

Vegetation Health Index (VHI)

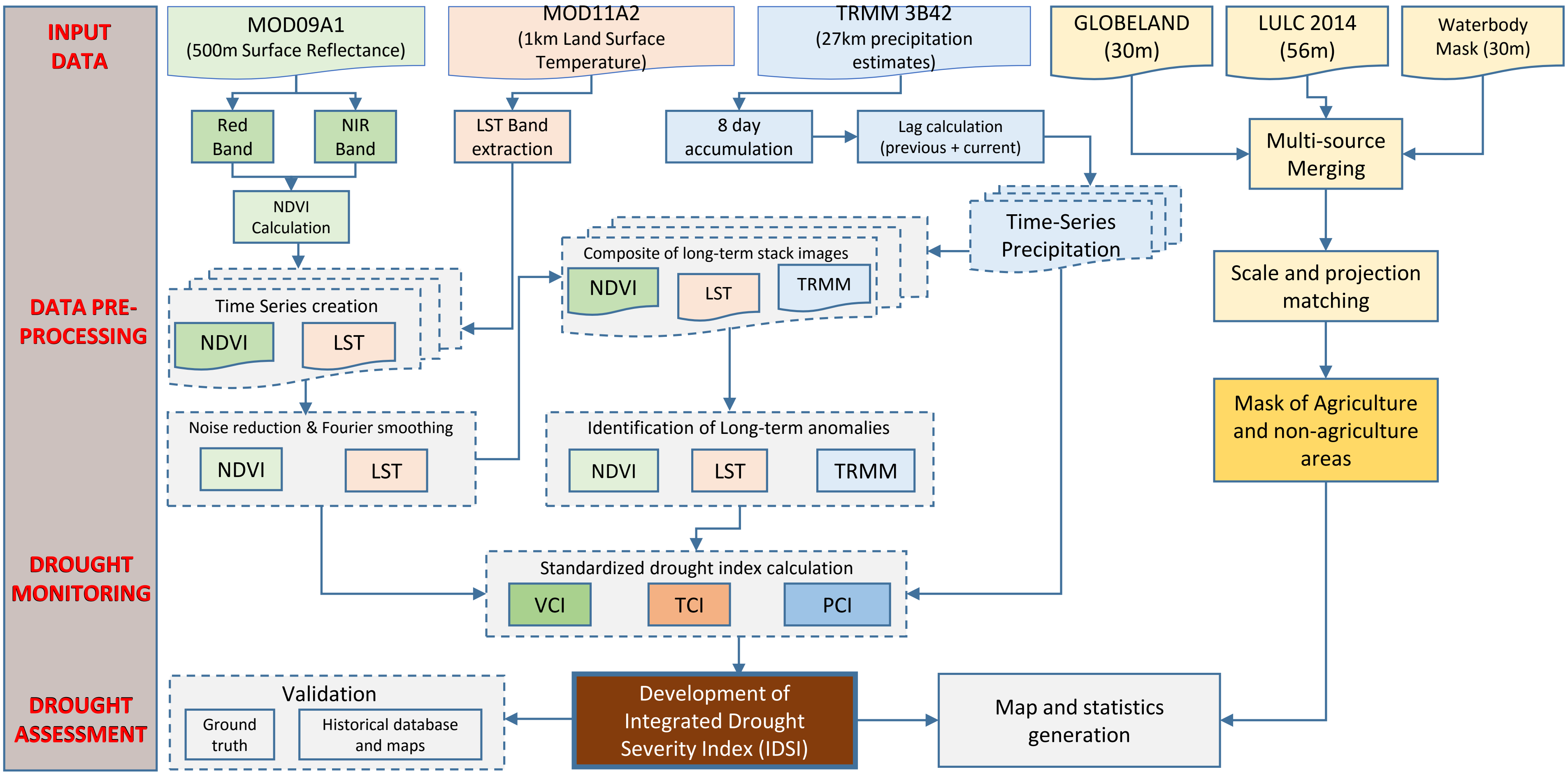
VHI = a*VCI + (1-a)* TCI

low VHI

high VHI

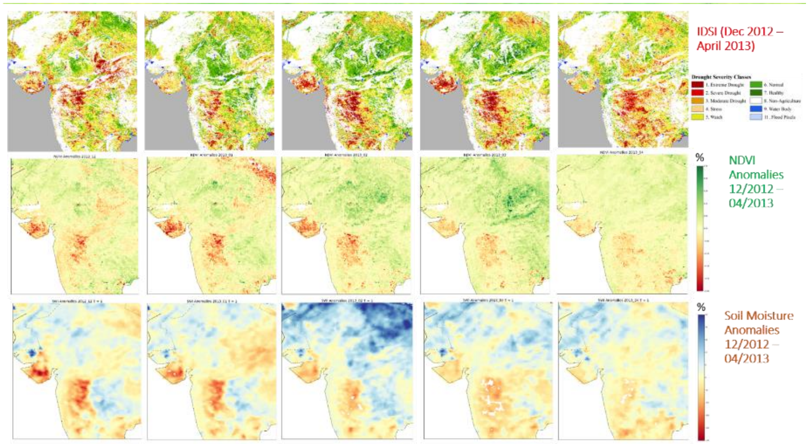
3. SADMS approach

Drought Monitoring Approach



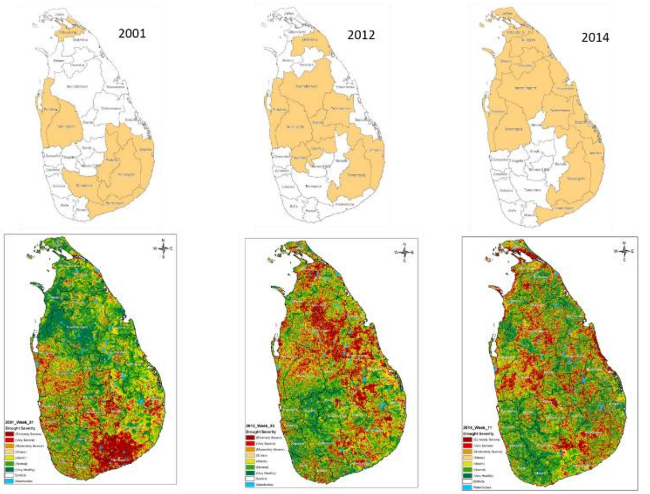
Notes: MOD09A1 – MODIS Surface Reflectance of every 8-Day product at 500m resolution; MOD11A1 – MODIS Land Surface Temperature (LST) daily product at 1,000m resolution; TRMM – Tropical Rainfall Measuring Mission; LULC NRSC – Land Use and Land Cover from National Remote Sensing Centre; Water body mask from Landsat images; NDVI – Normalized Difference Vegetation Index; VCI – Vegetation Condition Index; TCI – Temperature Condition Index (TCI); Precipitation Condition Index (PCI), IDSI – Integrated Drought Severity Index

DMS validation from maps to field scale

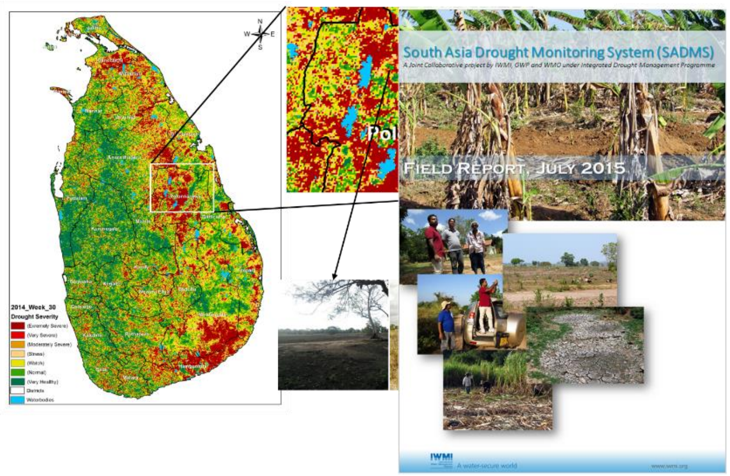


- Comparison of IDSI, NDVI and Surface Soil Moisture anomaly for the drought year Dec 2012 – April 2013
- High correlation observed among the IDSI and other essential variables in drought prediction and early warning.
- The SM can be used to predict by 15-30days in advance on the vegetation condition for better decision making among stakeholders

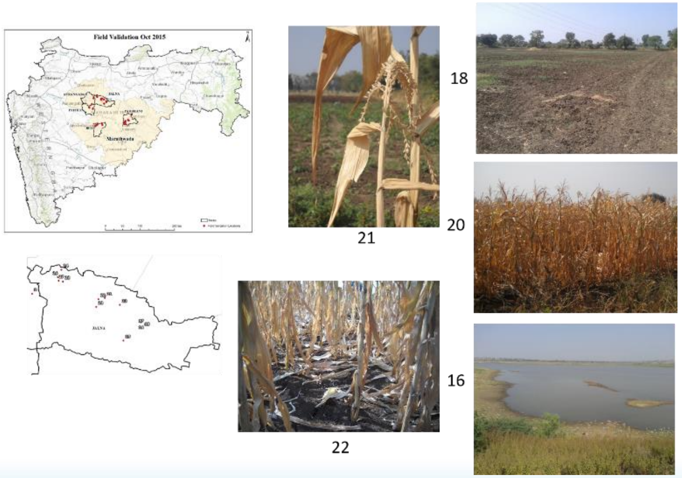
SL Disaster Management Centre (DMC) Drought Maps



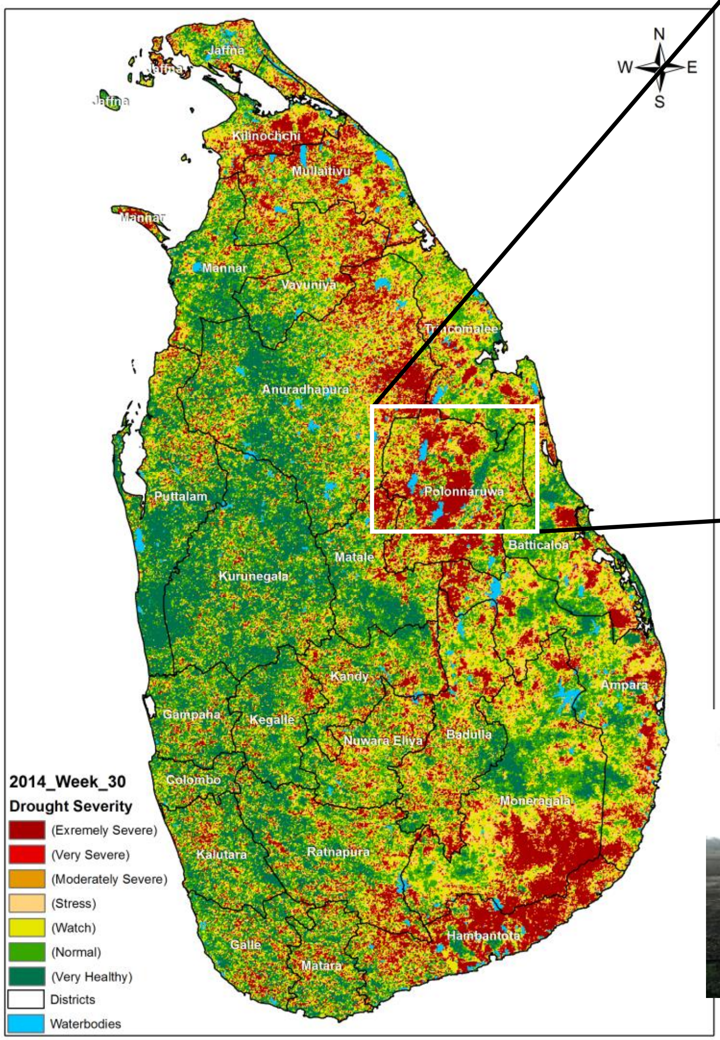
Characterizing Drought Severity

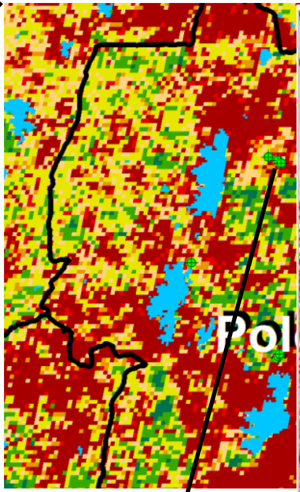


2015 DROUGHT IN MAHARASHTRA STATE, INDIA



Characterizing Drought Severity

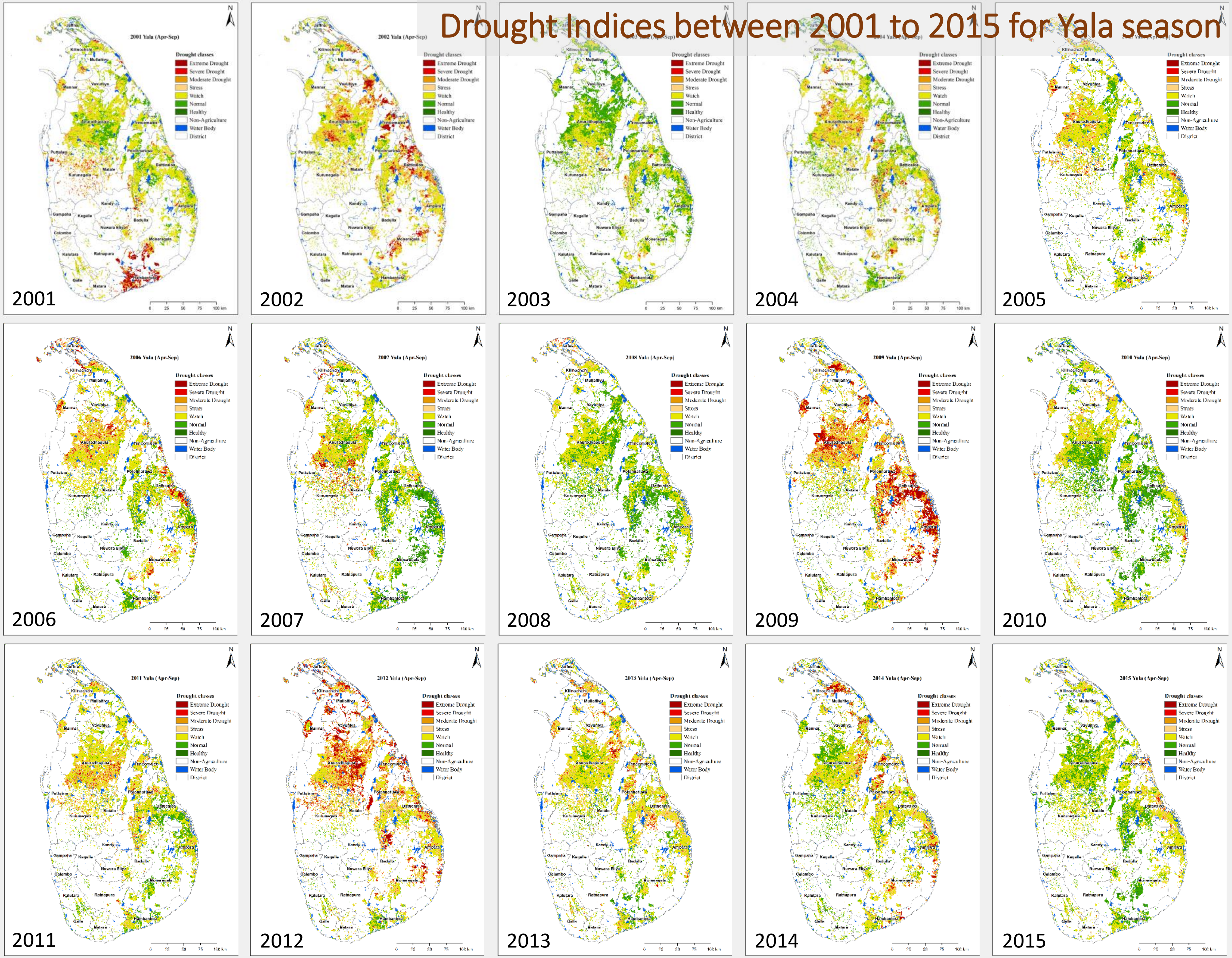




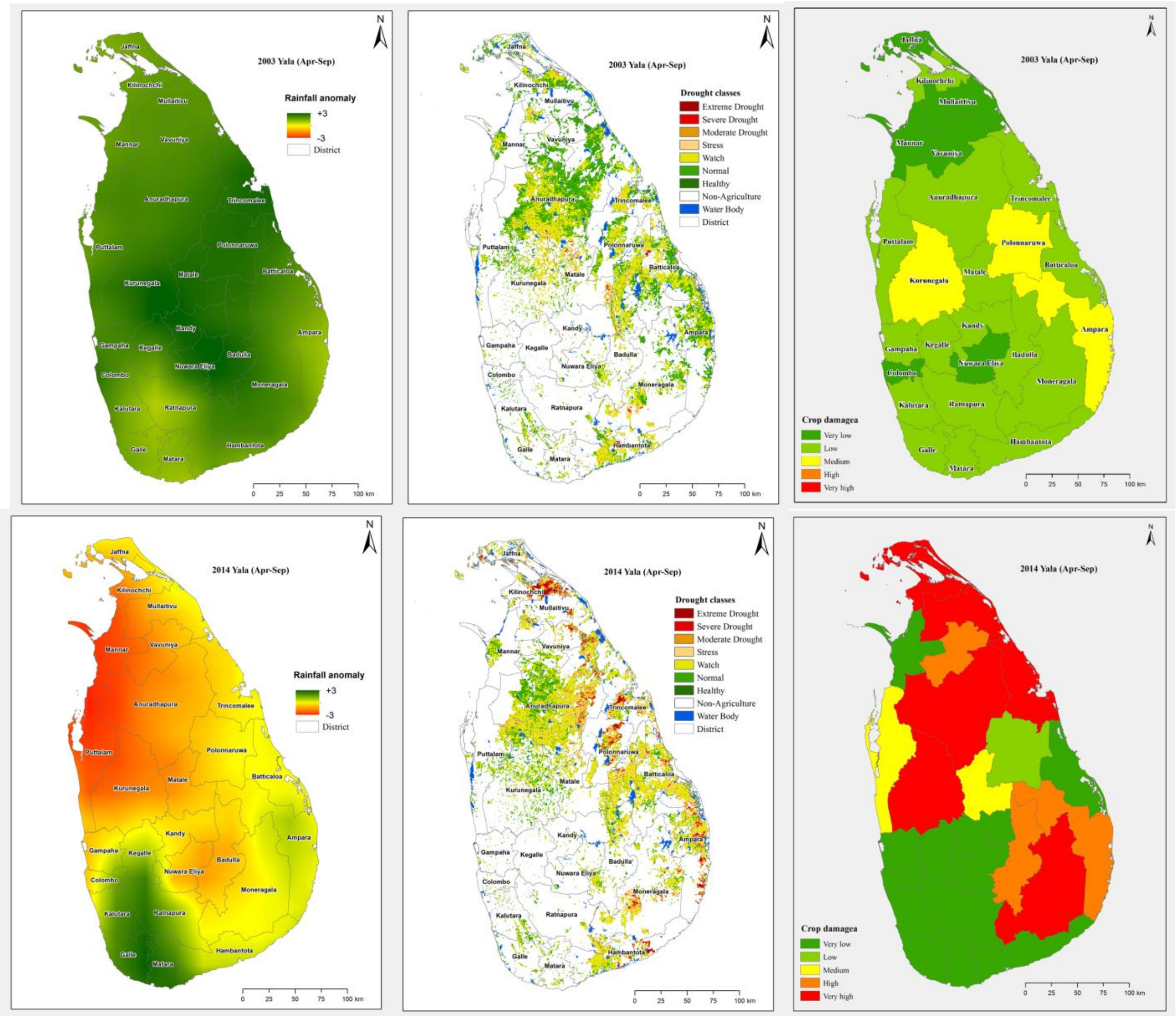
Characterizing Drought Severity

Category	Description	Possible impacts	IDSI Ranges
D4	DS Extreme	Exceptional and widespread crop/pasture losses Shortages of water in reservoirs, streams, and wells creating water emergencies	< 5 (with very low values of VCI, PCI and TCI)
D3	DS Moderate	Major crop/pasture losses Widespread water shortages or restrictions	5 – 10 (with low values of VCI, PCI and TCI)
D2	DS Severe	Crop or pasture losses likely Water shortages common Water restrictions imposed	10 – 15 (with moderate values of VCI, low PCI and TCI)
D1	Stress	Some damage to crops, pastures Streams, reservoirs, or wells low, some water shortages developing or imminent Voluntary water-use restrictions requested	15 – 20 (with moderate VCI, low PCI and moderate TCI)
D0	Watch	Going into drought: short-term dryness slowing planting, growth of crops or pastures Coming out of drought: some lingering water deficits pastures or crops not fully recovered	20 – 40 (with moderate values of VCI, PCI and TCI)
Normal	Normal		>40 (vegetation growth is normal with essential variables with a function of high VCI-TCI-PCI)
Healthy	Healthy		>60 (vigor vegetation with strong correlation on climate indicators)

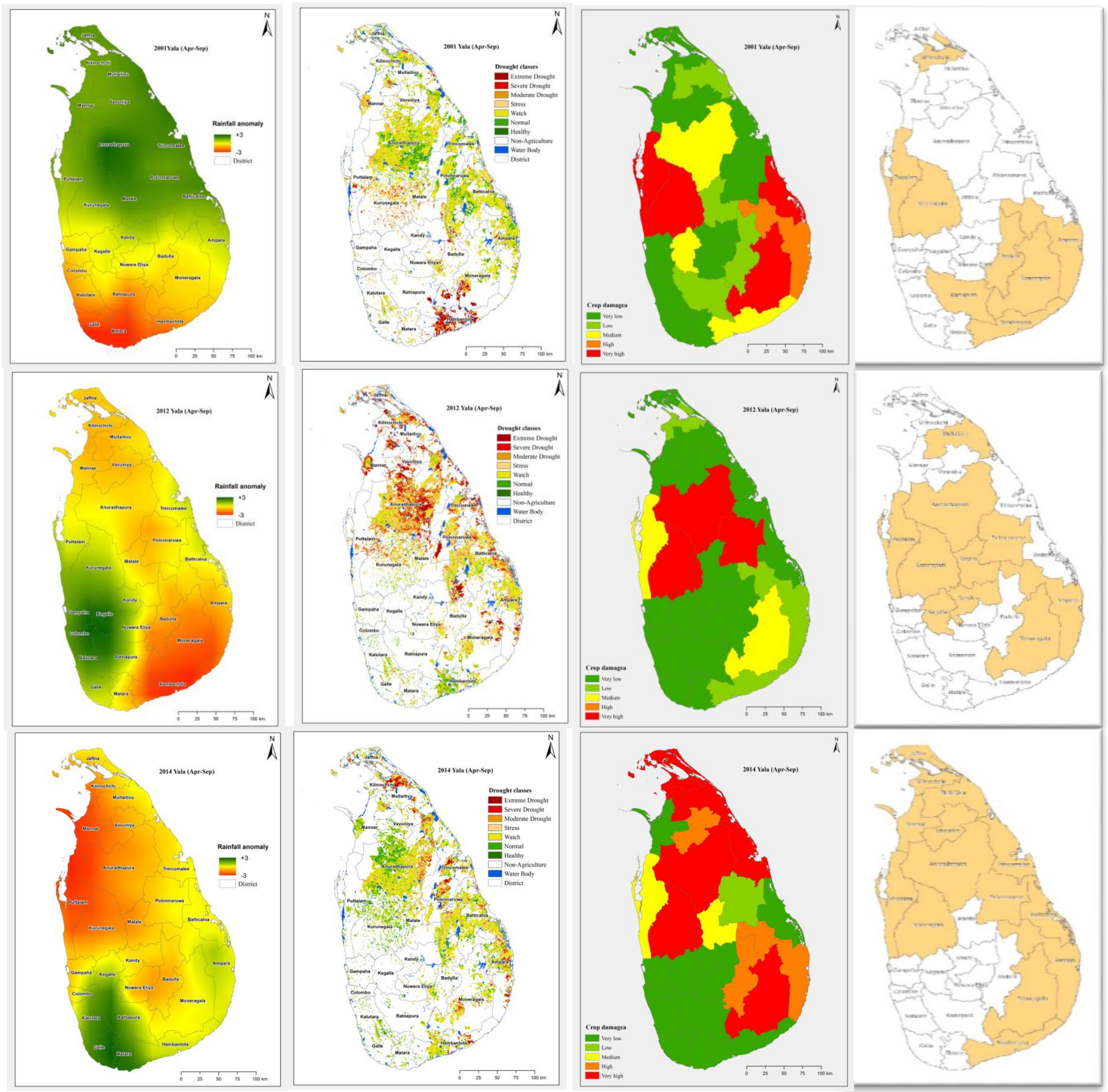
Drought Indices between 2001 to 2015 for Yala season



Comparison of Good Year (2003) and Bad year (2014)



Rainfall anomaly | Drought extent | Crop yield anomaly | DMC Reference Map



2001

2012

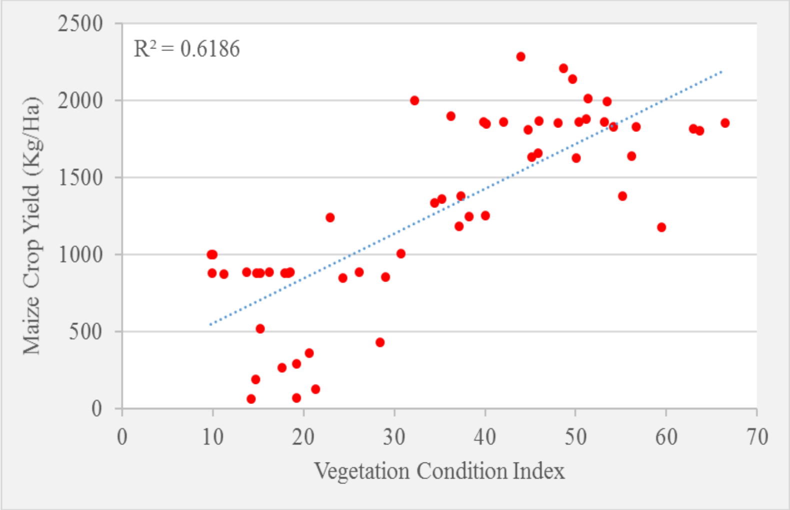
2014

Links of drought characteristics to agricultural production losses for the Yala seasons (SW Monsoon)

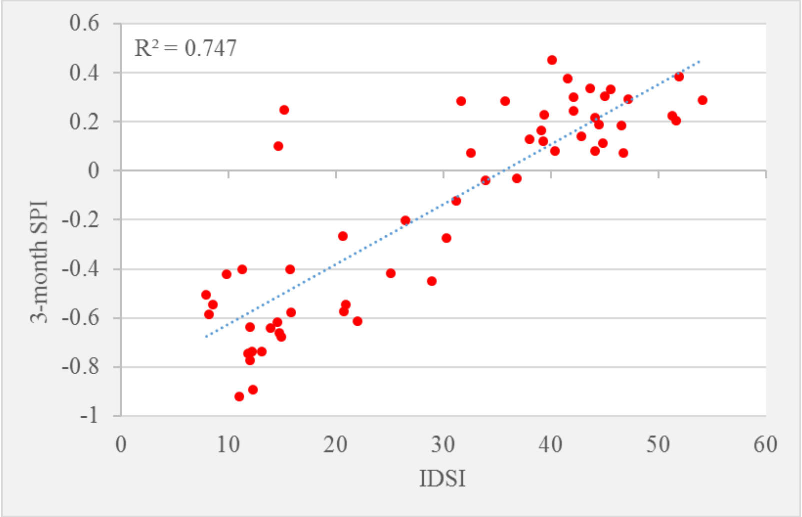
VCI, PCI and Drought Indices for drought year (2009) and normal year (2010), Rajasthan

Crop type: Maize

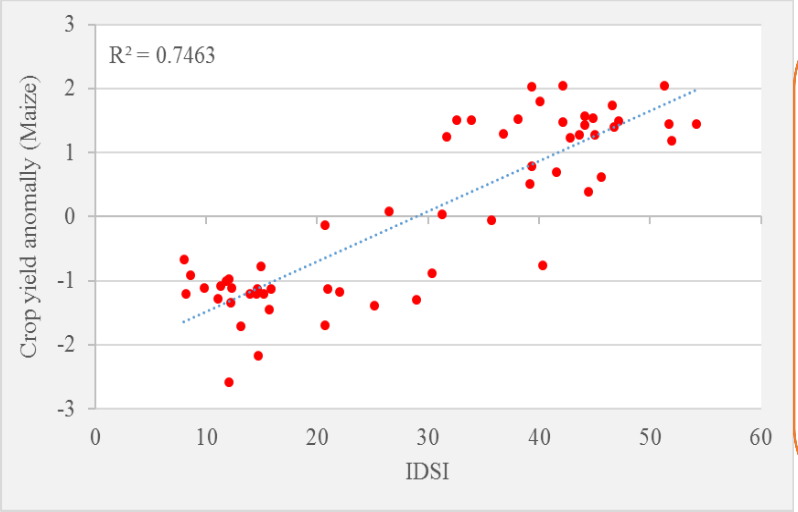
VCI vs. Crop Yield



SPI vs. IDSI

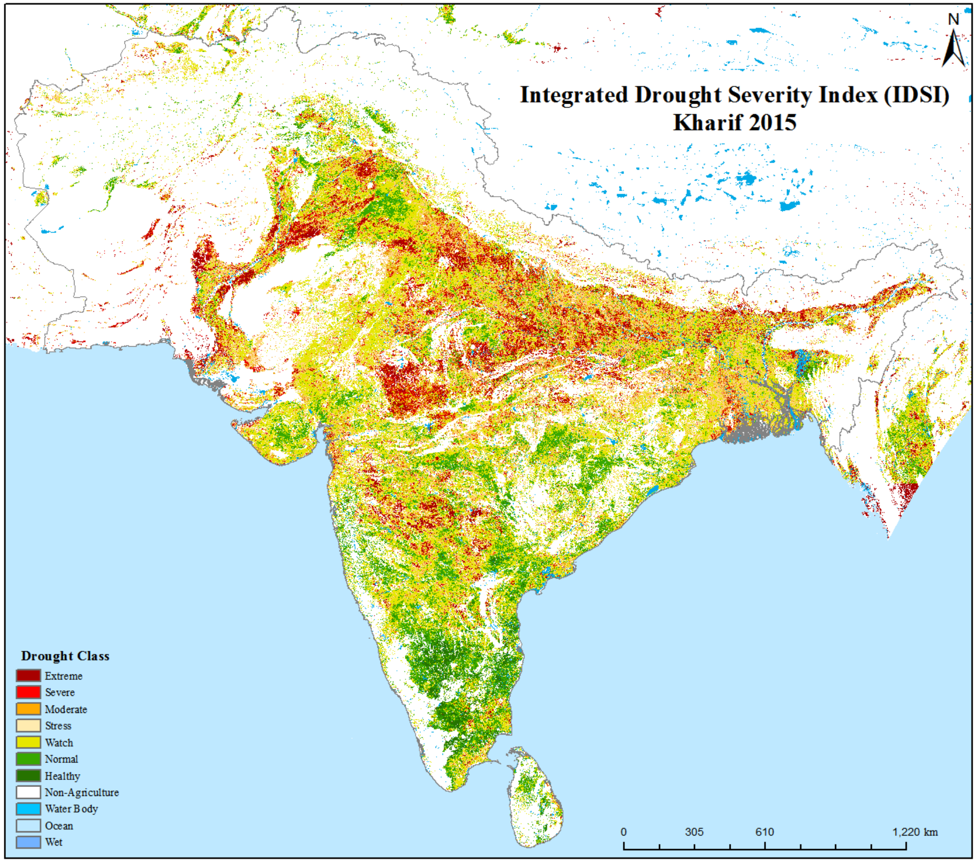


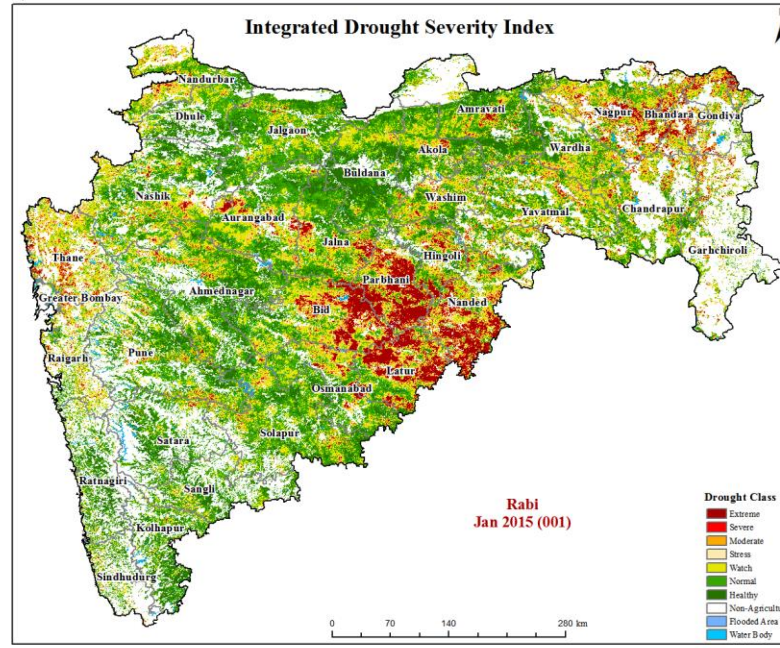
YAI vs. IDSI



- Average VCI of rain-fed season was compared with yield of major rain-fed (kharif) crops which reveals that a good agreement
- 3-month SPI also had a good correlation with IDSI for drought year and normal year
- High correlation co-efficient (r) was found to be 0.71, 0.72 and 0.71 (p = 0.05) for sorghum, pearl millet and maize respectively which reveals that there is a strong positive correlation present between VCI and yield of major kharif crops

SOUTH ASIA DROUGHT MONITOR SYSTEM (SA-DMS)

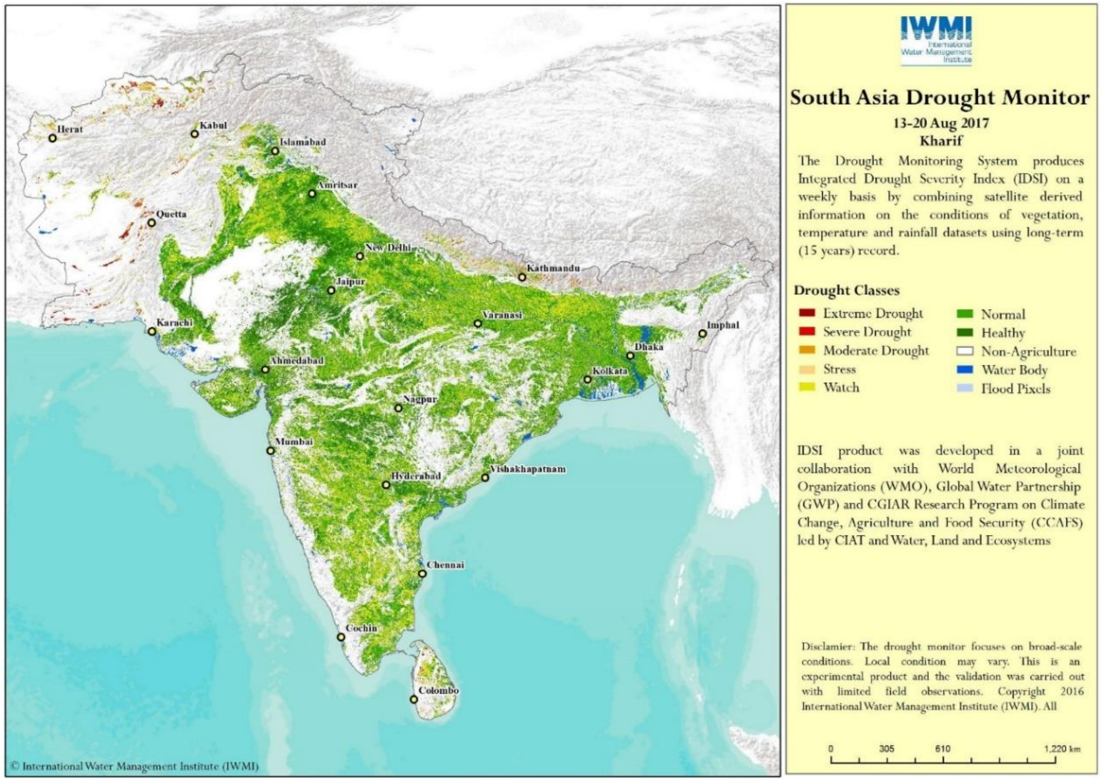


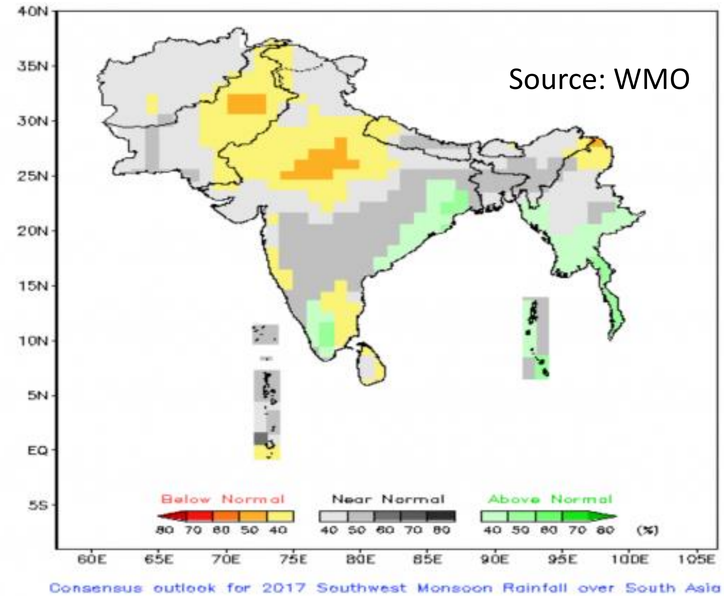


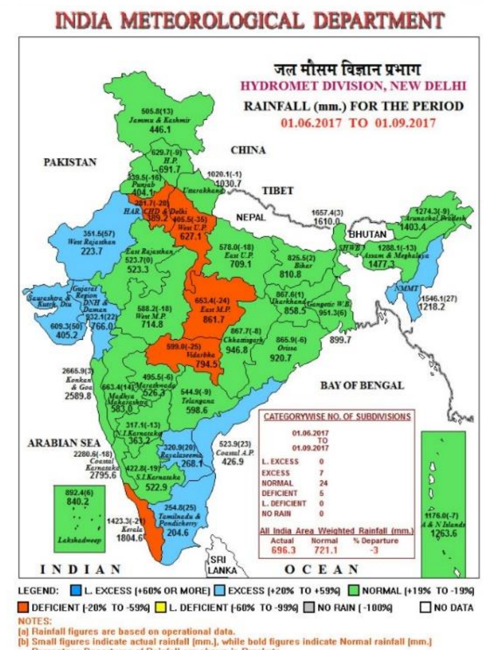
- First of its kind to establish for entire South Asia using multisource remote sensing observations;
- Historical drought risk mapping and assessment covering SA countries (2000 – Current);
- IDSI allows better understanding on drought frequency, duration over the 16years;
- Products are useful tools in drought mitigation studies and in decision-making process;

2015 field observations in Jalna, Maharashtra

Current status of drought condition over South Asia and Rainfall distribution over India







- Drought condition over South Asia seems relatively low compare to the previous years of 2012, 2014 and 2016.
- Areas under drought condition includes India(Southern Karnataka, Marathawada, Madhya Maharashtra, East & West MP), Sri Lanka (North Central, northwestern and eastern provinces), parts of Southern Nepal

Drought Assessment on Population Exposure and Agricultural losses

Country Name	Geographical area (km^2)	Agriculture area (km^2)	Average	% from total area	% from Agriculture area
India	3,263,578	1,734,193	683,538	20.94	39.42
Sri Lanka	65,846	22,013	5,956	9.05	27.06
Pakistan	793,931	286,805	105,484	13.29	36.78
Afghanistan	644,073	379,100	16,390	2.54	4.32
Bangladesh	135,033	105,130	35,767	26.49	34.02
Bhutan	39,652	2,776	326	0.82	11.73
Nepal	146,879	51,216	12,594	8.57	24.59

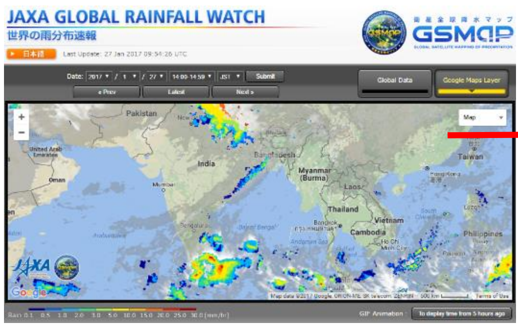
Country	Population	Average Affected (2001-2015)	% affected (2001-2015)
India	1,251,695,584	279,246,978	22.31
Sri Lanka	20,770,749	1,357,281	6.53
Pakistan	188,924,874	39,814,332	21.07
Afghanistan	32,564,342	2,748,627	8.44
Bangladesh	160,995,642	35,459,353	22.03
Bhutan	774,830	35,547	4.59
Nepal	28,679,524	5,737,401	20.01

- Average drought affected area in agriculture approx. 860,000sq.km for South Asia between 2001 to 2015;
- Among SA countries, India ranks the highest drought affected area ~683,000sq.km followed by Pakistan (105,484sq.km), Bangladesh (35,767sq.km)
- In terms of Population exposure from drought approx. 365 million people of which Indian parts covers 279million followed by 39 million in Pakistan, Bangladesh 35million and others

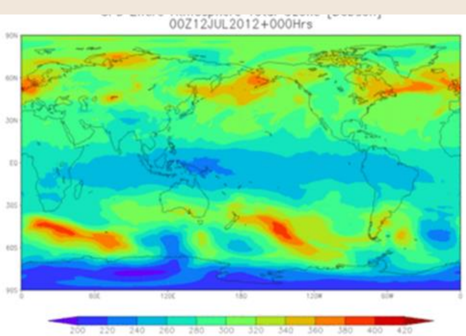
4. Experimental SADEWS and SM Drought Indices

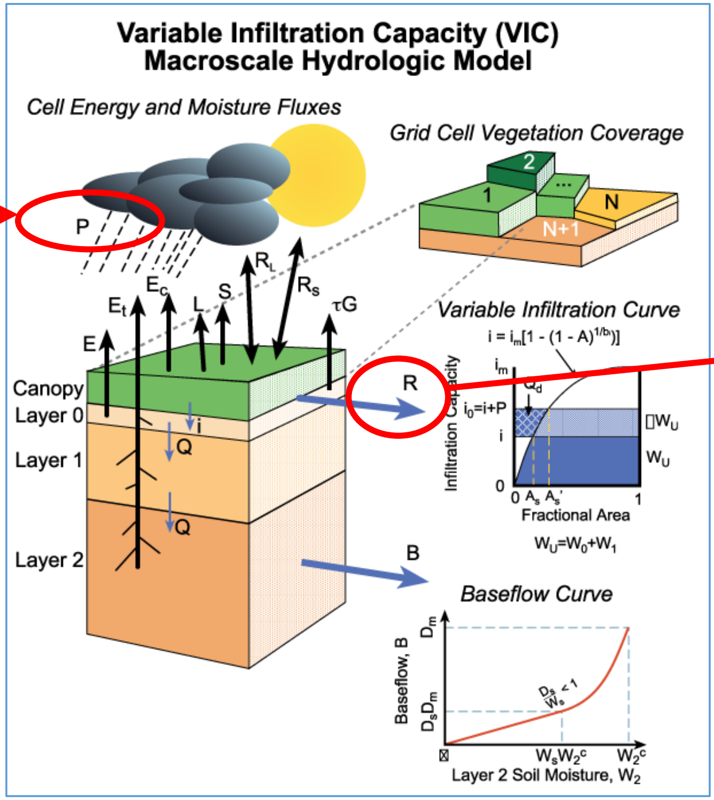
South Asia Drought Forecasting and Early Warning (SADEWS)

Near-real-time rainfall estimate

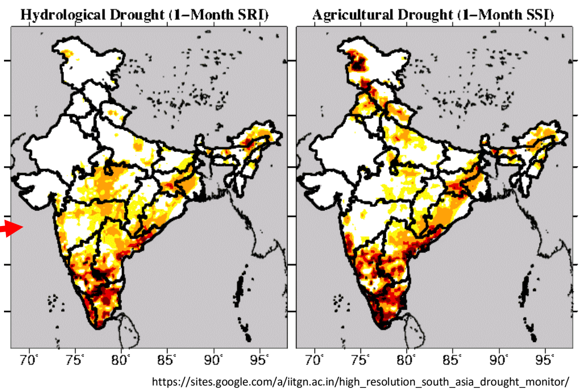


Rainfall forecast by NOAA GCFS and IITM





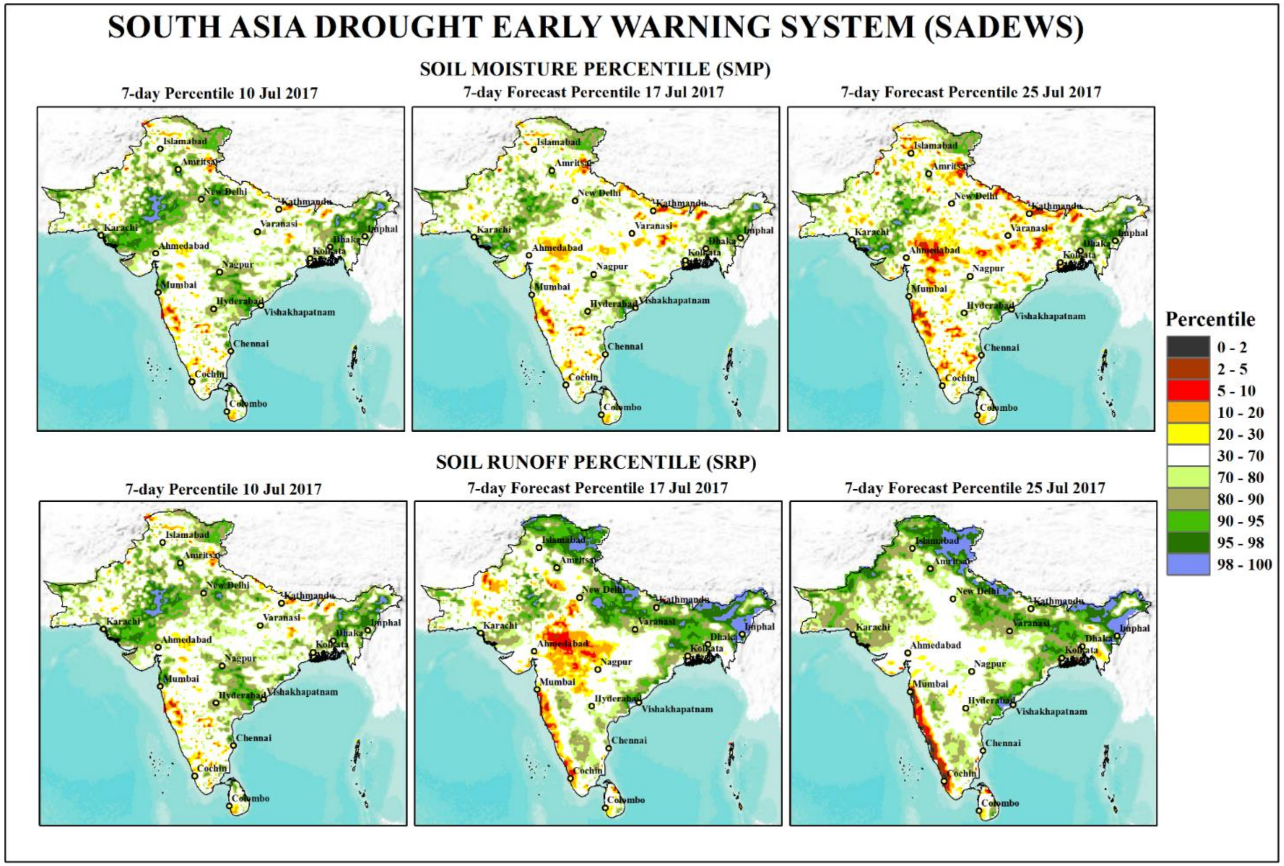
SRI: Hydrological drought severity
SSI: Agricultural drought severity



Forecasting impact on agriculture

Joint Collaboration of IIT-GN in model development and exploring with IITM/IMD to obtain weather forecast data

South Asia Drought Early Warning System (SADEWS)



Current Condition: 10 July 2017
Forecast Period : 17 July and 25 July 2017
Standardized Soil Moisture and Runoff Index for regional drought and early warning

Summary:

The experimental drought forecast products for research/scientific use based on 10th July 2017 initial condition. These forecast products are based on the real time weekly operational forecast generated by Global ENSemble (GENS), a weather forecast model made up of 21 separate forecasts, or ensemble members developed at The National Centers for Environmental Prediction (NCEP), NOAA.

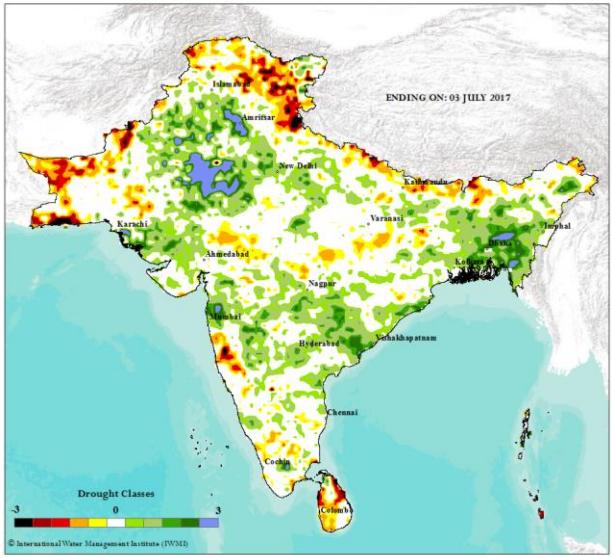
Drought Forecast Outlook:

- The initial condition has improved over Telangana, Andhra Pradesh, Rajasthan, Western UP and North-eastern states..
- Initial condition on the Soil Runoff Index (SRI) explains similar trend to SSI.
- Some level of dryness is expected in the following weeks over central parts of the region such as MP, eastern Gujarat and Jharkhand.
- The leeward side of the western ghats along the southern Maharashtra seems to be progressing towards dryness.
- In reference to IMD actual rainfall for India, several east-central states are in deficit rainfall condition which is affecting the crop productivity and advance need for State and Local authorities for better planning and coordination on water resources management.

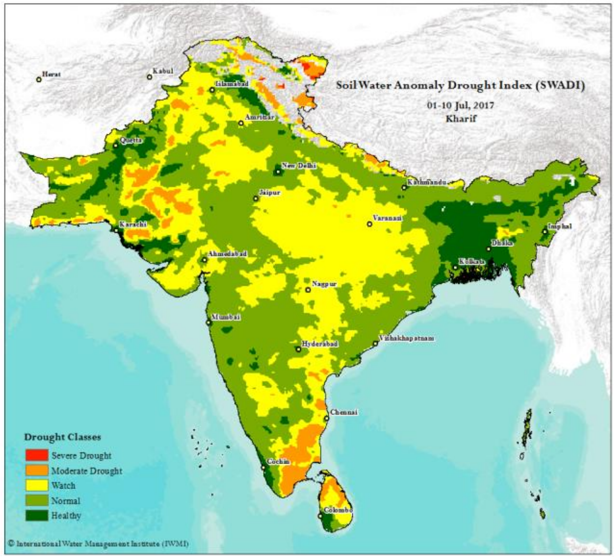
The SADEWS is regional scale early warning system developed as a collaborative project between International Water Management Institute (IWMI) and Indian Institute of Technology – Gandhi Nagar (IIT-GN).

SADMS – Drought Forecasting, Early Warning and Now casting

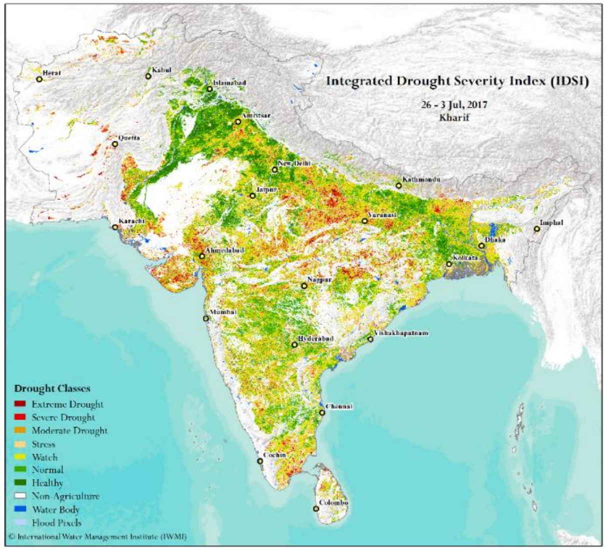
SA-DEWS



SWADI



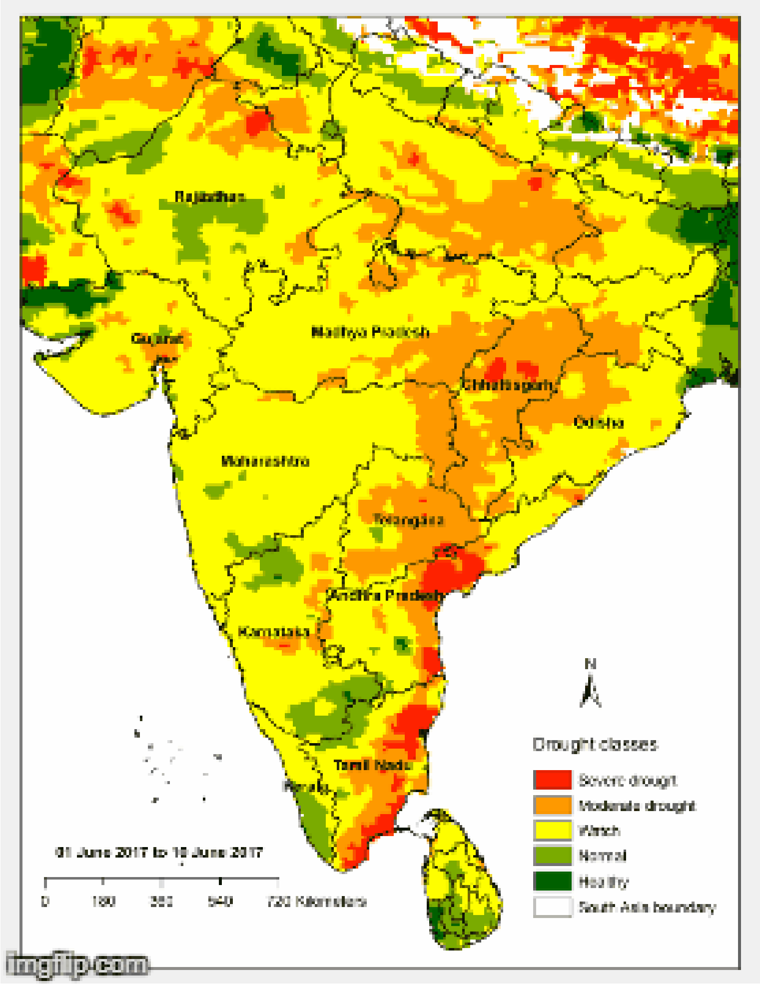
IDSI



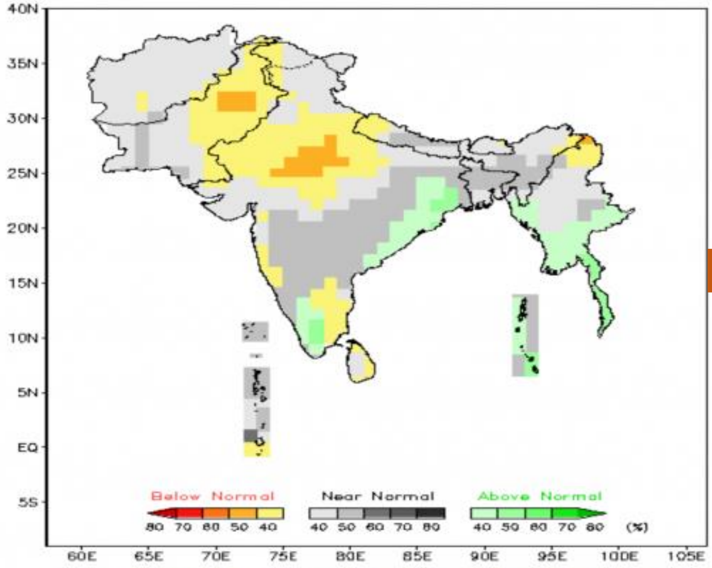
- South Asia-Drought Early Warning System (SA-DEWS) is an integrated approach based on satellite estimates of rainfall temperature, wind and soil type utilized in VIC model and the derived outputs namely Standardized Precipitation Index (3-Month), Standardized Soil Moisture Index (SSI) and Standardized Runoff Index (SRI).
- Soil Water Anomaly Drought Index (SWADI) is derived from satellite based decadal soil moisture product of ASCAT provided by EUMETSAT.
- Integrated Drought Severity Index (IDSI) is an integrated index that has been formulated using VCI, TCI & PCI at 500m resolution for agricultural land-use over South Asia.
- It can be observed, that during this time period all the three indices shows a close relation between each other. The peninsular India has reviving well from the drought situation. Parts of Bihar, Jharkhand and UP is facing some scarcity of rainfall which is well reflected in all the three indices. Some parts of Tamil Nadu is still facing moderate drought like scenario. North and Eastern parts of Sri Lanka is severely facing water stress resulting into crop damage and shortage of ground water.

Soil Moisture based Drought Index

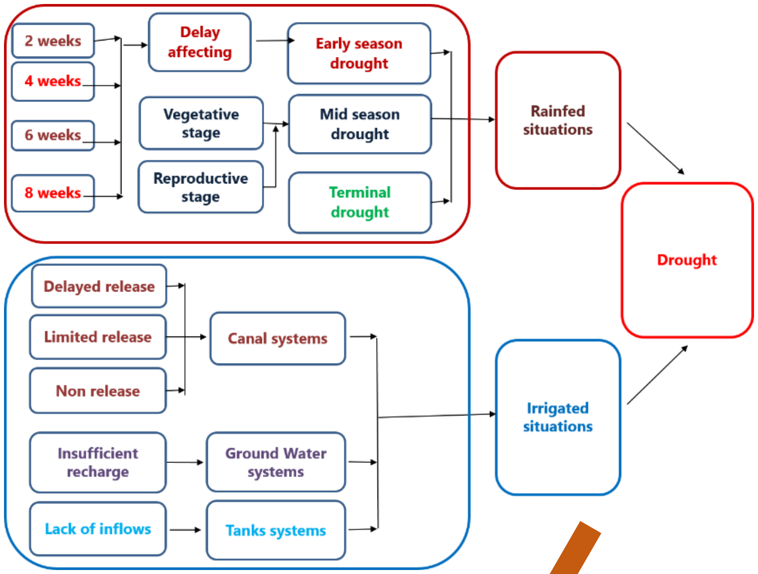
- Soil Water Index (SWI), developed by Europe's Copernicus Programme was used to calculate Soil Water Anomaly Drought Index (SWADI)
- SWADI involves the use of radar backscatter measurements from the Advanced Scatterometer (ASCAT) aboard the EUMETSAT MetOp satellite.
- Over the last 10 days, soils in parts of the region have been much drier than usual. Nowhere is current soil moisture as abnormally low as in Northern Sri Lanka and India's Tamil Nadu state.
- Although such conditions are a regular occurrence, the current situation stands out for its intensity and persistence, as was also the case during severe droughts in 2012 and 2014.

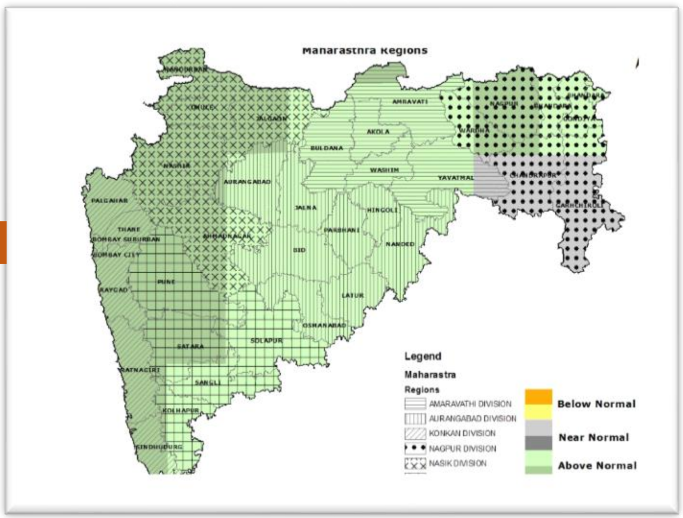


Drought Management & Contingency Plans



Consensus outlook for 2017 Southwest Monsoon Rainfall over South Asia





Source: CRIDA

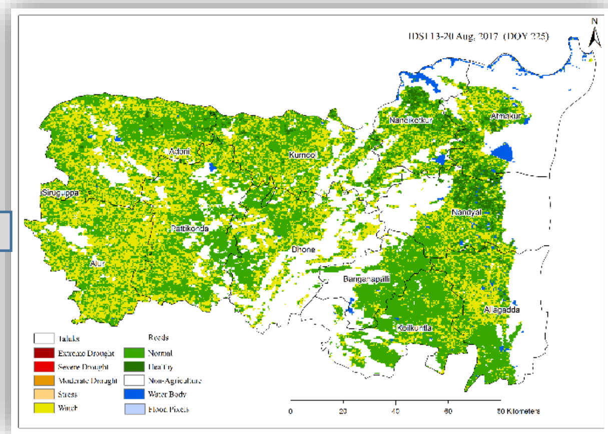
Based on the previous years i.e., 2015 and 2016 experience, during Kharif – 2017 contingency plan was proposed as below

If the rains are not received till 15th July, 2017									
S. No.	District	Crop wise Normal area (ha)	Crop wise area likely to be sown	Left over area	Crop wise areas proposed for Contingency		Seed requirement		Remarks
					Crop	Area	Crop/ variety	Qty. of seed req (Qtls)	
1	2	3	4	5	6	7	8	9	10
	Anantha puramu	801675	Groundnut+Redgram crops						

If the Rains are not received till 31st July, 2017									
S. No.	Mandal	Crop wise Normal area (ha)	Crop wise area likely to be sown	Left over area	Crop wise areas proposed for Contingency		Seed requirement		Remarks
					Crop	Area	Crop/ variety	Qty. of seed req (Qtls)	
1	2	3	4	5	6	7	8	9	10
	Anantha puramu	801675	Groundnut+Redgram crops						

Joint project of ICAR-CRIDA and IWMI on promoting drought resilience in pilot states in India

Drought Management & Contingency Plans



Stress condition of Foxtail Millet

RESEARCH PROGRAM ON Water, Land and Ecosystems

CGIAR

ICAR

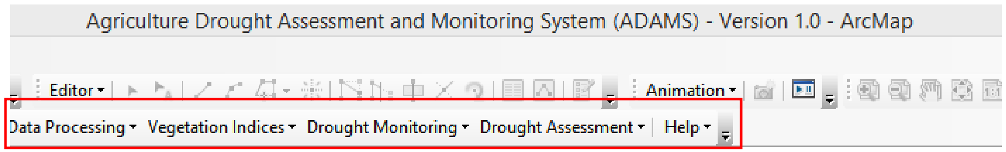
IWMI International Water Management Institute

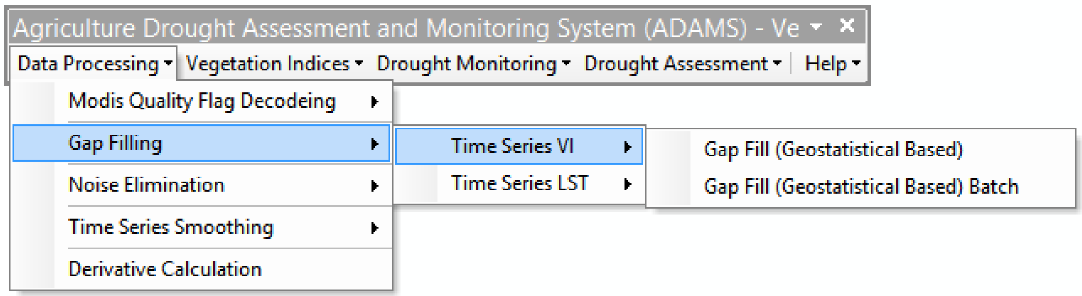
A water-secure world

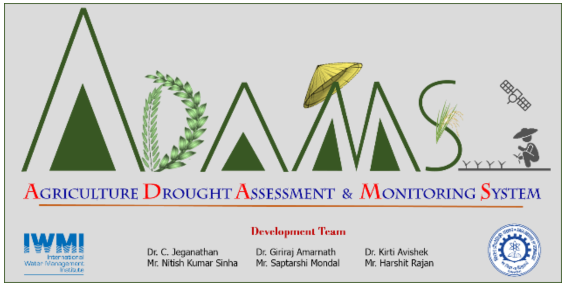
www.iwmi.org

5. SADMS Tools, Portal and Outreach

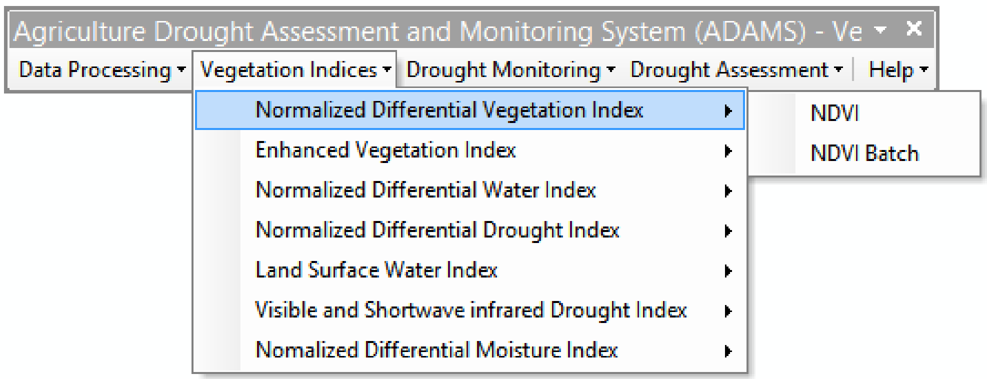
Drought Monitor tool (DMS)

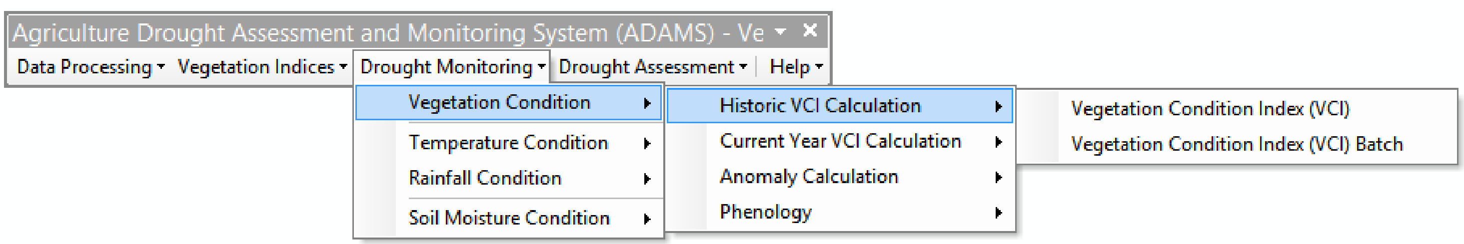


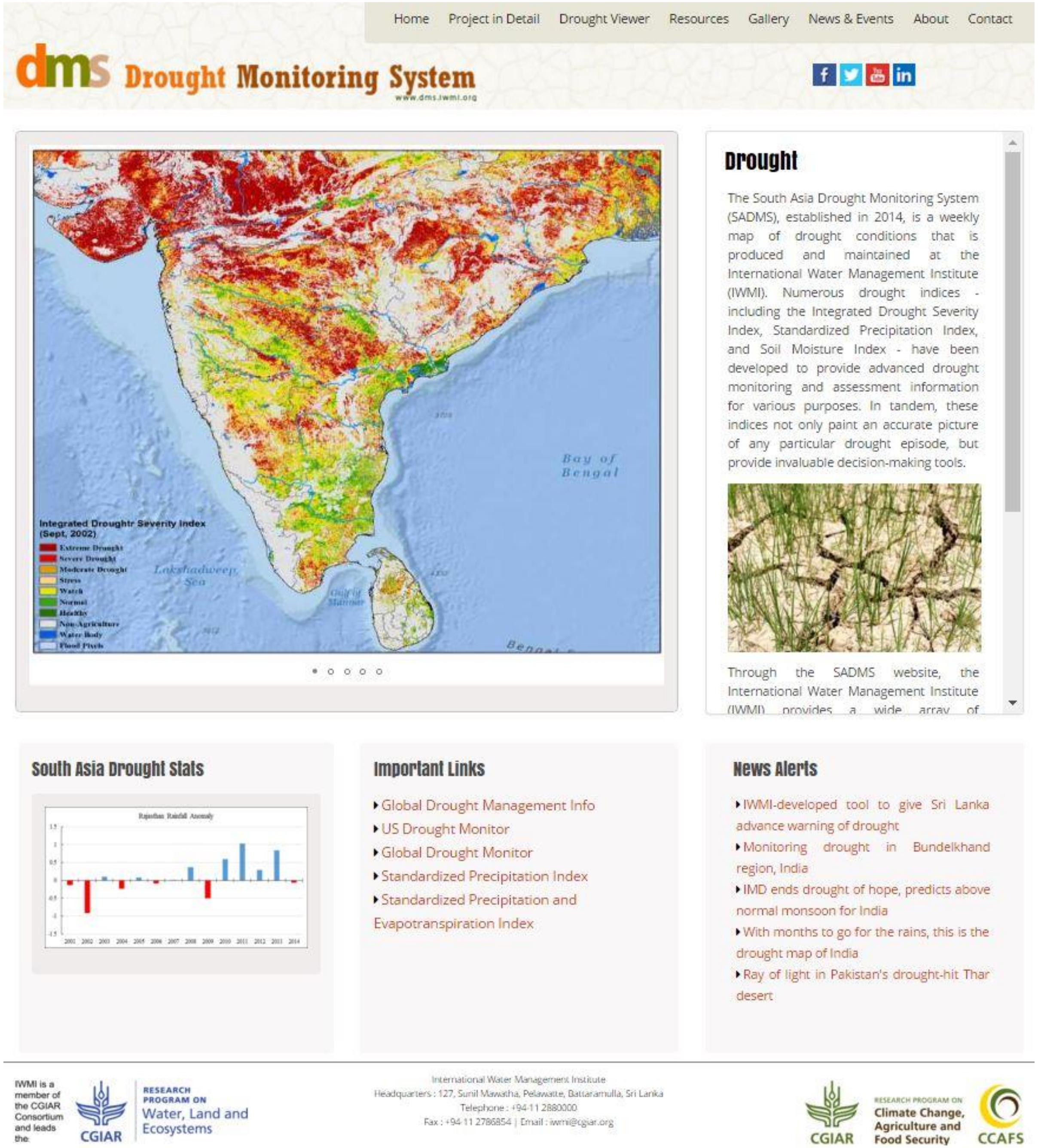




DMS tool was developed using ESRI ArcGIS interface





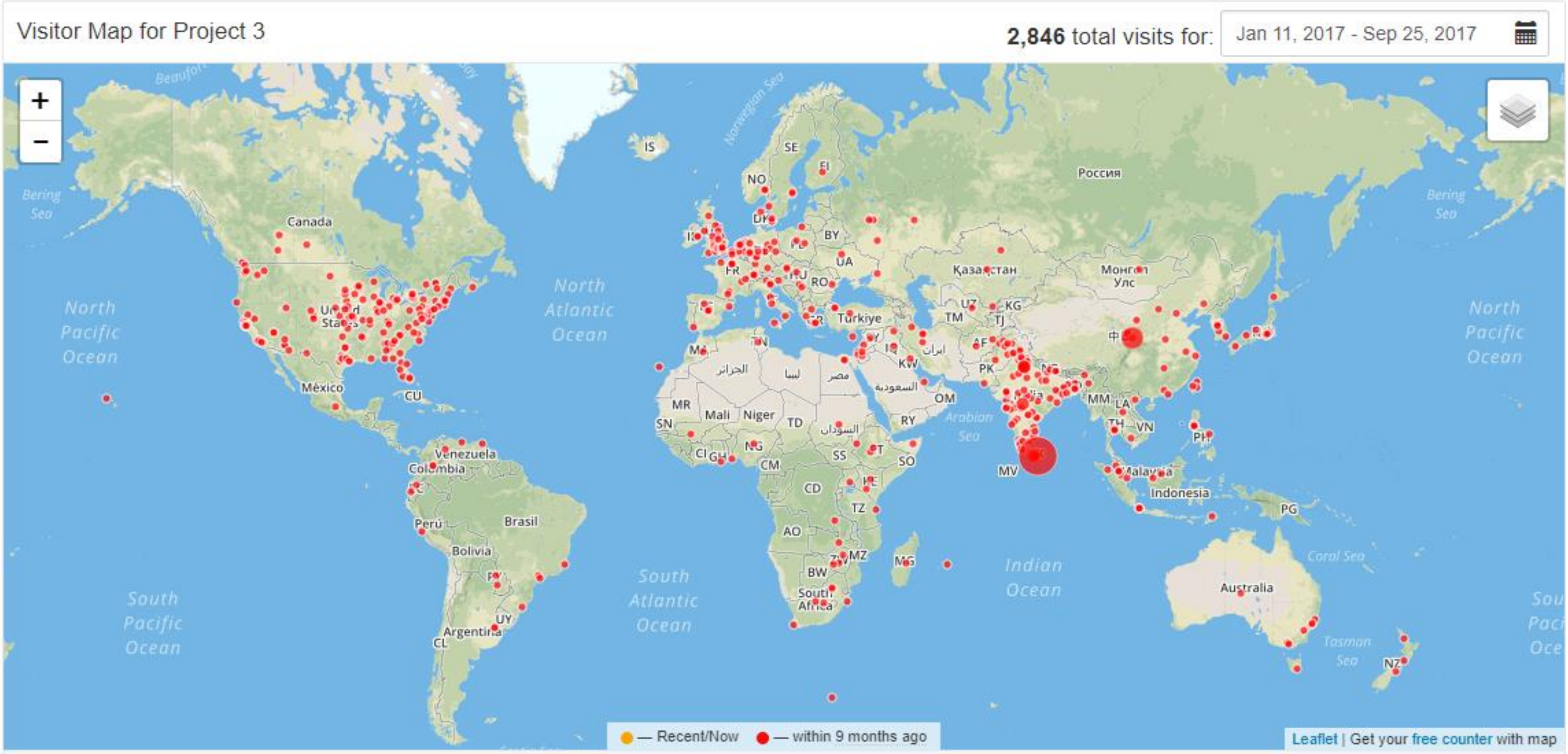


Key remarks

- An operational platform that integrates various drought products to provide advanced drought monitoring and assessment information for various purposes

- A first regional platform for South Asia and have inherently finer spatial detail (500m resolution) than other commonly available global drought products

Visitors to DMS Portal

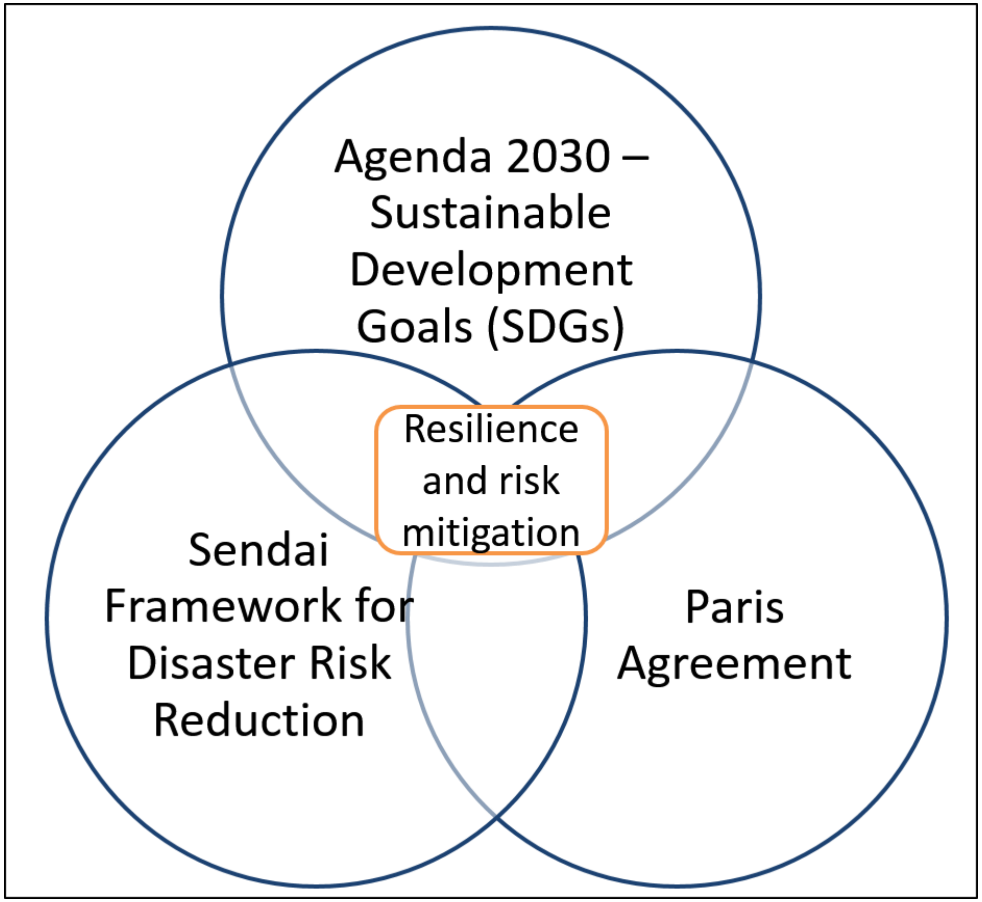


- More than 2800 visit to DMS and spread over 80 countries since Jan 2017
- Approx. 300 visit per month and dominant being India, Sri Lanka, USA, Canada, UK

Publications

6. SADMS Synergies and Next Steps

Linking SADMS with the national to global indicators



Addressing the SFDRR

Sendai Framework for Disaster Risk Reduction 2015 - 2030

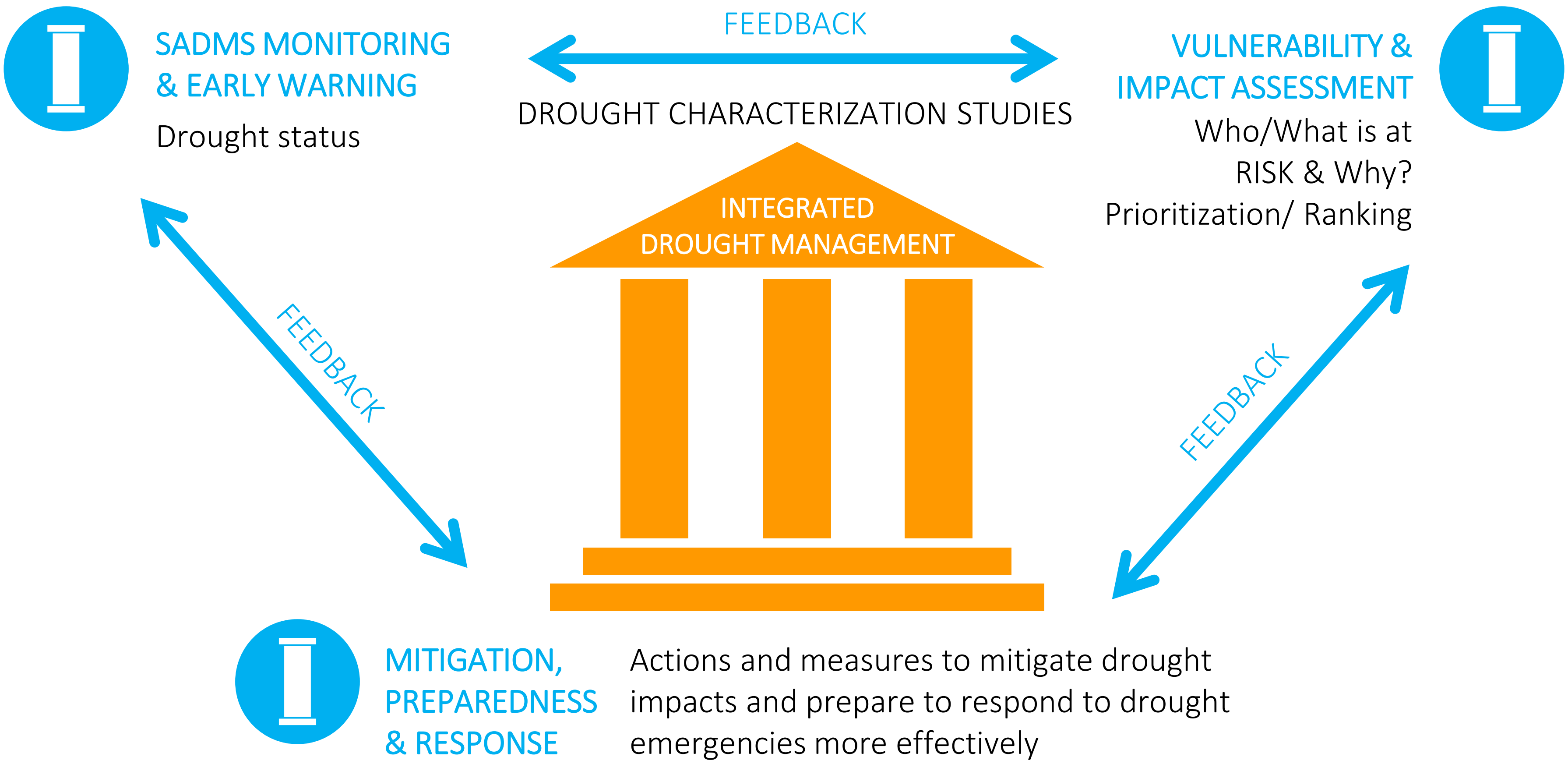
Understanding drought risk and drought Preparedness;
National Targets on indicators;

Sustainable Development Goals: the relevance of space technology

SADMS

New Proposal

Comprehensive Drought Management Plan (CDMP) – Sri Lanka



Source: IDMP

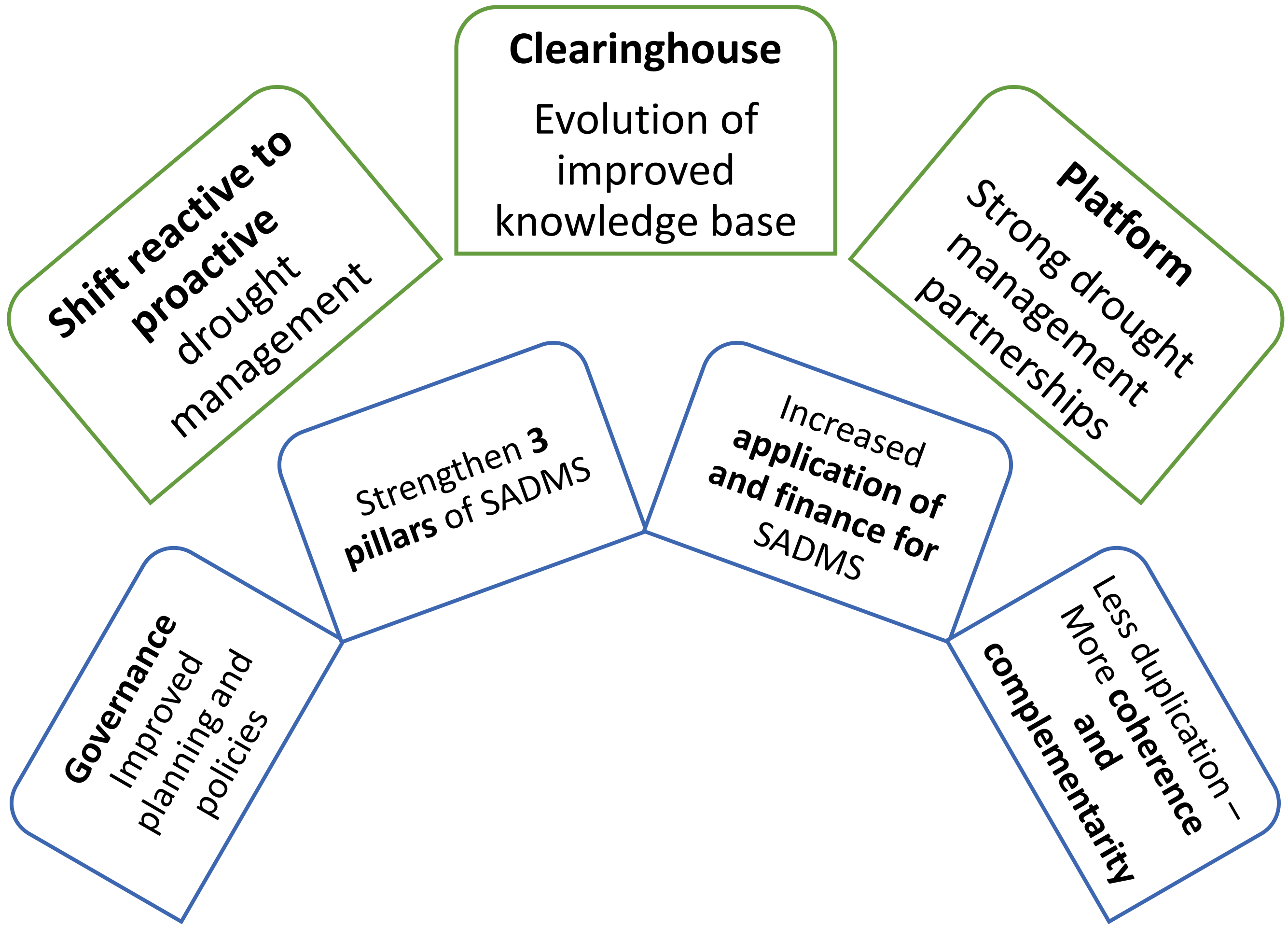
Vulnerability and Risk Assessment

Derivation of vulnerability indicators, combine information on hazard, exposure and vulnerability to assess overall drought risk and evaluate transferability of indicators between different countries.

Drought vulnerability analysis	Drought risk assessment	Evaluation of indicator transferability
↓	↓	↓
Vulnerability indicators of the social-agricultural system	Risk of people affected and loss in the agricultural sector	Unified set of indicators versus country specific indicators

Linking SDG, SFDRR to national indicators to measure and mitigation drought impacts

Outcomes



Source: IDMP / IWMI

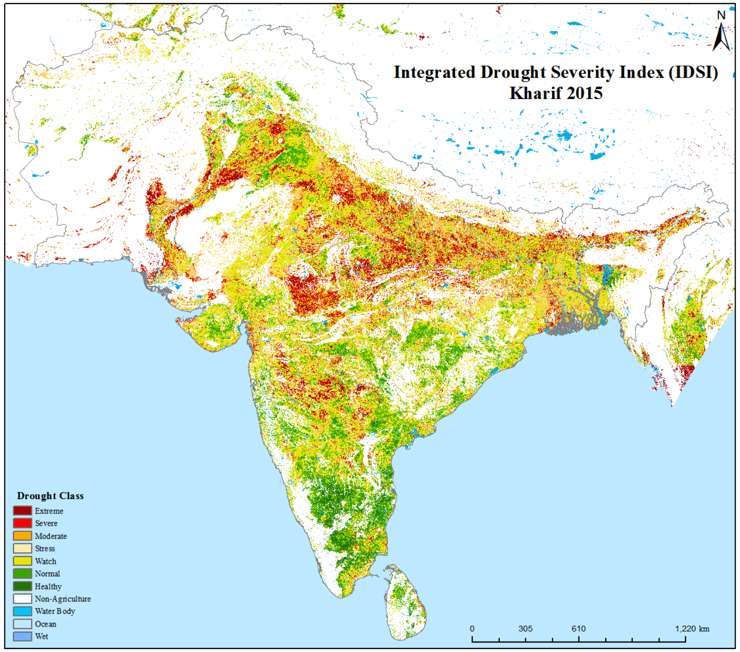
Plans for 2017-2019

MONITORING/
EARLY WARNING

Improvement of the drought monitoring

Drought User Service (SL-DMS)

- system which enables more accurate and efficient drought monitoring for the entire Sri Lanka
- an innovative tool integrating all available data, including large volume of remote sensing products and serving the authorities to monitor, forecast and respond during drought development faster and with higher precision



SL-DMS

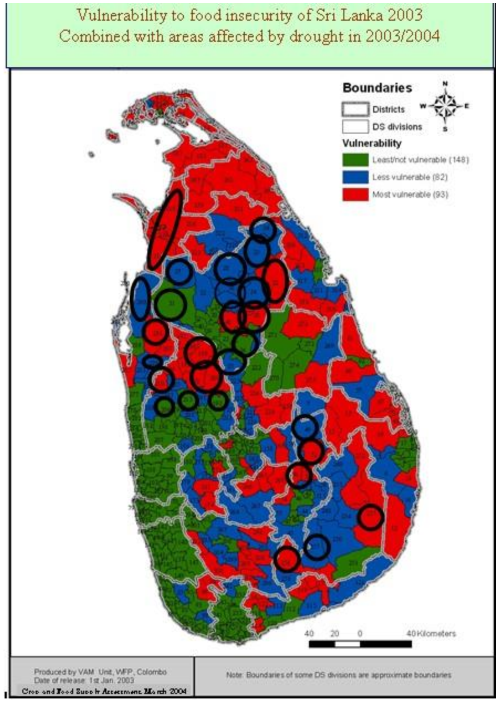
Plans for 2017-2019

VULNERABILITY & IMPACT ASSESSMENT

Unification of drought impacts and risk assessment

Drought Impact Assessment

- common methodology for near real-time drought impact assessment (reporters)
- common methodology for near real-time drought impact forecast
- establishment of network of reporters as additional source of information for drought impacts in agriculture



Drought Risk Assessment

- State-of-the-art analysis
- Common methodology for drought risk assessment
- Mapping of risk – regional atlas of drought risk

Plans for 2017-2019

MITIGATION &
PREPAREDNESS

Overcoming gaps in decision-making processes in drought management
Improve dialogue between the scientific and policy-making communities

Improvements of the drought management cycle – using Guidelines for preparation of the DMP

- update current status in the region
- template for institutional mapping
- techniques for identification of the gaps in the drought management processes
- preparation of the model/scheme on how should drought management in the region (countries) work

National and regional consultations/workshops, etc.

- better understanding and usage of the CDMP SL (and SADMS) products
- demonstrating positive effect of changed behavior (pro-active approach)

For further information

http://dms.iwmi.org

a.giriraj@cgiar.org

Photo: Samurdhi Ranasinghe / IWMI