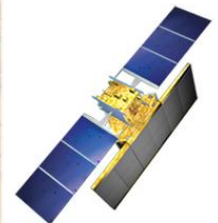# Operational Remote Sensing for Agricultural applications at national level

Mahalanobis National Crop Forecast Centre
Department of Agriculture, Cooperation & Farmers' Welfare
Ministry of Agriculture & Farmers' Welfare
Govt. of India

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Paddy crop affected due to severe water shortage during Kharif 2012

# Remote Sensing – Operational Use

1. Operational projects for agricultural monitoring using EO

   i.   **FASAL: Pre-harvest Crop Production Forecasting for 9 major crops at National/State/District level**

   ii. *NADAMS: District/sub-district level operational drought assessment for the drought prone states of the country*

   iii. *CHAMAN: Assessment of 7 horticultural crops in 185 districts and planning for horticultural development*

   iv. *PMFBY: Use of Satellite Data for Crop Insurance*

2. The Flagship Programmes (PMFBY, PMKSY, SHC, etc.) of Ministry of Agriculture advocate use of remote sensing data and geospatial tools for their implementation

FASAL Overall Methodology

Forecasting **Agricultural output** using **Space**, **Agro-meteorology** and **Land based observations**
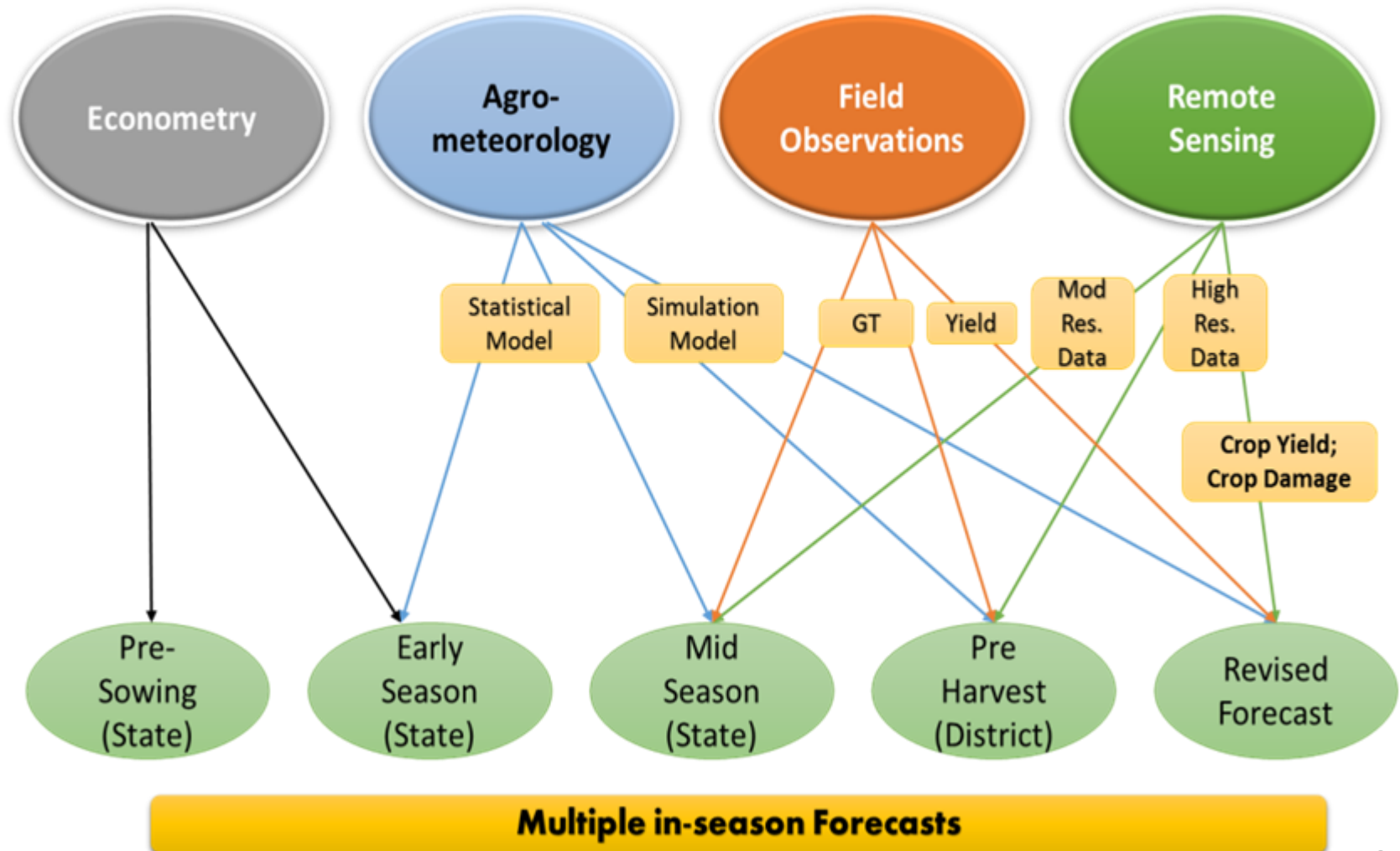
FASAL: Crop Forecasting

- FASAL (Forecasting Agricultural output using Space, Agrometeorlogy & Land based observations)

- Multiple Pre-harvest production forecasts of 9 major crops

- **Both optical (R2 AWiFS & LISS III; L8 OLI; S2 MSI) and Microwave (RISAT-1 SAR/Sentinel 1) Data**

- Yield Models (Remote sensing based/Agro-Meteorological/ Crop simulation/CCE-Based)

- **18 forecasts in a year at National/ state/ district level**

- >90 partner organisations (DACFW, 3 ISRO centres, 20 SDAs, 16 SRSACs, 46 AMFUs, IEG, IMD,MNCFC)

National/State/District Forecasts:

- Kharif Rice (3 Forecasts, 14 states)
- Rabi Rice (1, 5)
- Wheat (3,9)
- Rapeseed & Mustard (3,6)
- Jute (1,3)
- Cotton (2,9)
- Sugarcane (2,5)
- Rabi Sorghum (1,2)
- Rabi Pulses(2, 6)
- Tur (1,5)

| Knowledge partners |
| --- |
| National Remote Sensing Centre (NRSC), ISRO |
| Space Applications Centre (SAC), ISRO |
| Institute of Economic Growth (IEG) |
| India Meteorological Department (IMD) |
| State Agriculture Departments (20) |
| State Remote Sensing Centre(s) (16) |

FASAL: Crops Covered and Study States and Districts

Crop	States	No. of Districts	Schedule of Forecast
Jute	Assam, Bihar and West Bengal	27	Mid July
Kharif Rice	Andhra Pradesh, Assam, Bihar, Chhattisgarh, Haryana, Karnataka, Jharkhand, Madhya Pradesh, Odisha, Punjab, Uttar Pradesh, Telangana, West Bengal, Kerala and Tamil Nadu	348	Mid September Mid October Mid End
Rabi Rice	Andhra Pradesh, Telangana, Karnataka, Odisha and West Bengal	69	April End
Cotton	Andhra Pradesh, Gujarat, Haryana, Madhya Pradesh, Maharashtra, Punjab Rajasthan	89	October End November End
Sugarcane	Gujarat, Haryana, Maharashtra, Uttar Pradesh and Uttrakhand	57	July End November End
Rabi Sorghum	Karnataka and Maharashtra	20	January end/Feb First fortnight
Rapeseed-Mustard	Gujarat, Haryana, Madhya Pradesh, Rajasthan, Uttar Pradesh	84	December End January End Feb End/March First fortnight
Wheat	Bihar, Gujarat, Haryana, Himachal Pradesh, Madhya Pradesh, Punjab, Uttar Pradesh and Uttarakhand	260	January End February End April End
Pulses	Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Rajasthan and Uttar Pradesh	82	February End April End

Crop wise Yield Estimation Technique

Crops	Method of yield estimation				
	District/Met-Subdivision level Agro-meteorological models	Crop Simulation Model	Yield Models using Remote Sensing Indices (NDVI, VCI, Biomass)	Semi-Physical Models for Sugarcane, Wheat and R&M	Crop Cutting Experiments using RS based Sampling Plan
Kharif Rice	✔	✔	✔	✔	✔
Rabi Rice	✔	✘	✔	✘	✔
Wheat	✔	✔	✔	✔	✔
R&M	✔	✔	✔	✔	✔
Jute	✔	✘	✘	✘	✘
Cotton	✔	✔	✔	✘	✘
Sugarcane	✔	✘	✔	✘	✘
Rabi Sorghum	✔	✘	✔	✘	✘
Rabi Pulses	✔	✘	✔	✘	✘

Smartphone for Field Data Collection:
Support from BHUVAN

Ground Truth
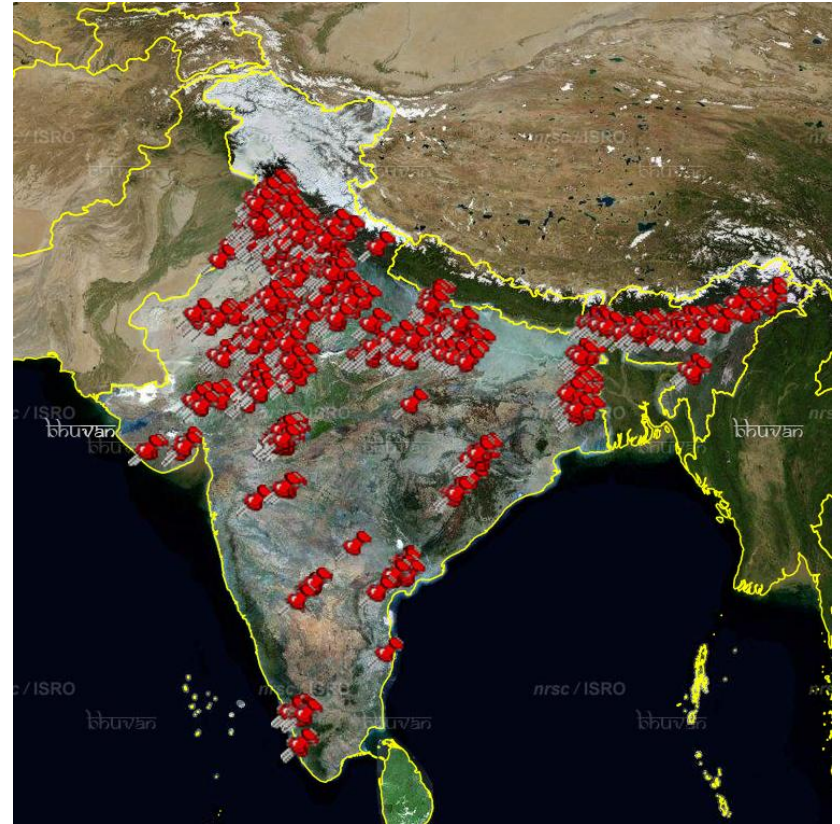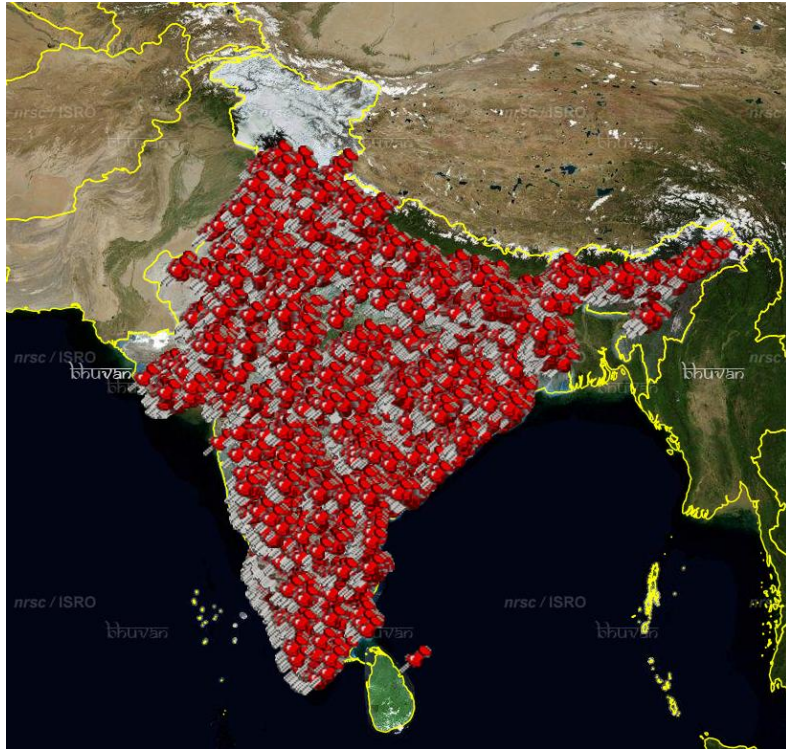
Crop Cutting Experiment

Crop wise comparison with DES (Area) (National Level)

Crop	2012-13--2019-20		Last three years	
	Area	Production	Area	Production
Kharif Rice	<5%	<5%	<3%	<5%
Wheat	<2%	<5%	<2%	<4%
Rabi Rice	<8%	<9%	<9%	<8%
Sugarcane	<11%	<8%	<15%	<6%
Rabi Pulses*	<6%	<14%		
Rabi Sorghum	<13%	<13%	<9%	<14%
Rapseed & Mustard	<8%	<13%	<9%	<18%
Cotton	<10%	<13%	<11%	<9%

*Started from 2017-18

Wish list for future

- **Expansion of estimates from current 9 to 17 crops.**
- **Sub district/Block level crop production forecast for major crops (Rice & Wheat).**
- **Development of National Crop Information Portal.**
- Efforts to integrate NAVIC and GAGAN based Navigation networks for improved geotagging applications
- Polygon based Ground truth for improved accuracy.
- **Envisaging/Operationalization of AI/ML based approaches for improved crop acreage and yield estimates (Rice, Wheat, Soybean & Maize).**
- Integration of various data available with ministry with cadastral information's available ISRO/SRSCs/State Government Departments towards making the use in Crop insurance, Statistics, Crop condition etc.

National Agricultural Drought Assessment and Monitoring System (NADAMS)

- **17 major agricultural drought prone states - (Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Haryana, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh and West Bengal).**

Ministry of Agriculture & Farmers' Welfare

- Overall coordination, Inter-Ministerial Crop Weather Watch Group (CWWG), Leading IMCT for Drought Assessment

India Meteorological Department

- Weather Forecasting, Drought Assessment using Rainfall

Central Water Commission

- Monitoring Storage situation in Major Reservoirs

MNCFC, DACFW and ISRO

- **Space technology based drought assessment (NADAMS)**

ICAR

- Contingency planning

DOLR/   MOWR/DACFW

- PMKSY-Watershed Development-Water Harv. Str. /Irrigation/Use efficiency

National Institute of Disaster Management

- Capacity Building

Parameters for Kharif Drought Declaration (Drought Manual, 2016)

Levels	Category	Parameters
Trigger 1 **(Mandatory Indicator)**	Rainfall Based	1. RF Deviation or SPI 2. Dry Spell
Trigger 2 **(Impact Indicator)** **Need to Select 3 out of 4 type of Indicators**	1. Remote Sensing 2. Crop Situation 3. Soil Moisture 4. Hydrological	1. NDVI & NDWI Deviation or VCI 2. Area under sowing 3. PASM or MAI 4. RSI/GWDI/SFDI
Verification	Field Data	GT in 5 sites, each, of 10% of Villages

RF – Rainfall

SPI – Standardized Precipitation Index

NDVI – Normalized Difference Vegetation Index

NDWI –Normalized Difference Wetness Index

PASM – Plant Available Soil Moisture

MAI – Moisture Adequacy Index

RSI – Reservoir Storage Index

GWDI – Ground Water Drought Index

SFDI – Stream Flow Drought Index

GT – Ground Truth

- ❑ *Severe drought: if two of the selected 3 impact indicators are in Severe category and 1 is in Moderate category*
- ❑ *Moderate drought: (i) if two of the selected 3 impact indicators are in 'Moderate' class. (ii) if two of th selected 3 impact indicators are in severe and 1 is in Normal category*
- ❑ *Normal: for all other cases.*
- ❑ *Trigger 2 will be set off in the event of a finding of 'severe' or 'moderate' drought.*
- ❑ *The State has an option to reduce the drought category by one rank (i.e. Severe to Moderate) if the irrigation percentage of the administrative region (District/Taluk/Block/Mandal), for which drought is being declared is more than 75%.*
- ❑ *Finally the drought assessed using impact indicators needs to be validated through ground truth.*

Key Variable, Indicators and source of Data for drought monitoring

S.I. No.	Key Variables	Indicators/Index	Source of Data
1.	Rainfall	Rainfall Deviation/SPI/Dry Spell	IMD District level weekly
2.	Crop Sown Area	Deviation from Normal	Resourcesat -2 AWiFS (56m), MODIS (250m), PROBA-V(330m) fortnightly NDVI products
3.	Satellite Based Crop Condition	NDVI, NDWI Deviation from Normal VCI of NDVI/NDWI	Satellite derived fortnightly NDVI products of Resourcesat -2 AWiFS (56m), MODIS (250m)
4.	Soil Moisture	Percent Available Soil Moisture	Water Balance model developed by NRSC (Input: NOAA CPC Rainfall, Global PET)
5.	Reservoir Levels	RSI	CWC
6.	Ground Water	Ground Water Drought Index	Post Monsoon Groundwater Data from Central Ground Water Board
7.	Irrigated Area and sources	Rainfed and irrigated area	DES

Future Plans/Goals

- **Sub-District level kharif drought assessment for 17 major agricultural states using Satellite, Meteorological and Ground data as per New Drought manual.**

- **Development of Geo Portal for national Drought monitoring (Visualisations & Download).**

- Development of Mechanism for Drought forewarning using extended range weather forecast.

- **Drought Vulnerability assessment and drought proofing at sub-district/watershed level.**

- **Grid Level Drought Assessment for major agricultural states using Satellite, Meteorological and Ground data as per New Drought manual.**

- **Decision Support System for Drought Monitoring.**

Coordinated Horticulture Assessment and MAnagement using GeoINformatics (CHAMAN)

Operationalization of techniques developed under Phase I (7 major horticulture crop)

Increasing the number of crops (7 to 10) and states (12-16)

Horticultural developmental studies (Expansion, Clustering) and their implementation in NER States (2-3 dist. in each State) and other prominent States

Research & Development Studies for Kharif Vegetables crop assessment, improvement of yield modelling, UAV use & precision farming etc.

Operational Crop Assessment

Crop	State	No. of Districts	Estimate Months/Nos
Banana(6)	Tamil Nadu, Andhra Pradesh, Maharashtra, Gujarat, Karnataka, Uttar Pradesh	34	Oct-Nov. (1)
Mango(8)	Uttar Pradesh, Gujarat, Karnataka, Andhra Pradesh, Telangana, Bihar, Tamil Nadu.	49	Sep-Oct. (1)
Citrus(9)	Andhra Pradesh, Telangana, Maharashtra, Punjab, Madhya Pradesh, Gujarat, Rajasthan, Karnataka, Tamil Nadu	27	Sep-Oct. (1)
Potato (7)	Uttar Pradesh, Bihar, West Bengal, Gujarat, Punjab, Bihar, Madhya Pradesh, Haryana.	77	Jan-Feb. (2: State & District level)
Onion(6)	Maharashtra, Gujarat, MP, Karnataka, Rajasthan, Bihar, Andhra Pradesh.	36	Jan.-Apr. (2: Late Kharif & Rabi)
Tomato(8)	Andhra Pradesh, Odisha, Karnataka, Madhya Pradesh, West Bengal, Bihar, Gujarat, Chhattisgarh.	64	Jan-Feb. (2: State & District level)
Chilli(7)	Andhra Pradesh, Telangana, Karnataka, West Bengal, Madhya Pradesh, Odisha, Maharashtra	40	Jan.-Feb. (1)

CHAMAN Districts-Phase II
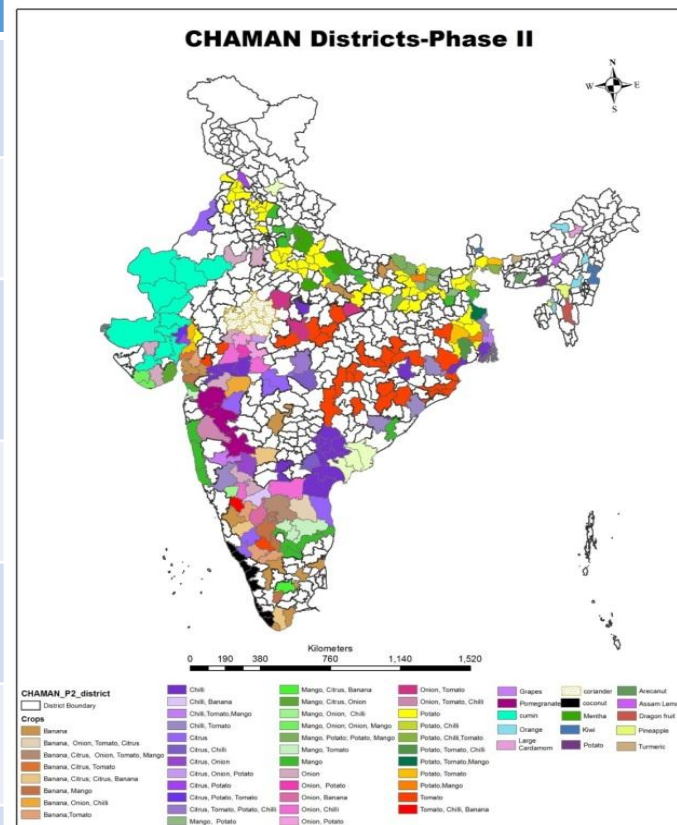
Knowledge Partners

SAC, NRSC, RCs, NESAC, ICAR, SRCs, IEG, IMD, CDB, State horticulture dept.

Future Plans/Goals

- **Envisaging/Operationalization of AI/ML based approaches for improved crop acreage and yield estimates (for TOP crops/plantations).**
- **Production forecasting of major 15 horticultural crops in selected districts of major states.**
- **Spatilization** of various horticultural data available with ministry/Government Departments.

Emphasis on Technology in PMFBY Guidelines

- PMFBY is an area-yield index based insurance, operates at village/ Gram panchayat level for major crops.
- Crop yield (Index for insurance) is derived through crop cutting experiments.
- PMFBY is a technology driven scheme y in three forms: 1) NCIP portal; 2) CCE Agri App and 3) Innovative Technologies i.e. Remote Sensing

Operational Guideline, 2016
- Technology recommended
- Smart Phone & RST
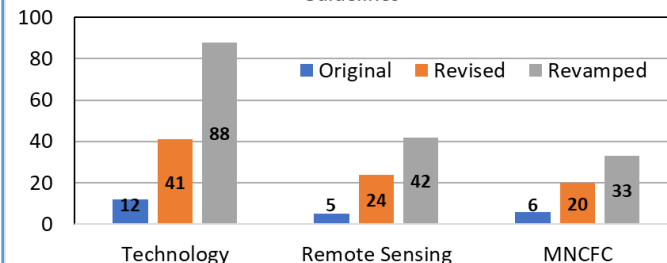- For Smart Sampling, Area Discrepancy, Yield Dispute, Estimation

Revised Guideline, 2018
- SOPs defined (Yield dispute, Area Discrepancy, Loss Assessment)
- Smartphone use Mandatory
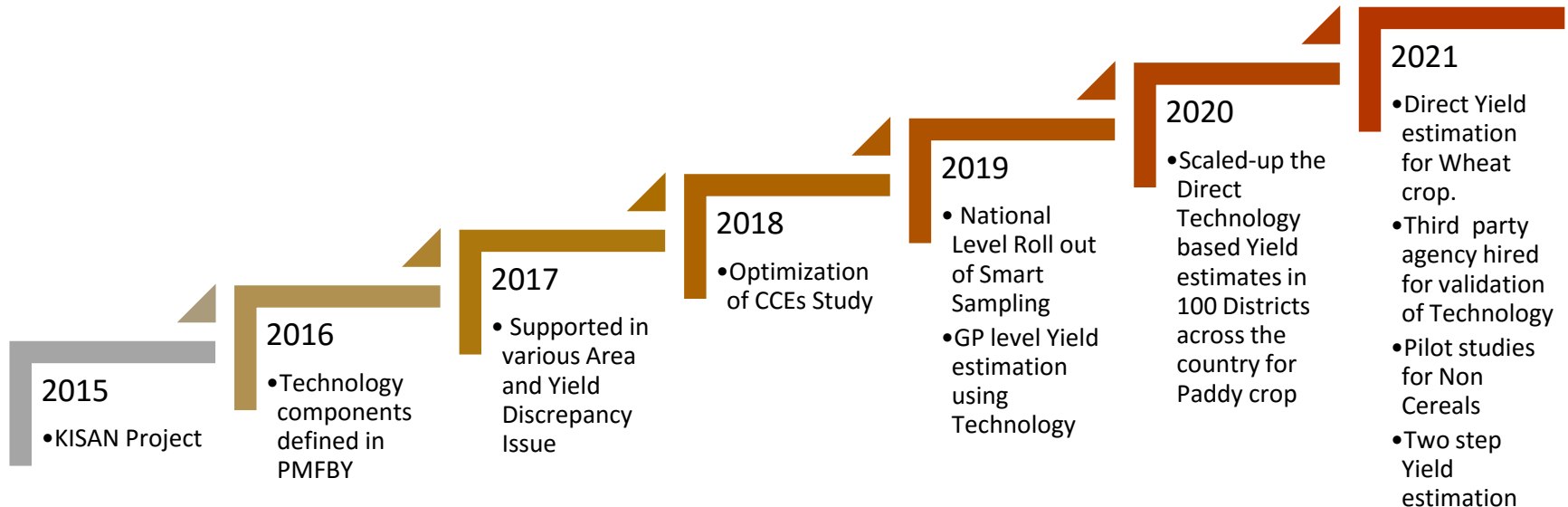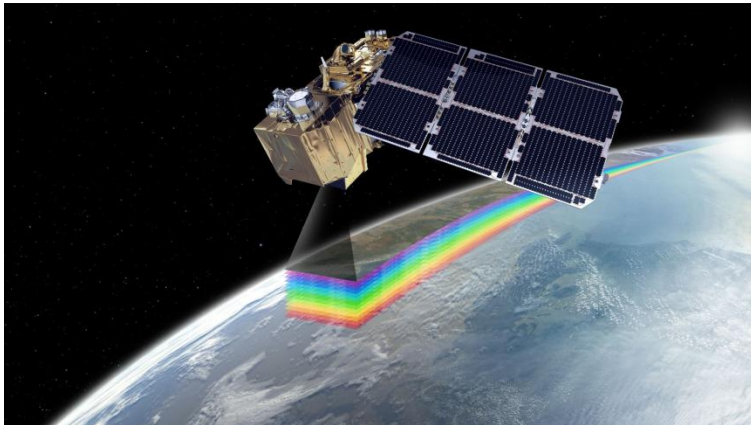- A special Section on Use of Innovative Technologies

Revamped Guideline, 2020
- Revised SOPs with more clarification
- SOPs for Smart Sampling, Two-Step Yield Estimation
- Area Discrepancy Resolution redefined

Number of Times the Terms are cited in PMFBY Guidelines

Term	Original	Revised	Revamped
Technology	12	41	88
Remote Sensing	5	24	42
MNCFC	6	20	33

Use of Technology for Crop insurance: Journey of Last 6 Years

2015
- KISAN Project

2016
- Technology components defined in PMFBY

2017
- Supported in various Area and Yield Discrepancy Issue

2018
- Optimization of CCEs Study

2019
- National Level Roll out of Smart Sampling
- GP level Yield estimation using Technology

2020
- Scaled-up the Direct Technology based Yield estimates in 100 Districts across the country for Paddy crop

2021
- Direct Yield estimation for Wheat crop.
- Third party agency hired for validation of Technology
- Pilot studies for Non Cereals
- Two step Yield estimation

Technology Use in Revamped PMFBY

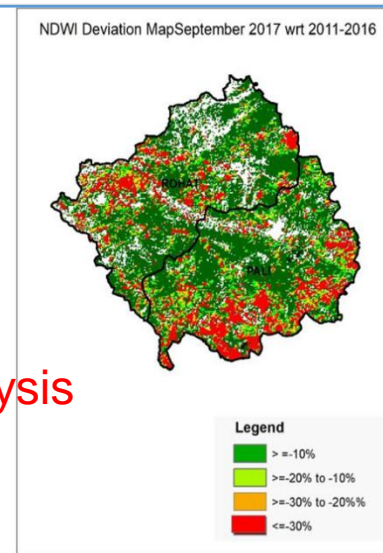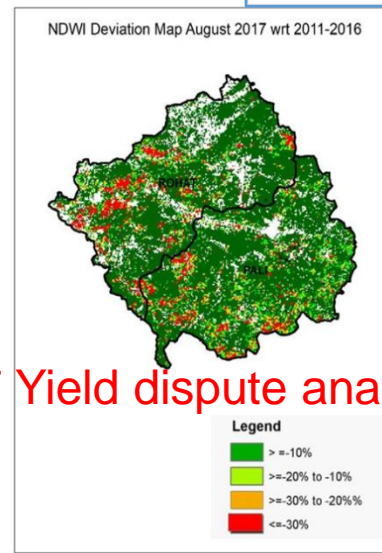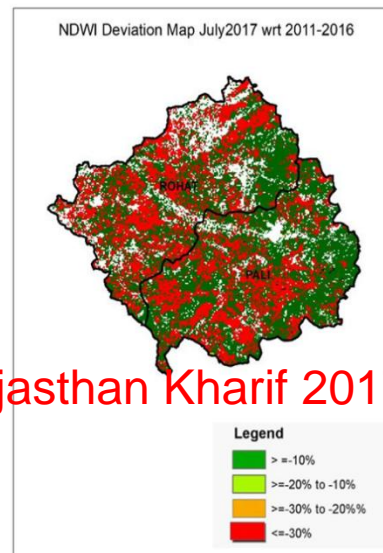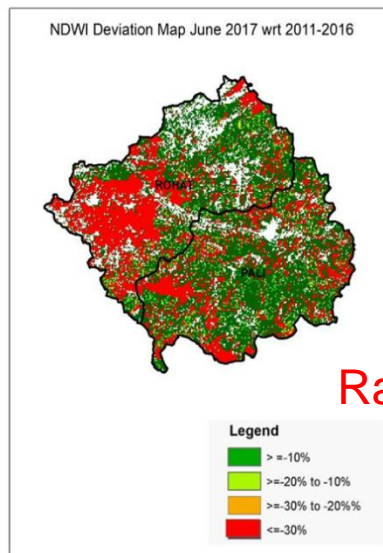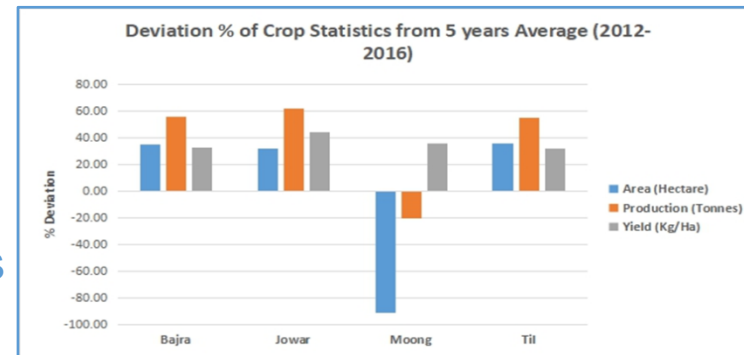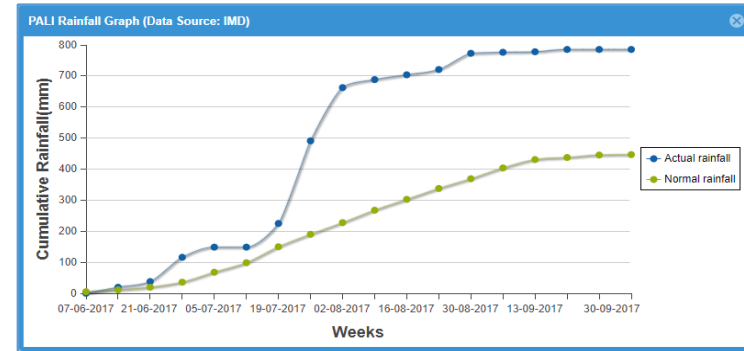| S. No.	Areas of Use	Inputs
1	Smart Sampling/ CCE Optimization	Crop map, Crop yield proxy map, IU Boundaries, Cadastral Map
2	Area Discrepancy/ Area Correction Factor	Crop map, Crop Statistics (block level), Large Ground truth
3	Yield Dispute Resolution	Crop map, Crop condition, Yield Models, Drought Report
4	Prevented sowing/ Failed Sowing	RS Data, AWS/ARG Data, Drought Report
5	Loss Assessment	Remote Sensing Indices, Drought Report, Weather Data

Smart Sampling Roll Out

- Kharif, 2020: Rice crop in 86 districts of Assam, Haryana, Karnataka, Madhya Pradesh, Odisha, and Uttar Pradesh, total 410000 CCE locations (triplicate).

- Kharif 2020 Pilot studies- 100 districts of 8 states total CCE locations- 323746.

- Rabi, 2020-21: Wheat in 7 States, 414522 CCE locations; Paddy in One state 11206 CCE locations.

- Crop map derived from satellite data was used as an input

- Satellite data based modeled yield (Productivity Efficiency Model) was used as parameter for stratification: Integrated with weather and field data

- Joint work of MNCFC, ISRO, State Remote Sensing Centres and State Agriculture Departments.

SST locations during Rabi 2020-21

Wheat SST locations 2020-21
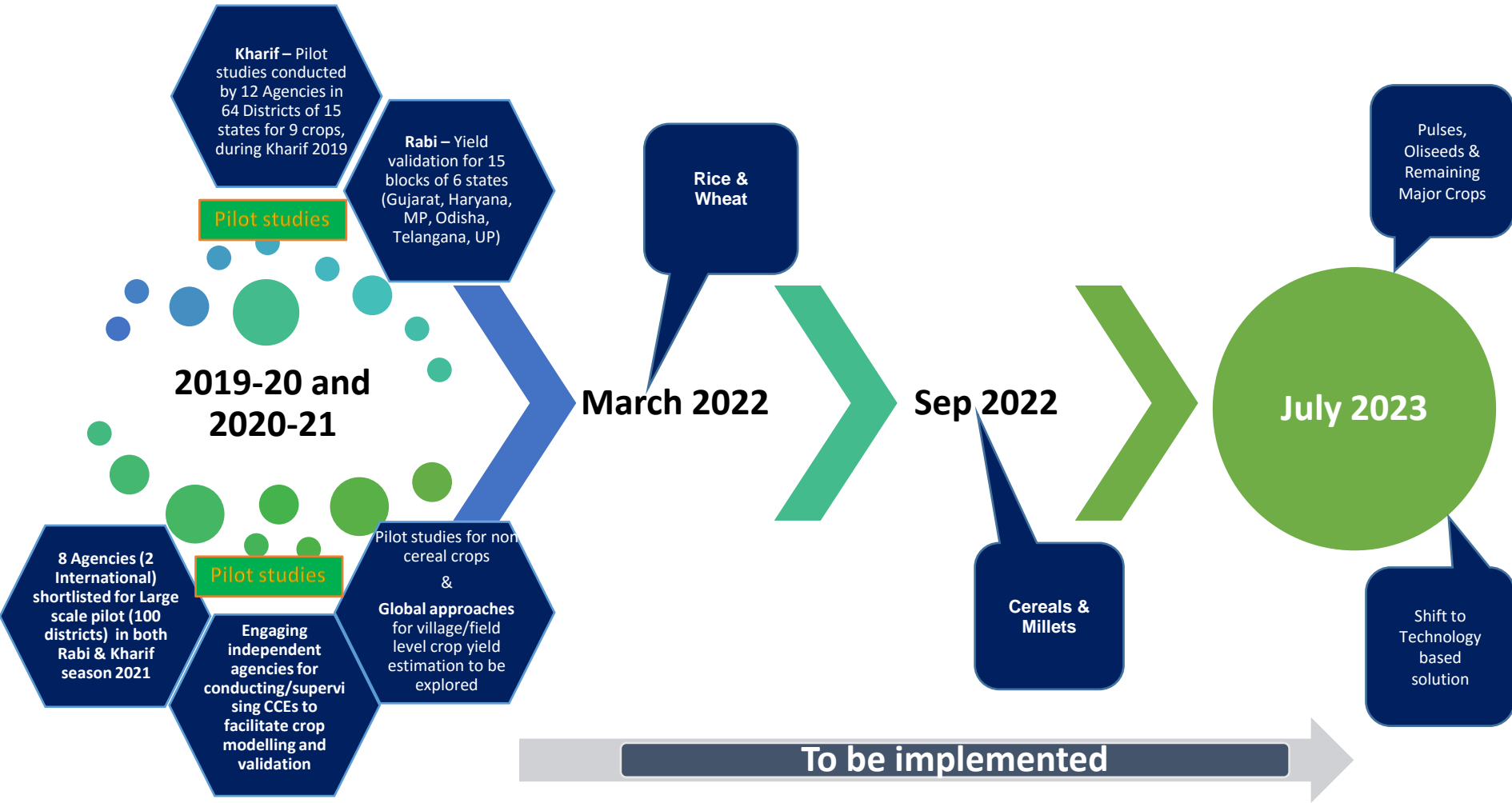

Paddy SST locations -2020-21
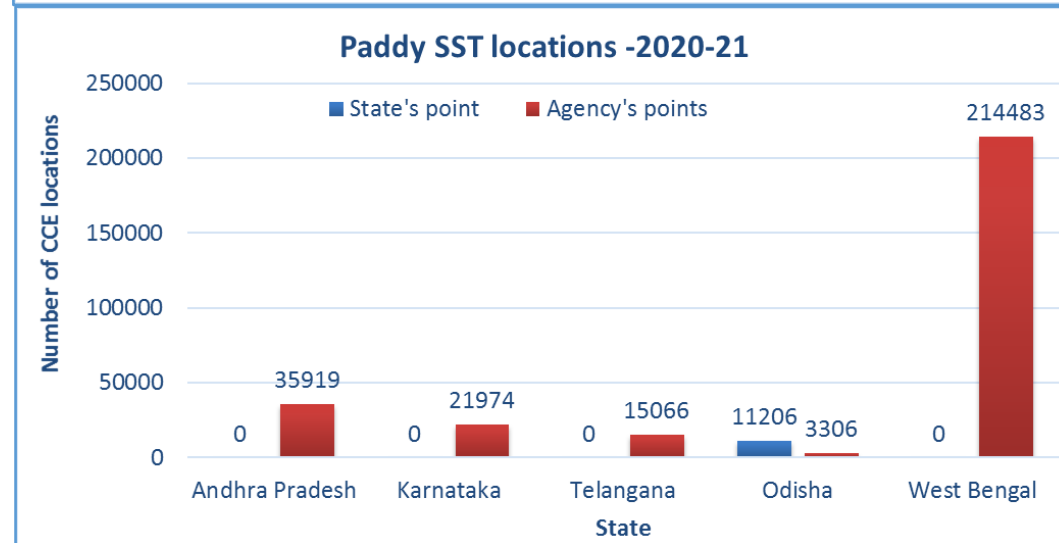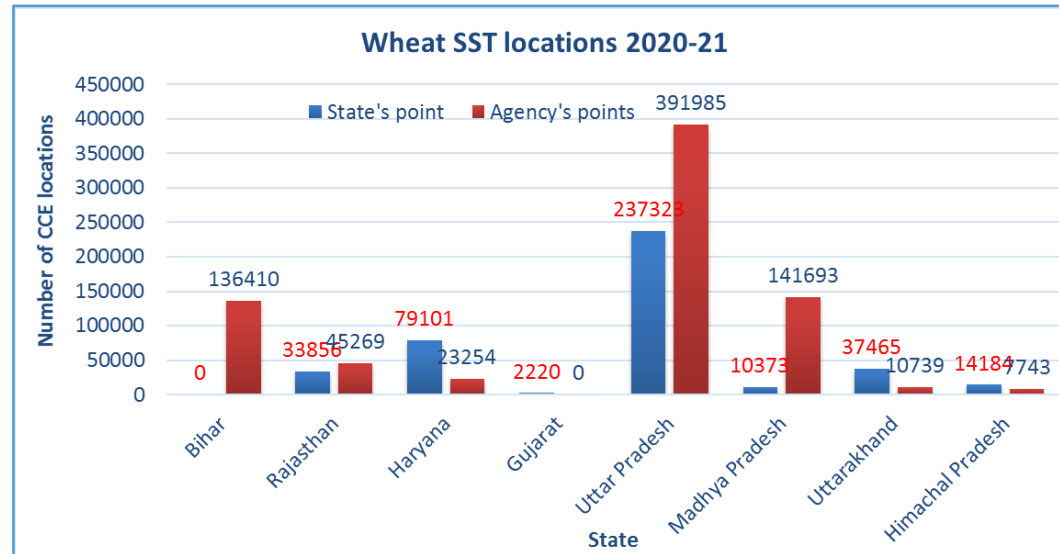
Yield Dispute Resolution, 2016-2021

- Gujarat   : Kharif 2016 : Cotton-2644 IUs
- Gujarat   : Kharif 2016 : Groundnut-77 IUs
- Karnataka : Rabi 2016   : 14 crops-1204 IUs
- Karnataka : Kharif 2017 : 7 crops-188 IUs
- Rajasthan : Kharif 2017 : 4 crops-27 IUs
- Haryana   : Kharif 2017 : Cotton -750 IUs
- Rajasthan : Kharif 2018 : 2 districts
- Odisha   : Kharif 2018 : 3 Taluks
- Maharashtra   : Rabi 2018-19: 2 Crops -112 IUs
- Rajasthan : Kharif 2017 : 3 Crops -59 IUs
- Uttar Pradesh : Rabi 2021   : Wheat crop 169 IUs

PALI Rainfall Graph (Data Source: IMD)

Deviation % of Crop Statistics from 5 years Average (2012-2016)

NDWI Deviation Map June 2017 wrt 2011-2016

Legend
- > =-10%
- >=-20% to -10%
- >=-30% to -20%%
- <=-30%

NDWI Deviation Map July2017 wrt 2011-2016

Legend
- > =-10%
- >=-20% to -10%
- >=-30% to -20%%
- <=-30%

NDWI Deviation Map August 2017 wrt 2011-2016

Legend
- > =-10%
- >=-20% to -10%
- >=-30% to -20%%
- <=-30%

NDWI Deviation MapSeptember 2017 wrt 2011-2016

Legend
- > =-10%
- >=-20% to -10%
- >=-30% to -20%%
- <=-30%

Rajasthan Kharif 2017 Yield dispute analysis

Gram Panchayat Level Yield Estimation: Pilot studies

Kharif – Pilot studies conducted by 12 Agencies in 64 Districts of 15 states for 9 crops, during Kharif 2019

Pilot studies

Rabi – Yield validation for 15 blocks of 6 states (Gujarat, Haryana, MP, Odisha, Telangana, UP)

2019-20 and 2020-21

8 Agencies (2 International) shortlisted for Large scale pilot (100 districts) in both Rabi & Kharif season 2021

Pilot studies

Engaging independent agencies for conducting/supervising CCEs to facilitate crop modelling and validation

Pilot studies for non cereal crops
&
Global approaches for village/field level crop yield estimation to be explored

Rice & Wheat

March 2022

Sep 2022

Cereals & Millets

Pulses, Oliseeds & Remaining Major Crops

July 2023

Shift to Technology based solution

To be implemented

Yield estimation: Technology used for Direct Yield estimation
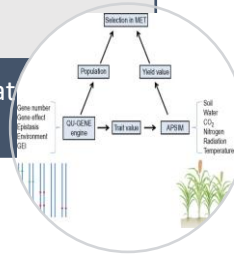
- High Resolution Satellite Data (both optical and SAR data) better than 25 m

  High Resolution Satellite

- Model should have been calibrated using Indian data. Remote Sensing data should be incorporated into crop Models.

  Crop Simulation Model

- UAVs at selected locations for Crop parameters discrimination

  UAVs

- Picture based analysis (at least 100 pictures per district). The pictures should be analyzed using AI&ML tools
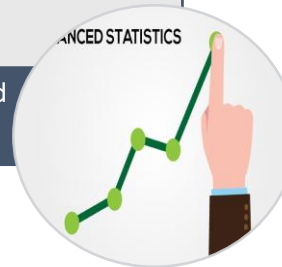
  Crop Photography

- AI &ML Techniques (e.g. ANN, CNN, RF, SVM, etc.)

  AI &ML

- Advanced Statistics/Approach/Tool

  Advanced Statistics

- Internet of Things

  IoTs

Thank You