Sustainable Satellite Systems for Assessing Agricultural Productivity

CJ Jagadeesha,NDRF-IEI, Bangalore
RM Vasagam,Chairman Aerospace Division Board ,IEI
LVM Reddy,Vice-President,IEI

Sustainable Satellite Systems…

The indices for evaluating productivity and efficiency are: 1. Relative yield total / land equivalent ratio (**LER**), 2.Effective land equivalent ratio (**ELER**), 3.Staple land equivalent ratio (**SLER**),4. Land equivalent coefficient (**LEC**) , 5.Area time equivalency ratio (**ATER**) , 6.Area harvest equivalency ratio (**AHER**) , 7.Crop performance ratio (CPR),8. Yield advantage index (YAI),8.Monetary equivalent ratio (MEA)

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The global cropland area database at 30m resolution **[GCAD-30]** is more useful in using area figures in a computer based calculations, modeling and visualization. Evaluation and productivity of multiple cropping systems is carried out by arriving at multiple cropping index **(MCI)** , diversity index(**DI**) , harvest diversity index (HDI) , simultaneous cropping index (SCI) , cultivated land utilization index (CLUI) , cropping intensity index (CII) , Specific crop intensity index **(SCI**) , relative cropping intensity index (**RCII**). GCAD -30 maps and database opens up the Pandora box of indicator based assessment of cropping systems study.

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The urgent need of the crop land mapping in order to address food and water security scenarios will require the methods to be automated , accurate, and able to provide cropland maps , statistics , and their characteristics (e.g, irrigated Vs rainfed, crop types , cropping intensities) rapidly (e.g, producing maps within few hours) year after year (hindcast , nowcast, forecast) over space and time once the mega file data cubes (MFDC) for the years are ready through automated methods using automated cropland classification algorithms(ACCAs). Fully automatic methods do not exist, especially over large areas.

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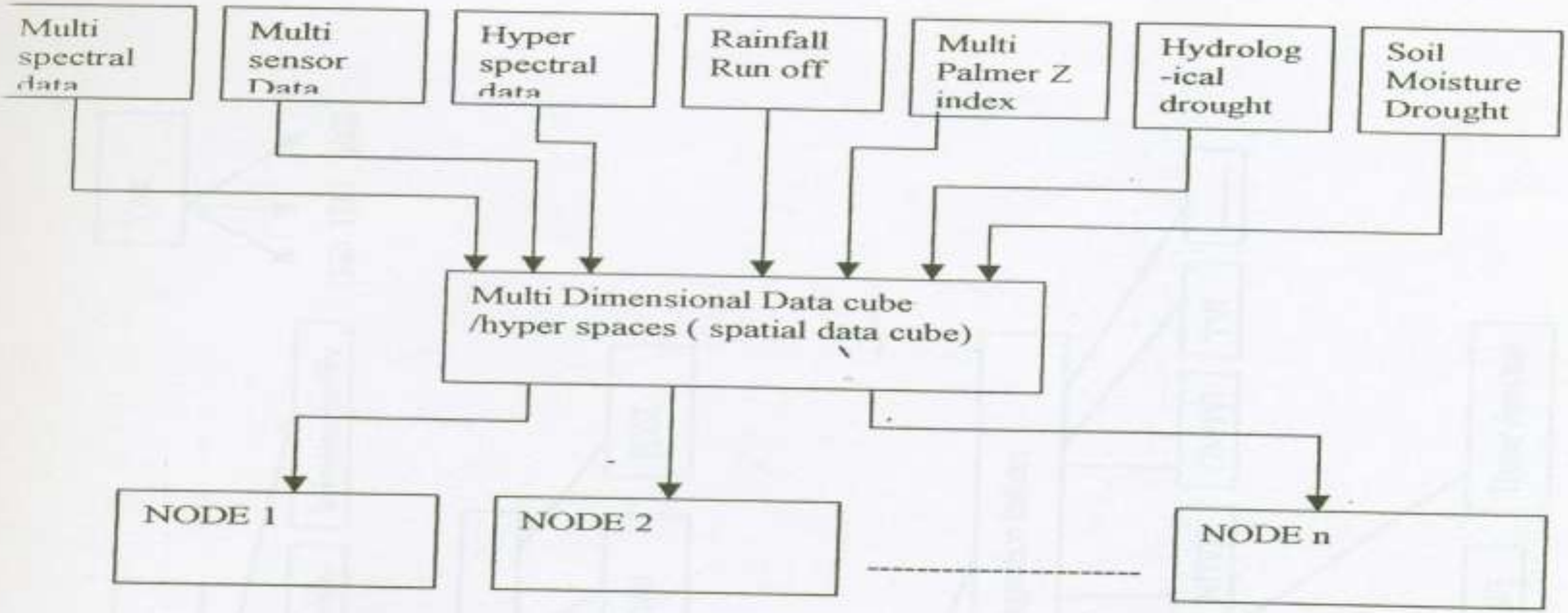
The best of existing methods are semi-automated, requiring substantial human interaction, and have large uncertainties when working with independent datasets. These semi-automated methods include: (a) spectral matching methods (**SMTs**),(b) ensemble of machine learning algorithms (**EMLAs**) (e.g., decision trees , neural networks), and (c) Classification and Regression Tree (**CART**)

Sustainable Satellite Systems….

TRL for Assessing Drought ------ a creeping phenomena ------ in India (small land holdings and multiple crops , data scarce scenario)-----

2 or 3

why ?



DMQL for obtaining Data mining primitives

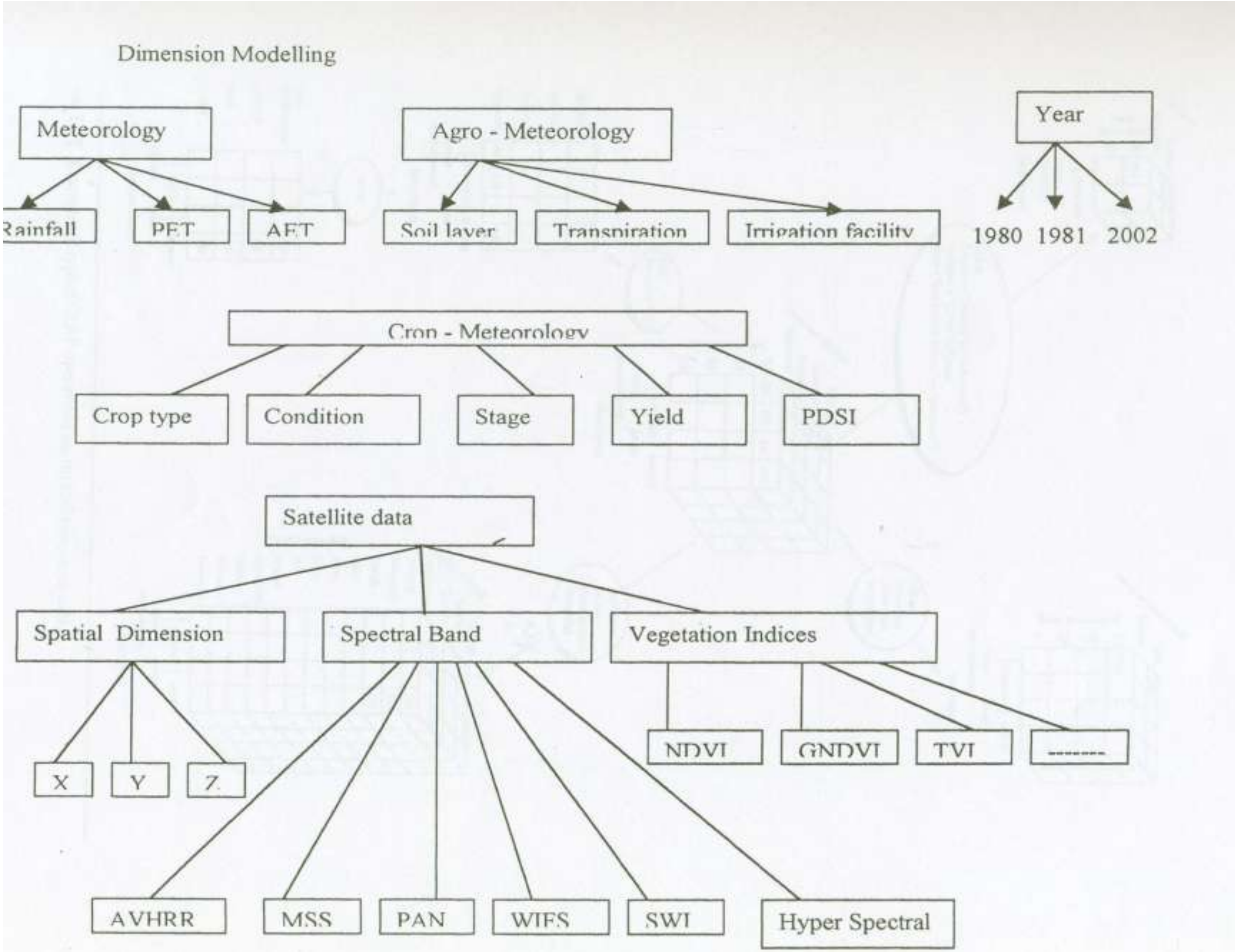
- Task relevant data
- Knowledge type to be mined
- Background knowledge
- Pattern interestingness measures
- Visualization discovered patterns

Classification A) by decision Tree Induction
Ex : ID-3 algorithm

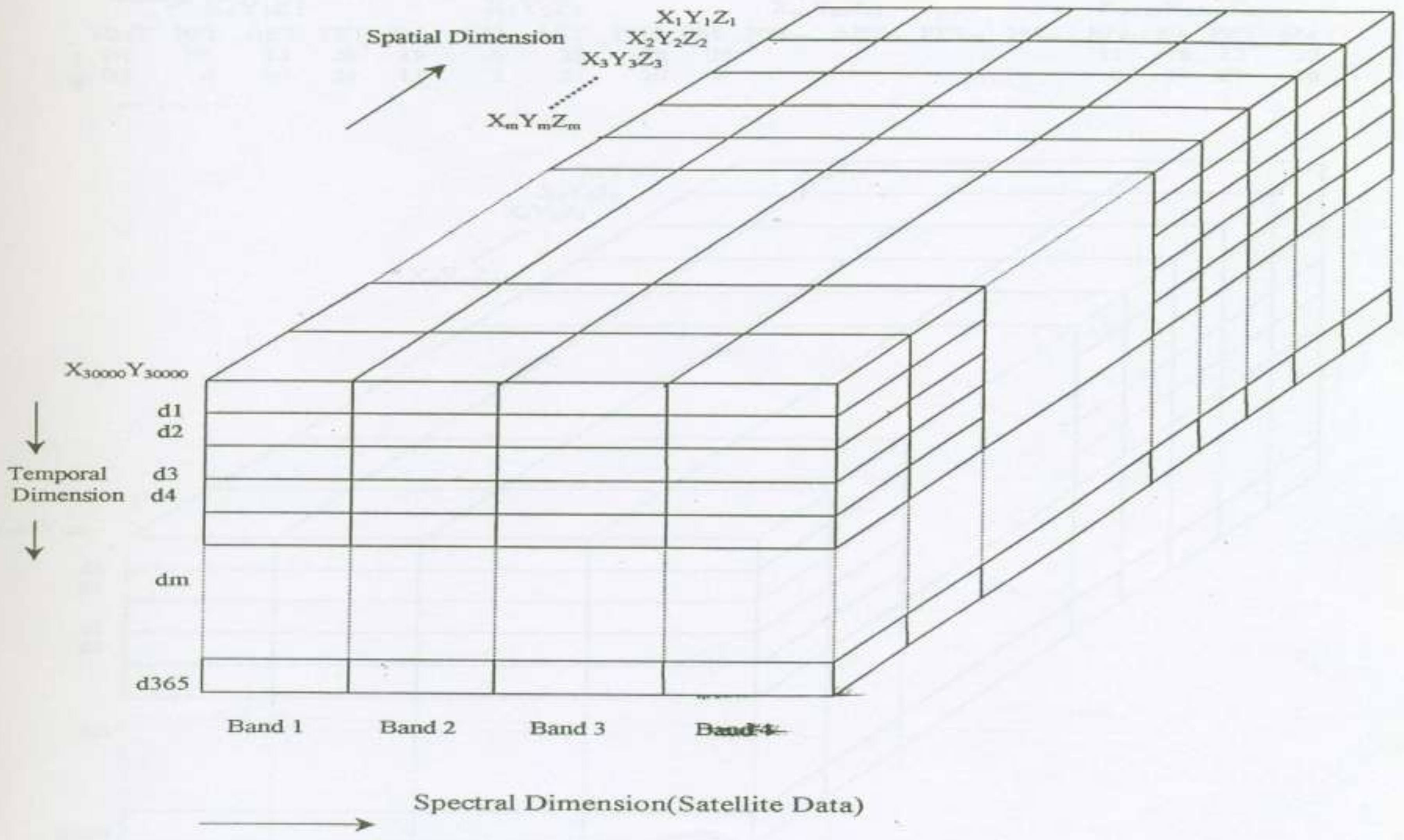
- Bayesian classification
- By Back propagation (NN)
- By Association Rule mining process.

B) by cluster Analysis

Distributed cooperative Pattern recognition (Fig 1)

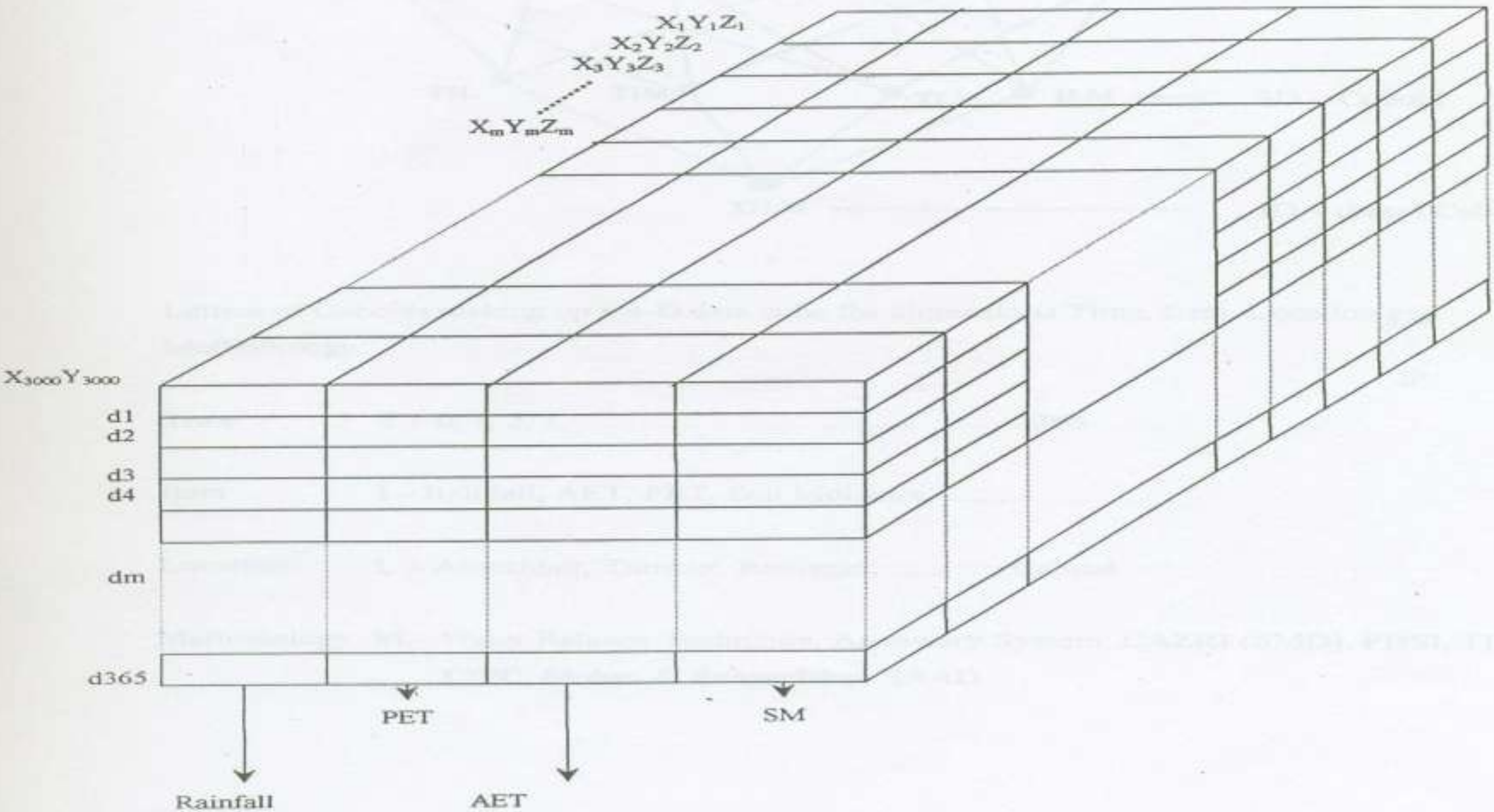

Dimension Modelling
Meteorology
Rainfall
PET
AET
Agro - Meteorology
Soil layer
Transpiration
Irrigation facility
Year
1980
1981
2002
Crop - Meteorology
Crop type
Condition
Stage
Yield
PDSI
Satellite data
Spatial Dimension
X
Y
Z
Spectral Band
AVHRR
MSS
PAN
WIFS
SWI
Hyper Spectral
Vegetation Indices
NDVI
GNDVI
TVI

DATA CUBE DIMENSION: REMOTE SENSING DATA

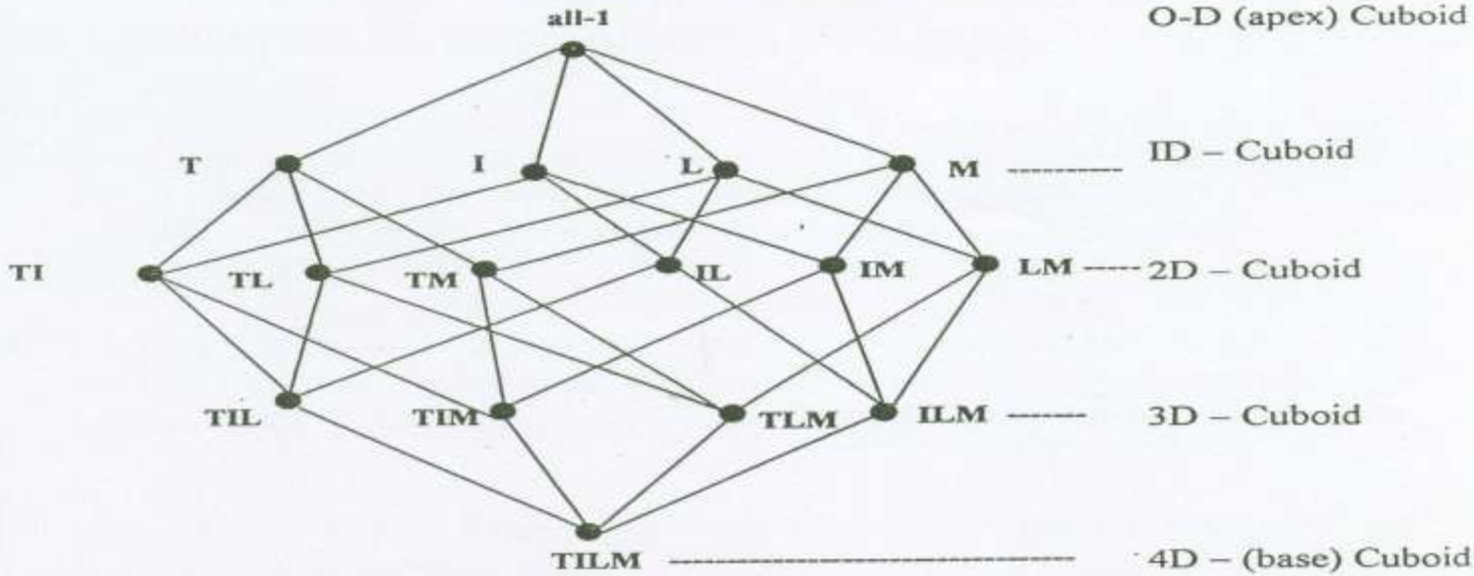


DATA CUBE DIMENSION:
AGRO-METEREOLOGY OF DROUGHT

TIME	X_1Y_1Z1 RFL	AET	PET	SM	$X_2Y_2Z_2$ RFL	AET	PET	SM	… $X_mY_mZ_m$ RFL_m	AET_m	PET_m	SM_m	… $X_{3000}Y_{3000}Z_{3000}$ RFL	ET	PET	SM
D1	10	25	28	15	8	22	28	25					12	18	22	20
D2	6	20	24	12	2	21	20	8					0	19	23	10
....																



LATTICE OF CUBOIDS



Lattice of Cuboids making up a 4-D data cube for dimensions Time, Item, Location and Methodology.

Time	T – 0, 1, 2, 3, ... 365
Item	I – Rainfall, AET, PET, Soil Moisture, ...
Location	L – Ananthpur, Tumkur, Ratnagiri, ...Calicut
Methodology	M – Water Balance Technique, Annawary System, CAZRI (SMD), PDSI, TI CWC, Mohan & Rangachary, SAAD

Karnataka approach+

SAAD (Sustainable Approach for alleviation of Drought)

Hydrology :

- Evaluation of surface water and ground water resources and identifying surplus and deficit areas in the district.
- Hydrological drought index 9 both surface water & ground water)
- Behavior of ground water levels
- Study of existing utility and present capacity of the minor irrigation tanks.
- Identify sites for water harvesting structures
- Spatial presentation of villagewise domestic water supply status position for all the taluks.

Agrometeorology

- Weekly, monthly & seasonal distribution, variability and trends of rainfall talukwise
- Detailed weekly water balance studies ,soiltype ,yields.
- Croping pattern analysis.

Socio – Economic

- Village level – house hold primary data for selected villages representing taluka or district
- Infrastructure availability, financial institutuions and beneficiary assessment.
- Size – class analysis for identifying most vulnerable sections
- Migrations studies.

Table 2 Overview of the vegetation indices used in this study, including the formula used to calculate them and the literature used to determine calculations. λ = Wavelength, R_λ = Reflectances of band with central wavelength closest to wavelength λ. See appendix 1 for an explanation of the indices

Index	Calculation	Following
NDVI	$(R_{800}-R_{670})/(R_{800}+R_{670})$	Rouse et al. (1974)
MCARI	$[(R_{700}-R_{670})-0.2(R_{700}-R_{550})](R_{700}/T_{670})$	Daughtry et al. (1992)
mSR_{705}	$(R_{750}-R_{445})/(R_{705}-R_{445})$	Sims and Gamon (2002)
MSAVI	$\frac{1}{2}[2R_{800}+1-\mathrm{sqrt}(2(R_{800}+1)^2-8(R_{800}-R_{670}))]$	Qi et al. (1994)
OSAVI	$(1+0.16)(R_{800}-R_{670})/(R_{800}+R_{670}+0.16)$	Haboudane et al. (2002)
TCARI	$3[(R_{700}-R_{670})-0.2(R_{700}-R_{550})(R_{700}/R_{670})]$	Haboudane et al. (2002)
LAIVI	TCARI/OSAVI	Haboudane et al. (2002)
mND705	$(R_{750}-R_{705})/(R_{750}+R_{705}-2R_{445})$	Sims and Gamon (2002)
RDVI	$(R_{800}-R_{670})/\mathrm{sqrt}(R_{800}+R_{670})$	Haboudane et al. (2004)
TVI	$0.5[120(R_{750}-R_{550})-200(R_{670}-R_{550})]$	Broge and Leblanc (2000)
$NRI_{693,1559}$	$(R_{693}-R_{1559})/(R_{693}+R_{1559})$	Ferwerda et al. (2005)
$NRI_{693,1770}$	$(R_{693}-R_{1770})/(R_{693}+R_{1770})$	Ferwerda et al. (2005)
PRE	λ where $dR/d\lambda$ is Max $\mid 650\ nm < \lambda < 780\ nm$	Gong et al. (2002)
PYE	λ where $dR/d\lambda$ is Max $\mid 550\ nm < \lambda < 582\ nm$	Gong et al. (2002)
PIRE	λ where $dR/d\lambda$ is Max $\mid 1300\ nm < \lambda < 1460\ nm$	Gong et al. (2002)

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Some small satellite projects which can be thought of are:

- A. Small satellite for monitoring water reservoirs and their irrigated agriculture every ten days:
- One satellite with a ground station and the launching facility provided by ISRO (free of cost) : Rs.5 crores (one million dollars)
- Outputs: These below mentioned outputs help in managing the distress year water resources between inter-state water reservoirs.(It is not only the satellite data but proven applications using satellite data will be given to External Agents – user agencies)

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- 1. Every ten days satellite data on reservoir water spreads and irrigated command area crops.
- 2. The calibration and validation of area estimates with suitable image processing algorithms.
- 3. The feasible water available behind a water reservoir between dates of satellite overpass. (Use of available, proven algorithms for Indian Water Reservoirs of Multipurpose / Single purpose Medium and Major Projects (Live Storage Capacity preferably between 40 TMC to 150 TMC) TRL-10 at implementation level.**
- 4. The crop water use in the command area at engineering level (TRL-5). This needs to be calibrated before operationailastion ** (USGS-GCAD -30m Maps)
- 5. The regional models of water use considering ten important reservoirs in a basin. (TRL -6)

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B. **Small Satellites Constellation for Drought Monitoring and Crop Productivity.**

Two/ suitable number of small satellites carrying hyper spectral camera payloads are planned. Approximate Cost: Rupees Ten Crores each . Revisit capability of eight dates in growing season of the crop.

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- **Outputs:**
- **1. Hyper-spectral satellite data on regions / basins / catchments /watersheds of interest.**
- 2. Agricultural Drought classification based on NDVI from Large Scale to Small Scales (TRL-10) (TRL10)
- Yield forecasting using accumulated NDVI

Thank you

cjagadeesha @gmail.com

Cell : 9449066052