a DBT initiative

# FarmerZone
# Distributed Machine Intelligence for Sustainable Food Security

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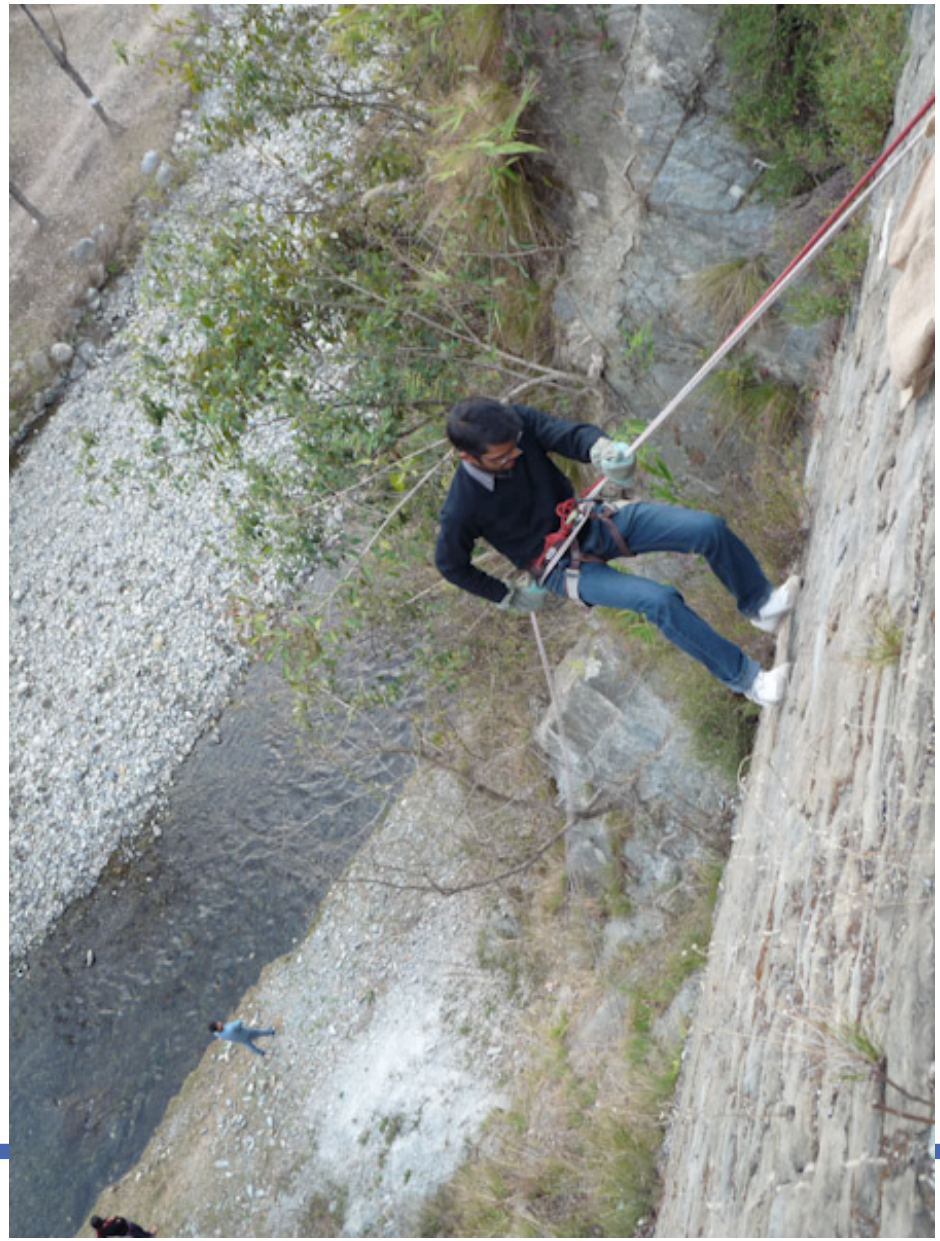
# Outline

- Development
- Sustainability
- Food Security
- FarmerZone
- Conclusions



# India - a land of contrasts

Dense urban areas

10,000 people/sq. km

400 m population

Sparse rural areas

600,000 villages

pop. 1,000-25,000

800 m rural population

Large affluent population (Western levels)

Very much larger middle and lower-middle class

- *Development is essential*

# Disruptive Development

## Green Revolution

- Pluses:
  - eradicated famines that used to kill millions
  - eliminated hunger for most Indians
- Minuses:
  - Health hazards of pesticides and fertilisers
  - Loss of bio-diversity
- Conclusions:
  - Pluses far outweigh minuses
  - Further progress by organic farming, precision farming, etc

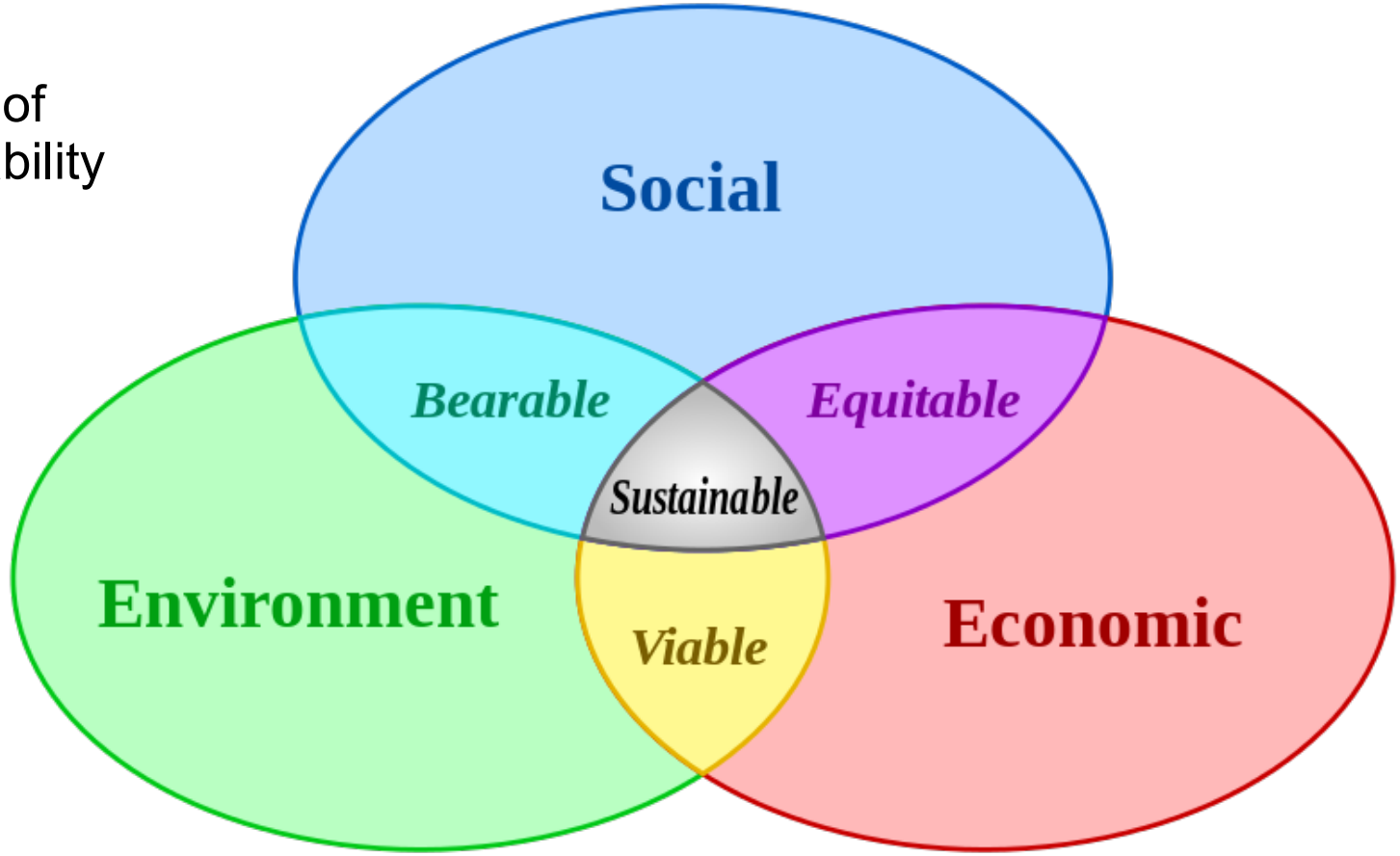
# … Disruptive Development

## Mobile Phones

- Pluses:
  - Teledensity increased from 0.8% in 1990 to 93% in 2017
  - Transformed life in rural and urban India
- Minuses:
  - Disrupting social boundaries, distraction, health hazards, …
  - Hazardous E-waste
- Conclusions:
  - Pluses far outweigh minuses

# Sustainable Development

3 pillars of sustainability




"improves the quality of human life while living within the carrying capacity of supporting eco-systems"

https://en.wikipedia.org/wiki/Sustainability

# World Food Security

- By 2050, world's population increase 34% to 9.1 billion
  Nearly all in developing countries
- Annual cereal production needs to rise 50% to 3 billion tonnes from 2.1 billion today
- Studies estimate that the aggregate negative impact of climate change on African agricultural output up to 2080-2100 could be 15% - 30%

Food and Agriculture Organization of the United Nations

# Challenges of Indian Agriculture

- Agricultural growth rate has reduced to 1.7% in the last three years
- Land degradation a major threat to India's food and environmental security
  - Large tracts of farmlands in India barren due to imbalanced fertilizer use, excessive use of a single fertilizer, urea
  - About 30% of the 5,723 administrative blocks in the country report groundwater dropping to unsustainable levels
- Increasingly, farming not seen as a viable job for rural youth

# Challenges of Indian agriculture

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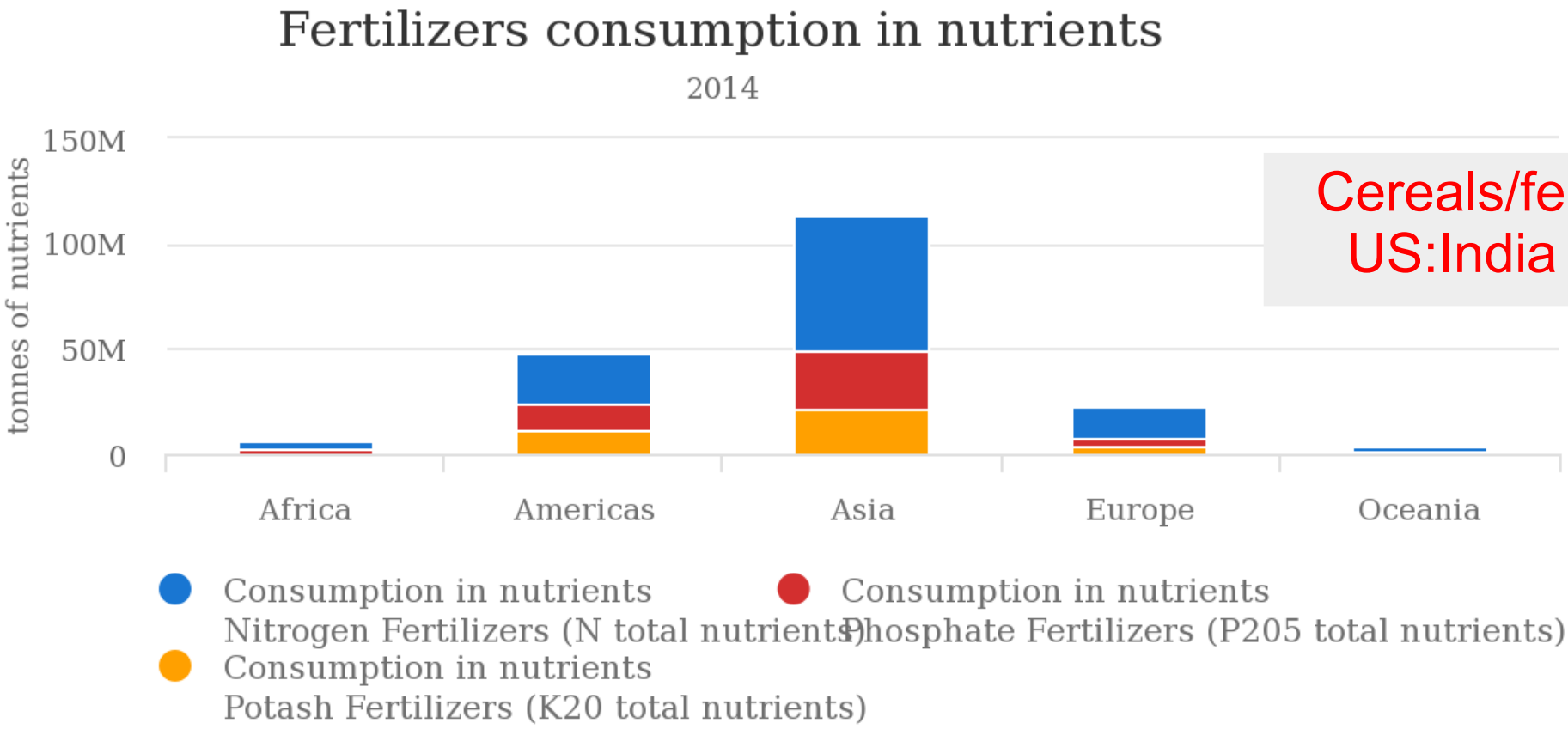



Cereals/fertilizer US:India ~2:1

# Precision Agriculture

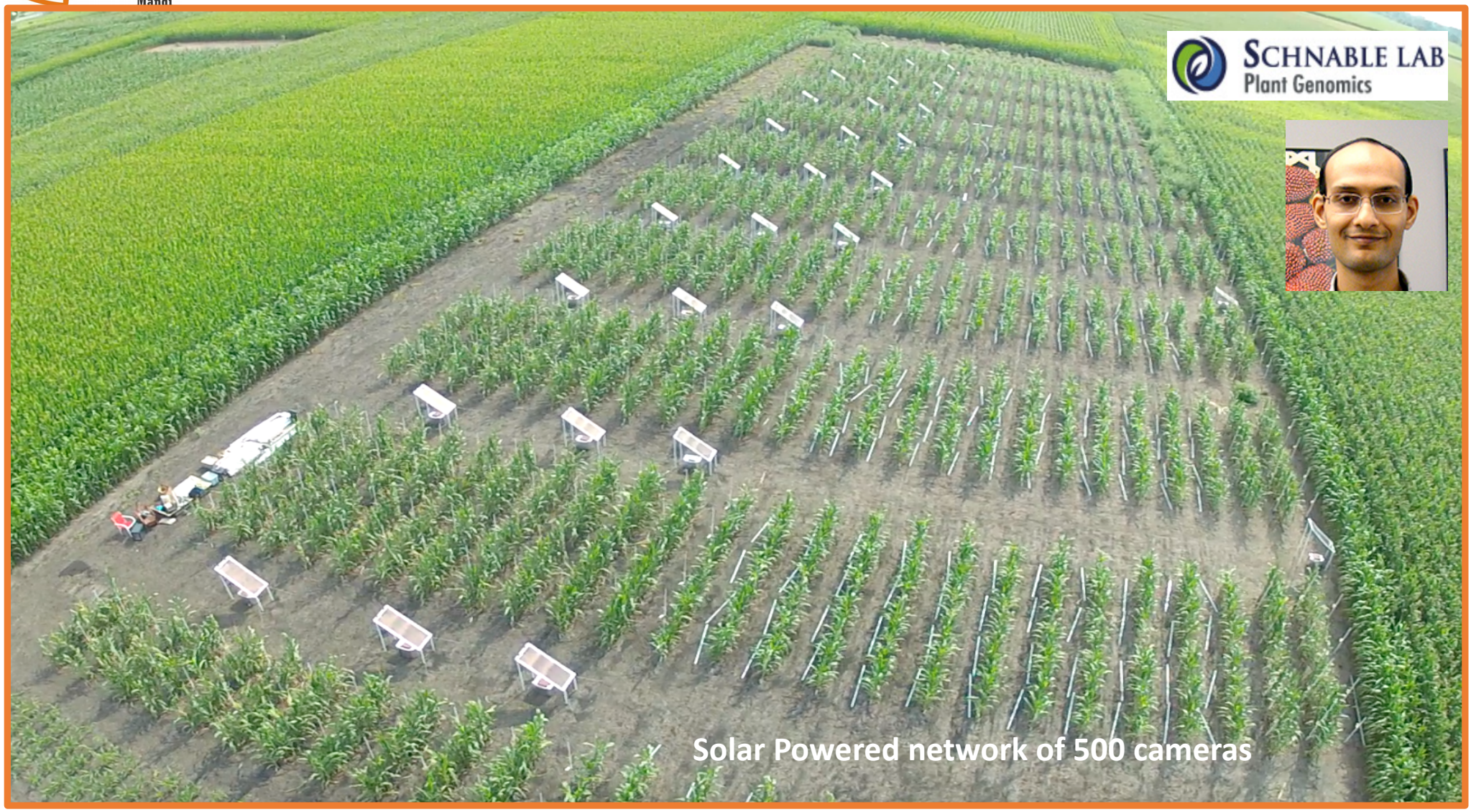
Precision Agriculture:

- *Farming management*: observing, measuring and responding to inter- and intra-field variability in crops
- *Farming practices*: application of fertilisers and pesticides when and where needed

Precision Agri → can feed world population for decades with current resources


Bleicher, "Farming By the Numbers", *IEEE Spectrum*, June 2013
McBratney, Whelan, & Ancev, "Future Directions of Precision Agriculture". *Precision Agriculture*, 6, 7-23, 2005.

# IoT for Precision Agiculture




Solar-powered sensors in a corn field

# Technology Disruptions for Precision Agriculture

IoT: Inexpensive sensors connected to Internet

Weather stations:

- IMD: Rs. 10s lakhs each, in major towns, district HQ
  - Highly accurate
- IoT: Rs. 1,000s each, in every farm or field
  - Less accurate
  - Correct using statistical software

Likewise, soil moisture sensors, web cameras, …

- Costs declined from Rs. lakhs to Rs. 1,000s
- Long-life with batteries/solar-power

$\Longrightarrow$ Vast quantities of data about every locality

# … Technology Disruptions

## Cloud Storage and Computing

- Easy, world-wide sharing of data

## Data Analytics

- Vast amounts of inaccurate data ==> de-noise to improve accuracy

## Machine Learning

- Given large number of case histories, ML algorithms identify patterns to make predictions
- Learns from experience

# … Precision Agriculture

Goal: define a decision support system for whole farm management to optimise returns on inputs with minimal use of resources

Study farm-level conditions of soil, environment, and monitor plant growth, build Machine Learning AI models to

- Relate productivity with geography, environment, water, fertilizer
- Early warning of stresses and disease
- Determine ideal crop variety specific to the locality
- Determine best practices including crop rotation
- Fill gaps in online data

# Multiple Sources of Agri Data

| Sample of Data Providers | | |
|---|---|---|
| **Data Provider** | **Type of Data** | **Note** |
| ISRO/NASA | Satellite images | Legacy and current multi-spatial and temporal. |
| Data.gov.in | Agri Data: Market prices, agri schemes progress, ... | All central govt data |
| IMD | Weather data | Legacy, current, prediction |
| State Revenue departments | Land records Harvest Data | Legacy and updates Seasonal |
| Plant Village | Crowdsourced/ curated data | Wide variety of plants. Images, pest/disease identification info |
| ICAR | Package of Practices Advisory | Current |
| Agricultural Marketing Companies | Produce price information | Legacy Current |
| | | |

| | | |
|---|---|---|
| NABARD | Goverment subsidy data Subsidies Assistance Schemes | Very influential player with lot of data and resources |
| MoA | Diverse data | Legacy, current |
| MoRD (state and central) | Schemes, benefits, eligibility, coverage, funds utilized | Deep data about rural populations and economy |
| NSSO | Household data, income, spending patterns, etc. | Legacy and Periodic. Diverse data at high granularity |
| Ministry of Water Resources | Irrigation data, various schemes to improve water resources | Data Provider |
| Central Ground Water Board | Ground Water Survey Data | Legacy data |
| Ministry of Agriculture | Soil Health card data | Legacy data of 1.1 crore SHCs and data from ongoing and periodic soil tests |
| TAFE/Mahindra / ITC | Farm extension data | Many Agri companies will be interested in making their data open in such a platform |

A variety of formats (offline/online), cumbersome procedures

# Communications

## Today

- Near universal availability of intermittent shared wireless at 10s-100s kb/s
- Network failures and congestion are common

## 2035

- Universal availability of shared wireless at 1-100 Mb/s
- Congestion and failures will still cause “intermittent” behaviour for high-bandwidth uses

# Personal Hardware

| Parameter | 2015 | 2035* |
|---|---|---|
| Pocket-sized device | Lava 356 phone | XYZ digital assistant |
| CPU | 1 core, 1 GHz | 8,000 core, 1 GHz |
| RAM | 0.5 GB | 4 TB |
| Storage | 32GB | 128 TB |
| Network (wireless from telco) | 100 kb/s shared | 100 Mb/s shared |
| Display | 2”x2” | 10”x10” foldable |
| Security | PIN (insecure) | Biometric (unbreakable) |
| Cost (in 2015 Rs.) | Rs. 4,500 | Rs. 2,000 |

2035: Cradle-to-grave pocket device = 8,000 today's laptops

* Based on Moore's Law

# Fundamental Laws (informally)

Moore's Law: the performance of computer hardware doubles every 1.5 years

Metcalfe's Law: the usefulness of a network is proportional to the square of the number of users

Law of Large Numbers: behaviour of a large population tends to a predictable normal distribution

==> Machine learning AI

# Pervasive Cloud?

- Pervasive Cloud for *all* purposes – Gmail, Flickr, Facebook, Aadhaar, Amazon, Flipkart, National Digital Repository, PayTM, Visa, Wikipedia, Youtube, Github, ...
- Benefits are obvious:
  - Seamless, inexpensive access to information, communication, computation, storage, entertainment for everyone, everywhere
  - Bridge the digital divide

FarmerZone
a pervasive cloud for India's farmers

# FarmerZone: A Public Agri-Data Utility

## FarmerZone: a DBT Initiative

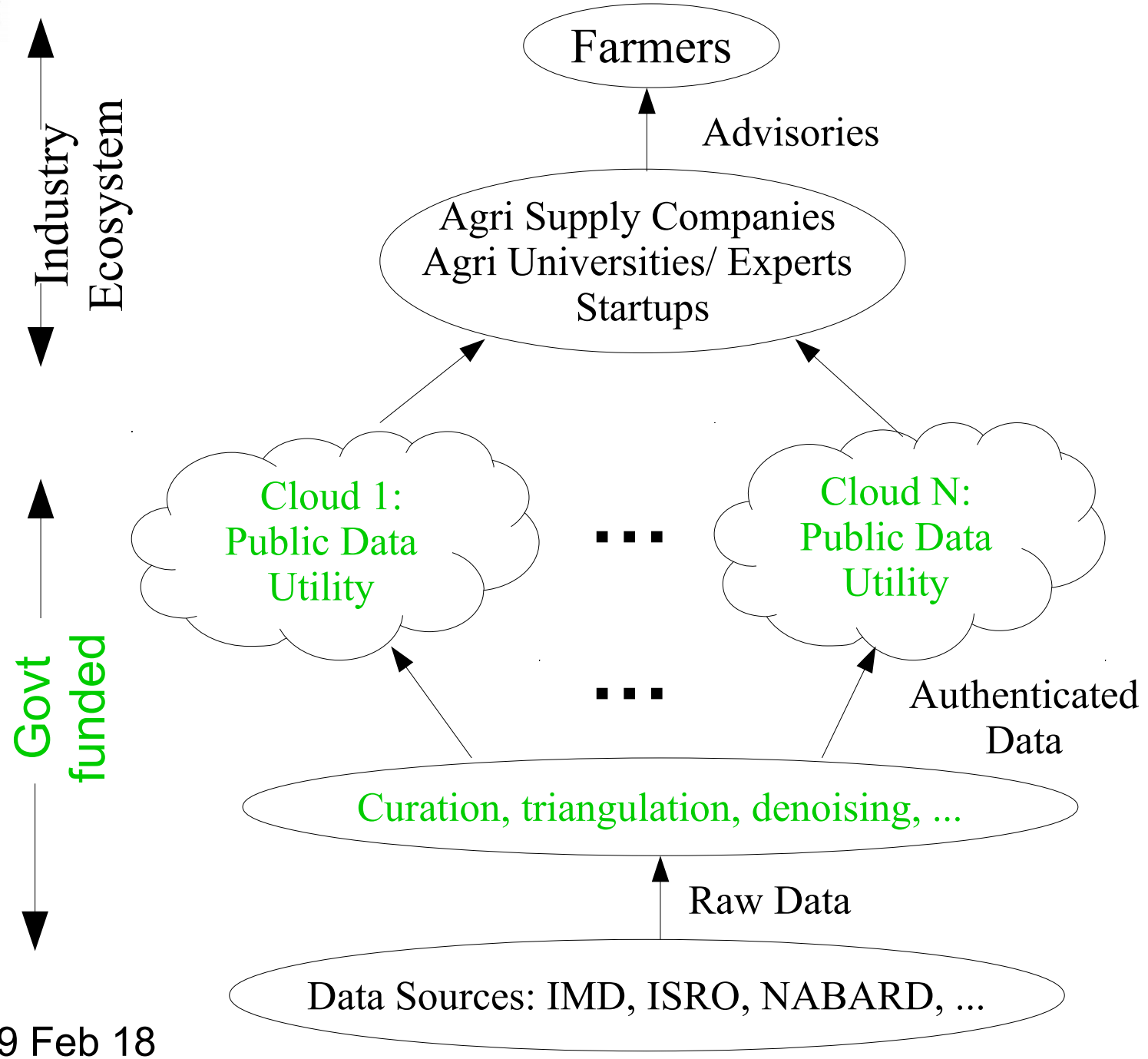
**An intuitive cloud-based platform that will collect, collate and curate field and remotely-sensed data with market intelligence to create smart agriculture solutions for small farmers.**

A Market Zone will connect farm produce to viable markets.

## Expected Outcomes

Improved crop yields, smart crop choices, disaster preparedness, reliable market access and improved livelihoods for smallholder farmers.

# FarmerZone: A DBT Initiative



# IIT Mandi + CPRI: Pilot Project

## IIT Mandi

- Develop and operate a FarmerZone for potato farmers in Himachal and Punjab
- Linkages with farmer coops, farm supply industry
- Innovation in machine learning for advisories
- Architecture for a national federation of FarmerZones

## Central Potato Research Institute

- Develop data models to enhance productivity and utilisation of potato
- Provide crop/pest-control/etc data for different seed varieties developed by the Institute
- Training in research methodologies and modern technologies for potato production

# FarmerZone at IIT Mandi

- Enormous potential for development and deployment of end-to-end Agricultural IoT solutions in and around Himachal Pradesh
- Especially beneficial for small farms

- Yield prediction
- Environmental monitoring
- Pest detection
- Water stress and smart irrigation
- 2-5 years project

## IIT Mandi Faculty

**Dr. Srikant Srinivasan**
IoT systems for agriculture

**Dr. Shyam Masakapalli**
Plant physiology and metabolism

**Dr. A. D. Dileep**
Machine Learning

**Dr. Sriram Kailasam**
Big Data systems

# Conclusions

- Disruptive changes in technology
  ⟹Novel approaches to resource management
  - IoT – pervasive, low-cost sensors
  - Data mining and analytics
  - Machine learning AI
- FarmerZone: a pilot project to apply these new technologies to optimise resource usage in farming

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# To Participate

- Opportunities for MS/PhD research scholars and full-time project engineers
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