Drones, Deep Learning and Doubling Small Farmer’s Income
A White Paper

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June 18 2019

1) Introduction

Agriculture in India contributes to about 17% of GDP, consumes 22% of electricity (peak demand rising to 29%), deploys 50% of manpower and consumes a whopping 80% of water resources.

At present the consumption of water is very high and productivity is low even in comparison to China (see Figure below).
According to 10-th Agriculture Census of 2015-16, Small and marginal farmers with less than two hectares of land account for 86.2% of all farmers in India.

In addition to water, the farmer’s expenditure towards fertilizer and pesticides is also quite high due to inadequate information on the condition of the soil (humidity, nutrients), condition of the crop, presence of weeds in his farm. It is this inadequate information that leads to excess use of inputs, stunted growth and sub-optimal output.

Now there is a growing awareness that unless technologies are developed that are tailored to meet the needs of small farmer and deployed, the goal of doubling the farmer’s income and increasing the contribution of agriculture to GDP will not be realizable.

It is, therefore, clear that, one of the most affected among farming community is the small farmer who does not have means to manage his farm productivity unless technology is brought in. Precision agriculture addresses this issue. Low cost drones, light weight low cost cameras, Artificial Intelligence / Deep learning technologies have the potential to address the issues of small farmer and provide cost effective solutions.

2) Existing Farm Practices

Besides, the best practices in India have a very traditional bearing and have not significantly changed over time. The good-old methods relying on rains as per traditional calendar are becoming irrelevant in the face of changing climate.

Farming practices in India are rooted in traditional practices. The farmer often takes crucial decisions based on age old practices that have been evolved over a long period of time. However, with changing land-use pattern, shrinking farm sizes and difficult to predict monsoon, a small farmer owning no more than 5 acres of land would not do well to continue to adhere to decision making based on such advisories.
The eco-system that a present farmer is exposed to is not favorable either. Availability of information on quality of inputs (water, fertilizers and soil) is often absent or inaccurate. This results in virtually blind use of input resources with very poor understanding of their impact on the crop yield.

It should also be noted that predicting weather over tropical regions is fundamentally more difficult and much harder if the projections are to be made over smaller regions.

3) Technology Interventions

Arguments above clearly suggest that increasing the productivity, enhancing the income of the small farmer and ensuring sustainable agriculture are vital in a country like India. This can be achieved with application of emerging technologies in the sector to maximize production. Precision agriculture is the technology that enhances farming productivity. It prepares the land for farming, ensures equally fertile vegetation across the field, monitors plantations during in season growth, detects early onset of pests and diseases. It also ensures application of farm input in right amount, at right time, at right location through harvest and post harvest processes. Precision agriculture involves remote sensing, use of geographical information system (GIS), global positioning system (GPS), image processing to determine soil nutrient composition, early detection of pests/diseases, application of farm inputs like fertilisers, herbicides, water etc.

Precision Agriculture Aviation (PAA) technologies combined with Artificial Intelligence/Deep Learning (AI/DL) technologies are developing rapidly in the recent years and are proving to be major tools for precision agriculture. There is sufficient evidence to suggest that AI/DL methods can provide very effective solutions for near real-time crop management. This is vital for small farmers since missing a sowing window can be disastrous and late detection of pests and arbitrary application of pesticides and nutrients will not only lower the productivity but also affect the quality significantly.

3.1 Remote sensing technologies for PAA:

The rapid acquisition and analysis of crop information is a pre-requisite and forms the basis for carrying out precision agriculture practices. Advances in these technologies are proving to be the key to breaking the bottlenecks restricting the development and application of precision agriculture.

The existing agricultural remote sensing technologies are classified into (a) satellite, (b) aircraft, (c) unmanned aerial vehicle (UAV) platforms.

3.1.1 Satellite based:

Satellite based remote sensing technologies are widely used to provide guidance in global agricultural production. In India also this is in use for the last two decades. Indian agricultural scientists have done a
lot of work using satellite images. The image processing and data processing has been a major challenge in the practice of agriculture. Features of images from vegetation need to be extracted, segmented and finally fed into model. The processes are slow, suitable for overall assessment but not useful to a small farmer.

3.1.2 Aircraft based remote sensing:

Aircraft based remote sensing is flexible and versatile for fields to be imaged at variable altitudes depending on the spatial resolution required. While these technologies are better than satellite based systems, however are not within the reach of small farmers.

3.1.3 UAV based remote sensing:

UAVs offer one of simple construction, low cost operations and maintenance, a compact and light weight foot print; simple to operate and high flexibility as a remote sensing platform. The UAV based systems are ideally suited for small farms prevalent in India.

In recent years, rapid development of compact, light-weight, low cost, durable sensors and other devices has further enhanced suitability of UAV systems for precision agriculture.

3.1.4 UAV based Aerial Spraying Technologies:

Spraying is a critical agricultural aviation service that provides rapid response to sudden pest outbreaks. Unmanned agricultural aviation spraying has the advantage of low labour operational costs with no damage to crops or soil physical structure. UAV based aerial spraying technology is proving to be a boon especially for small and medium sized farms.

4) Near Real-Time Image Processing Using AI/Deep Learning

Real time processing is needed to bridge the gap between remote sensing and application of pesticides/supply of nutrients. Data analysis and interpretation is one of the most important parts of precision agriculture.

As stated earlier, images are collected using remote sensing techniques and are analysed to develop models to determine right treatment plans for different types and regions.

Different techniques have been applied to the processes, from the use of neural network, support vector machine, fuzzy logic approach and recently, the most effective approach for generating fast and excellent results, deep learning approach of convolution neural networks for image classification.

Literature shows that performance of Deep Learning/CNN have achieved accuracy of above 97 % which outperforms other methods that have achieved much less accuracy of 70 to 80 % only. While these technologies appear to be quite promising, the training of algorithms would need enormous amount of images/data.
High performance computing, along with AI/DL algorithms available as public/private cloud would be needed for developing the CNN algorithms suitable for various crops and soil conditions.

**5) Phenomics**

Agricultural scientists need to gather phenomics data for each of the crops and soil conditions under controlled conditions/field conditions to enable development of DL based algorithms that could detect soil condition, nutrient deficiency, disease condition etc. This forms one of the most important steps towards providing training data set for AI/DL algorithms.

General Aeronautics pvt Ltd (GAPL) has developed a range of drones tailored to meet the requirements of small farmers. It is working closely with farmers, agriculture universities, research laboratories to develop end to end technologies as indicated below.

- Crop and soil health monitoring.
- Early-stage disease identification
- Data analytics for various crop related aspects
- Drone (UAV) based image processing
- Variable Rate Technologies
- Drones for spraying of pesticides/insecticides
- Development of Efficient Communication Technologies
- App based solutions (near real-time monitoring)

The following are the Parameters being considered for study:

- **Soil:**
  - **Macro-nutrients:** Nitrogen, Phosphorous and Potassium (NPK)
  - **Micro-nutrients:** Iron, Zinc, Sulphur, Boron
  - **Miscellaneous:** Soil moisture, conductivity, pH

- **Weather:**
  - Temperature, Humidity, Sunshine hours

**6) Results of Trials**

The Agri drone developed by General Aeronautics Pvt ltd has been deployed to spray of insecticides and pesticides over plantations such as coconut, arecanut and over crops such as rice, ragi, bajra etc. The GA team is working closely with research labs such as CPCRI and academic institutes such as IISc to take the drone technology forward and interacting with 4PI institute, IIIT Bangalore to develop the ML/DL technologies for the benefit of small farmers.
Rapid developments in drone technologies, availability of low cost drones; improvements in computing power and storage leading to availability of cloud computing at low cost; advances in AI algorithms and data proliferation are enabling low cost precision agriculture practice, which even a small farmer in India can afford.

Time is ripe for multidisciplinary teams to join hands with the farmers and bring the much needed precision agriculture technology to the doorstep of the farmer and realize the global doubling of the income of small farmer in India.

7) About “General Aeronautics Private Limited”

General Aeronautics Pvt Ltd. is a leading aviation product and engineering service provider in India that specializes in design, development, integration and support solutions for manned aircraft and unmanned air vehicle systems for civilian and military aviation sectors internationally. General Aeronautics is one of a select few companies globally and the only one of its kind in India with capability to undertake comprehensive design of aircraft and offer solutions from concept to realization. Our multidisciplinary engineering and optimization services range from new aircraft development to improvement of existing aircraft according to customer requirements and specifications. Our versatile product range of unmanned aerial systems spans civilian, military, agricultural and humanitarian applications.

We provide a vertically integrated range of end-to-end design and optimization services to OEMs and Tier-1 partners covering discrete work packages to full turnkey solutions at complete aircraft system level down to subsystem and component levels. The engineering team, with several hundred man-years of experience in design and development of aerial systems, represents the highest global standards of aircraft engineering and innovative talent. Team members bring in expertise backed by a proven global record of contributions towards advancing the state of art of aerospace vehicle design and development.

[Image of a drone in agricultural setting]

Fig 1: GA-Agri Drone