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Luck that is Twirling in the Sky: Utility of Drones in the Farming Sector

Abstract

The road to efficiency, efficacy is important for sustainability. It'll take goals, strategies and simulations with techniques to compliment development alternatives. One is the unmanned aerial vehicles (UAVs). Its utilities are many...in resolving logistic objectives to acquire inputs to act and control procedures for desired outcome with depth over distances. It is examined for use in cultivation in developing India situation. Unless, the agricultural wars would reach our door-step that we cannot turn away from. India would rather bargain on a flight plan to UAV and not just make do with a game of leapfrog.

Rural India, silently questions in these stifling times, but alas! ... with no answers. With crops after crops failing, all people are able to do is stare in despair, gaze and may be yawn. Life ultimately ends up upside down. A distressed section of the society wanders as labour, another section turns resentful, still another faction turns party-political, and some end up radical; some even do the unthinkable with their lives. The *Vikash* juggernaut trudges on with a cacophony of: the last remaining Indian village post electrified, a drought loan waiver, an LPG cylinder reaching every household, 'Swachhata' slogans, National Rural Employment Guarantee Act (NREGA), Awash Yojana, skill development, progressive education, cashless transactions and faster, safer internet services, or the National Health Protection Scheme (NHPS) augurs on one hand...but all is obscured with the suffusing gloominess of the farmers.

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In complete contrast to this harsh reality, is a world transcending the frontiers of science in the form of the autonomous ‘man-machines’, for example, Sophia, the humanoid world citizen using purely analogue electronics to mimic brain, or the ‘cyber-punk’ *chaps* in ‘Dr Who’ (British science-fiction television programme), the movie ‘Matrix’, or ‘Enthiran’ or ‘Twice Upon A Time’. Other prime examples would be Tesla’s self-driving car or Indian Space Research Organization (ISRO’s) Polar Satellite Launch Vehicle (PSLV) that positioned one hundred and four satellites in orbit or the clever “Robocleanz”, household vacuum cleaner, etc.... We can go on and on since the list is eternal and almost endless. Thus, the moot issue of the root cause or the helplessness of rural India inspires us to discuss the feasibility, advantages and disadvantages of UAV (unmanned aerial vehicle) or in common parlance, the robot ‘drone’.

Let us discuss the various sectors that drones (UAVs) have been employed in, over the years, in various different countries:

UAV in Governance

On the farthest brink of complexities, a UAV simplifies the most arduous ‘reach and restore’ tasks which the ‘State’ may wish to achieve for the people, or to dive down to the bottom of their resources, or to harness existing reserves, and to apply new methods. Some of the specific geo-spatial conundrums to be discussed and considerations that would be applied to these would hold equally true for similar issues and aspirations in any geographies of the Indian subcontinent or beyond. As an example, let us take the case of Odisha State.

1. Capital City: Bhubaneswar
2. Population: 41,974,218, Area: 155,707 sq. km. (11th and 9th of States respectively; <http://www.odisha.gov.in/>)
3. No. of districts: 30 (<http://oddistricts.nic.in/>)
4. No. of blocks: 314 (<http://www.nuaodisha.com/BlockInOdisha.aspx>)

As with any of Indian state, the scope is as follows:

- (i) Odisha mineral geographical, territorial probe and surveillance;
- (ii) Fisheries research and natural disaster intervention;
- (iii) Forestry: poaching or dangerous activities prevention, anti-arms-smuggling;
- (iv) Farming and agricultural researching;
- (v) Tracking and action for urban security, pollution, land, mines, ports, buildings, villages, mobs, traffics, deluges, fires, airstreams, riot or epidemic vectors...the actual list just keeps getting longer.

In all this, the scope is to tie up broken systems with UAV's; the authorities must be conveyed its essence, moot proposal, and pursue the matter for implementing it in the state.

The Farming and Agricultural Domain

Let us consider the profile of Odisha:

1. Taking arable land as 50%, and 30% population making a living on agriculture; infer that in 314 blocks, 155,707 sq. km. and 41.97 million population; per block, 250 sq. kms farming land exists for the 40,000 reliant population.
2. Then removing 75% as aged and child labour or allowing for some sex divides, per block the land will be 250 sq. kms and the population will be 10,000 as adults in farming or related vocations.
3. Out of 250 sq. kms block, if one forms ten 25 sq. kms farms with a 1,000 headcount each...we can count 500 owners (big or small) and land labourers...by fair dice.
4. The result: the number of such farms in Odisha state would equal about 3,000. They can easily operate with modern practices...and of course, UAV assisted management. (to be covered in detail further on in this article).
5. Account ownership (and allow trading among owners) in the form of demat shares. The profit sharing should be between all concerned parties;- salaried employments, job wages or casual hires, or a mix of all.
6. Livestock, meat and dairy or future pursuits can be thrown in, in tune with the farm economics. Farms can even start developing new dwellings. This will transform the landscape of the State, make breaking news in all media. Motto will be #Multiply.Gains.and.Save.Resources, #new.Beginnings, #new.Trials.And.Research, #go.Green, #marketing.Success, #Profits, and #race.for.Excellence

Agriculture is Our Worth

India's population heft has flourished beyond 1.25 billion; India and China make 40% of world humanity. We are the amazing, human resource, pools or unfathomable, consumer oceans. A populous nation would, and can, upscale to a mighty agricultural base and then be the provider for other nations. In conjecture, after cold-wars or cyber wars, will agricultural wars be unleashed? (Now that is a thought that can be spooky!)

Contemporary drifts are about sustainability, indicating that the:

- (1) State will need to double the agricultural produce for purging hunger (captive consumption) as well as for selling abroad;
- (2) State will have to do so with an aim to elevate farmers' status to full potential in a decade or less;
- (3) They will have to do this, while optimally using, reusing, reserving resources and heeding that the environment is not approaching its sunset; and
- (4) This all whilst facing the global warming's hostile impacts, crop diseases or farming deficits that will continue to be on the upsurge.

United we stand; farmers can fulfil most of their dreams with collective farming. Herein the stakeholders will be state, institutions, activists, and people – all performing their individual roles, and yet there will be a big void, which would actually prove easy to close, by the UAV!

How can the UAVs Help Rural India, Particularly in the Farming Sector?

- (1) Soil and field early analysis and life-stage managing:
 - (a) Mapping precisely in 2D imagery/ 3-D modelling of landscape & soil at the start of crop cycle
 - (b) Planning the seed,
 - (c) Planting patterns
 - (d) After-planting management (e.g. of nitrogen-level, dampness).
 (Result: Taking software and knowledge inputs, assigning crops area wise, shrewd planning of land and water, fertilizer usage, and so on)
- (2) *Crop imbedding*: Shoot pods with seeds and nutrients directly in to the ground by drone-based planting systems reliably with above 75% GPS accuracy.

(Result: achieves a higher uptake rate against the prevailing fifty-fifty or even less, is efficiently done, saves on human effort, avoids overkill or lop-sided planting, optimizes nutrients, and thus sustains life: "Saves time and cost resources by up to 85%".
- (3) *Crop spraying*: Scans the area and sprays correct quantity of fertilizer, and pesticide uniformly.

(Results: even coverage, higher efficiency, aerial spraying multiple times faster than with traditional labour or ground equipment or machinery.)

- (4) *Crop nursing*: Provides animations (time-series analysis) to show the precise growth of crop. Also provides thermal signature insights for areas with insufficient soil moisture or areas having excess water-pooling. This would in turn help improving quality of crop by timely intervention.

(Result: Reveals production failings and enables effective crop management by removing the human errors of monitoring ineptitude and challenges of farming which get even more magnified than ever in more unpredictable weather disorders. Also leads to optimization of the water supply, preventing not just floods but also droughts. (and ultimately yields healthy crops)

- (5) *Crop health*: Identifies parts of the field that are dry or need improvements: RGB imagery or from analyzing reflection of visible light and NIR (Near InfraRed) or displaying the heat signature the crop emits, by HD or hyper-spectral, multi-spectral, or thermal sensors present on the drone, signifying the relative density and health of the crop.

(Result: helps in tracking overall health of the crop, normalized difference vegetation indices (NDVI), spotting bacterial or fungal infections in plants or crops in initial stages to indicate action that can save an entire orchard or a crop, and optimizing irrigation, minimizing chemicals seeping in to the earth for preservation of ground water.)

- (6) *Crop failure analysis*: In case of failure of crop, an analysis will be available to the farmer and also accessible to the insurance agency to efficiently process and pay for losses.

- (7) *Others*: Developing fields, roads, water ways, Checking farm properties, e.g. irrigation systems and pivots, Scaring away birds and pests, Monitoring cattle, livestock and tracing on large properties, Roofs, silo, fences, gates and dam inspections

And so, uptake from UAV would finally be wealth of large quantities of valuable data, easy aggregation of the same, with facilitated analysis, and modelling improvements. So basically, a research and future-safe, clever work culture.

Oops...the optimized water angle! Can it spin...a Mahanadi water war or a Kaveri water war out off our agenda?

Then and Now

In western farms traditional scanning of fields used large sensors and manned aircraft in advanced sector at funds prohibitive for general medium farms. It

now employs small multispectral imaging sensors on small economical UAV which has enabled a much more precise view of the farm and resulted more effective managing and maximized ability to plan, e.g. where and how crops should be planted.

Heavy item, e.g. fertilizer or pesticides reconnaissance for of the entire crop is done with cost and time saving by autonomous UAV deployment than with operating a vehicle and lifting items manually or machinery for carrying and delivering.

Added benefits are livestock management, as can count and monitor livestock for any missing animals, any giving birth, any injured in a herd, or any under an attack and in need of help, etc.

So, where and how many users may be of these modern aerial tools or may or not be contemplating it? Do they self-operate or are third parties acting? Which drones are popular? What more is in industry?

Measuring Vegetation (VIS-NIR-RE Spectroscopy)

Normalized Difference Vegetation Index (NDVI)

By the action of photosynthesis, leaf chlorophyll intensely absorbs incumbent ‘visible’ sunlight (VIS) that is emitting green, from 0.4 to 0.712 μm wave bands. And, the leaf cell strongly reflects NIR or ‘near-infrared’ which is from 0.712 to 1.1 μm bands.

Detectors on a ‘Landsat’ or any other UAV can sense the intensity of both reflectances coming off a vegetation or a part of it in a landscape and calculate NDVI for it as the difference over sum, and form an NDVI image of the distribution. $\text{NDVI} = (\text{NIR} - \text{VIS}) / (\text{NIR} + \text{VIS})$

Normalized Difference Red-Edge Index (NDRE): Substituting NDVI’s visual band with NDRE’s red edge band (0.674 μm -0.712 μm bands) is to balance out for an even more overwhelming chlorophyll saturation response to the visual light spectrum, particularly in mid to advanced grown crops or such plants or a large area crop land where visual light absorption is maximum at just the topmost layers of vegetation.

The normalized difference formula, using the ratio of ‘Near-Infrared’ and the ‘edge of Red’ bands is: $\text{NDRE} = (\text{NIR} - \text{RE}) / (\text{NIR} + \text{RE})$.¹

Distinctive Thermal Signature

The soil dehydrates differentially, forming a distribution of moisture and heat that is absorbed/radiated. The water deficient (or diseased crop) portion is

warmer and a high resolution infrared detector depicts this distribution as blue for high moisture and red-yellows for drier parts.

Also, a combination of visible, NIR, and thermal bands' sensors can pick up both water deficiency and the stress on the crops in the fields. Other important sensors are passive microwave, and radar for soil moisture and active microwave for vegetation.²

Scanning for resolution: NDVI or NDRE index or surface temperature interplay may be mapped over a land area pixel which is 1 sq. km or more and it can be at sub-pixel levels too through changing flying height.

It is obvious that, for vegetation health, NDVI or NDRE or thermal reference score is 'the more the better'. Using the imagery is akin to sending crop under MRI at scan centre.

What else can we measure...Soil salinity, Insect armies?

Drones in the Field?

In December 2017 'The Farm Journal Plus' pulse poll had published that: 33% USA farmers confirm using drones themselves or through a third party and 31% others were mulling over whether to use it, with approximately 37% saying 'No' (N = 1092).³

- DJI (Dà-Jiāng Innovations, Guangdong) when launching the first agricultural drone had assessed in 2016, a \$ 75 million future market.
- Global Markets Insights Inc. place Commercial Drones sold in 2016 as over 100,000 units at > \$ 2 billion, growth increasing by 25% CAGR and to hit \$17billion by 2024.⁴
- National Oceanic and Atmospheric Administration's (NOAA) AVHRR (advanced very-high-resolution radiometer) is a radiation-detection imager for measuring reflectance from the Earth in five spectral bands with six detectors and can quantify the photosynthetic capacity of the vegetation in a given pixel.⁵
- DJI MG 15 has a precision flight, which provides ground sensing, nozzles substituting for more optimal spraying, and intelligent operation planning.
- PHANTOM 4 Pro Deluxe is a clip-on NDVI sensor kit for a consumer drone, with FIELDAGENT software by Sentera.
- FIELDAGENT by Sentera makes ortho-mosaic maps, conveys NDVI and NDRE insights, collaborates with John Deere Centre (MyJohnDeere.com)

On *MyJohnDeere.com* is the Operations Center, a central location to connect agricultural machines, operators and fields.

- DJI M100 is a drone with all kinds of possibilities of customization in mind, for multiple camera sensors and battery payloads, with MICASENSE.
- MICASENSE as a sensor with analytics is capable of making chlorophyll and weed detection maps, time series maps, digital surface models (DSM), and reports disease or stress variation easily.
- DJI ZENMUSE XT is capable of spotting crop stress or disease, tracks fertilizer, monitors trends over time and tracks livestock; it also offers GOPRO flying software, and can integrate with Skymatics, Aglytix and John Deere agriculture management software.
- SKYMATICS is an aerial mapping, inspection, and data analysis service. SKYCLAIM is a fully scalable image analysis service using advanced learning algorithm that provides crop loss analysis after weather strikes hard.
- AGLYTIX intervenes in the agricultural supply chain for quality, production, cost saving opportunities, safety and sustainability practices at the field level. It generates solvers and crunches them using big data of multiple sources to detect, locate, quantify, predict, and diagnose crop issues. AGLYTIX STAND ANALYSIS also determines gaps in the field with RGB imagery, provides an economic impact report, and a shape file with gap severity and location
- FARMLENS is an app for data processing and analytics with basic as well as pro features.
- AGRIBOTIX is another package, which integrates with many devices, and services.
- DRONEDEPLOY app: brings UAV flying to our mobile touch-screens.
- INTERDRONES made a landing in Las Vegas in 2017 September (International Drone Conference and Exposition which was the landmark commercial drone conference, which gathered more than 3,500 UAV professionals for three days of intensive training, and exhibiting boundary pushing hardware....)

So far, however, this only scrapes the tip of an ice-berg, but it is hefty cool step towards progress. Hip Hip Hurray!

UAV, Who?

Why is it looking a little sinister down here? Where do we go, India inc.? To our villagers with survey questionnaires, asking our farmers directly from the field?

When we enter the keywords #UAVdrones, #dronesInIndia, #Agricultural Drones, #FlyingDronesLegal, etc in our net browsers however, we discover that our Army used UAV's back in the unrest of Kargil in 1999, and they were used by movie makers, even earlier. Mumbai's Francesco's Pizzeria launched a pizza drone in 2013, delivering the pie to the owner's 'friends'... thus technically "not doing a commercial transaction" in order to sidestep the stipulation for regulation of no commercial use. "Social Drones" in Uttarakhand were the #breaking news, being used in disaster relief after the 2013 flooding. 'Airpix drone' photography was even used in a campaign to rebuild Uttarakhand.

'Garuda Robotics' was started by a 20-year old college drop-out (Pulkit Jaiswal), who produces software to gather and analyze the data that is collected. 'Edall Systems' provides engineering, design and manufacturing services, as well as drone development, and training programs for students and professionals. 'Idea Forge's' *Netra UAV* is a surveillance quad-copter, used primarily by CRPF and UP Special Task Force. 'Aurora Integrated Systems' *Urban View*, a lightweight reconnaissance drone, and *Altius MK-II*, a medium-range, medium-altitude autonomous vehicle used for surveillance, target acquisition or reconnaissance, are provided to DRDO as well as directly to the Indian Army.

The mushrooming Indian drone start-ups are:

Aarav Unmanned Systems

Aerialair.in

Aerizone Creative Labs

Aerotheo.com

Airpix

Aurora Integrated Systems

Edall Systems

IdeaForge

Kadet Defence Systems

MUAV Drones India

Om UAV Systems

Phenix Drones

Pixeldo

Qubercomm Technologies
Quidich Innovation Labs
SenseHawk
Skylark Drones
Sree Sai Aerotech Innovations
WeDoSky

... Also some other new ones and they have stories to tell. Chinese toy drones are also sold freely in Indian cities and online stores.

Guidelines and/or Policies Regarding Drone Usage in India

The world over, innovative ways surfaced to regulate drone usage. Japan police used drones with nets to trap punk drones. The Netherlands police got eagles to seize rogue drones. The US Federal Aviation Administration requires drones to get GPS ID registered and the user to register with the agency for remote pilot certificate.

In India, no regulations, policies or guidelines exist for civilian drones. The capital police actually chased down all drones for the 69th Republic Day parade after an unusual drone was spotted over the airport. Again, paradoxically, they did it with assistance from their own drone. In Mumbai, a monthly police newsletter against using drones has become the norm, after a 2015 drone sighting over the atomic research centre. In 2016, a tourist at Khajuraho was detained for a drone photo-shoot without any permission...but whose permission? (from the authorities?... but which body was to be classified as the correct authority for a drone misdemeanour?)

So, now, the Indian government November 2017 draft UAV rules have been proposed, to stipulate for the following:

- (i) UIN (RFID SIM);
- (ii) collision-warning light;
- (iii) Unmanned Aircraft Operator Permit (UAOP);
- (iv) training;
- (v) insurance;
- (vi) clearances; and
- (vii) a security program (to fly back if malfunctioned).

Going forth:

#1: Categorization: Nano, micro, mini, small and large drone, 5 types from 0-150 kgs.

- #2: Nano, the sub 250 g, won't require any security clearance.
- #3: It can be used for photography, medical uses, ad film making, e-commerce ... etc.
- #4: flying above 200 ft or within '500 m' from airport and coast line, restricted.
- #5: Except Nano other types will require clearances from various departments.
- #6: Drones <2 kg flying within 200 m radius can fly after registered, without further clearance.
- #7: Strict privacy norms and approved route to be complied. Mobile flying platform barred.⁶

Minister of State for Civil Aviation Jayant Sinha said in the April 2018 at the Indo-French, Defense and Aerospace Cooperation meet, "Why don't India and France take up the leadership as far as drones are concerned where standards, technology, control parameters have to be harmonised and perhaps create international drone alliance...." Former Union Minister for Civil Aviation P. Ashok Gajapathi Raju had also told in November 2017 that, "Drones would be massively used for improving agriculture and exploring oil and gas all over the country". So, one can surmise that the drone rules are more than welcome.

Who Knows What the Future Holds?

Drones may pervade the skies and swell, and become available for farmers to buy. Moreover, this cannot be classified as toying.... Our agricultural production should be doubled by cutting costs from significant factors...that is done by UAV...the pluses to eclipse the minuses. When a farm would get a drone, it should be more about knowledge and skills, and using it safely and effectively. Then, what is the role of the state or other institutions in all this? It should be towards taking technology to the base of the pyramid, isn't it? Surely, the list should instead go by:

- (1) Providing or subsidizing and regulating the drones
- (2) Training agriculturists, people
- (3) Evaluation and research for more yields, reduced costs
- (4) Provide crop insurance, digital market place
- (5) Creating new tech, new licensing, monitoring, training, research jobs
- (6) Drone specialty in institutions, training centres
- (7) More earnings, more profits. More profits will look whopping big on a blue chip.

So be it! Is it likely to stimulate action of the authorities? Reiterating the Odisha case, we can make 3000 of ‘25 sq. km’ farms. 800-1000 of proud men and women owners and workers, would constitute the farm, and form a board. The farm could flourish with crops, animals, aviary, plantations, roads, landscapes, water ways, a drone landing strip, barns, composting stations, RO, equipment, warehouses, a training academies, hospitable cottages, possibly even an elderly home with congenial amenities...and cultivate the phenomenon of “a name that shines and inspires...” All this and more is theirs! Jobs will be in all possible fields: of crops, livestock, construction, operations, marketing or evolve some more job titles. Serious professionals will be at work.

A New Way

Farming will be around the UAV marvel. With or without state it is likely to see tremendous success or end up being a charade. Technology is capable of retiring today’s equipment before one can realize; it is so technical that one can check out for more all the time. And it’s about employing future-safe, enduring technology.⁷ Some basics to keep in mind, regarding this new way are:

1. UAV size, payload, battery pack, altitude, overlap, spin rate, winds, etc will limit the number of passes, flying time, coverage, etc.
2. Quad, hexa or octo-copters have 4, 6 or 8 rotors each.
3. A Quadcopter with one rotor defunct, may questionably come down like a rock but then, so will the others, right? or has it changed?
4. On one charge, image scanning may cover 75-100 acres (0.5 sq. kms) in 30-60 minutes.
5. LiPo batteries may survive for 300 charge cycles, and NiMh batteries, much more

After having loaded flight plan through PC or smartphone and a UAV armed, it’s to flying auto or step out monitoring it, shooting images...and doing prodigious farming.

How to Arm the Farm?

1. What drones are to be included in the fleet?
2. Where to buy them, get services related to them, and/or related licenses?
3. How to get financing for investing in them or the funds?
4. What will be the registration, operations, safety, enforcement, and possible dispute chores?

5. Which special drones can be borrowed specifically by the farms, and how often?
6. How to improve constructions and layout, and create more activities related to *arming the farming*?
7. How to aim for improved management, by using the strategy of success recognitions, and achievement rewards?
8. Who would be the partners for analytics, planning and services? and Why?
9. What are the department's targets, development modelling plans, and benefits or risks which exist in the project, and Why?

Specialists will consider farm, size, activities, targets, time-lines and resolve, as well as optimize.

State Role – Pinocchio Test

1. Hard-hitting on state exchequer? Whereas recurring relief and waivers are bad, allowing UAVs, State will make the difference – it's not sops. State can this way control agricultural income too.
2. Did 'The Farm Journal Plus' have only 33% Americans using it? It showed other 31% actively considering it. Anyway, USA land reforms and challenges differ. India's crashing agriculture and brimming population is why India should take the plunge right away.
3. Will the Cooperatives break? State has great responsibility in setting up of the cooperatives, listing of scrips, promoting and regulating; timely helping for seeds, nutrients, pesticides; marketing logistics, insurance etc.
4. State can't entangle much? It is a duty: the state should work with the farms, supply or lease drones, and position the agronomists. The Corporates under CSR should adopt a district or some blocks. Institutions should lead technical incubation.
5. Will the Drones take away/ decrease human employment/ jobs?
This is lame. The drones will collect and resolve big data, and let humans do what they do better which is decision-making. The drones will deliver fast on a large scale, bring accuracy, resolve tedious logistics and people will ofcourse supervise it. Instead of decreasing employment, new specializations and technological openings or services will surface. All the while, it will produce more to feed more mouths; earn more for farmers and they will have much more time to live normal lives or can even have more holidays.

6. Let go and why fret (*jaane bhi do?*) On the course of crops failing, malaises booming, with no positive action further, multitudes will ignore that life is a one-time gift. It can bring hunger to epidemics.

Waiting for the agricultural wars' advent at our door-step, that we cannot turn away, will prove to be too late. India would rather bargain on a flight plan to UAVs and not just make do with a game of leapfrog.

Notes

1. "NDVI vs. NDRE: What's the Difference?", <https://sentera.com/ndvi-vs-ndre-whats-difference/>
2. <http://ces.iisc.ernet.in/hpg/envis/Remote/section331.htm>
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