USE OF DRONE FOR EFFICIENT WATER MANAGEMENT: A CASE STUDY

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ABSTRACT

Water, which is a vital valuable, finite, renewable and shared resource demanded by several sectors, should be managed optimally. The stress due to unavailability or limited availability of water is growing at alarming rate. Irrigation sector is the biggest consumer of water as more than 80% of available water resources in India are being presently utilized for irrigation purpose, serving at just 25 to 40 % water use efficiency. Therefore, it is necessary to improve the irrigation and water use efficiency for getting maximum yield.

Drones are playing an increasing role in solving issues in agriculture and irrigation management. The use of Unmanned Aerial Vehicles (UAVs), also known as drones, and connected analytics has great potential to support and address some of the most pressing problems faced by agriculture in terms of access to actionable real-time quality data. Goldman Sachs predicts that the agriculture sector will be the second largest user of drones in the world in the next five years.

This paper presents a case study of use of Drone for mapping of command area of irrigation project in Pune region of Maharashtra State of India. The activity of drone survey was carried out on about 500,000 ha area. The objective of drone survey was to identify the crop wise area and using this information preparation of statement of water charges. The outcome of drone survey resulted in accurate estimation of area irrigated and accurate identification of crops. This helped department officials in saving in time and increased revenue. This technique brings transparency as drone images are preserved and can be verified.

Keywords: Drone in water management, Unmanned Aerial Vehicles, Information & Communication Technology, Crop Area Measurement, image processing, orthomosaic image

1. INTRODUCTION

Sustainable development and efficient management of water is a complex challenge all over the world. Water is crucial for the existence of life on this earth. Water ensures food security, feed livestock, maintain organic life and fulfil domestic and industrial needs. Besides engineering and scientific angle, the present water situation has political, legal, environmental, social, economic and even religious connotations. The increasing gap between demand and availability of water is becoming crucial issue which divides people in to ‘haves’ and ‘have not’ in every nation. Further, to add pressure, apart from geographical demarcations, water divided people from urban and rural, rich and poor. Without efficient water management and optimum utilisation of this essential, scarce and valuable commodity, ecosystem will experience water crisis in future due to increasing water demand verses decreasing per capital water availability. The Climate Change is expected to worsen the situation. As per Intergovernmental panel on Climate Change, by 2050, more than one billion people in Asia alone are

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projected to experience the negative impact as a result of Climate Change. The United Nations projects that by 2050; as many as three out of four people around the globe could be affected by water scarcity.

In order to improve water use efficiency, advanced Information and Communication Technology (ICT) is playing vital role. The technologies such as Drones are now widely used in water management in order to address crucial issues faced in agriculture and irrigation sector. Various issues in agriculture management arise due to climate change are crucial and there is immediate need for adoption of advanced technologies such as drones, image processing etc. In order to achieve the Sustainable Development Goals (SDGs) by 2030, it is necessary to initiate pilot experiments using drones in order to curb the issues faced by this sector. The Food and Agriculture Organisation of United Nations published “e-Agriculture Strategy Guide” (FAO, e-Agriculture Strategy Guide, 2016) (available at http://www.fao.org/3/a-i5564e.pdf) which is good reference document for successful identification, development and implementation of sustainable ICT solutions for agriculture. The framework mentioned in this report takes multi-stakeholder process in developing ICT for agriculture solutions. Further following resources are available in this sector-

- E-agriculture in action (2016) by FAO
- E-agriculture in action – Drones for Agriculture (2018) by FAO
- Use of ICT for agriculture such as Mobile technologies for agriculture and rural development (2012) by FAO
- Information and communication technologies for agriculture and rural development (2013) by FAO
- Success stories on information and communication technologies for agriculture and rural development (2015) by FAO

2. ABOUT DRONES

The Unmanned Aerial Vehicles (UAVs), which is also known as drones, and necessary data collection and analysis has great potential to support and address some of the most pressing problems faced by agriculture and water management sector in terms of access quality data in less time and at less cost. As per Goldman Sachs report, it had been predicted that the agriculture sector will be the second largest user of drones in the world by 2022.

3. APPLICATIONS OF DRONES IN WATER AND AGRICULTURE SECTOR:

The use of drones in agriculture is in the field of crop production, early warning systems, disaster risk reduction, crop assessment, area measurement, crop planning and growth monitoring, spraying of pesticides, control on water management, etc. Precision farming combines sensor data and imaging with real-time data analytics to improve farm productivity through mapping spatial variability in the field. Data collected through drone sorties provide the much-needed wealth of raw data to activate analytical models for agriculture. In supporting precision farming, drones can do soil health scans, monitor crop health, assist in planning irrigation schedules, apply fertilizers, estimate yield data and provide valuable data for weather analysis. Data collected through drones combined with other data sources and analytic solutions provide actionable information.

Drones are also increasingly used in the agricultural insurance and assessment sector, including in insurance claims forensics. Drone imagery is very useful in giving an accurate estimate of loss. Companies such as Skymet are using drones to provide agriculture survey services to insurance companies and the state governments of Maharashtra, Gujarat, Rajasthan and Madhya Pradesh in the Republic of India.
The drones used by FAO in the Republic of the Philippines are equipped with photogrammetric and navigation equipment with a ground resolution of up to three centimetres. This can be programmed to detect details such as NDVI, water stress or lack of specific nutrients in crops. The drone-supporting mapping efforts in the Republic of the Philippines are now being mainstreamed under the FAO’s disaster risk reduction and management (DRRM) and climate change adaptation (CCA) strategies.

In Maharashtra State of India, drone is widely used for measuring the area under irrigation. This information is used for carrying out analysis of water consumption and identification of crop type. Based on crop type and area under crop, the water charges have been estimated. This helped Government department to speed up activity and bring transparency.

4. **CASE STUDY - DRONE IN IRRIGATION MANAGEMENT IN MAHARASHTRA**

The drones are used for measuring the area under irrigation in the state of Maharashtra. Drone technology had been successfully used in water and irrigation sector for measuring area of irrigated land and identifying the type of crop. The activity was undertaken at Pune in Water Resources Department and it resulted in drastically increase in irrigated area and additional assessment. Total area irrigated is increased to 13.884 Lakh ha from last year’s assessment of 10.71 lakh ha with true presentation of the actual crops on the field. This resulted increased assessment by Rs. 50 Crores. This drone technology brought transparency and efficiency in the functioning of department thereby reducing dependency on manpower.

5. **CHALLENGES IN WATER MANAGEMENT**

The water sector in Maharashtra is faced with critical challenges. First, competition among different sectors has increased dramatically, giving rise to disputes and conflicts. Of the total water used in the state, about 80% goes to irrigation, 12% for domestic water supplies, 4% for industrial use, and the remainder for other uses such as livestock, and hydro and thermal power. With an urban population of about 41 million (42%), and rapidly growing urban centres and industries, the long term efficient and equitable intra and inter-sectoral management of the state’s scarce water resources will become more critical. Second, poor quality irrigation service delivery is undermining the performance of irrigated agriculture. Third, limited cost recovery in the irrigation sector contributed to inefficient on-farm use of irrigation water and added to the fiscal burden of the state. Fourth, planning and management of water resources in the state are fragmented and un-coordinated and is not being done holistically, treating surface & groundwater as one resource.

6. **APPLICATION OF DRONE FOR AREA MEASUREMENT:**

The farmers receive water through canals or pipeline and water bill is charged based on volumetric basis in case of Water Users Association (WUA) and water bill is based on area irrigated and type of crop in case of individual farmer. Following are the various method of crop assessment-

As irrigation revenue of department is based on crop area and also type of crop, it is necessary to have accurate estimation of Crop Area and Type of Crop. It is necessary to accurately measure the area irrigated in command area of irrigation project. The revenue is dependent on type of crop and area irrigated. Therefore, it is necessary to measure the area accurately and identify the crop. The department had adopted water pricing policy which requires recovery of O&M charges from revenue. Also, from this revenue, it is expected that O&M of irrigation infrastructure is carried out. Therefore, it is necessary to accurately measure area under irrigation and type of crop grown and accordingly assessment is carried out. The manual methods of assessment are very tedious, time consuming, human-centric, non-transparent. Hence there was urgent
need for suitable method for area measurement and irrigation assessment. Hence advancement in Information & Communication Technology is adopted in this sector and methodology for crop assessment is developed.

![Methods of Crop Assessment](image)

Fig 1. Methods of Crop Assessment

7. **BENEFITS OF DRONE SURVEY**

Following are the important benefits of use of drone survey for crop identification and area measurement:

- Real Time control on Irrigation Rotation and capturing of evidence. Control on unauthorized water use & control on filed staff.
- Area irrigated outside of command and on backwater can be surveyed and assessed accurately.
- Precise information of area irrigated with accurate crop identification leading to realistic assessment of crop type and area with preservation of data for verification and other purposes.
- Bring transparency and accountability and thereby improving water use efficiency & increase in revenue.
- Requires less manpower and this is outsourced solution. Hence less dependency on departmental staff.
- Compared to all other methods, this method is cost effective. The cost of assessment for 1 ha area is about Rs. 156.
- It is necessary to meet out management expenses including repairs, establishment etc. from irrigation revenue. Hence correct assessment is necessary. Drone survey is accurate to the tune of 2 cm. Hence area measurement & crop identification is very accurate.
- The results can be obtained in short span of time (about 3-4 weeks) which leads to speedy processing.
- Once survey data is available, this data can be shared with other departments and it can be used for land use planning and mapping activities.
8. METHODOLOGY OF DRONE SURVEY

Following steps are involved in drone survey:

**Fig 2. Drone Survey Methodology**

9. SELECTION OF AREA OF SURVEY & ESTIMATE

The first step is to identify the area to be surveyed on Google Earth. The command area as well as uncommand area is marked and using Tool of measurement, the area is measured. This is shown below in Fig. 3.

**Fig 3. Selection of Area to be surveyed**

10. FLIGHT PLANNING

Sophisticated software’s are available in order to decide the flight plan. The speed of drone, flying height, overlaps planned for the photographs, camera specifications, route of flight etc. are important parameters for flight planning. The optimum flight route is
decided by the software based on area to be surveyed (which can be liner or polygonal). The range of drone and battery life decides the area to be surveyed in one flight. Further time of survey is also decided considering sunlight availability and clouds.

11. ACTUAL DRONE SURVEY

Once all necessary activities are done, drone survey is carried out at field. The necessary overlaps on photos are maintained and flight is completed. Necessary permission is obtained from competent authority before carrying out drone survey. The type of drones used and its specifications are given below-

| Table 1. Specifications of Drones |
|-----------------------------------|----------------|----------------|
| Sr. No. | Item                        | Fixed Wing Drone | Quad Copter |
| 1.      | Weight                      | 2.5 to 6 kg      | 1.5 to 5 kg |
| 2.      | Speed                       | 11 to 17 m/s     | 8 to 10 m/s |
| 3.      | Battery Type                | Lithium Polymer  | Lithium Polymer |
| 4.      | Photo Capture Capacity      | 3 photos / second| 3 photos / second |
| 5.      | Flight altitude             | 150 m            | 90 m         |
| 6.      | Flight duration             | 90 min           | 45 min       |
| 7.      | Area covered in single flight | 4 to 5 sq. km  | 2 to 4 sq. km |
| 9.      | Type of terrain             | Plain area       | Hilly area   |

During actual drone survey, the altitude was maintained 100-150 m and about 30 to 40 % overlap was maintained on all four sides of photos.

12. IMAGE PROCESSING, CREATING ORTHOMOSSAIC & GEO-REFERENCING

Once drone survey is carried out, all images are transferred to the computer using sophisticated software.
All the images are geo-tagged according to flight log. The orthomosaic image is prepared using photogrammetry software.

Fig. 5. Creation of Orthomosaic Image
Image Source: https://medium.com/new-farmer/what-is-an-orthomosaic-photo-11140c0601df

13. SUPERIMPOSING VILLAGE MAP

Once orthomosaic image is prepared, the Digital village maps (which is a map showing boundaries of fields in a village and its reference number) from revenue authorities.

Fig 6. Superimposing Village map on orthomosaic image
The next step is to superimpose this village map on orthomosaic image. The village map as well as orthomosaic image shall be georeferenced.

Fig 7. Superimposed Village map

Once this activity is done, the canal network, roads and necessary details are marked.

14. **AREA ASSESSMENT AND CROP IDENTIFICATION**

The area of every survey number shown on village map is measured using software. Further using orthomosaic image, the crop is identified.

Fig 8. Actual Drone Survey Images

Fig 9. Actual Drone Survey Images
15. DATA ENTRY IN STANDARD FORMAT

Once area of every field is available and crop grown on that field is known, this data is entered in standard format in order to assess the revenue. In State of Maharashtra following form is used-

![Fig 10. Crop Assessment format](image)

16. DISPUTE RESOLUTION

Once assessment sheet is ready with officials, next step is to disclose these documents to the farmers. Generally, these documents are sent to Gram Panchayat and displayed on notice board. The farmer can raise their objection about area, type of crop or assessment amount within 1 month from disclosure to the nearest office. In case no objection is raised by any farmer, the assessment is finalised and farmers are requested to pay the water charges to the department.

In case there is an objection, the officer will check the issue with drone imaginaries and farmer is also requested to check it. Since drone image is a very transparent and undisputable evidence available with the officials, the claim can be settled immediately without any further scope for dispute. Thus, drone technology is very useful in bringing transparency by creating necessary evidence.

17. IMPACT OF DRONE SURVEY

The drone technology was used for crop assessment first time in Pune Irrigation Division for assessment of area in command of Shetfal Dam, Tal-Indapur, Dist-Pune. About 10,000 ha area was surveyed and area measurement and crop identification exercise were carried out on pilot basis. Once this experiment resulted good benefits, it was decided to roll out this survey for command area in Satara district. Following projects are selected for drone survey-
Table 2. Details of survey

<table>
<thead>
<tr>
<th>Type of Project</th>
<th>Name of Project</th>
<th>Area of Drone Survey (ha)</th>
<th>No. of Villages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Planned</td>
<td>Measured</td>
</tr>
<tr>
<td>Major</td>
<td>Dhom Irrigation Project</td>
<td>49,500</td>
<td>49,040</td>
</tr>
<tr>
<td>Major</td>
<td>Kaner Irrigation Project</td>
<td>32,751</td>
<td>33,371</td>
</tr>
<tr>
<td>Major</td>
<td>Dhom Balakawadi Irrigation Project</td>
<td>26,192</td>
<td>34,776</td>
</tr>
<tr>
<td>Minor</td>
<td>Kolhapuri Type Weirs on Wang / Uttarmand / Morna / Tarali Rivers</td>
<td>4919</td>
<td>17,562</td>
</tr>
<tr>
<td>Minor</td>
<td>Kolhapuri Type Weir on Urmodi River</td>
<td>13,580</td>
<td>6,679</td>
</tr>
<tr>
<td>Minor</td>
<td>Kolhapuri Type Weirs on Koyna River</td>
<td>13,141</td>
<td>12,465</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,40,083</td>
<td>1,53,893</td>
</tr>
</tbody>
</table>

After carrying out drone survey over 1,53,893 ha area belonging to 651 villages, the analysis was carried out in order to analyse the impact of drone survey. Following table shows the result:-

Table 3. Impact of Drone Survey

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Project</th>
<th>Irrigation Area as per Project Report (ha)</th>
<th>No. of Villages</th>
<th>Area of villages as per Revenue Records (ha)</th>
<th>Area measured by Drone Survey (ha)</th>
<th>Area of Assessment after drone survey is carried out (ha)</th>
<th>Assessed area before drone survey (ha)</th>
<th>Percentage increase in area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Dhom Irrigation Project</td>
<td>32,925</td>
<td>179</td>
<td>78,101</td>
<td>49,040</td>
<td>34,728</td>
<td>10,805</td>
<td>221%</td>
</tr>
<tr>
<td>2)</td>
<td>Kaner Irrigation Project</td>
<td>24,317</td>
<td>160</td>
<td>71,768</td>
<td>33,371</td>
<td>20,828</td>
<td>10,643</td>
<td>96%</td>
</tr>
<tr>
<td>3)</td>
<td>Dhom Balakawadi Irrigation Project</td>
<td>18,100</td>
<td>90</td>
<td>65,453</td>
<td>34,776</td>
<td>Under Process</td>
<td>Under Process</td>
<td>---</td>
</tr>
<tr>
<td>4)</td>
<td>Kolhapuri Type Weirs on Wang / Uttarmand / Morna / Tarali Rivers</td>
<td>11,401</td>
<td>118</td>
<td>27,639</td>
<td>17,562</td>
<td>12,531</td>
<td>2,759</td>
<td>354%</td>
</tr>
<tr>
<td>5)</td>
<td>Kolhapuri Type Weir on Urmodi River</td>
<td>9,570</td>
<td>78</td>
<td>29,600</td>
<td>12,465</td>
<td>7,516</td>
<td>4,853</td>
<td>55%</td>
</tr>
<tr>
<td>6)</td>
<td>Kolhapuri Type Weirs on Koyna River</td>
<td>9,570</td>
<td>78</td>
<td>29,600</td>
<td>12,465</td>
<td>7,516</td>
<td>4,853</td>
<td>55%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>97,220</td>
<td>651</td>
<td>2,85,109</td>
<td>1,53,893</td>
<td>78,220</td>
<td>30,143</td>
<td>159%</td>
</tr>
</tbody>
</table>
From above details it is clear that drone survey resulted in accurate measurement of area and thereby increase in area by minimum 55% and maximum 354%. After success in Satara and Pune district, extensive drive was taken in Western Maharashtra in Krishna Basin in order to carry out drone survey. Following are some images of drone survey-

Fig 10. Actual Drone Survey Images
Drone technology had been successfully used in water and irrigation sector for measuring area of irrigated land and identifying the type of crop. The activity was undertaken at Pune in Water Resources Department and it resulted in drastically increase in irrigated area and additional assessment. Total area irrigated is increased to 13.884 Lakh ha from last year’s assessment of 10.71 lakh ha with true presentation of the actual crops on the field. This resulted increased assessment by Rs. 50 Crores. This drone technology brought transparency and efficiency in the functioning of department thereby reducing dependency on manpower.

18. WAY AHEAD – MOBILE APP FOR CROP MEASUREMENT

Once drone survey is carried out for specific project, the database of orthomosaic image, area details, ownership details, farmer details, crop details, village details, irrigation network details are available. These databases may be georeferenced and overlapped to get details of assessment within a village. In order to carry out crop assessment for next season, there is no need for drone survey. A mobile app can be developed which will have this information in suitable format. A farmer / department staff / outsourced person will go to the field, he will open mobile app, and using GPS of mobile device, app will show real time location of person standing in the field over the orthomosaic image. The person will capture geo-time stamped photo of crop after selecting details of survey number and he will enter the area of that crop. Thus, two important parameters can be captured immediately, using which assessment details can be arrived out. In case there are more than one crop in a land parcel, then person will enter accordingly. This will lead to decentralisation of crop measurement activity and will save lot of time and farmer himself will be in a position to self-declare his area and crop.

19. DISADVANTAGES AND LIMITATIONS

Although there are many advantages of drone survey for crop assessment, there are following some dis-advantages and limitations-

Risk of violation of privacy: Drone captures high resolution images or record activities in survey area, which is otherwise un-accessible. This may lead to attack on privacy. Proper care needs to taken while surveying near township.

Hacking threat: Drones are controlled by the base control. Hackers can intercept the data link network and access control system.

Accident threat: Drones fly above ground and if due to any reason it goes out of control, it may lead to accident.

Risk of legal violation: With the laws and regulations surrounding drone flight constantly changing, the growing list of restrictions surrounding air space could potentially lead to financial or legal fines.

Disruptive technology: Drone technology and allied software’s are under constant developments, updates and new models means that the current designs may quickly become obsolete.

Battery life: The limitation of drone survey is battery life. It limits the flying time of the.

Dependency on weather: Extreme forms of rain, fog or wind can all inhibit the devices ability to fly or even record the required space. Rain can damage the electronic components of drone. For capturing images, sufficient sunlight is required.
20. CONCLUSION

The drone technology is very useful in irrigation management for identification of crop type and area. This information is used for assessment of irrigation revenue. This technique is advanced, fast, accurate, minimum manpower required, non-human centric, transparent, evidence based, verification enabled. The pilot experiments carried out in Western Maharashtra resulted in increase in transparency in measurement of area which ultimately resulted in increase in revenue. Once drone imageries are available, these can be used as a base map in a mobile application which can be utilize for next seasons assessment.

This data can be persevered and may be given to the other departments such as revenue department, agriculture department, rural development department, public works departments etc. for their use. Thus, this is very reliable and useful technology.

REFERENCES


PwC. (2016). Clarity from above: PwC global report on the commercial applications of drone technology.