

**ULTRA RESOLUTION UAV  
BASED GEO-ICT ENABLED  
PROPERTY TAX MANAGEMENT  
SYSTEM FOR MUNICIPAL AREA  
OF BHIWANI**

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## Overview

Governments across the globe are facing unparalleled demand to enhance the effectiveness and maximizing revenue. Property taxes has emerged as a major revenue source for Urban Local Bodies (ULBs). Land and Properties are considered as very vital entities for both the Citizen and the Government. The property has a strong sense of ownership associated with this since it is a very valuable personal asset for the citizen. Similarly, property act as a means of governance. For the rapidly sprawling urban areas, property information forms a foundation for urban planning as well as for revenue generation. And, many of the citizen centric utility services such as electricity, water, sewerage, etc. are also allied to the property.

In Haryana, Property Tax is one of the main revenue sources for Urban Local Bodies. Residential, Commercial, Industrial, Institutional, Government Properties and vacant land situated within the limits of Municipal Council (MC) are assessed for Property Tax and all those assessed are expected to pay the Property Tax. Property Tax is assessed once in every five years whereas supplementary assessment is made every year. Citizens have right to raise grievance, if any, in assessment process.

Municipal Council of Bhiwani (MCB) with Municipal area of 30.19 square kilometer and 60,000 (approximate) properties was struggling with the property tax assessment. Although few attempts were made by them in past years but all gone in vain, since the method adopted in past was non-transparent. This method had led to significantly lower demand from Municipal Council Bhiwani and ever lower realization of property tax. The citizens were not penalized adequately for not depositing their tax demands. There were a large number of unassessed properties which were not under the Tax net, causing a huge revenue loss to the MCB. The taxation principles followed by the MCB were not in accordance to the Act. Given the lack of uniform procedure of taxation, properties were wrongly assessed and the details maintained by the MCB were inaccurate and inconsistent leading to lack of faith in the assessment of Property Tax by citizen.

It was difficult to arrive at meaningful policy decisions, with credible data not being available to the Municipal Council Bhiwani (MCB). To increase the accuracy and transparency about the information of all properties within Municipal Council Bhiwani limit, Deputy Commissioner of Bhiwani who is the Chief Administrative and Revenue Officer of the District, brainstormed for adoption/use of modern techno-

innovative approach based on geospatial techniques. The MCB implemented a new GIS enabled property tax system developed by the Haryana Space Applications Centre, Department of Science and Technology. The scope of work constituted the Unmanned Aerial Vehicle (UAV)/ Drone based aerial mapping for the Municipal area of Bhiwani and utilizing the feature extracted output as the base for the fresh property tax survey. The Geo-enabled system was designed to allow officials to more accurately determine whether tax had been paid for a property, to better monitor overall progress in property tax collection across each ward and the MCB as a whole, to allow for taxes to be paid via alternate channels such as at citizen centric service and to aid in the process of generating accounting Statements for the MCB as a whole.

## Story/Narrative

Bhiwani District is one of the 22 Districts of Haryana State in Northern India. Created on 22 December 1972, the District was the largest District of State by area before the creation of Charkhi Dadri as a separate District. The District headquarters is the city of Bhiwani, which is around 124 kilometers (77 miles) from the national capital Delhi. Bhiwani city, it is believed, was founded by a Rajput named Neem Singh after his wife Bhani. The name Bhani later changed to Bhiyani and subsequently to Bhiwani.

Bhiwani Municipal Council (MC) covers an area of 30.19 Sq. Kilometers. The Bhiwani District comprises of 3235.49 square kilometers of rural and 47.74 square kilometers of urban area. Bhiwani District having a population of 11,32,169 consists of 600,723 male population and 5,31,446 female population. Decadal growth rate of 14.7 percent has been recorded in the District during 2001-2011 period (Census, 2011). Figure 1 shows the limits of MCB area.



*Figure 1. Limits of Bhiwani Municipal Council*

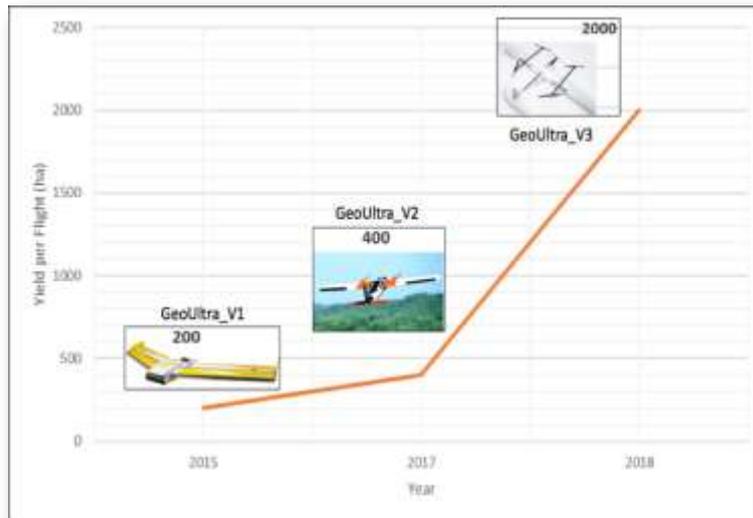
The taxation principles for Property Tax followed by the MCB were not in accordance to the Act. Given the lack of uniform procedure of taxation, properties were wrongly assessed and the data maintained by the MCB were inaccurate and inconsistent. The records maintained in manual registers were also prone to tampering.

There was a delay in preparing the defaulters list that adversely affected the collection of property tax. The citizens were unable to get their property tax demand on time. The handwritten property tax notices by Bill Collector to the property owners were prone to lot of calculation and clerical errors resulting in frustration. The citizens also complained about the tampering of property details entered in the manual form.

The Geo-enabled system was designed to allow MCB officials to determine more easily whether tax had been paid for a property, to better monitor overall progress in property tax collection across each ward and the MCB as a whole, to allow for taxes to be paid via alternate channels such as at citizen centric service, and to aid in the process of generating accounting Statements for the MCB as a whole. At this stage of the project, the distribution of online generated assessment bills and payment through payment gateway has been implemented.

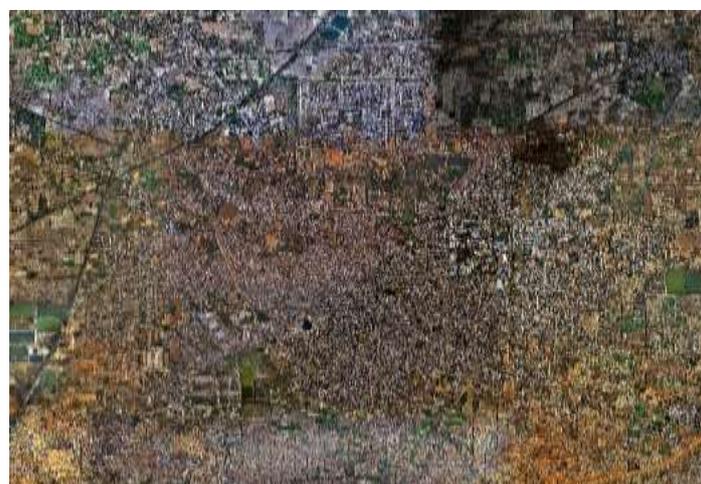
The project constituted the Unmanned Aerial Vehicle (UAV)/ Drone based aerial mapping for the Municipal area of Bhiwani and utilizing the feature extracted output as the base for the fresh property tax survey. But this exercise was not straight forward implemented on Bhiwani and had a long scuffle for standardization of this UAV based mapping which was a newfangled technologies way back in 2015. This technological innovation started when Haryana Space Applications Centre (HARSAC) along with Science & Technology Park, Pune (DST, GOI) evolved the process of UAV data capturing, processing and handling. The UAV available at that time had many pros and cons associated with them. The initial UAVs were single rotor which lost signals at many times in the vicinity of electromagnetic fields generated from High Tension lines. These were solved by introduction of dual rotor UAV in 2016 but then accuracy was compromised since the UAV were having Real time Kinematic (RTK) GPS processing which didn't give satisfactory results once the UAV goes out of the base range which hampered the accuracy of the project. To cater these cumulative problems, a hybrid Vertical Take-off and Landing (VTOL) fixed wing UAV with Post processing Kinematics (PPK) was used in Bhiwani. These

efforts of standardizing UAV protocol have increased the coverage per flight from 200 hectares in 2015 to 2000 hectares of coverage in 2017-18 (Figure 2).

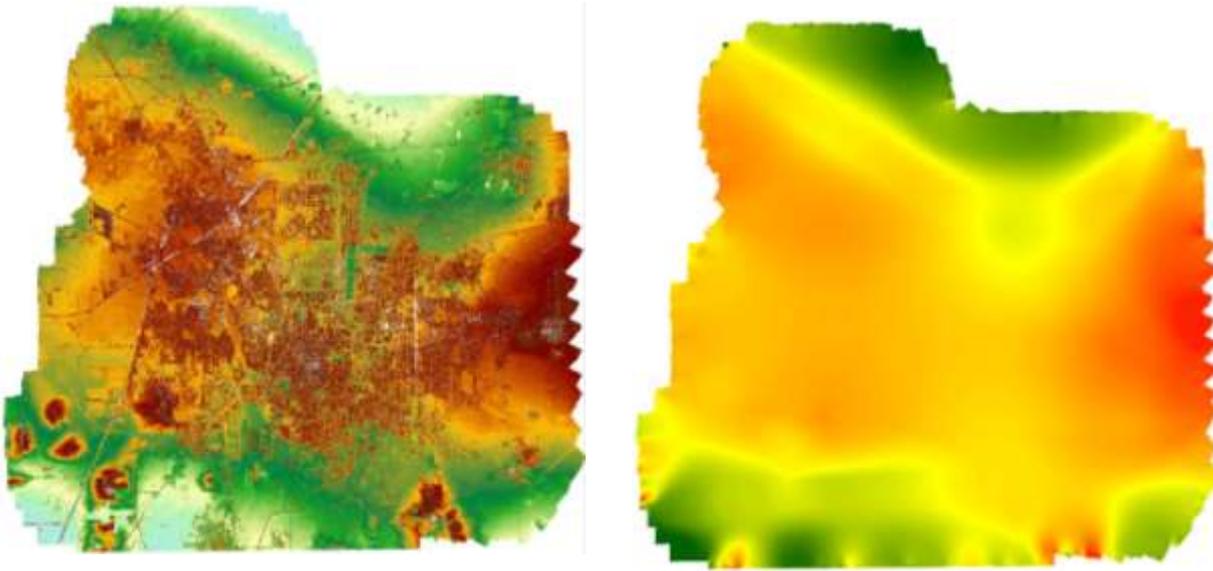


*Figure 2. Increased coverage per flight from 2015 to 2017*

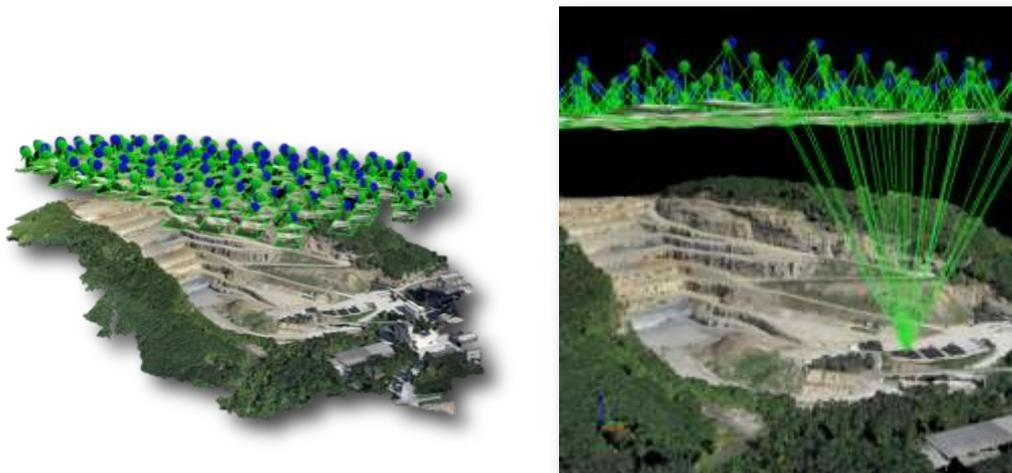
Adopted methodology involved the acquisition of ortho-rectified images from a 42-megapixel camera mounted on a hybrid vertical takeoff and landing drone. The outputs of the process were 5 cm ultra-high resolution 3-band true color orthomosaic (terrain corrected) geospatial data product in GeoTIFF format generated with minimum 75% forward overlap and 60% side image overlap (Figure 3), 5 cm High resolution digital surface model geospatial data product in GeoTIFF format, 5 cm High resolution digital terrain model geospatial data product in GeoTIFF format, Contours with 50 cm interval in ESRI Shape file (Figure 4). 3D spatial information from unmanned aerial vehicles (UAV) images is provided in the form of 3D point clouds (Figure 5). Further using the 3- band ortho-rectified data, property parcel were manually extracted.



*Figure 3: 3-band True color orthomosaic (5cm)*



*Figure 4 (a & b): Digital Surface Model (5 cm) and Digital Terrain Model (5 cm)*



*Figure 5. 3D Point Cloud*

A smartphone-based solution from Environmental System Research Institute (ESRI) named Collector for ArcGIS was used for the survey purposes. A feature access service with sync enabled technique to work in offline mode was deployed using cloud technology. An ArcSDE based geodatabase was created with the necessary domains and fields to facilitate the survey team to allow them to collect the data with minimum entry efforts (Figure 6).



*Figure 6. Field survey data collection*

The first and foremost problem faced during execution of project was handling of the UAV data. The 70 Sq. Km of the Municipal area was having a data of 4 TB. To handle and to process such kind of huge data was very challenging. The second challenge was to design a property database so as to cater to the needs of Municipal Council which was preferred to be paperless. Therefore, mobile application based geo-enabled survey was designed. The complete survey is offline and the edits performed in a day are synced once the team gets in a network area or where WIFI facility is available. In terms of efforts being put for orienting the users towards the survey being conducted and the service that will be offered to them, various camps have been organized by the worthy Deputy Commissioner, Bhiwani with the help of Municipal Council officers to sensitize the people of Bhiwani regarding the need of this survey.

In terms of efforts, a dedicated team of scientists, project fellows & assistants along with the survey staff of 30 people were involved. The project was designed with the initial duration for 1 year in which the acquisition of the UAV data along with creation of base layers and collection of property data is included. The total cost of project is INR 36 lacs.

The time taken to sync the edits to the cloud database depends on the amount of property which are being synced at a time. For a total 100 properties, it hardly takes 20 minutes, while the payment transactions hardly takes 7-10 seconds.

The positional accuracy of the property data is accurate to centimeter level as 5-centimeter unmanned aerial vehicle data is being used as the base map for property point identification and area calculation of the property. The attribute accuracy of the current survey is being evaluated in terms of the past property tax data available with the Municipal Council.

The property tax data is audited by the officers of Municipal Council of Bhiwani and simultaneously, the people being sensitized during the camps also present their documents in case of their grievances with respect to the discrepancies in the tax assessment sheet which is generated online by the user.

The dissemination of the property data for the Municipal Council as well as for the citizens is web enabled wherein the decision makers of the Council can assess the total revenue earned in the current financial year, whereas the citizens can download their assessments, can lodge their grievances for any change in the bill or in data and pay their bills online (Figure 7).

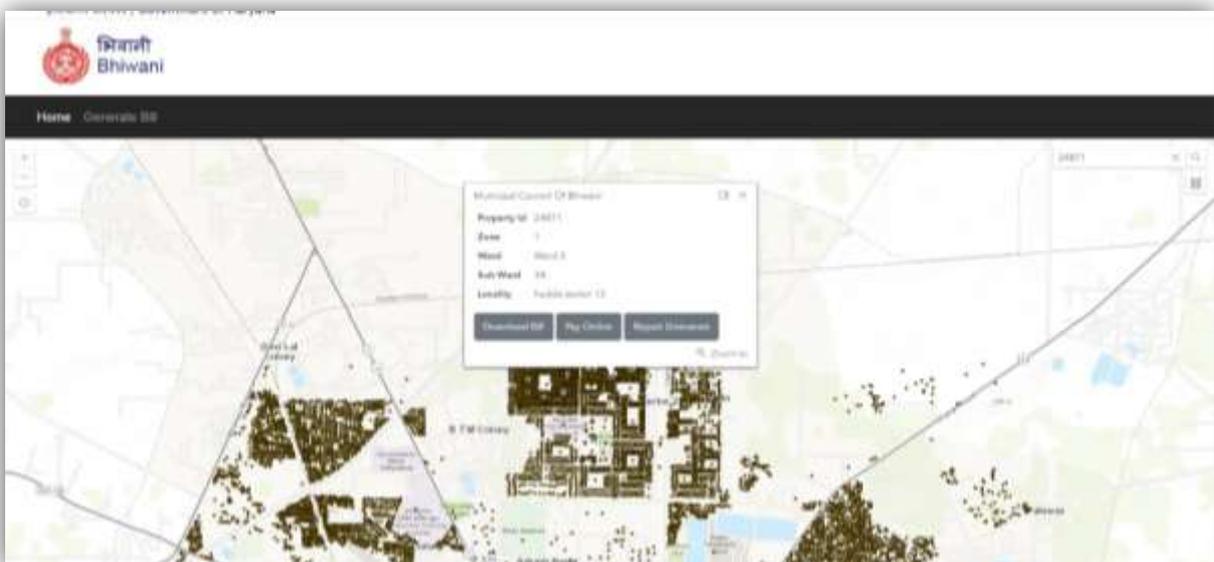


Figure 7. On-line Property tax bill generation

The complete online system has been designed in accordance and needs of the stakeholders, i.e. MC Bhiwani. All the previous year data has been supplied by

them and the current year data is being validated by them. A team has been designated by Deputy Commissioner, Bhiwani from MC for the project.

In terms of accessibility, the project has manifold improvised the user experience with the payment of property tax data since earlier everything was done in conventional manner and even if they want to pay, they didn't have the access to the property id against which they have to submit the tax. Now they can search through their name, address, colony name, locality, etc. The online system is very much transparent since it is acting as a single window solution for assessing the tax, payment of tax and grievance redressal also. The complete system is paperless and the user can register any changes in their data through online portal and even view the progress of their file online and even SMS and email services are configured for future perspectives.



*Figure 8. On-line grievance redressal system*

The service delivery channel for the user is a single window web enabled solution for assessing the tax, payment of tax and grievance redressal also. The complete system is paperless and the user can view their property details, register any changes in their data through online portal and even can view the progress of their file online.

Currently, the project is handled by skill staff of the Haryana Space Applications Centre and in order to assure the sustainability of any of such kind of system requires the hiring of candidates who can continue the legacy of the work done and efforts being plunged in for the project. Since it is now operational, it will become

a self-sustaining revenue model as the salary of the staff and other expenses incurred on the maintenance of this system will be generated from the system itself.

Approximately 31329 number of Properties are surveyed till date and amount of Property Tax calculated is double than the previous collection. Property tax assessment downloaded and distributed till date is 18,000. The objectives of the project have fulfilled G2G and G2C benefits to the target audience.

The Unique property Id created for Municipal Council Bhiwani is unique in every aspect as it is based on location parameters (such as Longitude, Latitude, Altitude/Floor) and is immutable since property location is static. It is not based on some colony code, ward number, zone number which are dynamic and liable to change every year. The unique id concept developed for Bhiwani can be implemented for entire State maintaining the uniqueness (Figure 9).



Figure 9. Unique property ID generation

Proper assessment of properties and efficient collection of tax is vital for Municipal Corporations as property tax is the primary source of income for these authorities. In a bid to improve their functioning, several Municipalities across India have introduced innovative practices in property tax assessment and administration. Reform of the property tax systems is also one of the mandatory reforms under the Jawaharlal Nehru Urban Renewal Mission (JNNURM). The mandate under the JNNURM emphasizes the need for implementation of online system for property tax through a proper mapping of properties using a GIS system. As a result, many

Municipalities have adopted GIS-based property tax system to strengthen their revenues.

## Way Forward

The project constituted the Unmanned Aerial Vehicle (UAV)/ Drone based aerial mapping for the Municipal area of Bhiwani and utilizing the feature extracted output as the base for the fresh property tax survey with following key feature:

- 1) The Geo-enabled system was designed to allow officials to determine more easily whether tax had been paid for a property,
- 2) to better monitor overall progress in property tax collection across each ward and the MCB as a whole,
- 3) to allow for taxes to be paid via alternate channels such as at citizen centric service,
- 4) to aid in the process of generating accounting statements for the MCB as a whole, and
- 5) creation of an online grievance redressal system

Grievance Redressal Module is designed to allow citizens to submit their grievance related to owner or property details (Figure 10a and b). Grievance System is a procedure to receive and act on grievances reported by citizens accessing online portal. Citizen has to get registered through the grievance portal. In order to submit any grievance, a list of mandatory documents is required to complete the submission. Portal also facilitates the citizen to check the progress of his grievance by using his mobile number.

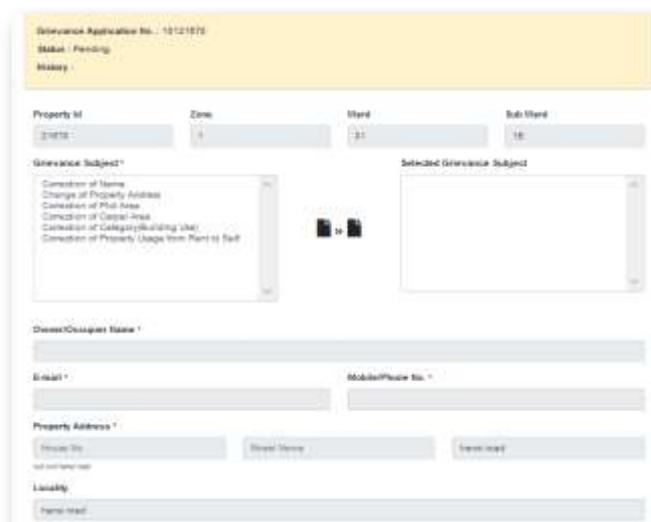


Figure 10(a). Grievance Redressal Module

Environmental System Research Institute's (ESRI's) server deployment technology has been extensively used for this project. ESRI's softwares are OGC compliant and their products are interoperable that is platform independent. The field data collection App is available for all the platforms. The data is being maintained at the high security premises and is available only through cloud and there are no such security concerns associated with it.

Currently, in a day, approximately 500-600 properties are being surveyed in a day through geo-enabled mobile based application which includes the data about the property, floor, ownership details along with geo-tagged photos. The payment gateway-based transactions are yet to start.

Total Plot Area(Sq. Yds.)	Property Category	Property Type	Property Sub Type	Floor	Floor size Covered/Carpet Area(Sq. Ft.)	Self Occupied/Rent
101640	Mix Us	Paying Guest	Paying Guest	Gr	480	Self occupy
101640	Mix Us	Vacant Plot	Industry	Gr	88780	Self occupy
101640	Mix Us	Industry	Industry	Gr	10500	Self occupy
101640	Mix Us	Shop	Shop	Gr	150	Self occupy
101640	Mix Us	House	Independent	Gr	2800	Self occupy
101640	Mix Us	Shop	Shop	Gr	1800	Self occupy
101640	Mix Us	Shop	Shop	Gr	220	Self occupy

Attachment Required \*

Selected subject required attachments will show up here.

I declare that the information provided by me in the application is true to the best of my knowledge and shall be liable for any action for wrong information provided by me under the MC rules.

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Figure 10(b). Grievance Redressal Module

The complete solution is online acting as a single window solution for assessing the tax, payment of tax and grievance redressal also. Thus, the user need not go to any place and get all the facilities on his/her mobile phone. The system is 24 x 7 working and therefore the user can access the same anytime.

The system design is adaptable to any future changes desired by the stakeholders and is scalable also since the current property holders in Bhiwani are 60,000 but the system has practically no limitation even if the number of the property tax payers increased in the future.

The system design can be replicated at any place in Haryana since the tax rates for Council, Committee and Corporation within Haryana are universal and can be implemented with ease and there is no such restriction in replication and scalability as of now.

## Teaching Notes

### Learning objectives:

- Importance of innovation and technology to bring transparency and proper accountability in Property tax management
- As-Is situation analysis and identification of pain points in the existing property tax management system and the solution provided by the MCB

### Suggested questions and Analysis:

- a) What are the key points to be kept in mind while replicating the UAV based Property tax management model in other States?
- b) To take up the number of registrations on the UAV based property tax management portal, what are the top three key features/ application highlights that you can explain to a common man?
- c) Group discussion and Role play:
  - a. How can the grievances and complaints of the citizens be handled in a better way? A way to improve the grievance redressal module.
  - b. What additional features may be added in the software to make it faster and more accurate?

### Role play activity

Make 2 groups of 5-6 people each. The first group representing Mr. Suraj and his team from Municipal Council of Bhiwani (Group A) and the other group representing citizens with property tax issues (Group B).

- Group A should discuss the issues pertaining to property tax management and the solution for getting the issues fixed
- Group B should discuss the issues with the manual property tax calculations and its repercussions

**Summary-** Key lessons learnt (15 minutes). Each participant shall write down a summary in not more than 500 words highlighting key learning from the case.

## Abbreviations

Abbreviations	Full Form
MC	Municipal Council
MCB	Municipal Council of Bhiwani
UAV	Unmanned Aerial Vehicle
RTK	Real time Kinematic
VTOL	Vertical Take-off and Landing
PPK	Post processing Kinematics
ESRI	Environmental System Research Institute
HARSAC	Haryana Space Applications Centre
JNNURM	Jawaharlal Nehru Urban Renewal Mission
GIS	Geographical Information System
G2C	Government to Citizen
OGC	Open Geospatial Consortium
Gol	Government of India
SDE	Spatial Database Engine