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# Modifying an Old Rugged Jeep to Develop a Platform for Agriculture Purpose and for Proximal and Remote Soil Sensing Usage

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**ABSTRACT:** - The agriculture sector is contributing in huge proportion in the economic development of India. As per the data available on [tradingeconomics.com](http://tradingeconomics.com) sows that agriculture sector accounts for around 14% of the country's economy and 55% of India's total employment. Similar to the other sectors like manufacturing, service, education, etc., the agriculture sector is also passing through drastic technological changes. A major change of revolution has been there in this sector due to usage of IoT, AI, and allied technologies. Off road vehicles like tractors is basic requirement of farmers. Along with that, machines to; prepare soil, remove weed, plant, spray, and harvest are required by the farmers. Special purpose machines to monitor and control soil and crop health are also becoming essential. To meet the demands and compete with the global markets farmers are seeking for inventive solutions from the technocrats, though they are using the traditional methods still. The objective of this research is to provide the solutions for the community of the farmers by converting the on road vehicle in to the off road one, and facilitating it with electronics and allied technologies to develop a platform for agriculture purpose and for proximal and remote soil sensing usage.

**KEYWORDS:** Off-road vehicles, farming machinery, agro-business, vehicle customization, proximal soil sensing, precision agriculture

## I. INTRODUCTION

Vehicle customization is one of the interesting and useful practice in the Automobile Engineering. The basic concept of vehicle customization is to convert the existing model of the vehicle in to the different one as per the application. There have been the news always, that someone has converted the two wheeler to serve his purpose. Today the population of India and world is in the form of the exponential increase. At the same time there are limited resources to fulfil the food and energy requirements of this population. Agriculture field is facing the challenge on the fronts like manpower and technology. Middle-level farmer can hardly afford the vehicle like tractor and other expensive machines. On the other hand increasing number of individual on road vehicles are creating the problems of pollution and traffic congestion. The scrapping of old vehicles also creates a problem [1]. Hence the customization of the vehicle is the need of hour. Following objectives can be fulfilled by customization.

- 1) To use it for transportation of agro material and human workforce in farms.
- 2) To use it as a Advanced Mobile Soil Analysis Laboratory (AMSAL) and other arming work.

To turn the older version of the Regular On-Road Vehicle in to an Agro based off-road vehicle is definitely a challenge, but not too difficult.



## II. LITERATURE REVIEW

Already the community of the researchers is working to ease the problem of the farmers using the automation and related technologies. In case of Agro based vehicles instead of the aesthetics, ergonomics, the sturdiness of the vehicle is significant. Considering the farming operations and bulky structure of the agro vehicles, safety is considered as the most important factor in the agricultural vehicles [2]. In the vehicles like tractor, fuel consumption and limited sitting space is the point of the concern. Also the pollution and emission of gasses is also point of the discussion. Generally special purpose vehicles are designed to carry out the different operations. Most of the research is carried out in the field of soil testing and harvesting machines. Through the extensive research work, people are now successful in the development of Variable depth planting [3] and harvesting machine, and various models of planters and harvester vehicles are available in the market [4].

Soil testing is an important and essential part of the farming business. The recognition of soil quality helps the formers to take the decision regarding the crops. Traditional method of the soil testing is to submit the soil samples to laboratory. However this approach has been changing to the onsite testing of the soil. Hence scientists are developing the vehicles in that direction. The development of the automated soil tester is the significant stage in all this journey which is providing accurate results of the moisture content and temperature [3]. The further development is there to design and develop the un manned vehicles for the purpose of soil testing [5,6]. Researchers have worked on a device, that can be attached to the tractor to conduct the testing and generate the results using sensors and electronic devices. The recent development in this domain is application of robotic vehicle for the soil testing [7] A hydro-electro-mechanical device has been developed with the cloud based control software to test the soil properties, which provides accurate results. This device is efficient and durable too. Also the community of researchers is looking for fuel saving vehicles[8,9].

## III. GAP ANALYSIS

In India, soil test based nutrient management has emerged as a key issue in efforts to increase agricultural productivity and production since optimal use of nutrients, based on soil analysis can improve crop productivity and minimize wastage of these nutrients, thus minimizing impact on environmental leading to bias through optimal production. Deficiencies of primary, secondary and micronutrients have been observed in intensive cultivated areas. With about 120 million [10,11] farm holdings in the country like India, soil analyzing capacity of 40 million samples annually is required to enable analysis of each holding once in three years. This requires a substantial expansion in soil testing program in the States.

The number of static soil testing facilities in India is about 1,049. As a result, 7.4 million soil health cards were issued to farmers during 2010-11 [10,11]. However, recruitment and training of manpower have emerged as major bottlenecks in further expansion requiring attention of State Governments. For example in the State of Maharashtra, is facing several Constraints e.g. regular annual maintenance contract of imported equipment is necessary. Therefore, funds need to be made available for such purpose. Large amount of funds are required for the wages of laboratory attendant. There is also the need of trained and qualified manpower in the static soil testing facilities. There is also need of IT trained manpower for interpretation of analysis reports and preparation of recommendations and their online communication.

As an alternative to static soil testing facility, a mobile vehicle consisting a fleet of proximal soil sensing (PSS)[12, 13,14,15,16,17,18] scientific instruments can be advantageous due to many reasons. First it will require only 1 or 2 skilled human resource. For e.g. one person to drive the vehicle and the another person to perform all other operations that are generally conducted in the laboratory. Secondly, high density measurements can taken using multi sensing PSS platforms in continuous manner and their analysis can be done in situ, to produce high quality and accurate soil fertility maps in real time [19,20,21] In addition to this, the Mobile Soil Testing Laboratory (MSLA) can be advanced by integrating it with the cutting edge and allied technologies such as Internet of Things (IoT), 3D Printers, and Artificial Intelligence (AI) to take care of all logistic operations such as sensor data acquisition, cloud storage, and data analytics and risk analysis and data science parts without using an extra human operators [22,23,24,25]. From the literature survey, it can be said that the efforts to ease the soil testing operation has been taken in well manner, and many smart devices are discovered for the same purpose. However it is needed to construct the vehicle which can be used for transportation of humans as well as agricultural purpose. It is essential in today's environment.

IV. MATERIALS AND METHODS

IV.a SELECTION AND CUSTOMIZATION OF THE VEHICLE

Select any vehicle which is suitable for your application. Make the changes in that vehicle by considering commercial, financial and ultimately technical feasibility and requirement. Due to availability reasons, in our case we have taken 1980 MM540 Mahindra Jeep Model. As our primary purpose is, to use the vehicle multipurpose cause like transportation of human workforce and equipment and to perform agricultural operation such as soil testing. Hence the sturdy vehicle is selected. The above modifications have done by considering the working environment of the vehicle. And they are useful for the driving purpose of the vehicle. The significant purpose of this transformation is to make the vehicle useful for the agricultural application. Hence some additional electronic devices is attached to the vehicle for operational purpose. The Jeep is equipped with automatic wiper system, parking assistant system, and mobile operated vehicle system with the help of the Bluetooth chip. Hence the old model as (illustrated in Figure 1a) of jeep is completely converted in to a vehicle fully equipped with the modern technologies as illustrated in Figure 1b and Figures 2a and 2b.



Figure 1. The old Rugged Jeep (a) and itself after customization (b).

The vehicle illustrated in Figure 1a was adapted as it is and several processes were applied to it in the workshop facilities. The different workshop processes included, cleaning, body work, engine work, transmission work, electrical work, interior, exterior and aesthetics related work.

**MOBILE OPERATED VEHICLE SYSTEM**  
Sensor used: Bluetooth receiver

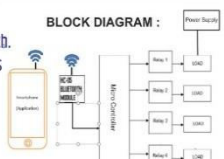
**CONSTRUCTION**

- The power is supplied through the 12V battery of the vehicle and is then converted into 5V.
- The system is connected to the original circuit of lighting and Horn in series

**WORKING**

We connect the phone to the vehicle system via bluetooth. We command the car's system by phone. The command is then received by bluetooth module. Then it goes to microprocessor. Microprocessor gets this command as input and processes it and produces appropriate output by actuating respective relays.

**BLOCK DIAGRAM:**



**PARKING ASSIST**  
Sensor used : Ultrasonic proximity sensor

**SPECIFICATIONS**

- Power supply 12V
- Operating range 15 meter
- Operating temperature -30 to +60 degree celsius
- wide angle: 170 degrees horizontal

**WORKING**

System turns on when vehicle is in reverse gear. Sensor emits ultrasonic waves these waves hit nearby object and bounce back and are captured by receiver. The time between sending and capturing is calculated by ECU and driver is alerted by audible tone or visual signals.

**CONSTRUCTION**

Sensor is fitted into the bumper of the vehicle. the display unit is located inside the driver cabin on the dashboard.

**BLOCK DIAGRAM:**

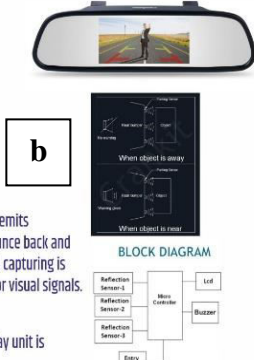


Figure 2. Mobile operated vehicle system (a) and its parking assistant system (b).

The function of the attached devices is explained as follows:

**Table 1.** Jeep customization parameters

SPECIFICATION OF OLD VEHICLE	SPECIFICATION OF CUSTOMIZED VEHICLE
Engine 4 Cylinder Peugeot Diesel	MAHINDRA MDI ENGIENE
Transmission system-4 Speed Manual	Differential 4x4 system
Final Drive 4 x 2	
Regular Tyre	Off Road tyre with alloy
Regular Brakes	Hydraulic Power Brakes
Regular Steering	Hydraulic Power Steering

**IV.a.a PARKING ASSISTANT**

The system turn on when the vehicle is in Reverse gear. Sensor emits ultrasonic waves, these waves hit nearby object and bounces back and captured by receiver. The time between sending and capturing is calculated by ECU and the driver is alerted by audible tone and visible signals (illustrated in Figures 2a).

**IV.a.b MOBILE OPERATED VEHICLE SYSTEM**

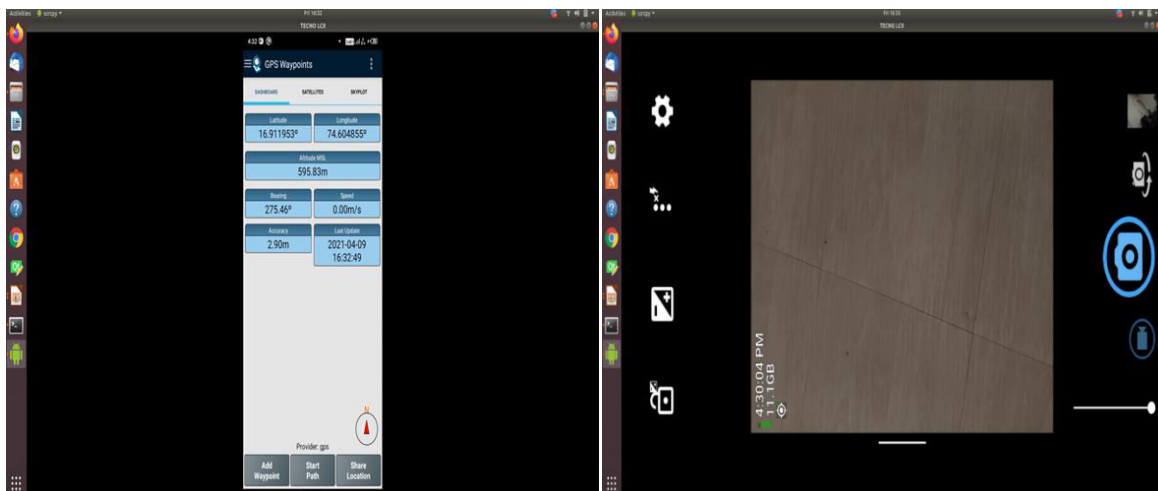
We can connect the phone to the Vehicle System via Bluetooth. The car can be commanded by phone using blue tooth system. The command received by the blue tooth system will be transmitted to the microprocessor. The microprocessor processes this command and produces desired output by actuating respective relays (illustrated in Figure 2b).

**IV.a.c AUTOMATIC WIPER SYSTEM**

In this system sensor is located on the outer side of the Vehicle, at the bottom of the windshield of the driver side. The processor and remaining circuit assembly is located at the hood. When the water comes in the contact with the sensor, we get output as low, otherwise output is high\which is processed then by microprocessor and motor is then actuated accordingly.

**IV.a.d MOBILE PHONE BASED SETUP FOR GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)**

The system is useful to map the agriculture field and coordinates. In our case we used an android phone based application called “GPS Way Points”. Due to availability reasons we used a smart phone model "Techno Spark Power 2". Also to collect the data from inside the Jeep we connected the mobile phone to an in house available Laptop computer using micro USB 2.0. To control the smart phone via the laptop we used a specialized application called “screpy”. screpy is a free and open-source screen mirroring application that allows control of an Android device from a Windows, macOS, or Linux desktop computer. The setup for it in lab condition is illustrated using Figures 3a.



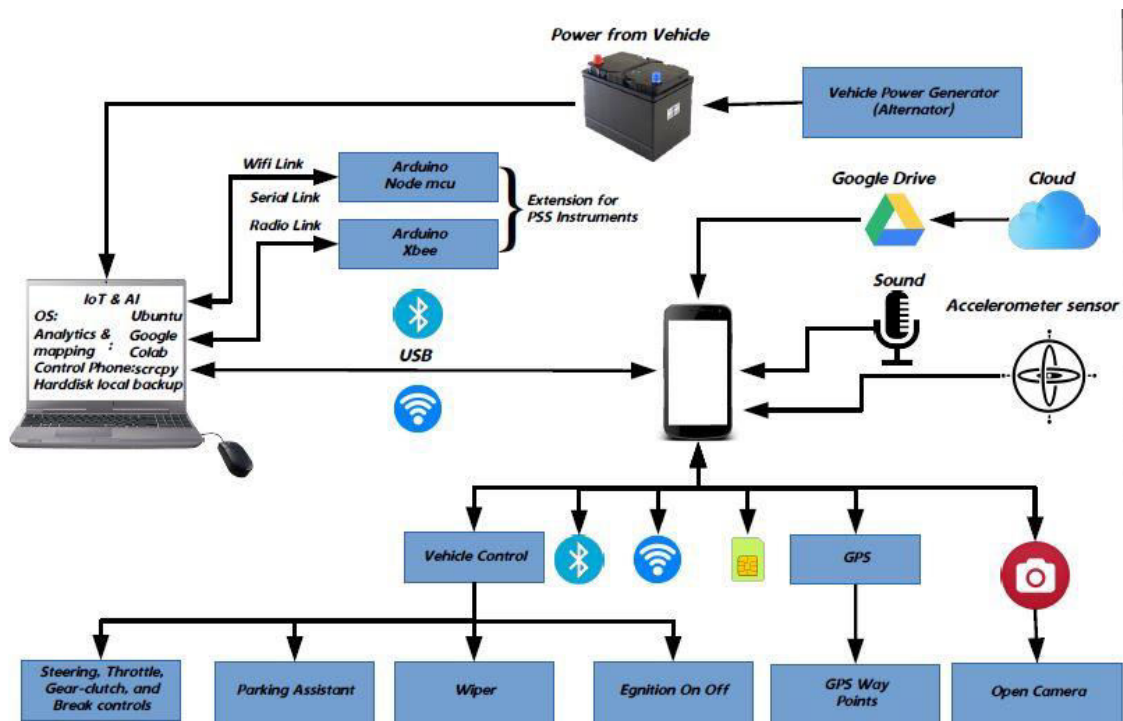
**Figure 3.** Laptop screen of the mobile phone based global navigation satellite system (GNSS) in lab (a), Laptop screen of the mobile phone based image capturing setup in laboratory(b).

**IV.a.e MOBILE PHONE BASED IMAGE CAPTURING SETUP**

The system is useful to capture images on soils surfaces in the agricultural fields. In our case we used an android phone based application called “Open Camera”. The connectivity and control of the camera was taken care in similar manner as explained in section IV.a.d. The setup for it in lab condition is illustrated using Figure 3b.

**IV.b THE FIELD DATA ACQUISITION, DATA ANALYTICS AND MAPPING SYSTEM**

The complete architecture of the field data acquisition, data analytics and mapping system is illustrated in Figure 4. From figure it is clear that the system consists of specially customized hardware devices and an in house developed software components. The entire system is enabled with cutting edge and allied technologies such as IoT, and AI to transmit and receive data from field to cloud, as well as to run analytics using algorithms based on Artificial Intelligence. The software for the FDADAMS is implemented on the readily available laptop and is integrated with a smart phone with specifications for both as listed in Figures 5a and 5b. The initial development of the software for FDADAMS is developed in Google Colab using Python 3.9 programming language, that runs on LINUX based OS called Ubuntu. Currently this system works in a semi-automatic mode. However, in future complete autonomous working is possible.



**Figure 4.** The architecture of the Field Data Acquisition Data Analytics and Mapping System (FDADAMS).

The human user takes care of all operations such controlling the smart phone applications to collect the GPS coordinates as well as capturing the images using the camera. The user also saves the data and uploads it to the Google Drive System. Later the user can run the analytic codes and apply it to the respective data sets of any types as are found available in the drive. Currently there are two algorithms developed and the process flow diagrams are illustrated in Figures 6a and 6b. The first algorithm runs analytics code on the text data type files (.csv, .kml) found available in the drive systems. Whereas, the second algorithm runs on the image type files (.jpeg) found available in the drive system.

For instance, two small areas located in Sangli District, Miraj Tehsil, in the state of Maharashtra, India were chosen to demonstrate the usefulness of the system. The first place was a small agricultural field located in a town named Madhavnagar and the other place was a open play ground located in a town named Budhgaon. The first field plot size was 60 m (length) easting and 28 m (wide) northing. Initially the customized jeep was passed tracing the field boundaries, later followed by 2 passes as diagonals followed by two passes from the centre of the field, the travel speed was 10 km/hr and the coordinates (Latitude and Longitude) were collected at a rate of 1 reading per second. The system used was a mobile phone GPS App “Way points” as discussed in section IV.a.d

The application interface had the capability to log the coordinates in timely manner and save them in .csv file and .kml file format. Later the files were exported to the Google Drive System and later re imported in to Google Colab to perform the analytics and to display the maps using the specially designed software. The original coordinates are able to be projected and converted in to metric units and can be plot on a graphical scale using mat plot library in Python.

Later the plot was laid off in Google Earth to illustrate its actual coordinates in the globe. In addition to above, the customized jeep was passed over the open play ground in a concentric ring fashion such that maximum coverage of the entire surface was possible. The speed was kept very low (~5km/hr.). While passing over the surface a total number of 977 geo-coded images were captured with 1 to 2 second intervals between each capture. Later the images were exported to the Google Drive System and the specially developed analytic algorithm were executed to extract the coordinates (Latitude, Longitude, and Altitude) as well as the average of the all 3 color of image pixels were calculated for each image.



Figure 5. Specifications of the Laptop Computer (a), Specifications of the Smart Phone (b)

IV.b METHOD FOR TESTING THE FIELD DATA ACQUISITION, DATA ANALYTICS AND MAPPING

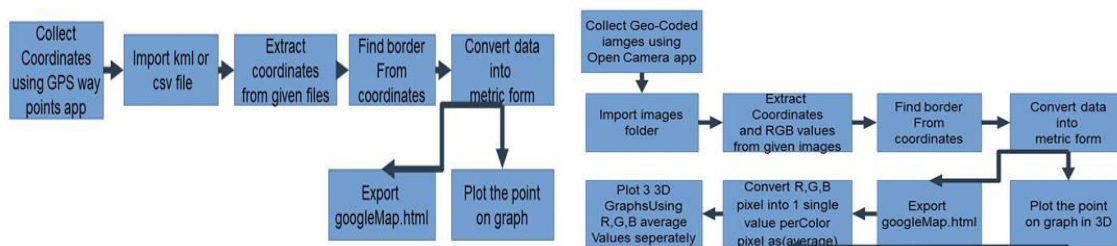


Figure 6. The process flow diagram used to collect the GPS Coordinates using the “GPS Waypoint App.” and Analyze its analysis using Python programming in Google COLAB (a) and the process flow diagram used to collect Soil Surface Images using the Open Camera App and its Analysis using Python programming in Google COLAB (b)

IV. c COSTING

Costing is an important issue in all this exercise. One can prefer to purchase the new vehicle. But this customization of the vehicle (prototype) required just three to six lakh Indian rupees (USD 3,916 to USD 6,528). The additional cost of the system will vary depending on the no and types of PSS instruments are going to be used. On the other hand the new vehicle can be purchased for either agro purpose or transportation purpose in this cost. Hence customization is always optimum than new purchase. facilities.

V. RESULTS AND DISCUSSIONS

Figures 7a, 7b, and 8a to 8d, illustrates the use of the customized jeep (AMSAL) when equipped with “FDADAMS”, to map the field boundary and within coordinates as well as to map the elevation, and the red, green, and blue pixel intensities of two open fields. When mentioning about the second area, i.e. the playground it was oval in shape. However it could fit within a rectangle having side dimensions of length=120 m and breadth =160 m. In terms of area, it should be approximately 2 hectares or 5 acres. Using this information a new data set was created and fed back to the analytics code to display the output either in the form of anchored points or maps of the colour pixels as illustrated in Figures 7b and 8a to 8d.

Both exercises was carried on a nice and warm sunny day before the local planting season or during vacation period (May 2020), when the soil wasn’t yet prepared, there for avoiding any damage to the soil surface as well as to crops. After conducting the exercise, very few traces of compaction were detected, which proves that the springs and the wide tires helped to avoid compaction as well as to drive smoothly on the field surface with ease. For time being we have shown the usefulness of a Smartphone based GPS and Camera as the simplest form of PSS tool [14,15,16,17]. However, by combining several innovations in future [26] this Advanced Mobile Soil Analysis Laboratory (AMSAL) can be used for several other purposes. Likewise using the Serial, Radio or Wi-Fi links (as show in Figure 5), the systems capability can be extended by adding a fleet of PSS scientific instruments to collect more data and to feed the analytics for extended purposes [27,28,29,30,31,32,33,34]. For e.g. an EM38 or Dualem Instrument can be dragged on the back of the vehicle to collect electrical conductivity measurements. On-the-spot analysing platform using a set of potentiometric sensors can be attached to the vehicle to collect measurements on soil chemical properties or a optical probe of hyper spectral sensor can be attached and dragged on the back of the vehicle to simultaneously collect multispectral measurements in subsurface soil and various physical, chemical, and biological properties can be predicted and mapped either in on-the-go or stop measure and go manner [12, 17]. The results can be compared to traditional and conventional methods [13, 18].

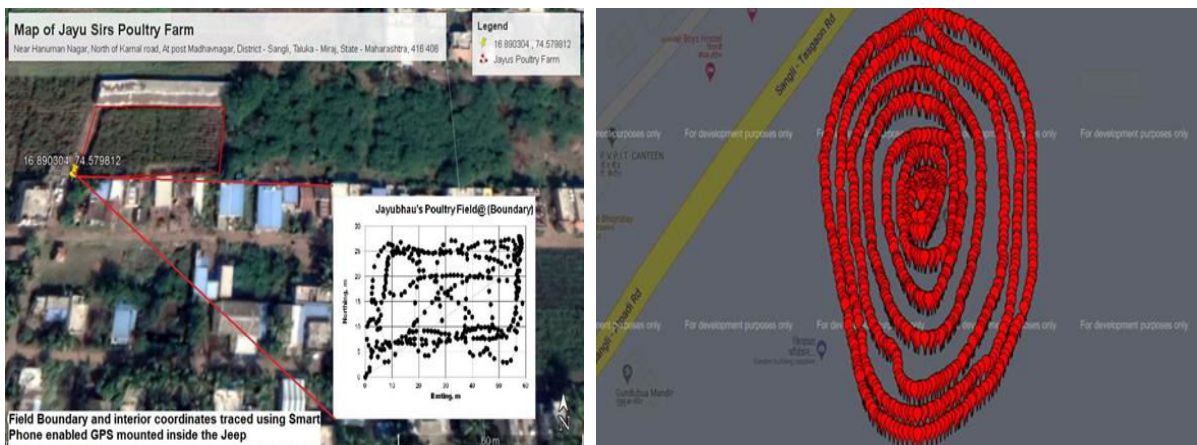
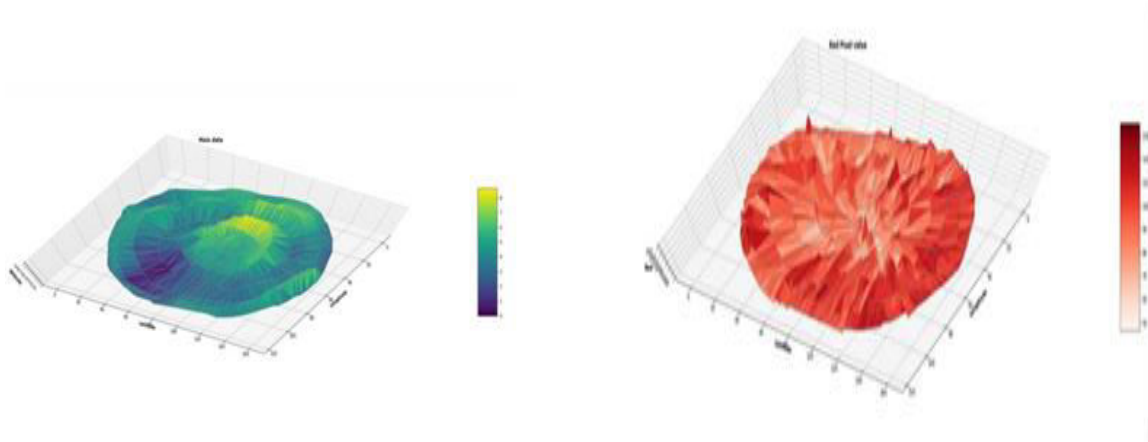


Figure 7. Mapping of the field boundary and some interior coordinates (a) and the map of the places tagged in the field where images were captured on soil surfaces.

VI. CONCLUSION

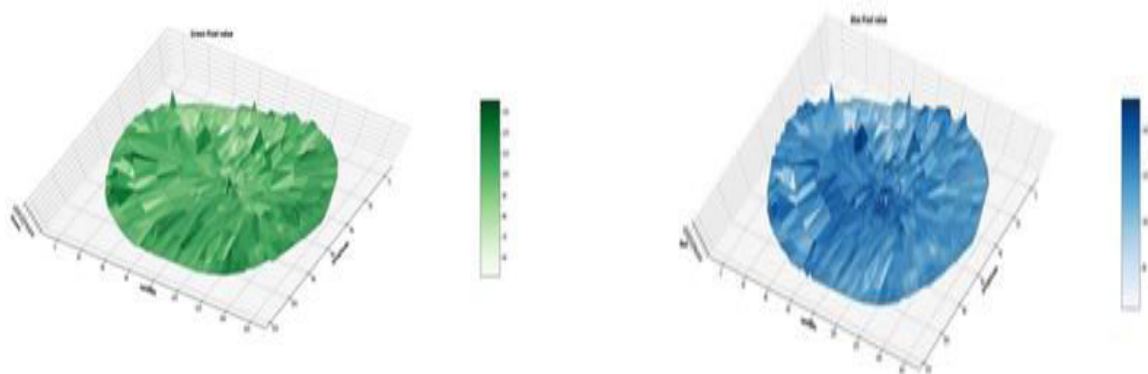
Recycled use of old rugged vehicles for agriculture purpose can be a beneficial way, while practicing Green Engineering solutions. Since old vehicles had less facilities and functions compared to the new generation of vehicles, vehicle customization is the needful activity in current situation. It will be also helpful to solve the problem of rugged automobiles, when the only option at present for rugged Automobile is to scrap the vehicle after its expiry of usage. Which may cause harmful effect on the environment. For Agricultural purpose, the farmer usually needs to purchase the new off road vehicle which costs more. Hence to full-fill the need of the farmer community, the customized automobile can be converted into a new vehicle, which can be used to transport human and farm material. In addition it can also be converted into an Advanced Mobile Soil Analysing Laboratory and can be based on the FDADAMS architecture as shown in this paper. The AMSAL can help to collect information about soil conditions and identify soil properties by using some extra PSS based attachments. By adding unmanned (Auto-Steer, Auto-Clutch-Gear, Auto Throttle and auto Breaking) features, the same vehicle can be used to collect information in day and night fashion. Hence the conversion of the rugged automobile in to a modified version is very useful from the point of view of Transportation of Human, Material , Agricultural, with benefits added benefits to the environmental. In fact customization of an old rugged automobile is the answer of the multiple existing issues.





**Figure 8a.** Field Elevation Map using coordinates extracted from the captured images.

**Figure 8b.** Red pixel intensity map using coordinates extracted from the captured images.



**Figure 8c.** Green pixel intensity map using coordinates extracted from the captured images.

**Figure 8d.** Blue pixel intensity map using coordinates extracted from the captured images.

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