



# TECHNICAL REPORT ON PHOTOGRAMMETRY AND LIDAR SURVEY FOR TOPOGRAPHIC MAP OF 15 VILLAGES

Xe Bang Hieng River Basin,  
Savannakhet Province

Implemented by:



Integrated Water Resources Management and  
Ecosystem based Adaptation in Xe BangHieng River  
basin and Luangprabang City

# Final Technical Report

## on

### Photogrammetry and LiDAR Survey for topographic Map of 15 villages Located at Five Districts, in Savannakhet Province



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## I. History

The UNDP-GEF LDCF “Integrated Water Resource Management and Ecosystem-based Adaptation in the Xe Bang Hieng River Basin and Luang Prabang City” project aims to support the government of Lao PDR to promote the integrated management of land and water resources at target sites in the Xe Bang Hieng River Basin and Luang Prabang City. This will increase the climate resilience of communities to the impacts of floods and droughts - both of which are projected to become more intense and frequent under future climate scenarios. The project will be implemented over the period of four-years from Dec 2022 to Dec 2026 by the Department of Water Resources of the Ministry of Natural Resources and Environment.

The project aims to strengthen the climate resilience of communities in two particularly vulnerable areas of Lao PDR – namely Savannakhet Province and Luang Prabang City – particularly focusing on the impacts of floods and droughts. This improved resilience will be achieved through three complementary project components, specifically:

- Component 1: Developing national and provincial capacities for Integrated Catchment Management (ICM) and integrated urban Ecosystem-based Adaptation (EbA) for climate risk reduction;
- Component 2: Ecosystem-based Adaptation (EbA) interventions, with supporting protective infrastructure and livelihood enhancement; and
- Component 3: Knowledge management and Monitoring and Evaluation

This assignment will be undertaken as part of Component 1 of the project, and will focus on providing key survey data that will later be used to identify flood risk areas at the village community level and as a key data source in developing fine-scale climate-resilient flood management strategies and land use plans for the project’s target communities.

We conducted an aerial survey and ground truth in 15 village area in cloud 15 villages to produce a Digital Terrain model. High definition (DTM). The project will use DTMs to create flood forecast maps and as input material in the development of climate resilience and land use plans for each village.

## II. The Project Purpose

The purpose of the project is to establish GPS ground control points in each project locations to referencing for UAV photogrammetry survey and UAV Lidar survey to create the Topographic Map of village in focus area selection to provide for the Project; Therefore the main GPS ground control points that were install and located of each project areas to use as reference base station for GPS static survey mode, RTK survey, UAV survey, UAV Lidar Survey and for Civil work in the future;

The LiDAR survey plays a crucial role in flood mapping by providing high-resolution topographic data that enhances understanding and management of flood risks. The specific purposes include: DTM, DEM and Contour line;

To generate precise Digital Elevation Models (DEMs) that represent the terrain's surface, which is essential for analyzing floodplain boundaries and understanding water flow dynamics;

To identify areas at risk of flooding by modeling potential flood scenarios based on elevation data, land use, and hydrological factors. This information is critical for disaster preparedness and response planning.

Aerial surveys and mapping assignment will focus on providing key survey data that will later be used to identify flood risk areas at the village community level and as a key data source in developing fine-scale climate-resilient flood management strategies and land use plans for the project’s target communities;

UNIQUESTEK CO., LTD has signed the contract with UNDP to implement the Aerial surveys and mapping of selected 15 village areas in Savannakhet Province under Integrated Water Resource Management and Ecosystem-based Adaptation in Xe Bang Hiang River Basin;

The survey was conducted during the period of time from 25 March 2024 – 30 July 2024 was completed field survey and office work by according to the signed contact agreement between UNDP and UNIQUESTEK co., Ltd, on undertake of Topographic map survey with UAV Mapping and Lidar mapping in 15 village areas selected were **20131** Ha; all survey activities were reference to the National Geodetic Network as coordinate system and Elevation and according to the Survey and Mapping Law of Lao PDR.

### III. The project area

Detail of Target village are given in the following table

No	Village Name	Area Ha	LABEL_POS
1	Sivilai	2,890.00	503973.203,1826946.971
2	Dongmeuang	1,778.50	526608.333,1829765.284
3	Paikha	1,067.70	521881.022,1823656.552
4	Nonesavang	1,658.00	536991.208,1812594.487
5	Songkhone	2,125.60	533827.371,1797180.395
6	Kaengdone	334.53	533968.175,1789254.346
7	Houaykho	1,585.10	547236.498,1788004.879
8	Huanghong	901.47	561000.597,1796212.099
9	Nachany gnai	2,618.80	571549.374,1801917.413
10	Kaenghouapa+Thamae	2,258.50	627570.924,1841537.405
11	Sopsalou	851.42	651769.826,1868510.306
12	Nongvilai	1,752.30	659712.480,1811598.578
13	Tangalai	340.12	662037.539,1804680.657
14	Savu 1	31.73	651509.509,1804035.715
15	savue 2 laboaman	27.81	649625.378,1806778.230
<b>Total Area</b>		<b>20,221.58</b>	

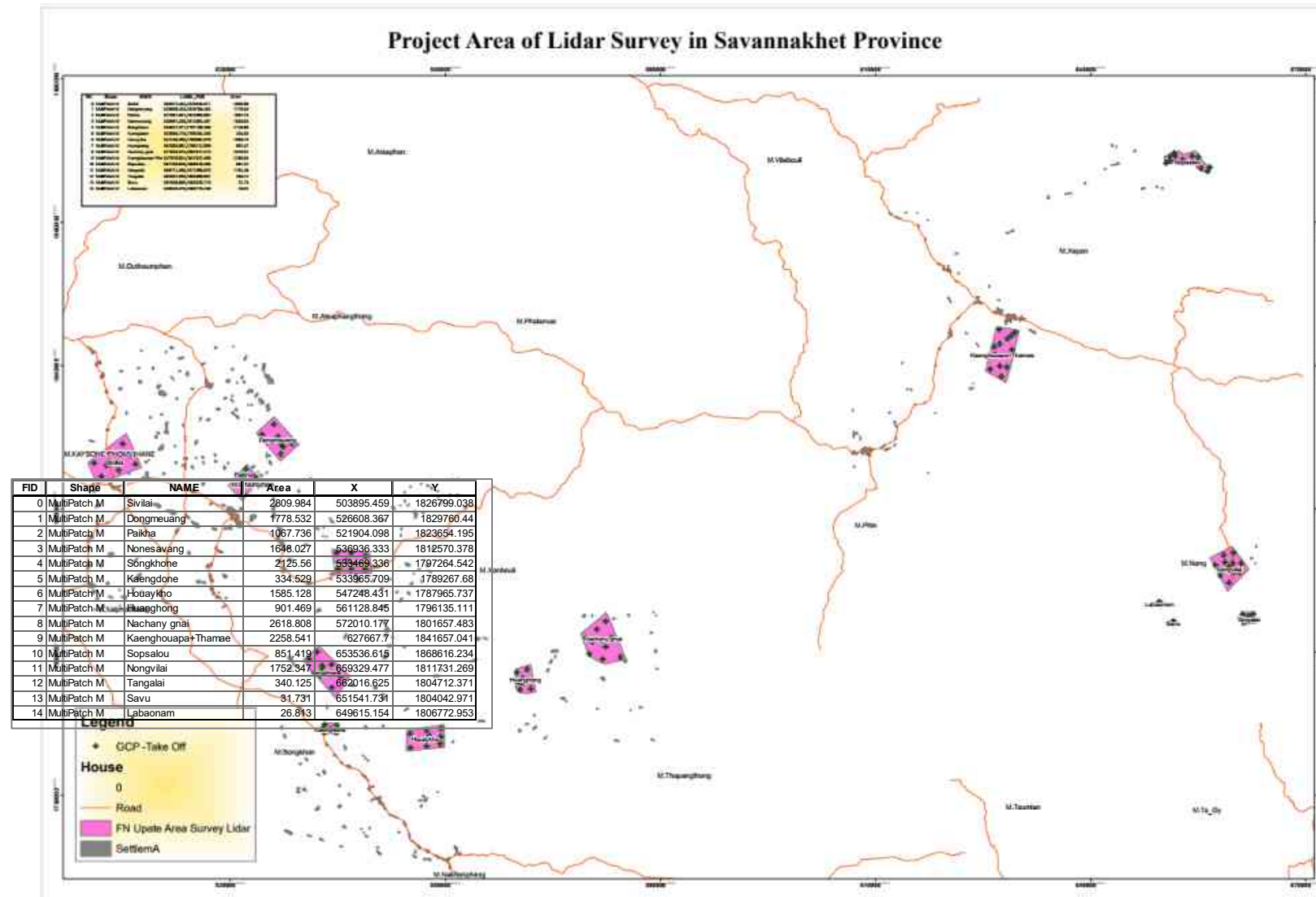


Figure 1: Map of Village Target

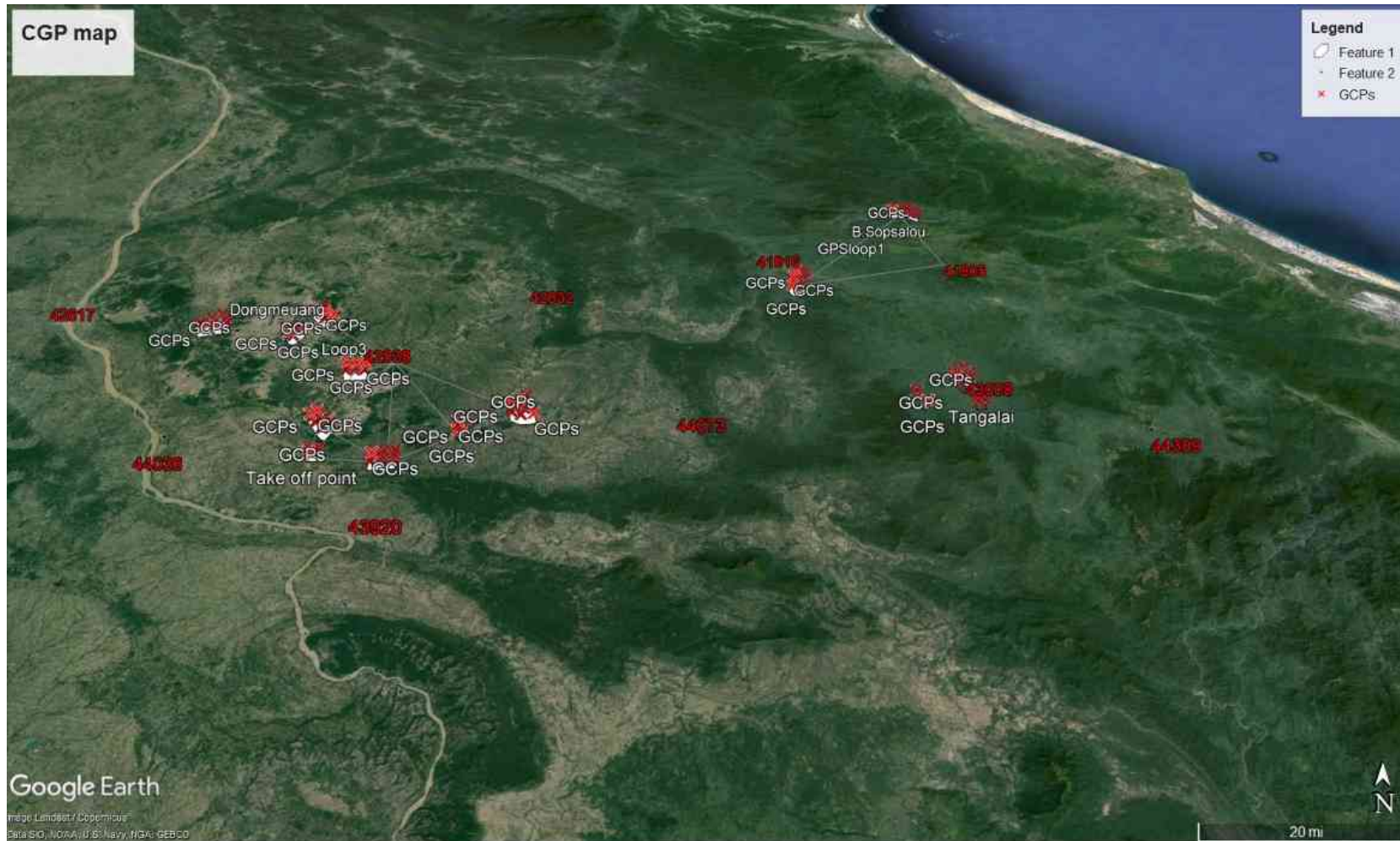


Figure 2: GCP map of Village Targe

## IV. METHODOLOGY

### 4.1 Project Objectives

The project aimed to create a GNSS Ground Control Points, detailed topographic map of the specified area using photogrammetry and LiDAR techniques. Key objectives included:

Accurately capturing terrain features and elevations; Assessing the effectiveness of combining photogrammetry and LiDAR data; Providing a reliable dataset as Orthophoto, DSM, DTM for flood Mapping and future planning and environmental assessments at the selection area in 15 village target area in 5 districts of Savannakhet Province, Lao PDR.

### 4.2 Scope of Survey work

In order to guarantee high positional accuracy According to Project's TOR. We defined the main objectives of this alignment in to 3 objectives:

- Create the Geodetic reference points
- UAV Photogrammetry
- UAV Lidar survey
- Data Analyse and Produce the DTM, point cloud, Orthomosaic, DSM Vertical accuracy 10 cm and GSD 1m or better.

Project Area: in 15 villages in Target Area at Savannakhet Province, with total Area is **20131 ha** Ha = **2012 sqkm** as below:

- Songkone District : 1. Kangdone village , 2. Songkon village, 3. Houaykor village;
- Champhone District: 1. Piaka Village, 2. Dongmeuang Village, 3. Sivilay Village;
- Xonnabouly District: 1. Nachanyai village, 2. Mueanghong village 3. Nonesavang Village;
- Xepon District: 1. Sopalou village, 2. kxanhoupa +Thamae village, 3. thame village;
- Nong District: 1. Nongvilai village, 2. Tangalai village, 3. Savu village and 4. Labaonam village.

### 4.3 Reference Data

#### 4.3.1 Horizontal Datum

The new GPS ground Control Points of each site area were used as the reference station for Photogrammetry survey, UAV Lidar Survey and all Survey in the project area case those points were surveyed and connected, computed to the National Geodetic reference at the five districts in Savannakhet Province; all those points are included in National Geodetic Network of National Geographic Department, Ministry of Home Affairs Lao PDR;

#### **The Lao National Datum 1997;**

which is a local geodetic datum and it is defined by the following parameters.

Spheroid: Krassovsky (a= 6378245,000, b= 6356863.018)  
Flattening:  $f = (a-b)/a$ ,  $1/f = 1: 298.300031662$

Eccentricity: 0.08181333  
Origin Station: Vientiane, Nong teng (GPS 00001)

Since 1997 the Lao National Datum 1997 has been adopted as Horizontal Datum to support of Topographic Survey and Mapping in Lao PDR.

-The transfer parameter format of the Lao national measurement data system in 1997 to the World Measurement Data System WGS 84 has the following:

$\Delta x = + 46.012 \text{ m}$   
 $\Delta y = - 127.108 \text{ m}$   
 $\Delta z = - 38.131 \text{ m}$

### **World Geodetic System (WGS-84)**

The World Geodetic System is Geodetic System which is used for Global Service Coordinates in the World. This system is used as basic for Global Positioning System (GPS) and services in US army and others.

Some parameters of WGS-84:

- Starting coordinates = Center of the earth;
- Major axis a = 6,378,137.0000 m
- Minor axis b= 6,356,752.3142 m
- Flattening  $F_x = 298.257223563$

## **4.4 Procedures of Work Implementation**

### **4.4.1 Installation of permanent ground control points.**

Field reconnaissance to select the points and installation of 15 of GPS ground Control Points in each project location of 15 villages area were done by Team survey of UNIQUESTEK.Co.,LTD, Therefore, the description of GPS ground control points were then prepared and show in Annexes in each site are;

### **4.4.2 Conducting GPS observation.**

a. The task of measuring the point of view.

In the measurement in each site area we were select the good place to install and observation new GPS Ground Control Points by Operating reference from the National Geodetic Network on 1<sup>st</sup> order of Lao PDR; the measurement took more than 02 hours per each session, in the data recording taking the national coordinate point 1 order as Number BM NGD 41805 that located at the Primary school of slan village, Xeopon District; the BM NGD 43008 located at Nongvilai village inside the Nong District's head office; the BM NGD 42838 located at Xonbouli District and BM NGD 43920 located at Songkhon District, Savannakhet Province, The GNSS observation Used 4 of National Geodetic Control points to transfer coordinate and Elevation into the new control points as 15 GPS ground control points.

The GPS observation was applied in accordance with the session planning and prepared by the survey team of Uniqtek survey team by followed Quick Start Program which is automatically run and recording



## 4.5 LiDAR Collection.

LiDAR data consists of an array of return times for reflected light pulses that are mapped with very precise latitude and longitude coordinates. The return times correlate to the elevation of the reflecting surface. Thus, each reflection (e.g. return) is represented as a precise point with latitude (x), longitude (y), and elevation (z) coordinates. The array of points is referred to as a point cloud which consists of all the reflections of the survey. The most distinct returns in the cloud are the first returns which may have reflected off of tree tops, water, or the ground. In forested areas, the first returns compose the canopy surface. Last returns typically are reflections off the ground unless blocked, which may occur in thick forest settings where the only remedy is to survey at a very high laser pulse rate to ensure a minimal number of ground returns. Before we were collected data by lidar we were created the GCP that can cover the Project area Because GCP it gives position and to improve Spatial Accuracy of Survey and Checking the point.

LIDAR works by pointing a laser at a target surface on the ground; The surface reflects the light back to the LIDAR equipment, and the sensor records the reflected light to measure the distance traveled. This data is then combined with the position and orientation of the LIDAR equipment, which is measured using the GPS receiver and internal measurement systems. This creates a set of three-dimensional spatial coordinates that include latitude, longitude and height, creating a combination of data that is called a point.

When land surveying with LiDAR, the LiDAR equipment collects innumerable points using the measurement methods described above. This collection of points is called a “point cloud.” This “point cloud” is what a LIDAR survey is conducted for it is the crucial data that companies use to create 3D models of the terrain that they are working with.

### 4.5.1 Conduction of UAV Ground control points (GCP)

Ground control points (GCP) are points of known coordinates in the area of interest which can be easily identifiable in photographs taken from a UAV (Figure 3). GCPs will increase the absolute accuracy and they can be either natural high-contrast points on the ground (e.g., the corner of a road marking, manhole covers etc.), or artificially marked GCPs. These are commonly measured with survey grade GPS. A ground control is required to calculate the scale, orientation, and absolute position information of the products for increased accuracy;

Our UAV which will be used in this project is equipped with a high precision GNSS unit which the positional data can be applied to process the images through a direct geo-referencing method which will generate high accurate map products with a minimal ground control. The ground control in this project will be used to add more accuracy to the maps as well as to verify the geographic accuracy of the final products. The GCPs will be distributed evenly throughout the area and will be measured with a survey grade GNSS unit.



Figure 3: Collect GCP before flight

The image acquisition will be done simultaneously with a fleet of UAVs covering study areas. In general, the flights are done at the same time of day preferably noon as the shadows are minimum and there is adequate light. The missions will be pre-designed according to the flight plan and uploaded and executed on site. A UAV operation checklist will be used to ensure a safe flawless flight. As safety is the primary concern during every UAV flight all the aircraft will be continuously monitored during the autonomous flight using long-range radio communication with the ground control station.

#### 4.5.2. Preparation for Flight Planning

Designing and executing a good image acquisition plan is the most important part of any aerial mapping project as the ultimate success of any photogrammetric project depends more upon good quality photography than on any other aspect. If the collected dataset is insufficient in quality, it will lead to poor results and even a total failure in processing. A flight plan (Figure 4) generally consists of two items (1) a flight map, which shows where the photographs are to be taken, and (2) specifications, which outline how to take them, including specific requirements such as the camera requirements, scale, flying height, end lap, side lap, etc. UAV mapping missions are usually flown in a specific pattern of parallel lines, commonly described as transects, which are connected to a series of waypoints.

Planning an UAV mission to survey a large area is a challenging task. As the flying will be done autonomously, the very first step is to understand the area properly. The area to be mapped will be analyzed using existing satellite images to get an overall picture about the area and terrain and then a proper reconnaissance survey will be conducted to identify obstacles such as power lines, variation of terrain elevation, sensitive areas (airports, no-fly zones), or other potential pitfalls (birds). The reconnaissance will also benefit in identifying potential launching

and landing sites and to establish the ground control. The area will be covered with a several identical mapping UAVs.

Attitude 238 m  
Speed 10m/s  
Side Overlap 70%, Fronts Overlap 80%  
Estimated Time 55 minuet Per Flight



Figure 4: Flying plan one of the site areas as in SongKhone Village, SongKhone District  
(For detail Flight plan Show in Annex of each site area)

## 4.6 Data Processing

### 4.6.1. DTM Generation from Photogrammetry

There are several methods in photogrammetry for processing aerial photo data to produce DEM, namely by stereo mating and stereo plotting. In this project the method used is stereo plotting. Interactive stereo plotting is done by means of 3D digitization on stereo software. The Exterior Orientation Parameter value is required for stereo plotting to be performed. The EOP value can be obtained in two events, namely the Aerial Triangulation (AT) stage and the Relative Orientation (RO) stage.

The EOP value obtained through the AT stage requires Bundle Adjustment software such as PCI Geomatics, Inpho, and so on. The process of making DEM using AT is easier because the EOP value is obtained without carrying out the Relative Orientation (RO) stage. This project uses a method to obtain EOP through the Relative Orientation process which goes through several processes, namely, Interior orientation, Relative Orientation, and Absolute Orientation. The software used to get the EOP value is DAT/EM. Here's a workflow for getting DTM via stereo plotting.

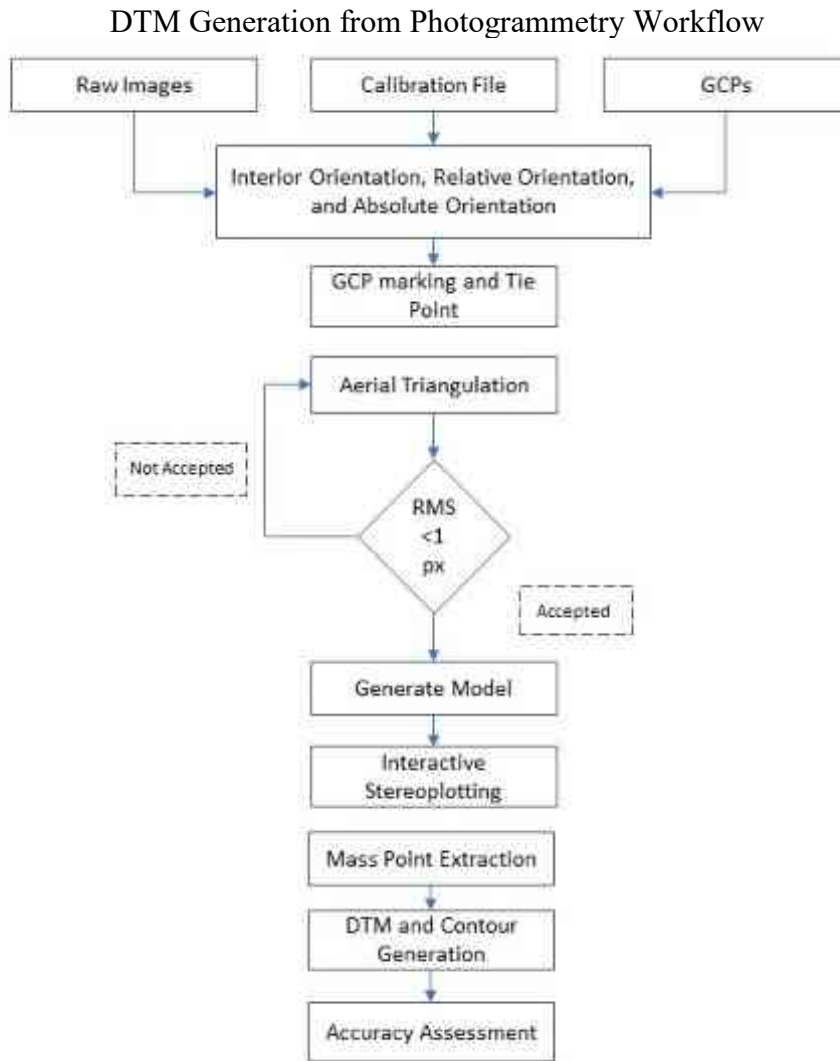


Figure 5: Processing steps on DTM Generation from Photogrammetry

#### 4.6.2. DTM Generation from LiDAR

To get accurate results for flood modeling, accurate altitude data is needed, especially in urban areas which are places that are directly affected by floods. With accurate DTM data, it can be seen which areas are affected so that preventive actions can be taken. Therefore, lidar data is needed in urban and surrounding areas;

DTM is generated through RAW LiDAR data filtering activities which still consist of DSM where there is still ground and other (non-ground) objects. Filtering is used to remove non-ground LiDAR point so that bare earth digital elevation model can be created from remaining ground LiDAR points. The design of filtering algorithm usually base on two criteria 1) the ground has the lowest elevation compare to object above it, and 2) elevation and slope change more slowly for bare earth than DSM. In this project using TIN base method, where TIN is a vector-based data structure for representing continuous surface. TIN is well suited for constructing terrain surface from LiDAR because 1) LiDAR points are often irregularly distributed due to variations in scan angle, attitude (pitch, yaw, and roll) of the UAV, and overlap between flight line, 2) adding or removing points into TIN can be implemented locally without reconstructing the whole TIN, 3) the speed of constructing TIN is usually much faster than the grid-based interpolation method. Here the workflow for get accurate LiDAR data.

### DTM Generation from LiDAR Workflow

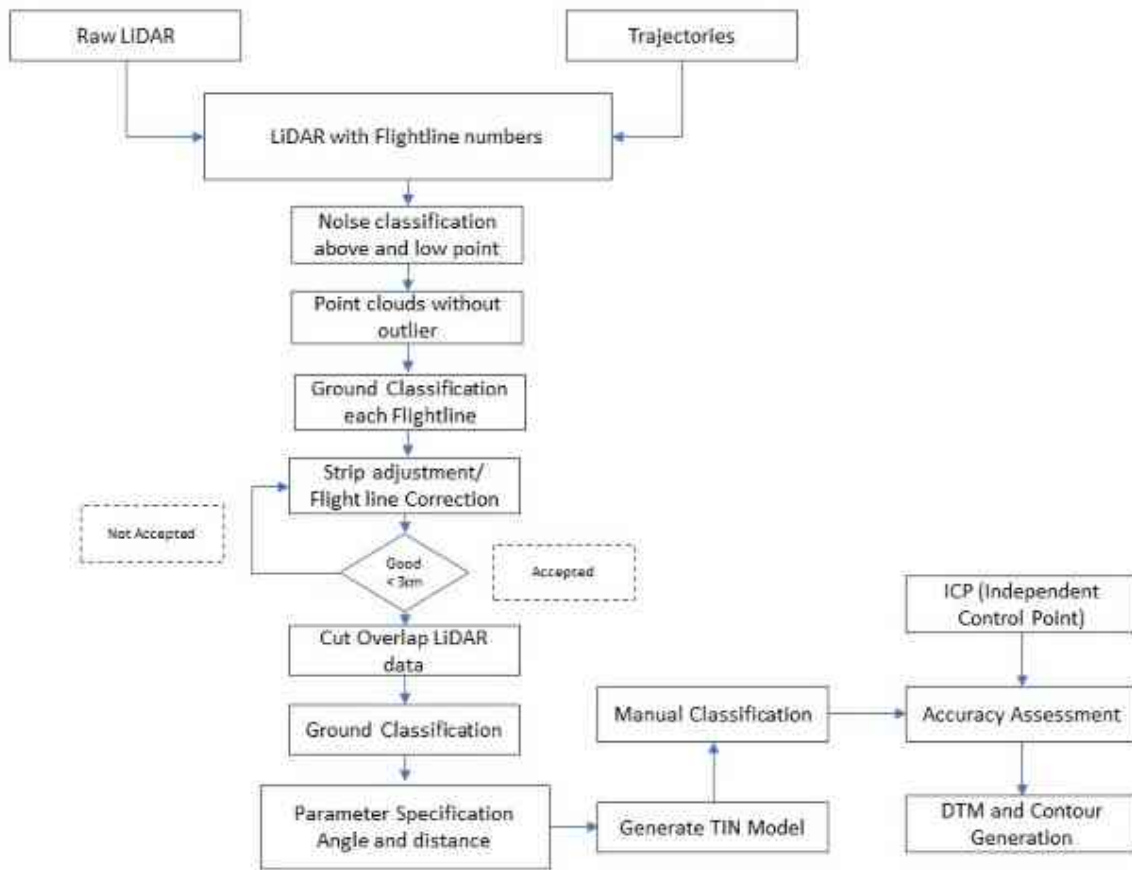


Figure 6: Processing steps on DTM Generation from LiDAR

On completion of the classification, the data is passed to our internal quality control, a project manager, who will run a Quality Control check on the data by generating contours. Our internal QC will check that the contours run in a fashion that is consistent with the terrain being mapped. If errors are found, then the tiles are returned to be reclassified. If they pass the QC check then the data is output to the files to be delivered.

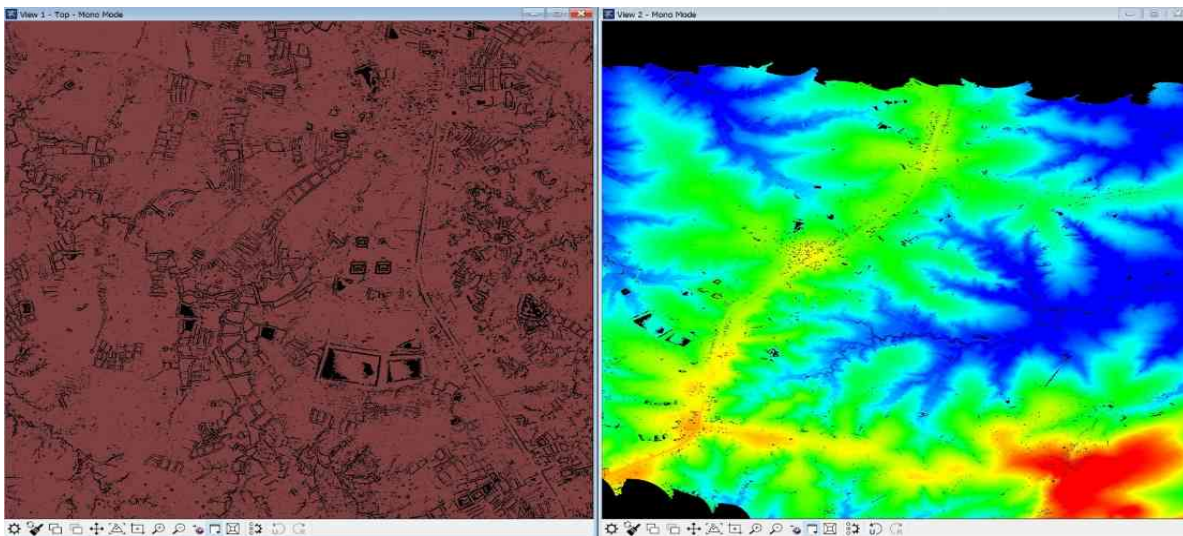


Figure 7: Classification Result

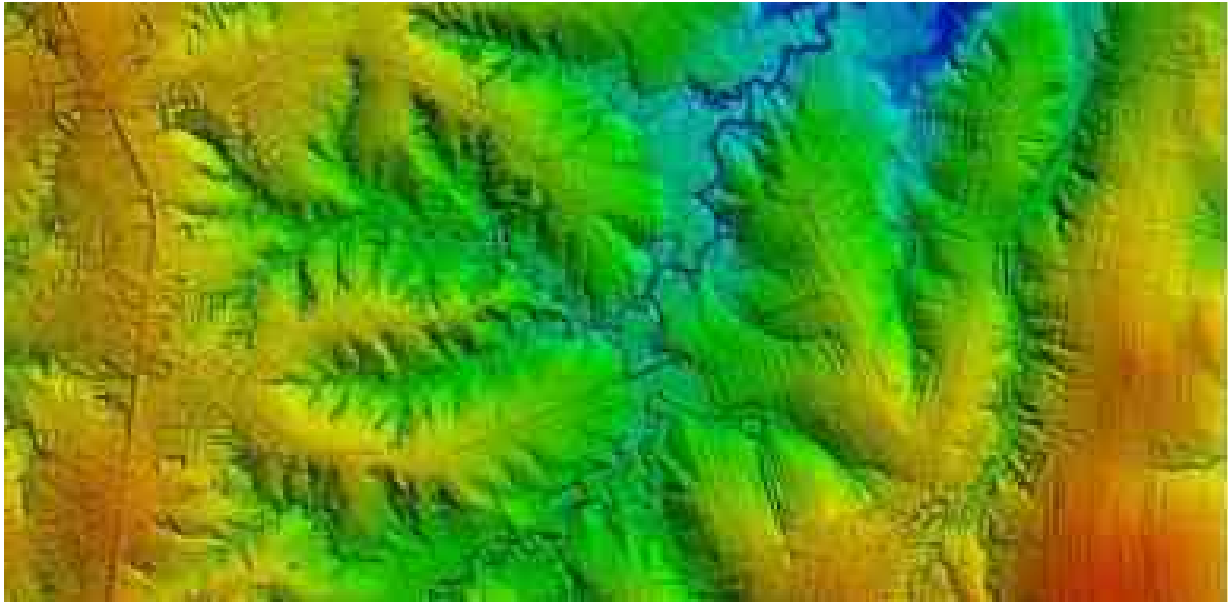


Figure 8: Digital Elevation Model: DEM) obtained after processing

After the classification process, we are able to generate DEM (DSM and DTM). A Digital Terrain Model (DTM) is a representative of the ground class by removing the noise and outliers at first. Contrary to DTM, a Digital Surface Model (DSM) is produced from all the point clouds above the ground

#### ➤ **Integration the DTM From LiDAR and Photogrammetry**

The process of DTM fusion involved the enhancing of accuracy UAV orthophoto DTM by anchoring to high accuracy LiDAR DTM. The UAV photogrammetry DTM accuracy is  $\pm 30$  cm while the LiDAR DTM accuracy is  $\pm 15$  cm. The DTM fusion process flow can be seen in Figure 12. The process started with the addition and reproject of both DTM where the elements of projection and vertical datum being synchronized. The resampling process takes part after reproject to make sure the DTM has controlled pixel size, vertical value, and horizontal value. After that, the blending distance was conducted to make sure the fused DTM has a seamline appearance minimize for the quality check. Lastly, resampling can be done to generate fused DTM based on UAV and LiDAR DTM products.

#### ➤ **Accuracy Assessment**

LiDAR UAV is relatively new technology. As such, there is healthy skepticism about its ability to provide x,y, and z elevation information as accurately as traditional in situ surveying and photogrammetry. To determine the accuracy of the LiDAR derived digital surface model (DSM) or bare earth digital terrain model (DTM), it is customary to identify in situ x,y,z check point, throughout the study area using a higher accuracy technique, such as total station or GPS geodetic. The nearest LiDAR information is then compared with location and elevation information associate with in situ checkpoint. The perform for a number checkpoint. The results are then used to compute the horizontal and vertical accuracy of the LiDAR data express as root mean square error. (RMSE)

##### a) Root means square error (RMSE)

According to the Technical guidance of Surveying, Mapping, and Aerial Photography, 2016. U.S. Department of the Interior. The Root Mean Square Error (RMSE) mostly used for

topographic survey accuracy allowable checking work as field data survey of GPS RTK comparing with the DEM data value. The square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points. The RMSE is used to estimate the absolute accuracy of both horizontal and vertical coordinates when standard or accepted values are known, as with GPS-surveyed check points of higher accuracy than the data being tested. The standard equations for calculating horizontal and vertical RMSE are provided below:

- RMSE, the horizontal root means square error in the x direction (easting):

$$\sqrt{\sum \frac{(x_n - x'_n)^2}{N}}$$

Where

$x_n$  is the set of N x coordinates being evaluated,

$x'_n$  is the corresponding set of check point x coordinates for the points being n evaluated,

N is the number of x coordinate check points, and

n is the identification number of each check point from 1 through N.

- RMSE, the horizontal root means square error in the y direction (northing):

$$\sqrt{\sum \frac{(y_n - y'_n)^2}{N}}$$

Where

$y_n$  is the set of N y coordinates being evaluated,

$y'_n$  is the corresponding set of check point y coordinates for the points being n evaluated,

N is the number of y coordinate check points, and

n is the identification number of each check point from 1 through N.

- RMSE, the horizontal root means square error in the radial direction that includes both x r and y coordinate errors:

$$\sqrt{(RMSE_x^2 + RMSE_y^2)}$$

Where

RMSE<sub>x</sub> is the RMSE in the x direction, and

RMSE<sub>y</sub> is the RMSE in the y direction

- RMSE, the vertical root means square error in the z direction (elevation):

$$\sqrt{\sum \frac{(z_n - z'_n)^2}{N}}$$

Where

$z_n$  is the set of N z values (elevations) being evaluated,

$z'_n$  is the corresponding set of check point elevations for the points being  $n$  evaluated,  
 $N$  is the number of  $z$  check points, and  
 $n$  is the identification number of each check point from 1 through  $N$ .

The standard recommends that minimum of 20 checkpoints should be used, for i.e.,  $n > 20$  checkpoints should be of substantially higher accuracy than remote sensing data derived product under investigation.

It is assumed that systematic errors have been eliminated as best as possible. If vertical error is normally distributed, the factor 1.9600 is applied to compute linear error at the 95% confidence level (Greenwalt and Schultz, 1968). Therefore, vertical accuracy, Accuracy  $z$ , reported according to the NSSDA shall be computed by the following formula: Accuracy = 1.960 \*RMSE $z$ .

## V. Deliverables

The following will be the standard deliverables for the project.

- Inception Report (geographical area, flight plan)
- ASCII files (.txt) and geo-tiff contains easting, northing, and elevation coordinates of classified ground strikes, **defining the Digital Terrain Model (DTM)**.
- ASCII files (.txt) and geo-tiff contains easting, northing, and elevation coordinates of first return data, **defining the Digital Surface Model (DSM)**.
- Supply ortho-rectified and geo-referenced RGB color digital mosaic images over the surveyed area. The image will be delivered as digital **ECW** files format.
- A final report covers details of data capture, survey datum, achieved accuracy (comparison with the LiDAR DTM and the measured ground points), GPS control stations, and desired results.

## VI. Result

### Lidar data and Lidar Point Cloud

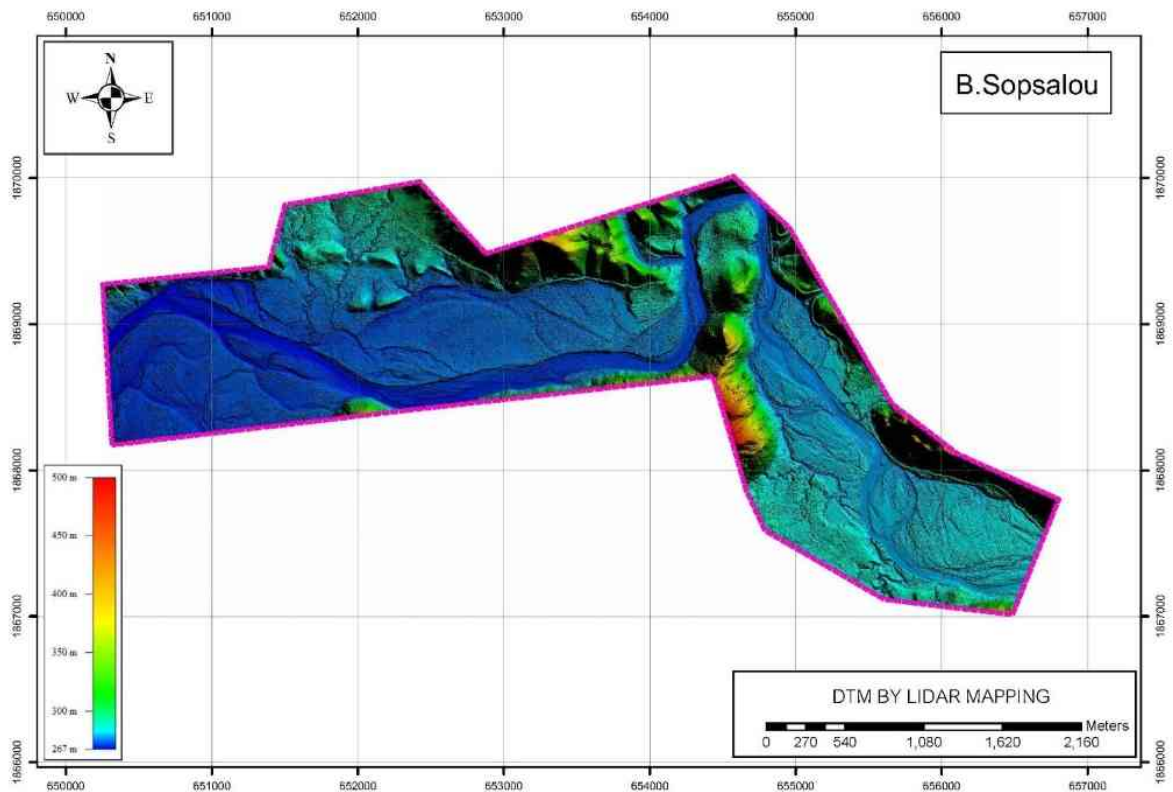


Figure 9: Digital Elevation Model: DEM) obtained after processing Sopsalou village

### Data of Orthophoto



Figure 10: Digital Elevation Model: DEM) obtained after processing Sopsalou village

## Contour Map Data

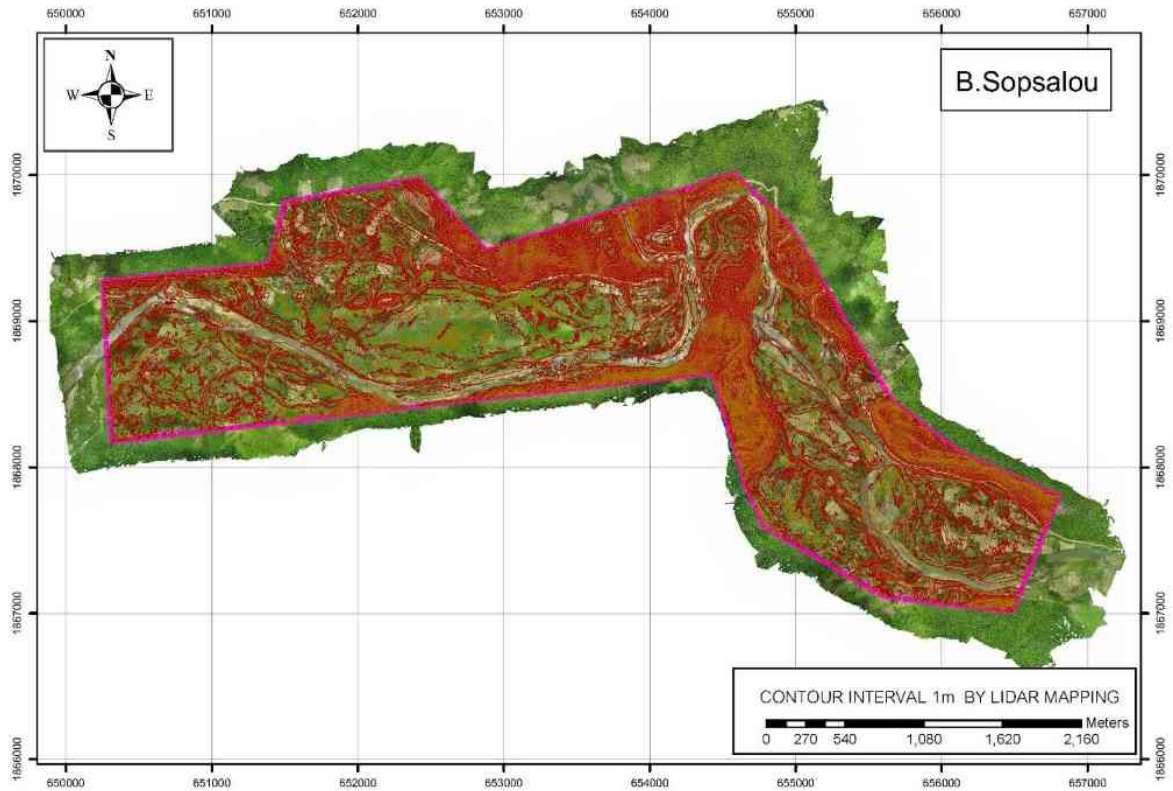
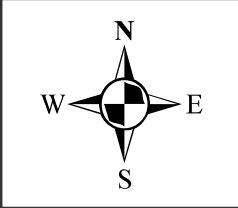
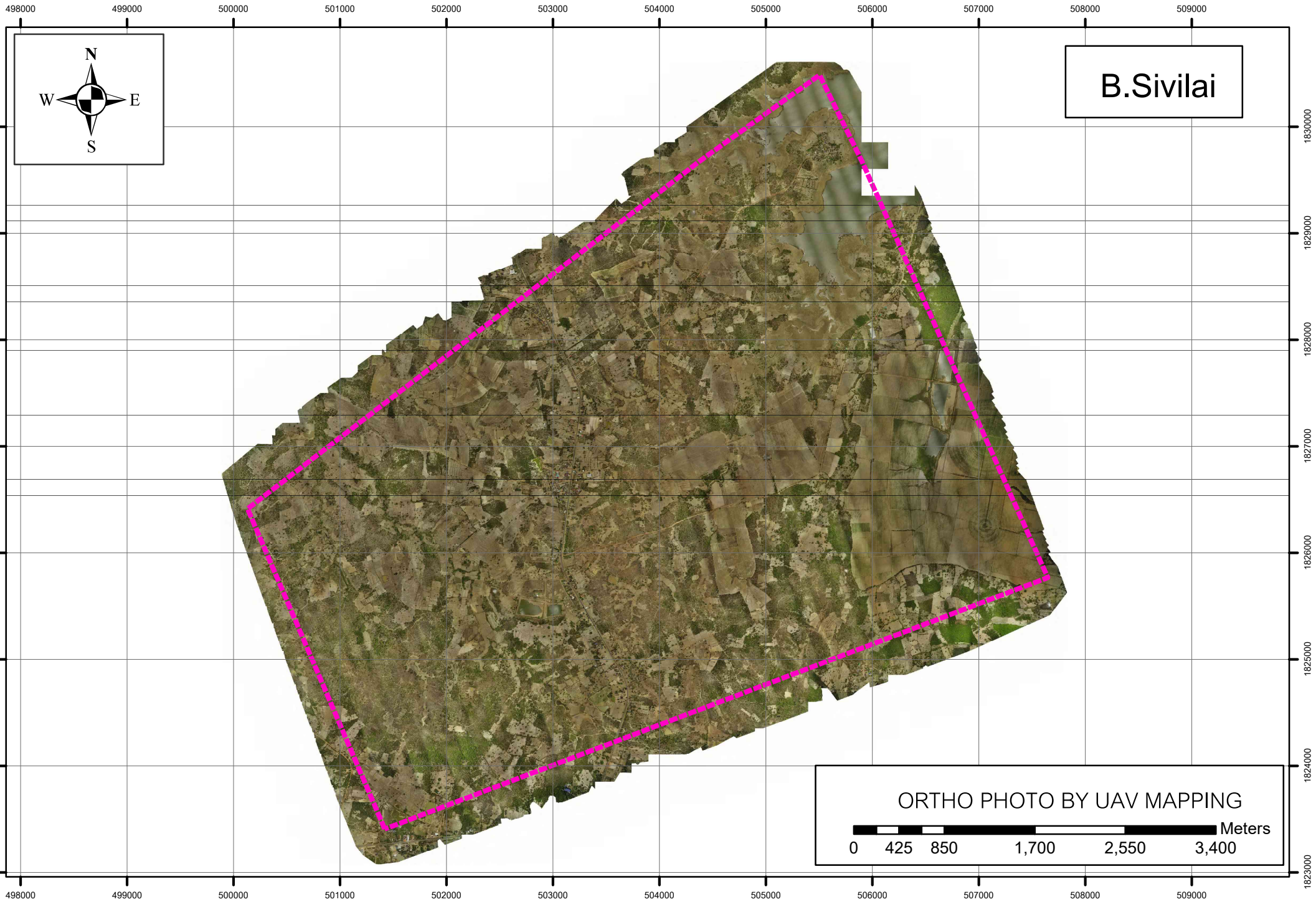
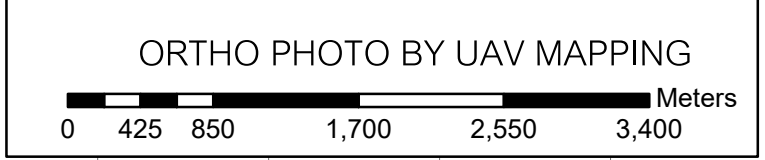
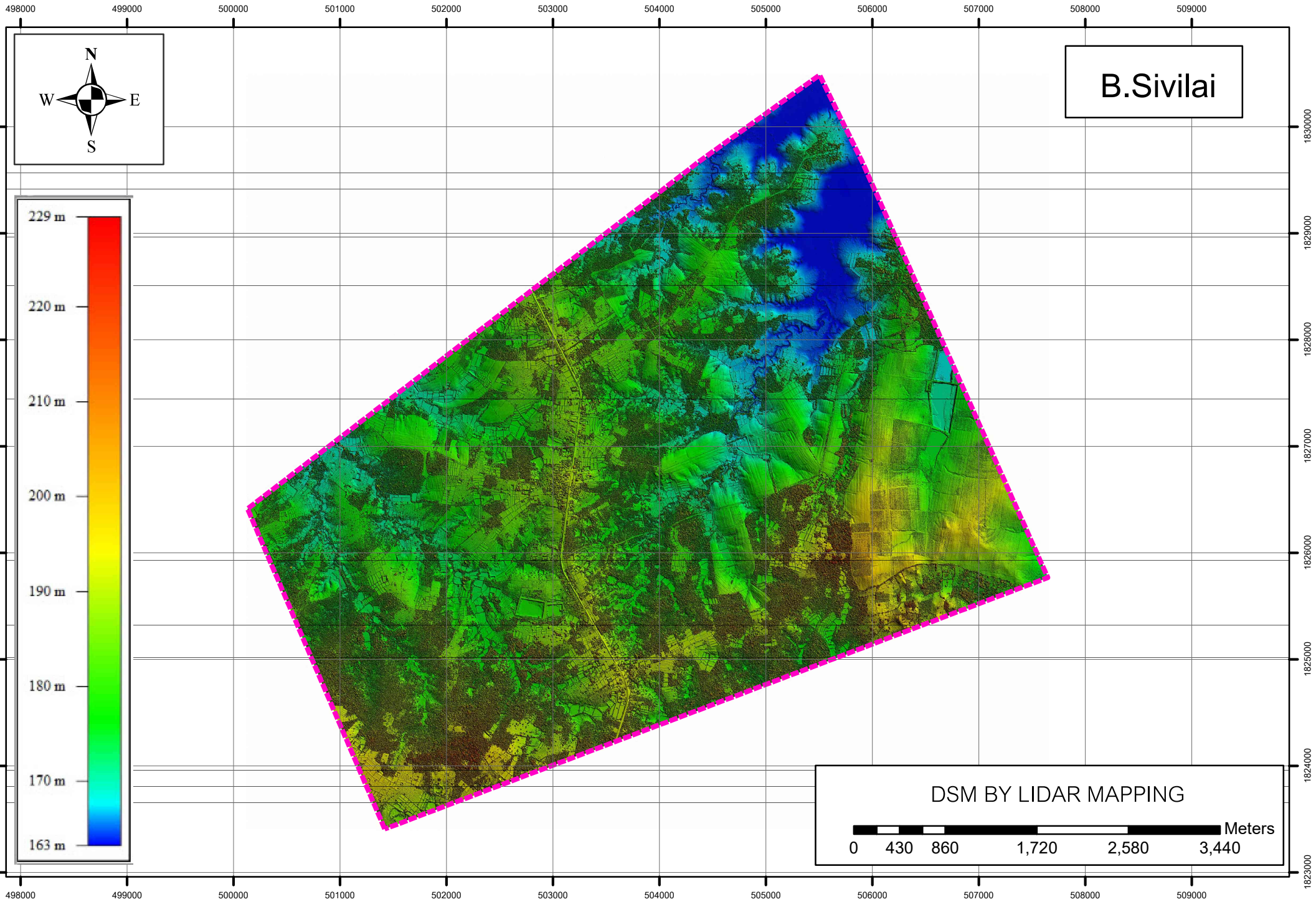


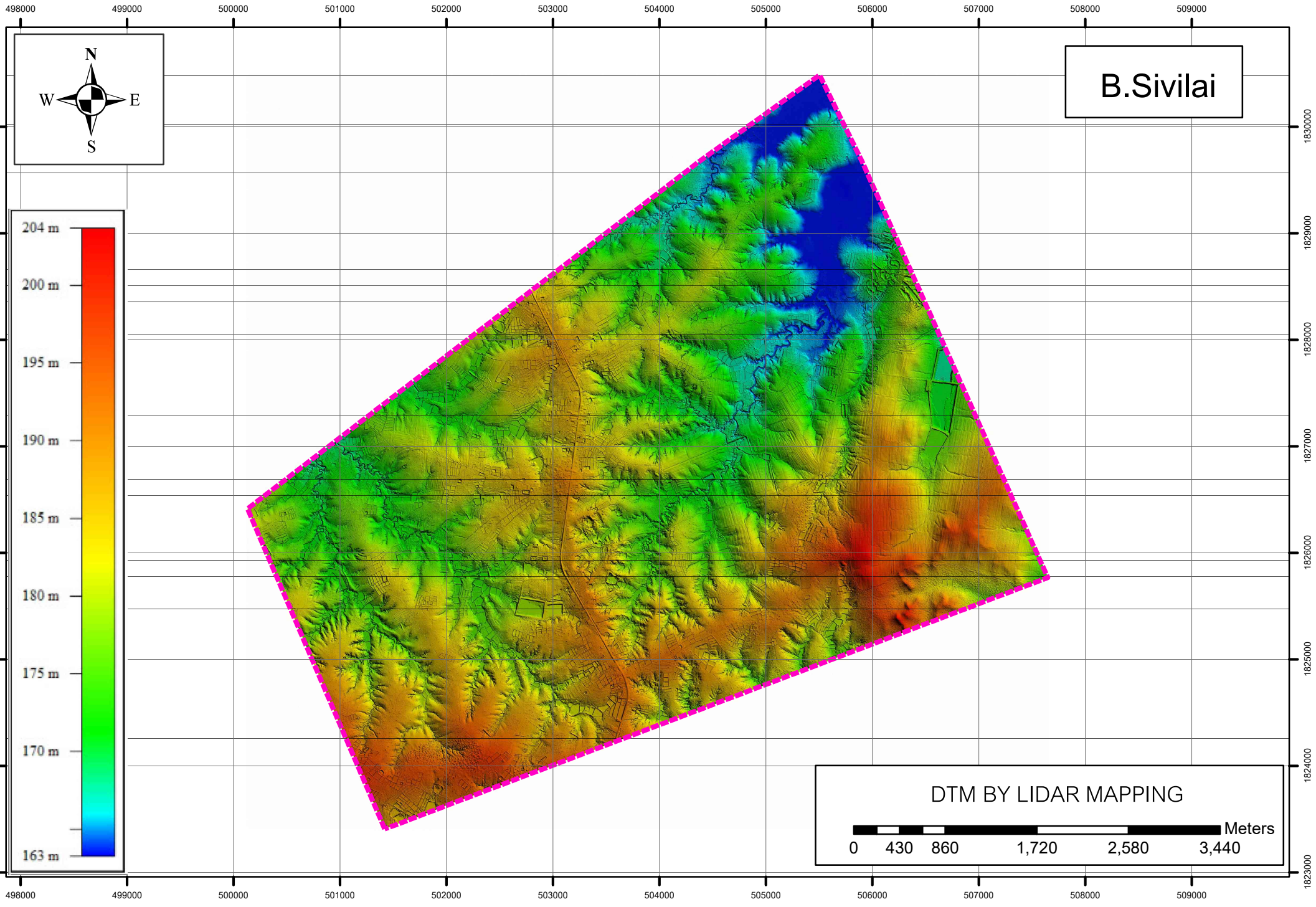
Figure 11: Digital Countour Map Sopsalou village  
(For All Detail Result of data show in Annex of Each site Project)

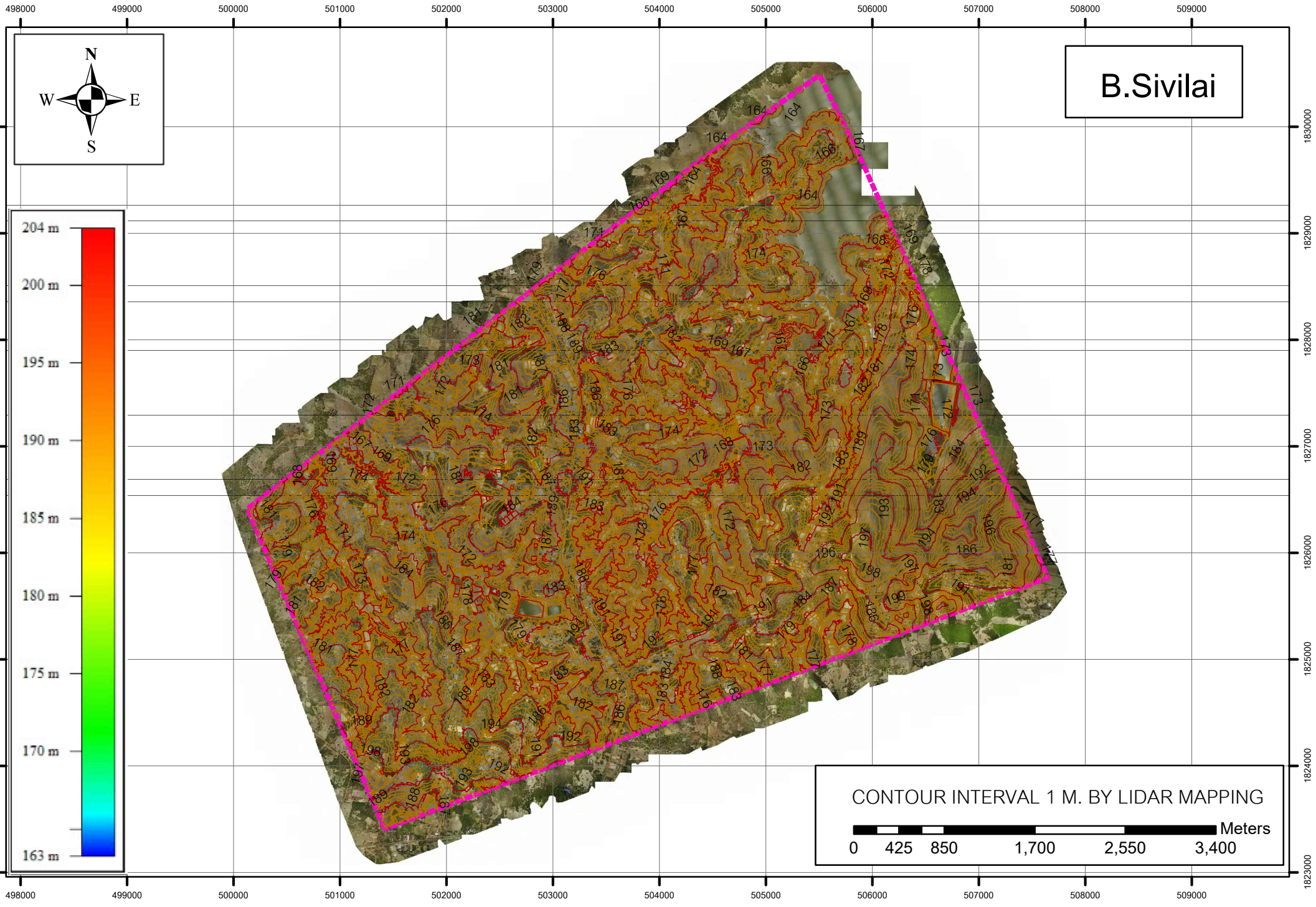


B.Sivilai

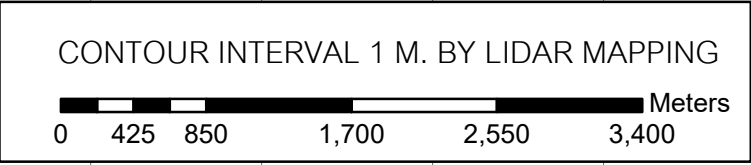
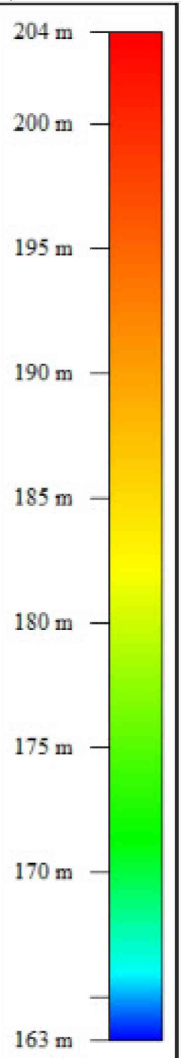








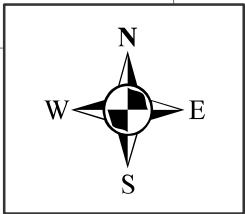
B. Sivilai



520000 520750 521500 522250 523000 523750 524500

1827250  
1826500  
1825750  
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1820500

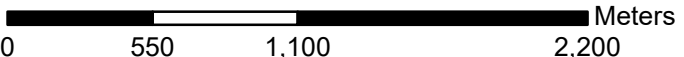
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1822750  
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1820500



B.Paikha

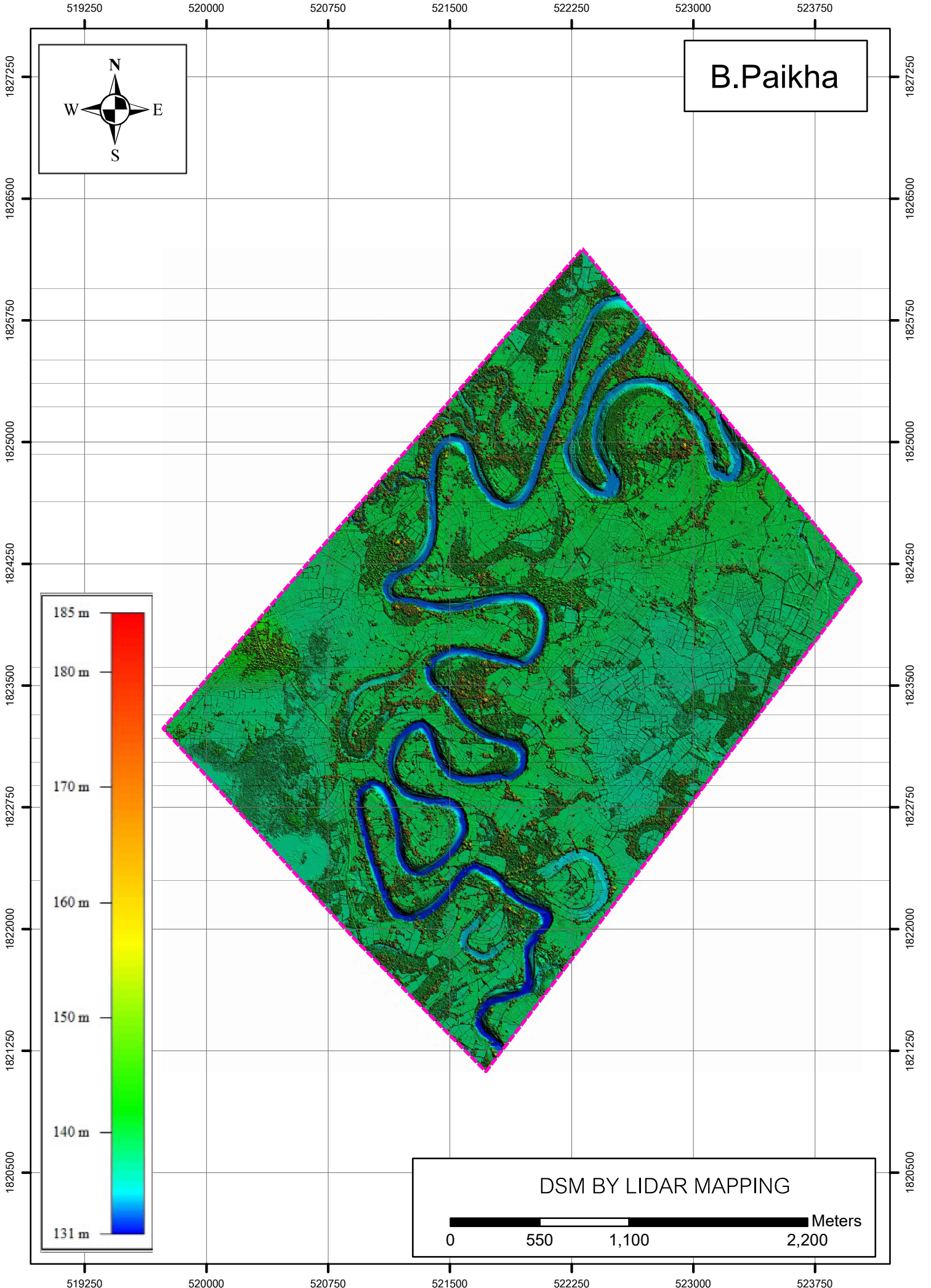


ORTHO PHOTO BY UAV MAPPING

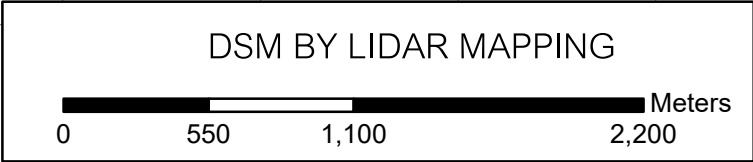
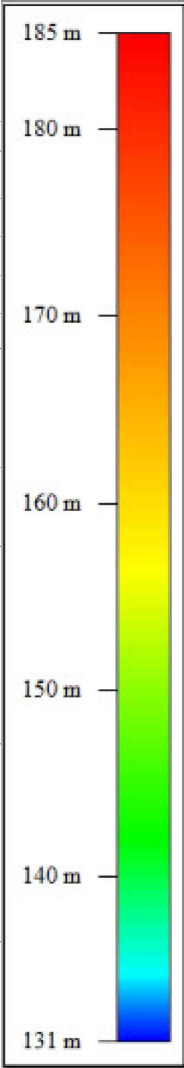


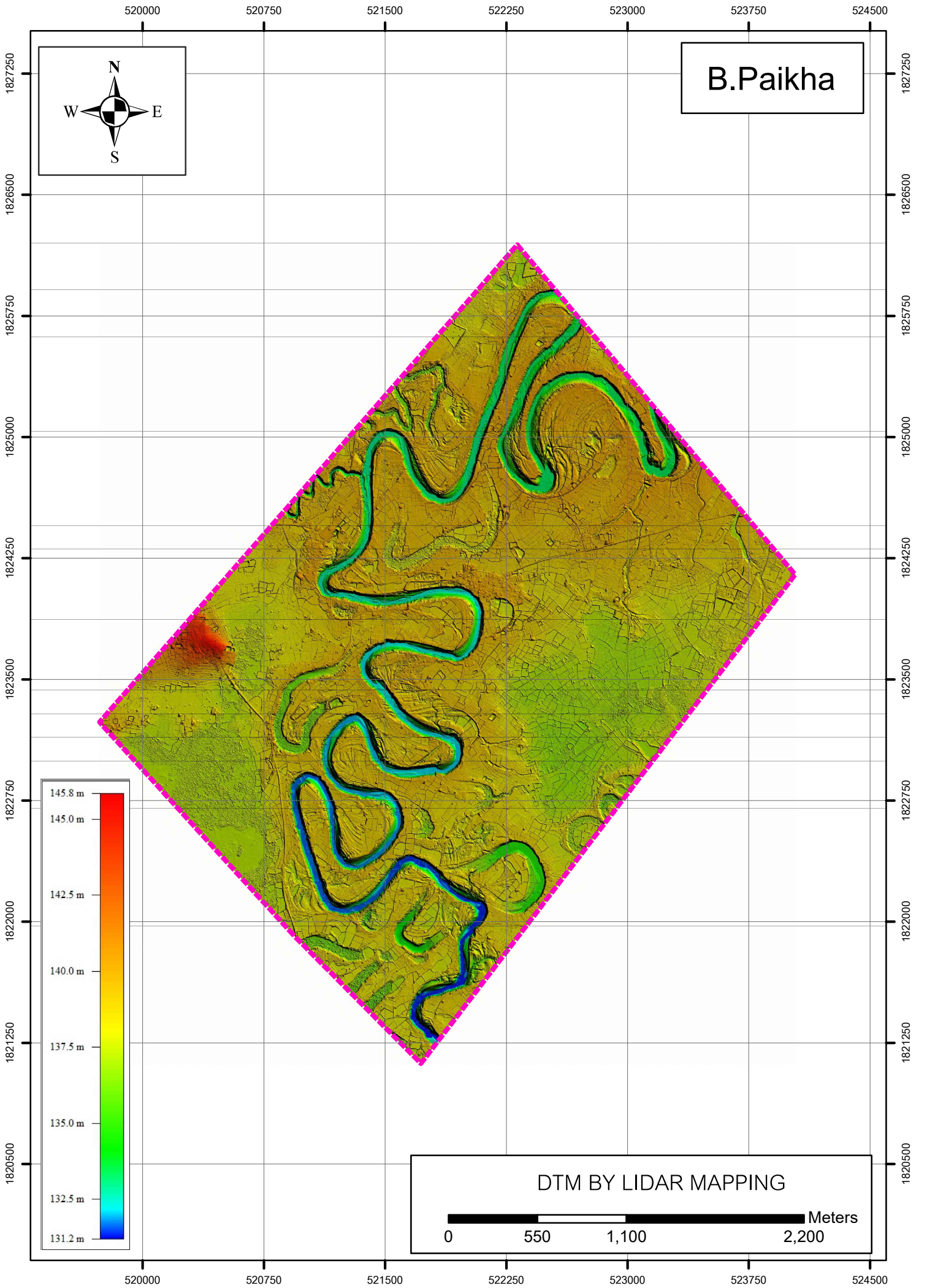
Meters

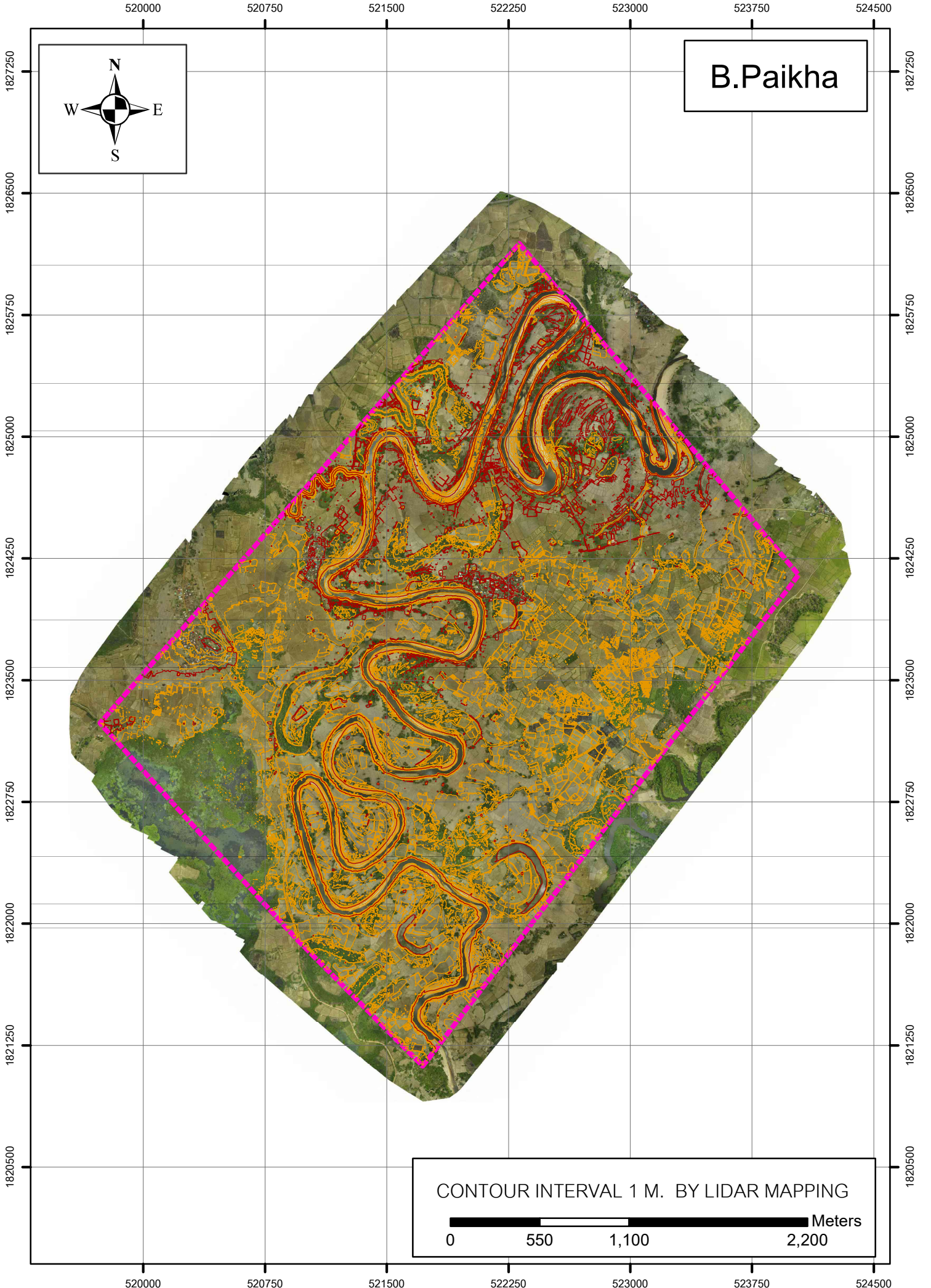
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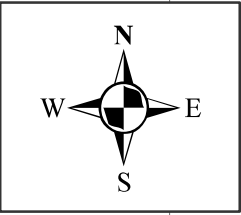
B.Paikha







B. Paikha









CONTOUR INTERVAL 1 M. BY LIDAR MAPPING




0 550 1,100 2,200 Meters

## VII. List Survey Equipment and Software Processing Available for the project

### 7.1 Hardware

No	Description	Manufacture	Brand/model /Capacity	Qty	Remark
1	<p><b>CHC i80 GNSS</b> <b>RTK i80</b></p> 	China	<p><b>CHC i80 GNSS</b> Real Time Kinematics (RTK) <b>Horizontal:</b> 8mm+1ppm RMS <b>Vertical:</b> 15mm+1ppm RMS Initialization Time:&lt;5s <b>Trimble Board BD970</b></p>	<b>06 sets</b>	With complete accessories good condition
2	<p><b>CHC i50 GNSS</b></p> 	China	<p>CHC i50 GNSS Real Time Kinematics (RTK) Horizontal: 8mm+1ppm RMS  Vertical: 15mm+1ppm RMS  Initialization Time:&lt;10s Processing Static  Horizontal: 3mm+0.5ppm RMS Vertical: 5mm+0.5ppm RMS</p>	<b>04 sets</b>	With complete accessories good condition
3	<p><b>JOUAV</b></p> 	China	<p>JO UAV CW 15 + MMW radar obstacle avoidance for forward and bottom detection + Binocular vision sensing + ADS-B situational awareness system + Point-to-point topographic-match intelligent flight Aircraft-grade reliability + Multi-sensor redundancy + Full digital bus avionics technology Endurance: 180-minute + Operation range:180 kilometer + Payload : 3kg + Max. Takeoff Altitude : 4500m</p>	<b>01 set</b>	With complete accessories good condition

4	<p style="text-align: center;"><b>Drone M300</b></p> 	China	<p>Matrice 300 RTK DJI</p> <ul style="list-style-type: none"> <li>- payloads simultaneously, with a maximum payload capacity of 2.7 kg.</li> <li>- Max flight time 55 min</li> <li>- Max speed 23m/s</li> <li>- Service Ceiling 7000m</li> <li>- Wind Resistance 15m/s</li> <li>- Transsion Rang 15 Km</li> <li>- Real time 2.4/5.8 GHZ RTK Positioning Accuracy</li> <li>- 1 cm+1 ppm (Horizontal)</li> <li>- 1.5 cm + 1 ppm (Vertical</li> </ul> <p>GNSS GPS+GLONASS+BeiDou+Ga lileo</p>	<b>03 sets</b>	With complete accessories good condition
5	<p style="text-align: center;"><b>Leica Sprinter 150 M</b></p> 	Switzerland	<p>Height accuracies: Standard deviation height measurement per 1 km double run (ISO 17123-2)</p> <p>Distance accuracies: Standard deviation distance measurement</p> <p>10 mm for D = 10 m and (Distance in m x 0.001) for D &gt; 10 m</p> <p>Optical measurement: With standard aluminum E-scale</p> <p>/Numeral staff: 2.5 mm</p> <p>Measuring modes: Single and Tracking</p> <p>Data storage: up to <b>1'000 points (only 150M)</b></p>	<b>01 set</b>	With complete accessories good condition
6	<p style="text-align: center;"><b>CHC D390 Echo Sounder</b></p> 	China	<p>Frequency: 200 kHz</p> <p>Output Power: 500 W RMSmax</p> <p>Depth Range: 0.15 m to 300 m</p> <p>Accuracy: <math>\pm 0.01 \text{ m} + 0.1\%</math> of depth</p> <p>Resolution: 0.01 m</p> <p>Sampling Rate: Up to 60 Hz</p> <p>Draft Adjustment: 0 m to 9.9 m</p> <p>Sound Velocity Adjustment: 1300 m/s to 1700 m/s</p>	<b>01 set</b>	With complete accessories good condition (Use case if project cover the river)

7	<p>Zenmuse P1 DJI</p> 	China	<ul style="list-style-type: none"> <li>- Accuracy without GCPs 3 cm horizontally / 5 cm vertically</li> <li>- High Efficiency 3 km2 covered in a single flight</li> <li>- <b>45 MP Full-frame Sensor</b></li> <li>- 3-axis Stabilized GimbalSmart Oblique Capture</li> <li>- Global Mechanical Shutter Speed 1/2000 Seconds</li> <li>- TimeSync 2.0 – synchronization at the microsecond level</li> </ul>	01 set	With complete accessories good condition
9	<p>ZenMuse L1 Lidar + RGB</p> 	China	<ul style="list-style-type: none"> <li>- Integrates a Lidar module an RGB camera, and a high-accuracy IMU</li> <li>- High Efficiency2 km2 covered in a single flight</li> <li>- High Accuracy Vertical Accuracy: 5 cm / Horizontal Accuracy: 10 cm</li> <li>- Point Rate: 240,000 pts/s</li> <li>- Supports 3 Returns</li> <li>- Detection Range: 450 m</li> <li>- IP54 Ingress Protection Level</li> <li>- Point Cloud LiveView</li> </ul>	02 sets	With complete accessories good condition
10	<p>Computer PC</p> 	This build is designed	<p>Processor (CPU): Intel i9-12900K          CPU Cooler: Fractal Design Celsius S36 Blackout          Motherboard: GIGABYTE Z690 AORUS ELITE AX          Memory: Kingston Fury Beast 2x32GB DDR4-3200          Storage (SSD): Kingston KC2500 500GB          Storage (SSD): Kingston KC2500 1TB          Video Card (GPU): NVIDIA RTX A5000 24GB          Power Supply (PSU): Enermax Revolution DF 850W 80+ Gold</p>	02 sets	good condition

			Case: Corsair 4000D Airflow Black Fans: 6x Noctua NFF12 PWM Black		
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## 7.2 Software List:

NO	Name	Qty	Band
1	Pix4D mapper Software	1	Pix 4
2	Land Star7 Software	8	CHC
3	ArcGIS Desktop	1	ESRI
4	CGO	3	CHC
5	Auto CAD	1	Leica
6	Co pre	1	CHC
7	Co Process	1	CHC
8	Global mapper	1	Bule marble
9	Auto desk Civil 3D	1	Auto desk
10	Auto Desk Recap	1	Auto desk
11	Auto Desk Land Desktop	1	Auto desk
12	Micro Station	1	Benly
13	Terra solid	1	DJI
14	DJI Terra	1	DJI

## VIII.Consultant Team:

### 8.1The Project Management Structure

In order to comply with the technical requirement and make sure our delivery is meeting the project objective and project timeline. We designed to set the team structure into 3 main teams:

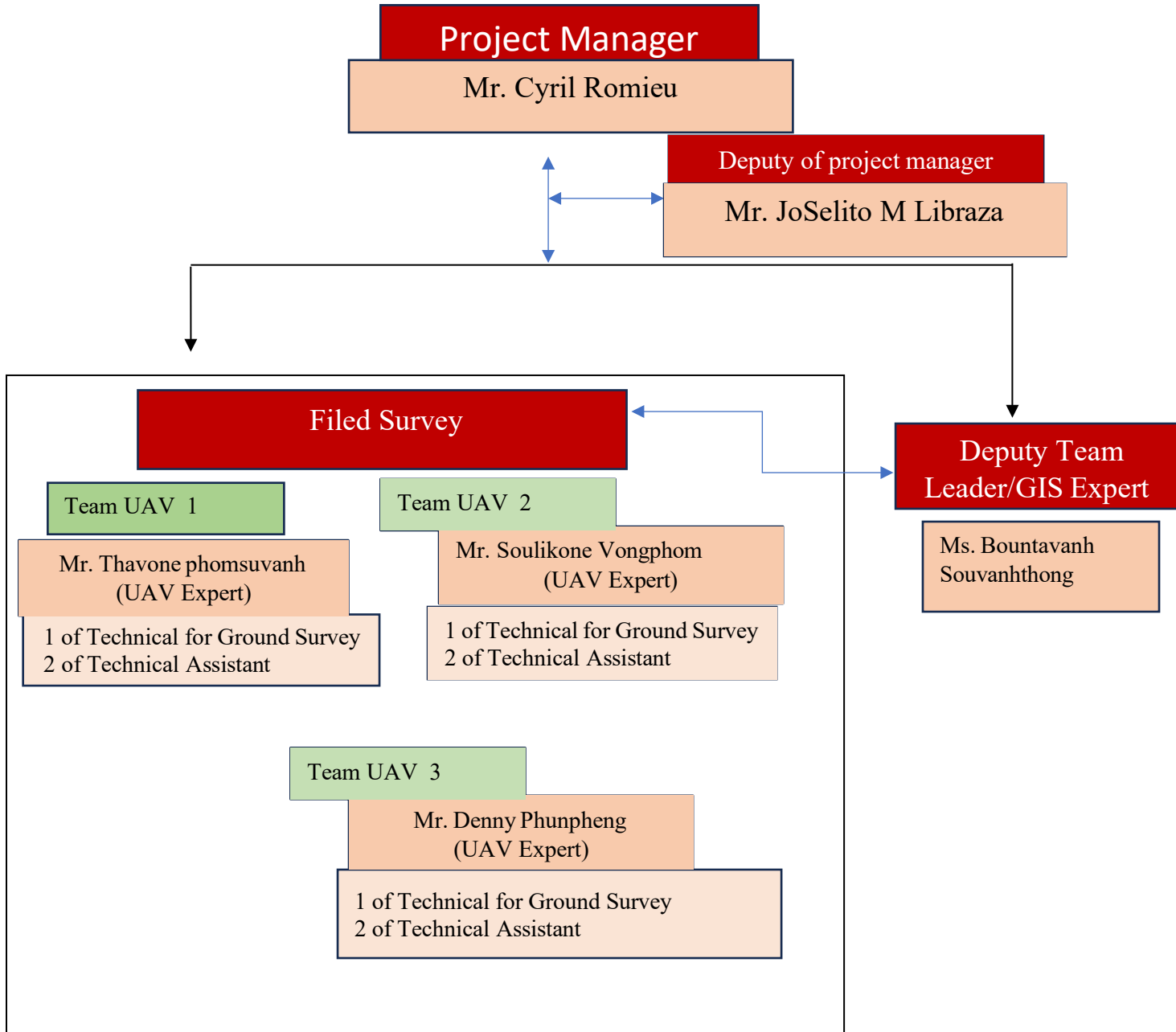
Main Team 1: Project Management Team (Documentation, Coordination and Management)

Main Team 2: Field Survey Team 1 (Songkhon District) and Field Survey Team 2 (Champhone and Xonnabouly District)

Main Team 3: Office Desktop Team (Data Analysis and Creation of DTMs and Reporting)

#### The Project Management Structure

- 1 Project Manager
- 3 UAV pilot Expert
- 1 GIS Expert
- 3 of Technical Support for Ground Survey
- 6 of Technical Support



## IX. Conclusion

The technical report on the LiDAR survey for Digital Elevation Model topographic mapping at 15 village areas in five districts of Savannakhet Province underscores the critical role of advanced surveying technologies in enhancing flood risk management and climate resilience. By employing a combination of UAV-based photogrammetry and LiDAR techniques, the project successfully generated high-resolution Digital Terrain Models (DTMs) and Digital Surface Models (DSMs) that provide essential data for understanding and mitigating flood risks in vulnerable communities;

The establishment of precise ground control points and rigorous data processing methodologies ensured the accuracy and reliability of the generated maps, which are vital for effective land use planning and disaster preparedness. The integration of these data products offers a robust foundation for developing climate-resilient strategies tailored to the specific needs of the targeted villages;

Overall, this project exemplifies the effectiveness of modern surveying methods in addressing environmental challenges, thereby contributing to the sustainable development goals of the region. The findings and methodologies outlined in the report serve as a valuable resource for future initiatives aimed at enhancing community resilience against climate-related impacts.

Vientiane Capital, July, 2024

**UNIQTEK CO. LTD**

{Authorized Representative



## ANNEX



**IWRM-EbA Project**  
**Project Management Unit**  
**Department of Water and Resources (DWR)**  
**Ministry of Agriculture and Environment (MAE)**



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