Institutionalization of UAVs for Land Affairs and Spatial Planning in Indonesia

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Key words: UAV, land administration, land base map, flying permit

SUMMARY

Since 2017, the Government of Indonesia has massively implemented land parcel registration by organizing a Complete Systematic Land Registration Program (called PTSL) – to meet the target of completing land registration in Indonesia by 2025. Progressively, target of the program has been increasing since it was first initiated: 5 million land parcels (2017), 7 million land parcels (2018), 9 million land parcels (2019) and 9 million land parcels (2020). Currently there are around 68,70 million validated land parcels from 79,05 million estimated registered land parcels in Indonesia. In the evaluation of PTSL work completion report, it was conveyed that one of the problems in achieving the work completion target was the base map unavailability. The base map referred to are spatial basic data sourced from remote sensing data processing, both high-resolution satellite images and aerial imageries.

Beside PTSL, there is also an urgent need to provide full coverage of base map for land affairs and spatial planning (e.g., agrarian reform, land control and detailed layout plan preparation). Land Base Map – the base layer for land affairs and spatial planning activities, are available for 38,69 million hectares (60,15 %) from 64,32 million hectares of non-forest areas in Indonesia. With limited availability of basic data, an appropriate solution/mechanism is needed to overcome the backlog of the problem on providing this basic data. The use of Unmanned Aerial Vehicle (UAV) for mapping activities has been recommended, yet trials of UAV for land affairs and spatial planning have also been applied. Realizing that a successful system in a country cannot be adapted to be implemented in Indonesia, since 2016 efforts have been made to increase institutional capacity related to UAV utilization to overcome the backlog of basic data needs in land affairs and spatial planning activities in Indonesia.

Based on the things above, the purpose of this paper is to elaborate on efforts that have been carried out to increase institutional capacity to utilize UAV for land affairs and spatial planning in Indonesia: starting from stipulating the procedure regulation (Republic of Indonesia, 2019), training and certifying the UAV pilot, training in aerial photo processing, procuring the UAV, and applying for UAV flying permit. Assessment is also conducted on the base survey and mapping projects for land affairs and spatial planning using UAV – the result of 5 years institutionalization efforts since 2016. The final results of the research are presented in conclusions, and are expected to be learning materials as well as research opportunities in the future.

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1. INTRODUCTION

The fundamental theory of modern land administration is the land management paradigm carried out, as mentioned by Williamson et al., (2009) that recognized land tenure, value, use and development as a comprehensive function. In Indonesia, the 4 functions of managing land have been organized under the same institution – Ministry of Land Affairs and Spatial Planning/National land Agency (ATR/BPN). The function of land affairs and spatial planning are intersecting in the same area where both requires spatial information. Thus, clustering those functions under the same organization was considered to be beneficial for a more efficient and effective way in governing the nation.

Managing the 4 land functions, the land systems and spatial planning were scheduled to be integrated through digital schemes – to support the land and spatial planning sector. A digital transformation roadmap was established, and one of the agenda was data validation – which then required for the complete-registered parcels in Indonesia. To achieve the needs for a complete data, Indonesia has outlined the full completion of registration for of their whole land area by 2025. Since 2017, Indonesia has been massively conducting the land registration throughout a program called Complete-Systematic Land Registration (PTSL). With the increasing annual target from the first initial year of 5 million land parcels to 9 million parcels by 2020, the cumulative target since 2017 to 2020 was 30 million land parcels – and it was known that 23.487.310 land parcels were successfully registered and certified through PTSL by the end of 2020.

With the achievement of 78% certified parcel through PTSL, it was disclosed that the incomplete base map for the whole country was one of the issues found during the process of PTSL. It was also mentioned in Republic of Indonesia (2020a) that the low number of base map availability was a constraint to conduct land service digitalization. Other than PTSL and digital service on the land sector, the urge to provide full coverage of base map for land affairs and spatial planning is also existed for agrarian reform, land control, detailed layout plan preparation, abandoned land, land valuation, land cosolidation, and land conflict and dispute. Land Base Map – the base layer for land affairs and spatial planning activities, are currently available for 38,69 million hectares (60,15 %) from 64,32 million hectares of non-forest areas in Indonesia.

Aiming at addressing the issue of unavailability of basic data, an appropriate solution was needed – and Unmanned Aerial Vehicle (UAV) was one of the proposed solutions. There were already several studies on the use of Unmanned Aerial Vehicle (UAV) for mapping activities, yet studies and recommendations of UAV for land affairs and spatial planning have also been applied (Manyoky et al., 2011; Wayumba et al., 2017; Ramadhani et al., 2018; Koeva et al.,

2020). However, we fully understand that one successful story from a country cannot just be practically implemented in Indonesia. Since 2016, efforts in increasing UAV-utilization capacity of the institution have been taken to address the constraint of basic data needs in land affairs and spatial planning activities in Indonesia. The purpose of this paper is to narrate those efforts in increasing institutional capacity to utilize UAV for land affairs and spatial planning in Indonesia: starting from stipulating the procedure regulation (Republic of Indonesia, 2019), training and certifying the UAV pilot, training in aerial photo processing, procuring the UAV, and applying for UAV flying permit.

2. DEVELOPMEN OF LAND AFFAIRS AND SPATIAL PLANNING IN INDONESIA

The dynamic development changes for affairs in land and spatial sector in Indonesia are in line with the dynamics condition of the country, politics and government structure (See Figure 1). During the development until the merge for land affairs and spatial planning under the same institution: Ministry of Land Affairs and Spatial Planning (ATR/BPN), there has been a massive change also in term of structural organization – as an adaptation towards the changes in the business process of the organization. Overall, the idea for the organization merging was already a form of adaptation for the Land Management Paradigm as elaborated by Williamson et al., (2009).

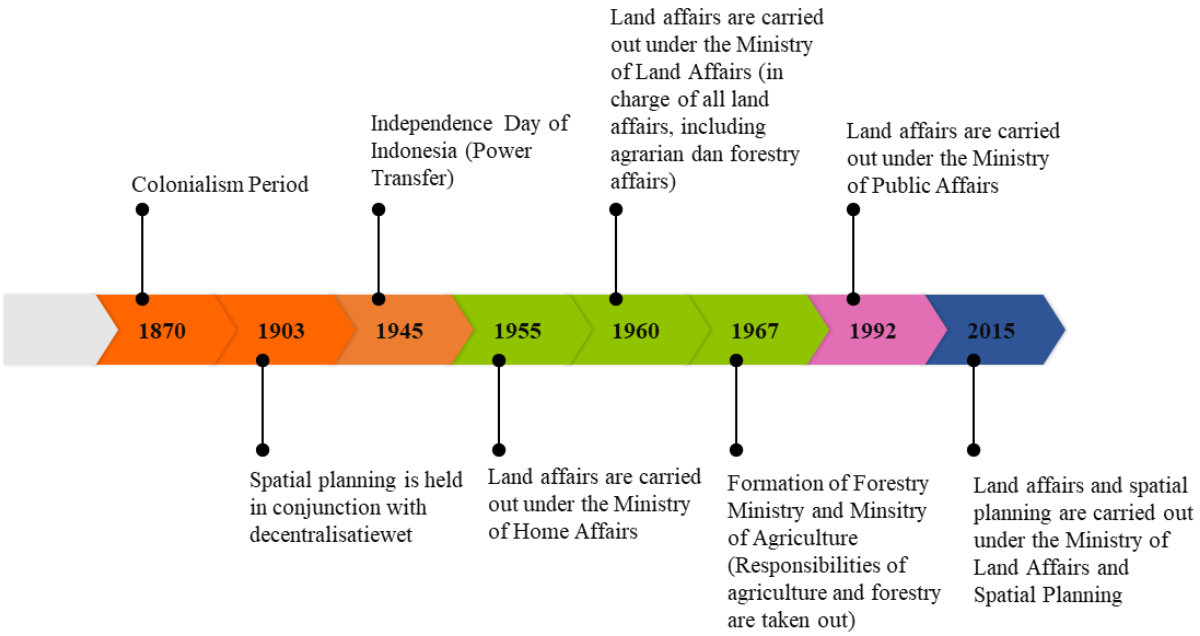

Figure 1. History of land management and spatial planning in Indonesia (Republic of Indonesia, 2020)

Throwingback to the era where land and spatial planning were still under a separated organization, the land affairs was rather focus on the land registration, while the spatial planning was more about how to plan the area developments. Allowing Land Management Paradigm to

be formulated as a policy to manage land and spatial affairs – now the structural form of how land is being managed in Indonesia also changes adapting the paradigm. The four functions of land: tenure, value, use and development – are embedded as the main core of the organizational management in managing land as a valuable resource. The goal – to actualize the trusted-world standard service on spatial planning and land management to the community – is expected to be achieved throughout the implementation of the four aspects on land policy.

With the four functions as the main core of the organization, the vision and mission of the land sector in Indonesia were formulated in 7 agendas: register all land parcels, realizing detailed plan for spatial planning (RDTR) throughout the whole Indonesia to optimize utilization and control over space, upgrading human resources competency standards towards world standard bureaucracy, becoming a center for land and spatial information based on information technology with innovation and collaboration, creating a modern service office by providing land and spatial planning products and services electronically, increasing the non-tax revenue by 10 times with land and spatial information services as the basis for the country revenue, and the last one is implementing a positive land system or land insurance to overcome community losses due to land disputes.

To achieve the agendas mentioned above, there is a high requirement for the availability of good quality and trusted land data and information. Currently there are ± 39 million parcels (50,13%) which are already validated from around 79 million land parcels. To successfully caryying out the data validation, there is also a need for an updated-good quality-and complete basic spatial data or land base map – which are also not yet fully available for the whole country. This circular problem must be addressed immediately otherwise the other problems might add up and causing even a larger problems, e.g. unable for data validation and result in anomaly data.

UAV – a technology which was firstly introduced for surveillance and now is mostly utilized in the agricultural sector – has been proposed to be one of the solution to provide a data spatial or basic map for any pruposes. Ramadhani et al (2018) mentioned that an institutional capacity is needed for further improvements for the use of UAV for cadastral purpose, this includes the improvements regarding the existing regulation, build and maintain the human resources, and provide adequate infrastructure and equipment.

3. EFFORTS TO INSTITUTIONALIZE UAV

4.1 Provision in Legal Instrument: Regulation for UAV Utilization in the Land Sector

To begin the implementation of UAV – hoping that it can address the backlog of land base-map, the first step taken was looking through the legal basis. From the first finding, it was known that the regulation on operational of UAV was the most common issues in other countries, whilst other problems are more related with technical-operational in the field, such as the battery capacity, mobility difficulties of the UAV, and also the take-off and landing issues. In Indonesia, back then when the efforts were firstly taken in 2016, regulation on operating UAV was already established. Basically, the flying permit for conducting aerial survey and mapping in Indonesia – including UAV, requires permits from 2 institutions:

Ministry of Transportation (for the UAV operation) and Ministry of Defence (for the survey and mapping activity). It was mentioned in the Republic of Indonesia (2020b) that the operational of UAV with flying height above 120 meter will need the flying permit, meanwhile the Republic of Indonesia (2020c) stated that any survey and mapping activity – including aerial survey will require for a security clearence. The output of UAV operational permit regulated by Republic of Indonesia (2020b) is a Notice to Airmen or Notice to Air Missions (US wording) – or called NOTAM, but the issuance of NOTAM itself consists of a sequential required steps involving several working units in 2 Ministries. (see figure 2).

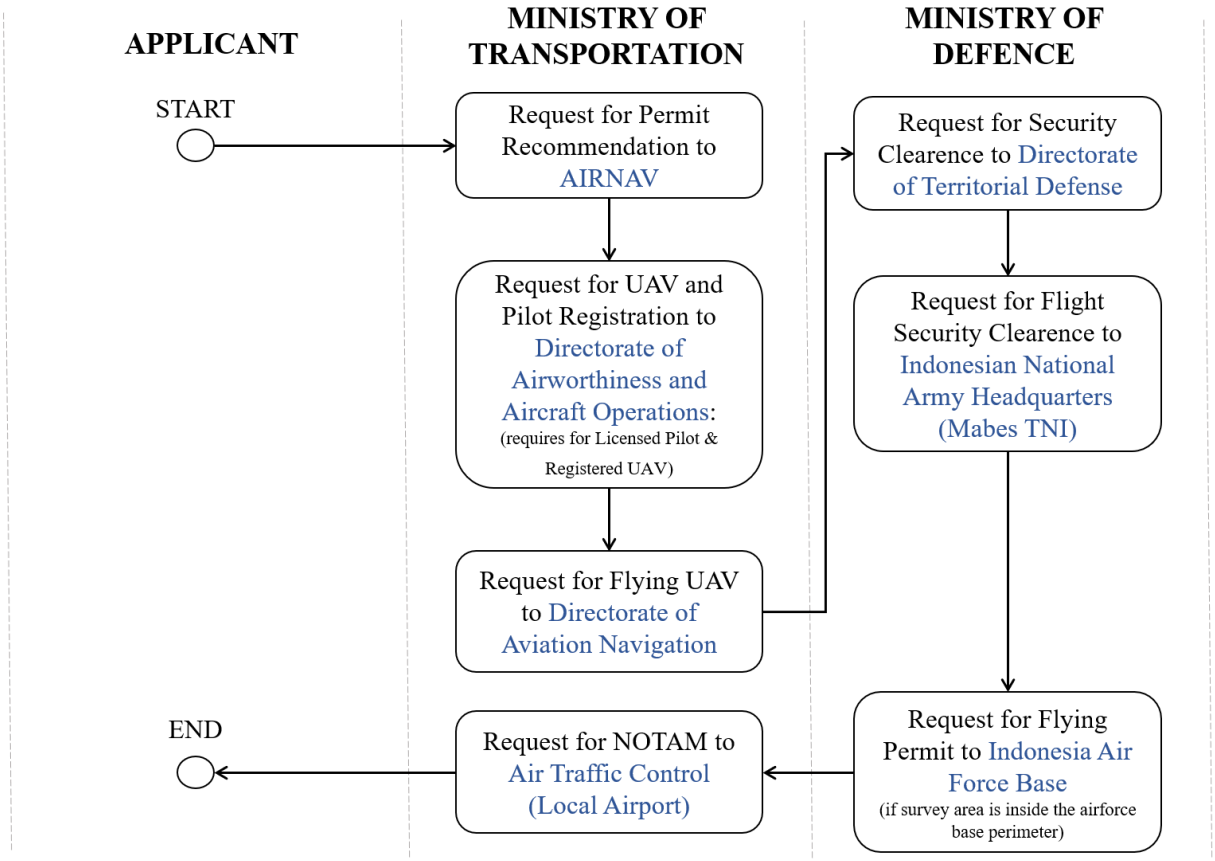

Figure 2. Flowchart for applying NOTAM in Indonesia

As mentioned before that the specific regulation on base-mapping using UAV was not yet formally acknowledged in Indonesia (no standard/regulation that includes such system for mapping), the inavailability of the legal document for conducting mapping using UAV has implications on the formal way to conduct project (especially those which are funded by the national budget). Geospatial Information Agency just launched the regulation in using UAV for survey and mapping in 2020 (Republic of Indonesia, 2020b). Prior to that, the reference that can be used to guide the base-maping activity using UAV was not yet available. Filling the absence with the urge to implement the UAV, ATR/BPN then stipulated the standard in 2019 (Republic of Indonesia, 2019). The standard was used to compile the pilot project in 2020, and also to embed the policy of using UAV as one of the proposed solution inside the organizational

budgeting framework – thus the implementation can also be included. The regulation issued by Republic of Indonesia (2019) described the method of base-mapping using remote sensing: high resolution satellite imageries and aerial photo (both manned and unmanned). Inside the document, the standard for quality control is also mentioned on the attachment. It took around in total 20 months to issued the regulation – starting from preparation, meetings, until finalization and issuance.

4.2 Human Resources Development: Certifying Pilot and Training for Data Processing

Still related to the legal document, the other possible issue was also found: there is a requirement for licensed pilot and registered UAV to any projects with flying height above 120 meter. Considering the average area for base-mapping is rather large of around 5000 hectares, the possible proposed flying height would be around 300 meter, thus it requires for a licensed pilot. Therefore, a trainning for UAV pilot was conducted in the early 2020 – to fulfill the requirement of certified pilot. The UAV pilot certifying was held by Indonesian Aero Sport Federation (FASI).) and the Indonesian Aviation Navigation Organizing Agency (AirNav). The agenda of the certifying was started by on-class trainning, on-field practising and examination (see Figure 3). Currently there are 135 officer of ATR/BPN that has been certified as UAV pilot.

Figure 3. Training and certifying UAV pilot

Expected that the capacity in acquiring photo map using UAV was already accomplished through tcertifying pilot, there was also a need to equip the officer with capacity for data processing. A trainning for data processing then conducted in 2020. The trainning was held during COVID-19 Pandemic by making use a hybrid combination – where some of the lectures were also held in an online manner. The courses outline for the trainning were arranged to meet the requirement for operator to process data from aerial photography using UAV: Introduction to Aerial Photo Acquisition Using PUNA, Aerial Photo Acquisition Planning Using PUNA, Aerial Photo Acquisition using PUNA, Processing of Aerial Photos Acquisition Using PUNA, Quality Assessment of Acquisition Results Using PUNA.

4.3 Providing Adequate Equipment

Although the UAV technology was just recently adopted for survey and mapping activities in the land sector, the procurement for the unit itself was already carried out in 2017. In total, there were 26 fixed-wing UAVs purchased and delivered to the Regional Offices of National land

Agency. Backthen, the idea was to give chance for each regional office to independently provide their own basemap and spatial data when needed. Unfortunately, five years later, it was reported that 22 of the UAVs are in a bad condition – and no longer used for any survey and mapping activity. It was also known from the reports that the issues with the procurement is the maintenance that has been quite difficult to be taken out – due to the constraints regarding budget or even the discontinued spare parts. With the existing procurement issues, providing a new and updated UAV has been quite difficult, therefore a solution was proposed: implement the rental system instead of buying a new unit. The rental system for the UAV was firstly used in the pilot project held in 2020 and 5 other following projects in 2021. However, this rental system has several weaknesss and also strengths. Comparation towards the two systems (rent and buy) are presented in Table 1. The cost for the rental and buying was exercised for the type of UAV which were defined to be most-fitted with the current needs for survey and mapping in Indonesia (fixed-wing, vertical and take-off landing feature, and embedded with post-processing-kinematic tools) – considering that the topography in most area of Indonesia are quite challenging.

Table 1. Comparison of the rental and buying system for UAV

	RENT*	BUY
(-)	1. Vendor is not available in every regions (mostly available in Jakarta) 2. Not available for incidental jobs 3. Not flexible in terms of the projects' time period 4. Not flexible in terms of the projects' location 5. More expensive (USD 1.052 /unit/hari or USD 392.661/unit/year) 6. Not included pilot and data processing operator 7. Shipping cost is not included	1. Requires for maintenance 2. There is a need for asset management 3. High risk for out-of-date possibility due to the rapid development of UAV technology 4. Extra cost for insurance
(+)	1. Already include the maintenance service 2. No need for asset management 3. Already include the insurance cost	1. Flexible in terms of the utilization 2. Comprehend both incidental and planned jobs 3. Time period for a project is flexible 4. Cheaper, with a rental budget of USD 392.661/unit/year can purchase 10 unit of fixed wing UAVs 5. Manpower is already available (licensed pilot & trained operator)

4.4 Pilot project – Providing Land Base-Map using UAV

In 2020, a pilot project for providing land base-map using UAV was executed. The project was firstly aimed to provide a mosaic orthophoto that can be used for creating land base-map. Location of the pilot project was in Majalengka Regency, West Java, Indonesia. It was chosen as the location because the base-map is not yet available in the region and also because the location was a potential location for PTSL. The project followed the guideline as mentioned in the Republic of Indonesia (2019) – with the support of internal officer who already certified as UAV pilot, and also fulfill the requirement for UAV permit operation. The UAV used in the pilot project was a rented UAV – which insurance cost included.

To begin the project, there were several administrative preparations carried out. For the administrative preparations, notification letter to the related stakeholders and all other documentats for flying permit were prepared. Following the rule of applying permit document as described in Figure 2, it was known that the standard duration for each step was different. In total, it took around 2 months from firstly requesting for 'Permit Recommendation' to AirNav – Ministry of Transportation at 24th August 2020, until accomplishing the NOTAM from ATC in Kertajati International Airport in Majalengka, West Java at 19th October 2020. Overall, the process was demanding for an effort – except the steps related with the Ministry of Transportation. Right now, the request for pilot registration or UAV registration can even be applied online using SIDOPI (can be accessed at https://imsis-djpu.dephub.go.id/drone). But the other steps were still required for a long-bureaucratic process with standard procedures that have not been clearly published.

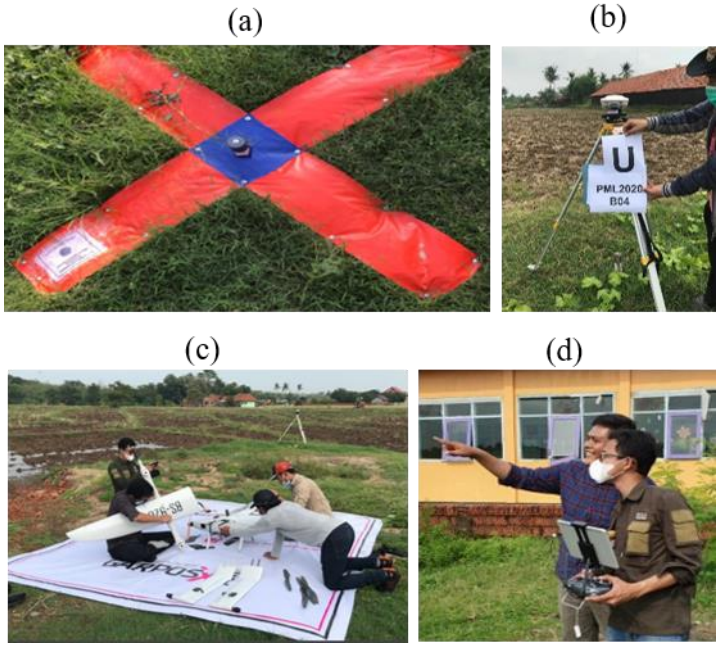

Figure 4. (a) pre-mark for data acquisition; (b) GCP survey; (c) preparation before aerial data acquisition; (d) the certified pilots

After acquiring the flying permition, the project then started by making plan for Ground Control Points (GCPs) distribution, to the installation of the premark, GCPs data collection, aerial image data acquistion using UAV, and data processing (see Figure 4). The summary of data acquisition is presented in Table 2. The data processing was included several steps: flight-log data downloading, photo geotagging with PPK data processed, orthomosaic using Agisoft Metashape (photos aligning, mesh building, DEM building, orthomosaic building), and the last one was cropping and exporting. Average ground sampling distance of 3,8 cm was derived from the project.

Table 2. Summary of data acquisition for the pilot project

I	**AREA OF INTEREST**	
a.	Number of Village	38
b.	Total Area	6000 Ha
II	**UAV SPECIFICATION**	
a.	Type	V-TOL (Vertical Takeoff Landing) + PPK
b.	Max flying duration	120 Minutes
c.	Max range	15 Km
III	**CAMERA**	
a.	Type	42 MP Sony DSC RX1 RII
b.	Lens	Fixed Lens
IV	**FLIGHT PLAN**	
a.	Height	300 Meter
b.	Overlap (Fwd/Side)	80/75 %
c.	GCP	74 Points
V	**PELAKSANAAN**	
a.	Personnel	13 Surveyors
b.	Project duration	13 days (19 to 31 Okt 2020)
c.	Number of Take-off-Landing)	30 Times

4. EVALUATION

To assess the narrated efforts made, an evaluation was conducted towards the projects of Land Base-mapping using UAV in 2021, by using 5 components for the management resource approach: Man, Method, Material, Machine, and Money. These 5 resources were taken to see how each component of the approach was implemented and how it has been established after the institutionalization. The projects conducted in 2021 were located in different provinces: Riau, Riau Islands (Kepulauan Riau), South Sumatera (Sumatera Selatan), Central Kalimantan (Kalimantan Tengah) and Papua. Similar to the pilot project conducted in 2020, those 5 projects were also implemented all the steps mentioned in the guideline and fulfilling the requirements for UAV flying permit. After the projects ended, a questionnaire was asked to be filled by the coordinator of the project. The questions outlined in the form were trying to capture the 5 approach components of man, method, material, machine and money.

4.1 Man

The ’man’ components evaluation showed that the capacity development conducted to support the institutionalization of UAV are already gave a significant value to the project actualization. From the 5 projects, all of them already supported with the certified pilot. There are 1 regional office who already have 3 pilots, but there are 3 regional offices which only have 1 pilot for the whole province. On the other hand, an improvement seems to be needed in terms of the processing operators available. The respondent informed that 3 projects were conducted with trainned operators, so the other 2 projects were processed with assistance from fellow operators outside the province. It was mentioned by all 5 respondents, that the training for UAV imageries data processing are still needed.

4.2 Method

Regarding the method, the efforts made through the stipulation of the detailed guideline regarding the use of UAV for base-mapping were stated to be well-understood by the respondents. When the respondents were asked whether they hav any concerns or constraints related with the method during the implementation of the projects, one respondent said they have issues related with the accuracy result, 2 of them mentioned the flying permits as a problem, and 2 others talked about an inadequate equipments. For the accuracy result delivered by the regional office of Papua, it showed a low accuracy and did not meet the specified accuracy – which was confirmed that the possible cause was due to the hilly topography with densed vegetation in the mapping area.

Going detailed on the flying permit part, a further confirmation to the respondents gave an overview that there have been several different treatments happened in the field in terms of the application for flying permit. It seems that although the regulation has been issued and the steps were already agreed, but every representative office – especially those in the regional level still has different 'perceived' information regarding the specified rules. However, when being asked what are the fastest and the longest steps of the flying permit application, the responses are as presented in Figure 5.

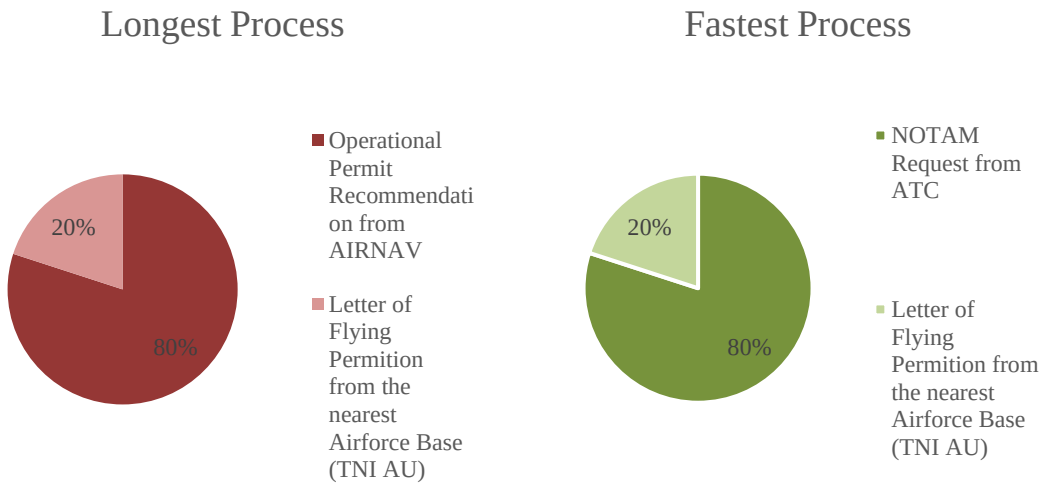

Figure 5. Duration perceived by the respondents for the application of UAV flying permit

4.3 Material

Material considered here is the input of any data source/raw data/information that was used for the projects. As stipulated in the technical guideline which were derived from the regulation of Republic of Indonesia (2019), all 5 projects were already using the same source for administrative boundary (delivered by Geospatial Information Agency of Indonesia, called BIG). For the planning, the google earth was used for orientation. Meanwhile the reference points are using different references that are available closest to their locations: either the Continuously Operating Reference Stations managed by ATR/BPN or BIG or Technical base

Points (TDT) Orde-2, and the elevation reference were using the countour map from an opensourced Shuttle Radar Topography Mission (SRTM).

4.4 Machine

Through the evaluation, it was known that for the machine, all of the projects are using a rented UAV with minimum specification of vertical and take-off (V-TOL) landing feature, embedded with post-processing-kinematic (PPK) tools, has digital censor, autopilot, and self-calibration. When being asked what are the issues related with equipment or instrument of survey, all of them responded the issues of workstation and software for imageries processing which was not sufficient enough to process the data. From one of the projects also known that there is an issue related with the storage capacity to keep the raw material from the project. The raw imageries were deleted after data processing because it took a large space inside the workstation. This is very unfortunate considering that raw data is also a potential asset that can be utilized for other further purposes in the future.

4.5 Money

The last evaluation component – money, was covered by checking the actualization of the allocated budget. From the allocated budget, the average usage is 87%. The initial average cost per hectare which is USD 3,57 for the whole 5 packages, with detailed price as mentioned in Figure 6 – shows that the highest cost per hectare is for Kepulauan Riau – due to the size of the area which is smaller than the other projects (2.500 Ha). Papua is also considered high, since the cost standard for Papua is also quite high, meanwhile the cost for 3 other projects is ± USD 3 per hectare for an area of 5.000 Hectare. With the budget given, the respondents stated that the budget is already sufficient for the actualization. However, all of the respondents also proposed for a consideration to include the cost for shipping and transporting the UAV which was not included in the previous projects.

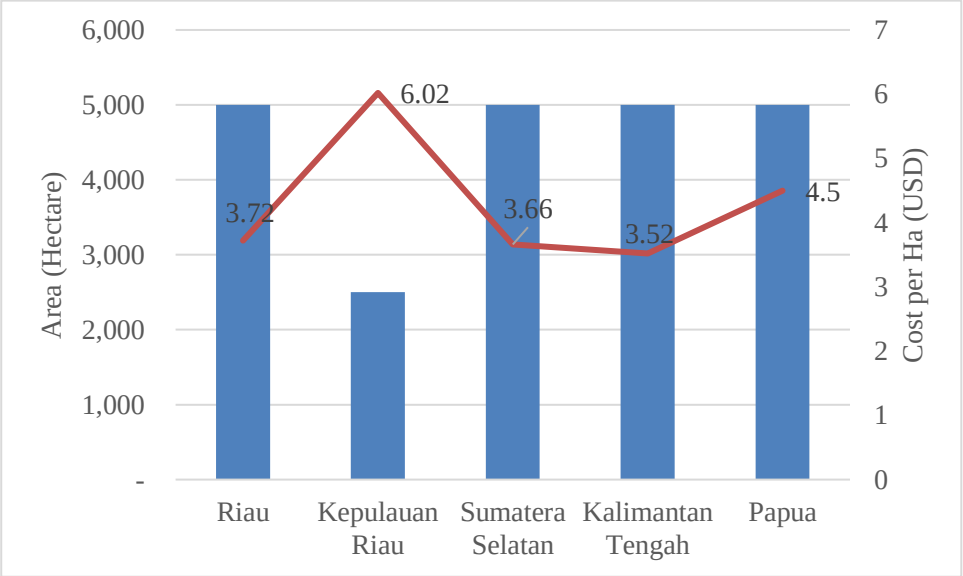

Figure 6. Cost per hectare for the projects

5. DISCUSSION – ROOM FOR IMPROVEMENTS

From the evaluation, the fact that all 5 projects already conducted with the role of 5 trainned yet certified pilots and also carried out with the specification mentioned in the guideline derived from Republic of Indonesia (2019), it shows a significant added value already made for the capacity institutionalization of UAV. However room for improvements are still needed in some aspects. For example, regarding the man component, the number of trainned operator for data processing were still very low. Thus, a trainning for such competency should be held to address this issue. However, the fact that the licenses for the UAV pilot also has an expiration date and should be renewable with a requirements of flight experiences (related with flying hours), it should also be considered for a refreshing course for the pilot – and even the recruitment for new pilots, given that the current pilots might be unable to conduct any survey due to promotion or moving to another division. Another example is from the respondent's statement on the issues they met during the application for flying permit document, the needs for a memorandum of understanding or cooperational agreement with the other stakeholders involved in the flying permit application seems to be very urgent to be conducted, otherwise it might affect the whole project prior to the execution.

The findings also found that the respondents mentioned the issue of inadequate workstations and data storages for data processing. The issue also happens in the headquarter of ATR/BPN. Currently, to manage data of aerial imageries, high resoultion satellite imageries, vector and polygon map with an average needs for 18 terrabyte capacity storage per year, it is projected that the headquarter would need an allocation for 90 Terrabyte capacity storage for the next 5 years. That is just the calculation for the headquarter unit needs – and not yet included the needs for the projected upcoming data which might come after the institutional capacity for UAV has been taken place. Imagine if every land office and regional office will have the capacity to provide their own spatial data – the needs for a powerful system that can facilitate the management of the 'big' data should also be accomodated. It should also be considered that the 'big' data should also be used, shared, and optimized for other usage – thus the chance for data sharing in terms of collaboration with other parties should be also be anticipated.

6. CONCLUSION

As the final remark, it can be concluded that the purpose of this paper is to narrate those efforts in increasing institutional capacity to utilize UAV for land affairs and spatial planning in Indonesia has been outlined in the writings. It is important to emphasize that the entire process of institutionalizing UAV is an effort to address a backlog, and like any method that utilizes a technological approach, there will always be a need to adapt to the development of the technology itself. So it is certain that the efforts presented in this paper will always open up for any opportunities for improvement and development, both in terms of improving the quality and quality of the human resources involved in the process, supporting equipment for its implementation, to legal instruments related with the policies, regulations and technical instructions. However, several important findings as the wrap up from this paper are summarized below:

- The use of UAVs is considered efficient to be conducted for providing large-scale base-map with an area that is relatively not large, thus it can be used for PTSL program which targeting a complete-systematic land registration for the whole village;
- Utilization of UAV is also suitable for land analysis project that requires the availability of the latest photo map updates in a certain area;
- With the ability of UAV that is increasingly developing, it is possible to be the solution for the needs of base map in land affairs and spatial planning – especially for areas that are not yet covered by the land base map availability, or even not yet provided as the requirements needed, e.g. need for an updated, better quality, or time series data;
- The production of land base map using UAVs needs the support and cooperation from the external stakeholders related – starting from the location determination, data collection (including the safety during the procedure of data acquisition), until the management and publication of the data.

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