Collaborative Mapping of Detailed Geospatial Data for Disaster and Climate Resilience in Indonesia

Trias Aditya, Iwan Gunawan
Suryani Amin, Hoferdy Zawani, Ruby Mangunsong

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PREFACE

The purpose of this technical note on collaborative mapping is to serve as a reference and guidance in applying collaborative mapping approach to support the land governance and detailed spatial planning. Surveying and mapping activities are indispensable activities to provide detailed geospatial information as a good foundation to develop diagnostics and problem solving alternatives in multi-faceted urban development that deals with disaster management, slum and poverty eradication. The strategies and techniques for coordinated data compilation, validation and improvements involving government officers and community representatives through collaborative mapping are presented in three different case studies in post Merapi eruption rehabilitation, Winongo and Ampal river area redevelopment. Those three case studies represent their own environmental problems due to either natural disaster (e.g., in case of Merapi) or climate driven flood inundation. The maps and geospatial information produced are seen as unified base canvases for supporting detailed spatial planning.

The provision and quality evaluation of base maps in collaborative mapping process are fundamental for accelerating geospatial data compilation and validation through participatory interaction. The information derived can contribute towards integrated and comprehensive spatial planning, disaster management, urban and rural land governance and development at site and local level.

We hope that this technical note can be used as technical reference to many on-going national initiatives toward one map policy implementation.

We would like to thank our local and national partners in Merapi area, Winongo and Ampal Riverbank during the implementation of pilot projects, the showcases reported in this technical note.

Authors,

May, 2017

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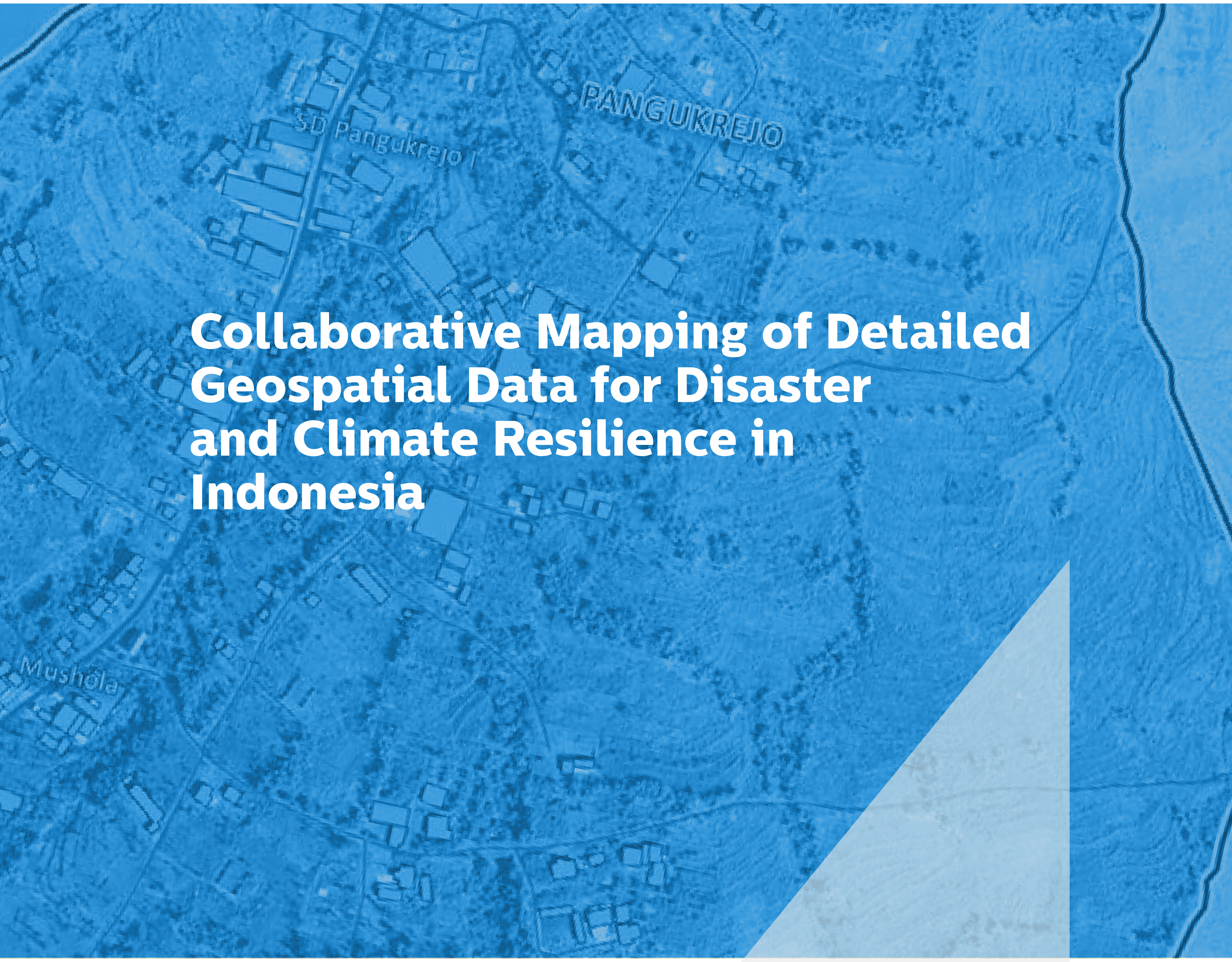
Lapangan Sepak Bola



Collaborative Mapping of Detailed Geospatial Data for Disaster and Climate Resilience in Indonesia

“Collaborative mapping creates a unified agreed-upon local basic and thematic maps usable to support planning and disaster management”

I. Context

The chapter provides an introduction to the concept of collaborative mapping and justification on how the approach could be used to respond to the need for detailed geospatial data for planning and problem solving. The chapter elaborates the framework and sequencial process to come up with a solution.

I.1. Definition

Collaborative mapping denotes the process in producing a reference local map presenting basic and thematic geospatial information that were acquired and compiled through joint survey and mapping activities involving local government, community and relevant stakeholders. The collaborative processes encompass a series of joint data acquisition and compilation, synchronization, verification and presentation using corrected aerial imageries or high resolution satellite imageries as the base images. Collaborative mapping's area of interest may start from the smallest unit area (e.g. neighbourhood areas) to larger area (e.g., block, corridor, or village) in a district or city blocks. Collaborative mapping processes may involve heterogeneous data (in the same level of detail) , various organizations, different perspectives, but the product should be used as a single reference for all parties, yet must comply with geometry quality requirements set out by the national mapping agency.

The notion of collaborative mapping here should be differentiated with participatory mapping. Participatory mapping emerges as a tool to provide convenient ways for community members to engage and participapte in planning or decision-making processes (see Aditya 2010). Kryger (2002) specified that participatory mapping utilizes a wide range of graphics visualization to encourage community participation in expressing spatially referenced views and deliberation (Rinner 2001, Cai and Yu 2009). While participatory mapping focuses on methods and processes in producing community-based maps (Craig and Elwood 1998, Sieber 2006, Chambers 2006, Elwood 2006), collaborative mapping here focuses on methods and processes to facilitate integration of government and community maps through field verification, structured discussions involving community members and government agencies.

The scientific foundation for Collaborative mapping closely related to Collabortive GIS which centered on the design, process, and methods in utilizing geospatial data and explotatory tools as well as structured discussions in a community to produce spatial planning and problem solving as well as decision making (Balram and Dragicevic 2008). Collaborative mapping here is seen as an advancement of participatory mapping design and processes in order to ensure the acceptace and use of community maps into actions.

I.2. Rationale

The lack of detailed spatial data required for supporting spatial plan and disaster responses hinders quick and accurate responses. Yet, many data acquisition and compilation initiatives can easily be found across the agencies, especially after a disaster event, on which the data accessibility and its quality differ from one agency to another agency. It has always been a challenging task to deal with heterogeneity of the data and their quality, avoiding possibilities for data sharing and the joint use of the data. This can be exemplified in many disaster events. Right after the disaster strikes, disaster responders and managers had difficulties to find and access detailed map including impacted areas, elevation data and detailed map depicting exposure information such as buildings, infrastructures, land uses. These detailed map and other spatially referenced information are needed by disaster responders and managers to support their plans and needs for coordination in the phase of disaster responses, relief and reconstruction. In case that the access is not a problem, the data might be available partially from one agency but might not be relevant to be integrated with other specific data from another agency because of the different level of detail.

The provision of a basic map seen as a base canvas in collaborative map production is crucial. An agreed and unified base map is the key asset to enable detailed thematic information integration. In that way, critical issues to city/district development such as flood risk mapping and slum mapping can be draped into and analysed accordingly.

That prerequisite map is important to be available at a city level in order to ensure that community-based spatial plan and government plan are using the same base map. As a such, the collaborative map canvas mashes up community and field data with local government /technical agencies data, enabling one map policy at local level (top-down and bottom-up data integration). The product of a collaborative mapping activity can then be used to support response and development program such as detail spatial planning, disaster risk planning, and land development. The application of collaborative map represents in this book is focused on the preparation of a detailed plan layout with oriented to, among others, the disaster risk reduction.

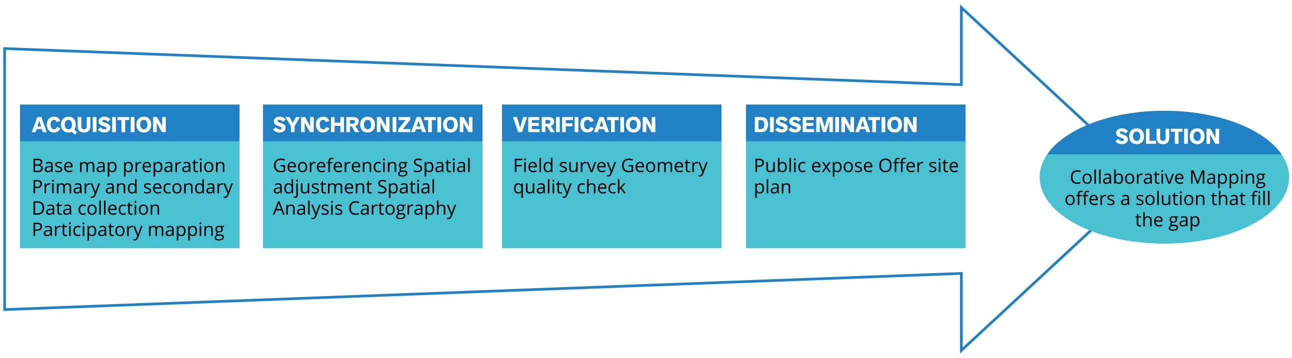
Figure 1 depicts a sequence of activities executed in the collaborative mapping process. The activities involve various stakeholders including the local disaster office, the local planning office, village officers, a community group of settlement planning, starting from data acquisition till validation. In each stages (acquisition-synchronization-verification-dissemination), discussions and inputs are annotated to geospatial features seen on the map, enabling the working map as a proxy to facilitate government-community communication and map updating.

The collaborative approach that follows this track of actions has been proven to be effective and efficient in answering the need for a single reference map to be used for planning and development in post Merapi eruptions. The activities were done in 4 months in total and the result is then used by local agencies, village officers, land office to support many planning and development activities, including land recertification for burnt areas. Collaborative maps that were produced were checked by both community representatives and local government/officers. Community representatives who inherit local knowledge contribute to data acquisition and verification through multiple participatory mapping sessions (see more in Chapter IV).

Local managers/officers who own underlying data and information contribute to the provision of secondary data and participate in the data verification activity. Collaborative maps are the outcome of the integration of top-down and bottom-up approaches. It offers more trusted and accurate map representations than just participatory maps. It creates a new information value attached to the collaborative map which can be seen as a joint effort accomplished by various agencies and groups in establishing a formalized geospatial information reference to support city/district developments.

Figure 1.

A sequence of activities done in collaborative mapping process



I.3. Drivers

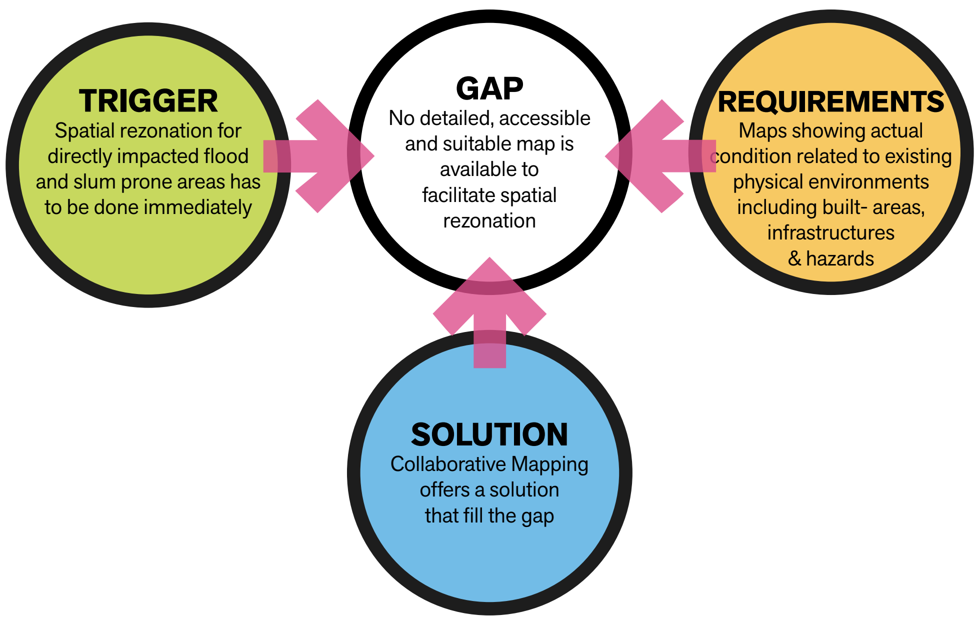
Local government is often required to provide appropriate and accurate spatial plans either in response to disaster events or in support of city redevelopment. Unfortunately, as found in many cities and districts, those spatial plans are difficult to be gained as different data quality from various agencies exist. Using existing practices and protocols, the data compilation and synchronization will take place very slowly. In addition, the basic map and thematic information are either not accessible or available. Yet, they have not been validated by community and relevant stakeholders. For that reason, in order to produce validated maps and information, government maps and community-based mapping needs to be integrated. This is where collaborative mapping offers a solution to fulfil the gap, as illustrated in Figure 2.

I.4. Gap

Poor detailed geospatial data availability and data management (e.g., low data availability, data with varied quality, managed by different users, not ready for spatial adjustment, lack capacity on spatial data management) cause local government and community fail to deliver appropriate and accurate responses and planning. For example, before Winongo collaborative map is available, the province and local governments of Yogyakarta had difficulties to calculate which and how many land parcels and buildings that will be affected by riverbank readjustment when the project is done.

Figure 2

Collaborative mapping framework: the mapping processes and the product connects the trigger and the gap to provide requirements for effective and efficient disaster risk and climate change management



I.5. Reasonable Deliverables

Some deliverables that can be produced from conducting collaborative mapping activities include:

A. Local government recognizes unified, agreed-upon geospatial datasets suited to planning and disaster management theme in a specified area.

Local government must be encouraged to take actions to use and endorse uses of good quality of geospatial data as a unified and formal resource in dealing with multipurpose city planning and development problems. The verification and involvement of national mapping agency, in case the basic imagery is not with them, in quality assurance is crucial to justify the appropriateness of the imageries used in collaborative map.

B. It helps the government to realize development plans, to better address poverty, and to reduce disaster vulnerability.

Government has been troubled with implementing development plans due to low quality of spatial datasets and management. One map would help them reduce geographical uncertainty leading to increasing transparency for investments, better program aligning, well targeting of beneficiaries and helping for effective program's monitoring and evaluation.

C. It supports the implementation of National One Map Policy (Single Reference, Database and System) at a city level, thus turning OMP into actions in support of local government.

As the local government shows high commitment, the collaborative map fulfils the demand for data access and data uses mandated by the Presidential Regulation No. 9/2016 about Acceleration on Implementation of One Map Policy at Scale 1:50,000. Indonesia's One Map Policy is an effort to establish a unified, agreed-upon geospatial dataset (e.g., land use, land tenure, disaster areas) that informs decision making at the sub-national levels. A unified, agreed-upon set of thematic geospatial datasets could benefit Indonesia in many ways. By increasing integration and synchronization of geospatial boundaries and areas across themes, it would help avoid unnecessary overlapping claims, reducing conflicts and inconsistencies. This is the first step toward the creation of a unified basic map of state lands, at least at scale 1:50,000, which currently not available. Critical to the One Map efforts is to operationalize the data sharing mechanism that promotes (as much as is possible) transparency, consistency, information sharing, and accountability. Acceleration to the provision of both basic map and thematic information that suited to on map policy thus becomes inevitable. Collaborative mapping support One Map Policy efforts by creating a unified agreed-upon local basic and thematic map (larger scale map than 1:50,000), usable to support sub-district and village-based spatial planning and disaster management.

What is collaborative mapping activity?

Collaboration is a joint activity that involves multi parties in a mutual working group that involves task sharing and synchronization that aims to achieve an ultimate goal. In participation ladder perspective, collaboration is an activity that is one step ahead from coordination and two steps ahead from cooperation. Collaborative mapping in this case study is a kind of mash up that combine various resources into one final product which is agreed map on disaster zone, sub village boundary, and buildings for spatial planning purposes.

What to collaborate?

Here is example from Merapi Collaborative mapping in 2013:

Data: Aerial photos, satellite imageries, GIS data, community spatial plans

Tools: GPS/GNSS geodetic type for accurate positioning, GIS software (QGIS), and Mobile GPS

Methods: Scientific data processing and participatory mapping/planning

Stakeholders: BPBD DIY/Yogyakarta Provincial Disaster Management Agency (coordinator), BPPTKG/Research and Technology Development of Geological Disaster, BIG/Geospatial Information Agency, Bappeda Sleman/Sleman District Development Planning Agency, BPBD Sleman/Sleman District Disaster Management Agency, DPPD Sleman/Sleman District land Control Department, BPN Sleman/Sleman District Land Office, PU ESDM DIY/Yogyakarta Provincial Public Works, Energy and Natural Resources Agency, Bappeda DIY/Yogyakarta Provincial Development Planning Agency, Balai Besar Serayu Opak/Serayu Opak River Basin Development Agency, Government of Umbulharjo, Kepuharjo, Glagaharjo villages of Cangkringan sub-district, REKOMPAK/Community-based Settlement Rehabilitation and Reconstruction, and university researchers

One Map Policy at a Glance

The One Map Policy term has been known since 2011 but the action has been slow. There is a new momentum following the July 2014 election of President Joko Widodo. One Map was first introduced under the President Susilo Bambang Yudhoyono Administration and was included in the Law on Geospatial Information (Law No. 4/2011). President Joko Widodo identified One Map Policy as a priority after taking office and re-confirmed his commitment as part of his CoP21 speech. In February 2016, the President issued a Presidential Regulation (9/2016) mandating acceleration of the implementation of One Map Policy at 1:50,000 of scale. Although not directly usable for collaborative mapping and detailed mapping at local level, this policy has been very positive to accelerate to the notion of one data for one development purpose. A working group lead by the Coordinating Ministry of Economics has been defining the scope of work for accelerating One Map Policy implementation that includes:

- Compilation of thematic data collected from agencies and local governments,
- Verification of data for data integration
- Synchronization within integrated data

The Geospatial Information Agency (BIG) chairs the Implementation Team, facilitating reconciliation upon conflicting data that requires cross-agency coordination. Coordination means collecting base maps and networks of survey control point and integrating thematic land information from various sources. Currently the Ministries of Energy and Mineral Resources, Environment and Forestry, Agriculture, Marine and Fisheries, Public Works and Housing, and Transportation, as well as the National Land Agencies all have authority to make sectoral maps. Under One Map, these agencies will continue to produce, maintain and update their respective datasets, but will make them accessible through a geoportal managed by BIG.

Objectives

It mainly aims at producing a single yet unified detailed map representing basic layers of the city/ district (existing buildings and settlement areas, transportation features, water and hydrographic features, administrative and local areas e.g. neighborhood area borders) plus focused thematic information depicting topic of interest including disaster management, slum alleviation, land development and city planning. The project activity is therefore enabling a collaborative platform within the city by which local governments and community representatives develop a large-scale risk mapping. The resulting map feeds into Neighbourhood Development Planning to increase resiliency towards disaster and climate change. The maps should be easy to use and updated by local governments.

Process and Activities

The collaborative map comprises of basic map and thematic layers that are produced from digital high resolution imageries. The source of imageries can be from aerial photographs, satellite imageries, or UAV (Unmanned Aerial Vehicle) images. The use of UAV is limited to some extent, mainly because the requirements to comply with national standard is considered uneasy (e.g. extensive uses of high accuracy Ground Control Points (GCPs), additional terrestrial height survey to improve z values, permits from transportation agency). The process to create the map can be divided into two main work, technical work and non-technical work. Technical work covers the development of orthorectified imageries (when the data has not been vertically corrected), raster to vector data conversion, and across agencies' data integration. Non-technical work include: engagement with local partners (government, local experts, and community), multi-stakeholders dialogue, and multi-stakeholders' verification and agreed upon. The general flow, how the technical and non-technical work evolve in the activity can be seen in Figure 3.

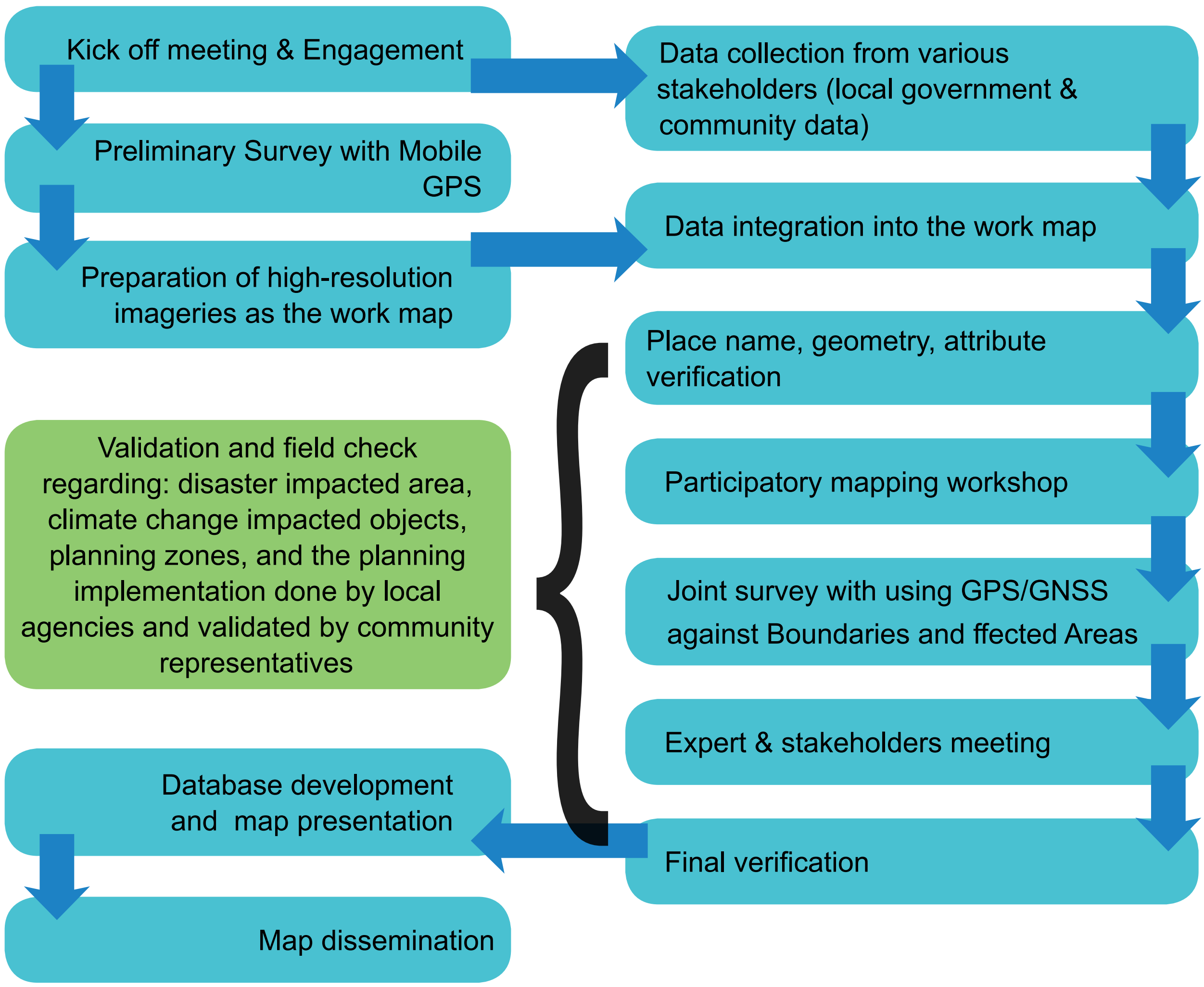
The flow of processes can be summarized as a follow:

a. It starts with coordination and engagement with the local government and local partners. Engagement with local governments, local experts and community must be done before the project was really started.

b. It must facilitate multi-stakholders' dialogue for data acquisition, compilation, verification and forum to resolve disputes over data representation and quality.

c. It must integrate various data into a spatially referenced platfrom admissible for planning and development purposes.

Figure 3
General flow of the processes



II. Method

The chapter presents required survey and mapping activities including participatory mapping activities for producing collaborative maps.   One of essential items to be assessed is the availability of aerial imageries to be used as a base imagery to plot and combine multi theme geospatial data matches with community participatory data.

II. 1. Approach

The keywords for the approaches undertaken in the collaborative mapping approach are: unified and validated large-scale map for planning and development, integrating top-down and bottom-up data, compliance to national map standard. In order to produce an agreed and reliable collaborative map, the following activity should be undertaken.

a. The activity establishes a geometrically correct and thematically validated large scale map (at scale 1:2,500 or 1:5,000) produced from an orthorectified high resolution imagery to help mainstreaming disaster risk management into development decisions. Given the relatively small area, this practice requires intensive collaboration from related stakeholders to agree on method of data compilation, validation, improvement.

b. It formulates thematic information outputs where the quality of its underlying basic map (at scale 1:2,500 or 1:5,000) are in compliance with National Map Standard and Guidelines, thus adding more confidences to local government and stakeholders to accept the map as the reference for follow-up disaster management and planning activities.

c. It employs local engineers and technician, preferably with GIS and geomatics engineering background, who have knowledge and experiences in working with community and in facilitating the mapping processes, including in facilitating validation and participatory mapping sessions.

d. It accommodates community participation in populating thematic data and in validating government data, enabling top-down and bottom-up.

e. It provides reliable yet simple methods for handling multiple data gained from different parties with various quality and levels of details (e.g. coordinate transformation, rubber sheet processes, map adjustments, and data selection and integration).

f. It provides spatial analysis for real world problems found in the field (e.g. detailed information on houses will be impacted directly by lahar, houses and land parcels within the building-free river embankment zones) that is useful to give insights to decision makers to plan scenarios for solutions.

The key challenge is to provide aerial imageries that meet requirements to be used as the base layer for detailed maps (scale 1:5,000 or larger). Currently, aerial imageries that are feasible to be used as the base layer must be orthorectified imageries which means the imageries have been corrected from errors due to topography variation and due to images distortion. The aerial imageries can be produced from very high resolution satellite imageries (e.g. having pixel size equals to 51 centimeters) or aerial photographs taken from (UAV) or aerial plane.

The methods can be broken into sub activities of spatial data collection, processing, validation and analysis. Technically the method include preparing orthorectified imageries, doing field verification survey, cross agencies data collection and compilation, participatory mapping, and cartographic work and analysis.

II. 2. Preparation of Orthorectified Imageries

In case satellite imageries have been orthorectified (e.g., by BIG), then the imagery can be used as a canvas layer to enable data integration and verification. In case the imageries have been from aerial photographs, it should be assumed that the imageries have been geometrically corrected.

Geometrically corrected here means:

a. The imagery has been adjusted to local horizontal position using highly accurate GCPs, measured using Geodetic GPS. The number of GCPs depends on the city/district area to be surveyed. For instance, a city that are covered by 2 scenes of high resolution satellite imageries (e.g., 1 scene: 16 km x 16 km) require 20-30 points of GCPs for a scene, depending on the terrain (topography surface) of the area.

b. The set of imageries must then be tied into DEM (Digital Elevation Model) of the city/district area to remove earth curvature effect and to improve coordinate accuracy. This process can be achieved using Remote Sensing/GIS software utilizing rigorous orthorectification approach.

The easiest way for local agencies to know whether the high resolution imageries are available for their city/district areas is to contact the national mapping agency about this. Further when the data is available, a formal request should be submitted to BIG to get the data.

Orthorectified imageries must facilitate multi-stakholders' dialogue for data acquisition, compilation, verification and forum to resolve disputes over data representation and quality. See **also Base map options**

II. 2. 1. Preliminary Survey

Preliminary survey are needed to check whether the coordinates are correctly calculated. Further, the images radiometric quality should be checked in order to make sure the imageries can be used as the canvas for participatory mapping activities. Preliminary survey also include delineation of neighborhood and villages' boundary together with village officers.

Joint Accurate GPS / GNSS Survey

Joint GPS/GNSS survey sessions were executed to produce validated sub village (dusun) boundaries and validated ATL boundaries. GPS Surveys for sub village boundaries updating were done by local government officers and village officers and sub village leaders. ATL boundaries validation activities were done together lead by BPPTKG and followed by BPBD DIY, BPBD Sleman, village officers and sub village leaders. GPS researchers and assistants were acted as facilitator/GPS operator and analysis.

All GPS surveys were documented using standard forms conveying detail implementation and signatures from representatives of stakeholders involved in the survey activities.

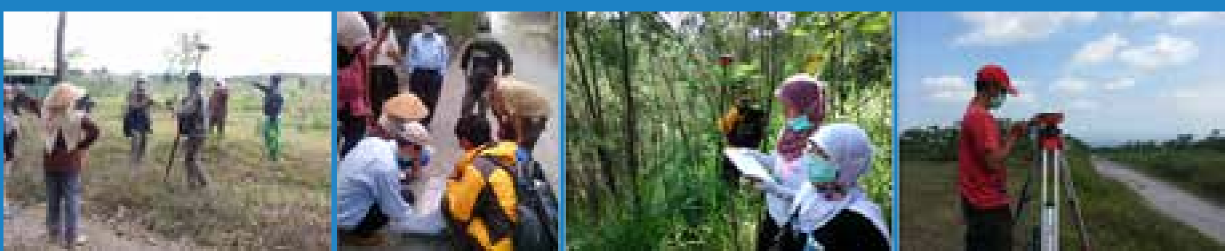


Figure 4
GPS Survey Activity

II. 2. 2. Use of Unmanned Aerial Vehicle Mapping when necessary

UAV can be used to cover missing areas or to cover small areas (e.g. less than 1000 ha) where required imageries are not available or they are available but with bad quality (e.g. clouds cover). It can be used with maximum concerns (e.g. must comply with transportation agency and telecommunication agency permit requirements). When it is done, field GCPs and additional field surveys especially for surveying terrain values are strictly required.

UAV flight mission must be designed properly in order to produce good quality aerial imageries covering the project area. Flight height of UAV must be in compliance with Ministry of Transportation Regulation (specified in the regulation of Ministry of Transportation No. 90/2015). In this regulation, it is specified that when the UAV's flight height is above 150 meters, the flight mission must be done under the government's permission.

GCPs must be installed on the field before the flight mission starts to control the resulted photographs. GCPs should be distributed in good numbers and must be surveyed using Geodetic GPS devices. UAV is equipped with high digital camera resolution to produce aerial photos and with GPS sensor to ease the flight control. In recent development of UAV devices, the camera can also be equipped with post processing kinematic GPS (PPK GPS) to enable better accuracy of UAV imageries.

II. 2. 3. Field survey

Field survey is needed to gather information on administrative boundaries and to collect additional data. Administrative boundaries and neighborhood boundaries are surveyed together with community representatives and local government officers.

Field survey is necessary in order to check the produced imageries and to make sure that orthorectified imageries can be used as the reference background for collaborative mapping Additional data collection sometimes is necessary. For example additional topographic survey especially using Total Station survey instrument to validate the riverbank profile.

II. 3. Cross agencies data collection and compilation

In order to collect all existing data regarding basic layers (administrative boundaries, buildings, land uses, infrastructures) and disaster related zones (impacted areas, hazard prone areas zonation, planning zonation) from stakeholders in the city of Yogyakarta, a series of institutional visit to technical agencies is required.

The visit is intended to collect all available yet related data in the project area. Later, the collected data are compiled and then plotted into the orthorectified imageries used as the base canvas.

II. 4. Participatory mapping

Participatory mapping is required to verify government spatial data and to collect views and aspiration of community members in forms of maps. In applying participatory mapping, the government can involve actively as facilitators or participants. In practice, participatory mapping can be utilized:

a. To facilitate community groups to validate geographic features, administrative boundaries of aerial imageries;

b. To facilitate community inputs regarding hazards, problems and proposed development;

c. To convert community maps from community mapping activities as spatial features plotted on top of the referenced aerial photos.

Participatory mapping can be done either through participatory mapping workshop or through joint field validation. In a participatory mapping workshop, a facilitator should provide guidelines and directions to make communication and coordination among participants can be effective and efficient, producing an accurate and complete participatory map (Aditya 2010). Participatory maps through photo maps were considered as the most effective means for community members to engage and produce maps.

II. 5. Cartographic work and spatial analysis

Cartographic work and spatial analysis are required to be done using Geographic Information System software. The work includes data compilation of secondary data and georeferencing work, rubber sheeting as well as boundary adjustment of multi theme geospatial data. For this purpose, orthorectified imageries can be seen as the reference data. The complete cartographic work and spatial analysis may include the task:

a. To digitize spatial features of building and public infrastructures as vector data;

b. To symbolize detailed data on transportation, settlement infrastructure, land parcels effectively for visual communication purposes;

c. To develop spatial analysis to investigate population density, building density, settlement infrastructure suitability, and disaster infrastructure needs in the project areas;

d. To visualize the results in forms of maps;

The result of cartographic work and spatial analysis is subject to be discussed and improved. For this purposes, a focus group discussion is necessary. The discussion can be focused:

a. To discuss with the expert on the recommendation based on the field activities;

b. To conduct a mapping workshop at the end of the program;

c. To develop standards and protocols for conducting joint survey involving stakeholders and community.

Participatory Mapping Workshops

Participatory Mapping workshops were done involving sub village leaders, vilage officers, local government officers in order to :

Validate and update the geometry of geospatial features of houses and buildings, roads, sub village boundaries and directly impaced areas (ATL) zones

Validate and enrich geospatial attributes of buildings and houses in 3 villages including building construction parameters, building use, clean water source, electricty,name of house hold leaders.

Figure 5.
Participatory mapping workshops for validating and updating geometry and data attributes attributes

III. Base Map Options

As stated earlier, one of motivating objectives for going with collaborative approaches is that the availability of basic geospatial data (e.g. geospatially referenced data layers) is poor, especially the availability of large-scale maps suitable to support local planning and disaster mitigation. Large scale maps, e.g. maps with scale 1:2,500 and 1:5,000 are essential to support local spatial plan or to develop detailed contingency plan (see Table 4.1.). Such large scale maps mostly were produced either from LIDAR/aerial photogrammetry mission or from satellite imageries data acquisition. As of 2015, it is reported that the coverage of large scale maps in Indonesia is very minimum, far too low for supporting local government agenda to provide spatial plans and disaster risk plan.

According to national law (UU No. 24/2007 on disaster management and No. 26/2009 on spatial planning), local government must provide plans represented in forms of planning maps. To fulfill this need, local agencies need to ask government agencies (in this case BIG and LAPAN) to provide the data. Most of data required by local agencies are high resolution satellite imageries or aerial imageries. As required by the authority, the imageries must have been orthorectified. It means that coordinates of the imageries must have been corrected against the ground control points and have been adjusted into digital elevation model of the mapping area.

The lack of basic maps and satellite imageries has pushed many local government initiate own survey and mapping missions. In principle, options for orthorectified imageries can be done through photogrammetry mapping (producing aerial photographs using airplane or UAV), satellite imageries acquisition and processing. In principle, the decision to choose which method to be implemented by local government highly depend with the level of detail to be achieved and the budget allocated by the local government. For instance, for supporting spatial plan that require map at scale 1:5,000, the use of orthorectified high resolution satellite imageries is sufficient. In order to produce maps with larger scale, local government need to have higher accuracy of imageries which only can be achieved using photogrammetry method (but not with UAV). Uses of UAV imageries could still be accepted for relatively small areas (e.g., not larger than 1,000 ha) or for corridor mapping where field control points and observations should be more than enough.

Table 3.1

The scale of maps and its practical use

SCALE	DESCRIPTION	USES
1:10,000	Houses and buildings look tiny tend to be grouped	Micro zonation
1:5,000	Houses and buildings look small but still visible	Detailed spatial plan
1:2,500	Houses and buildings look clear	Preliminary design and block plan

Table 3.2

Types of data sources for producing base layer in collaborative mapping

SENSOR/SOURCES	SCOPE	OUTPUT	BUDGET
Aerial Imageries+LIDAR	Basically not limited but will be efficient for > 10,000 ha	Aerial Photos+DEM	6-10 USD/ha, the larger area the cheaper the cost
Satellite Imageries	Not limited depending on the imageries availability	Imageries*	Minimum 1,200 USD/ scenes for archives
UAV	Smaller area (<1,000 ha), corridor shape area (5-8 km or smaller)	Imageries **	2-4 USD/ha

* It can be converted into orthorectified imageries when high resolution Digital Elevation Model (e.g. Map Contour from 1:10,000, elevation data from active sensors (LIDAR, SAR) are available.
** It can be converted into orthorectified imageries GCPs and more height measurements on the field are required.

Quality assurance

Quality assurance is mandatory especially to validate planimetric/horizontal quality of the base map becomes crucial because the data will be used by local government and local agencies. BIG owns a responsibility to assess and to check the base map quality. The result of the check will be the document specifying whether the result meet the quality requirement or not.

The result of the analysis should meet the required accuracy, e.g., for a map with 1:5,000 scale, the horizontal and vertical accuracy must be less than 50 cm (for scale 1:5,000) and less than 50 cm (1:2,300). In Winongo collaborative mapping mission, the basic map acquired from UAV photographs were successfully assessed by BIG and accepted as base map for the Winongo area at 1:5,000 (Type I) or at 1:2,500 (Type II).

IV. Case Studies

The studies have been dealt a lot with riverbank with disaster prone areas. Riverbank have been the good example on how effective spatial plan and monitoring have been crucial point to prevent and mitigate disasters. Riverbank areas in both Yogyakarta and Balikpapan are vulnerable to flood, landslides where settlement and disaster mitigation infrastructures are not well in place. The collaborative mapping cast stakeholders to explore problems and solutions through the map. The map is seen as a proxy to find best possible solutions for improved disaster risk reduction.

As the studies aim to produce a map to be used as a reference, the quality of the base map becomes crucial. For that reason, the base map of collaborative map, developed from aerial imageries or aerial satellites, must comply with national standard on the base map accuracy (BIG regulation No. 15/2014). This standard can be seen as quality assurance policy that the city and districts must meet when utilizing base maps in developing city plan and block plan.

The following parts will present case studies in utilizing collaborative mapping methods. The first is utilization of collaborative mapping approach in villages in Sleman impacted by the Merapi eruption for post disaster recovery. The second and third are the use case of collaborative mapping studies in Winongo and Ampal Rivers for risk sensitive urban redevelopment.

IV. 1. Mount merapi post-disaster recovery

CONTEXT

Mount Merapi is a very active stratovolcano situated between Central Java and Yogyakarta Province. The last major eruption was happened in 2010. The total damages and losses reached over four trillion rupiahs and have displaced more than 200.000 people according to a joint assessment study conducted by BNPB (National Disaster Management Authority), World Bank, UNDP in 2010. In 2011, community-based settlement rehabilitation and reconstruction project was initiated. The families relocated from their burnt villages to permanent houses in safer areas. The relationship between trigger, gap, requirements that motivate the risk zone mapping in Merapi post eruption project is given in Figure 6.

A hazard map depicting hazard prone areas has been published by Center of Volcanology and Disaster Mitigation (PVMBG). However, projection of affected areas and hazard prone areas on the field is difficult to confirm on its accuracy, due to the small scale of the map, i.e. 1:50,000. Mapping of pyroclastic flow and lahar hazard prone areas using LIDAR Mapping and GIS modelling were done by the BNPB, PVMBG through Agency for Technological Development and Research of Volcanology (BPPTK). In addition, the Ministry of Public Works (PU) produce settlement zonation based on disaster risk zones.

Figure 6

Rationale for conducting Merapi Detailed Risk Zone Mapping

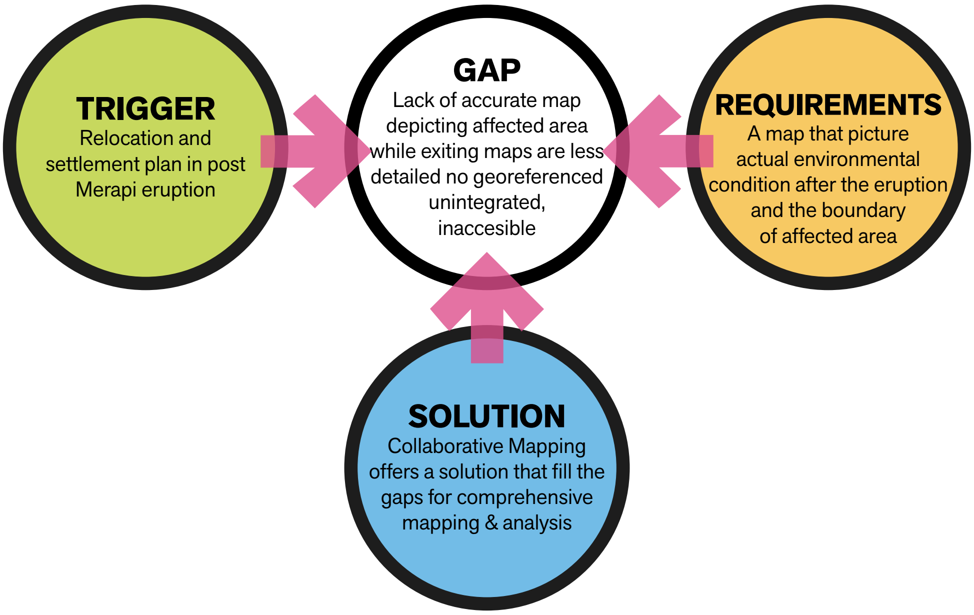


Figure 7
Footprints of Merapi lava flow

While there are many official maps concerning risk zones and safe settlements available, there are still difficulties to integrate and use the maps as decision-making support for operational planning and reconstruction activities. Meanwhile community maps, although maps provide detailed information, have no exact position on boundaries as the maps were not georeferenced. These facts raise two emerging needs for data integration and for ground truthing. Facts that available maps produced by various institutions and organizations were not created based on the same reference or standardised mapping system have made these maps difficult, if not impossible,to be integrated. Further, the available maps are also not accessible to the public while the mechanism for data dissemination is not effective and efficient. Thus, data integration require georeferencing processes and data management to make the data seamless and ready to be tested on the field.

Global Positioning Systems (GPS) and Geographic Information Systems (GIS) technologies for positioning and data management provide a solution on ground truthing on the field in order to develop collaborative maps depicting risk zones' boundaries.

COLLABORATORS

The mapping activities involved mainly BIG for technical consultation. BNPB and BPBD, Department of Public Work, River Authority (BBWS), BPPTK, National Land Agency provide existing hazard and thematic maps. Data gathering was facilitated by Bappeda of Yogyakarta province and Sleman District.

Primary data collecting involving district/village leaders. The data taken through series of discussion, interview and field survey. Community participation in the mapping processes became possible through the support from the team conducting Community-based Settlement Rehabilitation and Reconstruction (REKOMPAK) project.

The collaborators is working together in a joint survey and providing feedback during consultation workshop in order to validate the map. A group of survey and mapping team from University of Gadjah Mada (UGM) - a partner university was responsible to facilitate and implement technical work of the mapping supported byWorld Bank and GFDRR (Global Facility for Disaster Reduction and Recovery).

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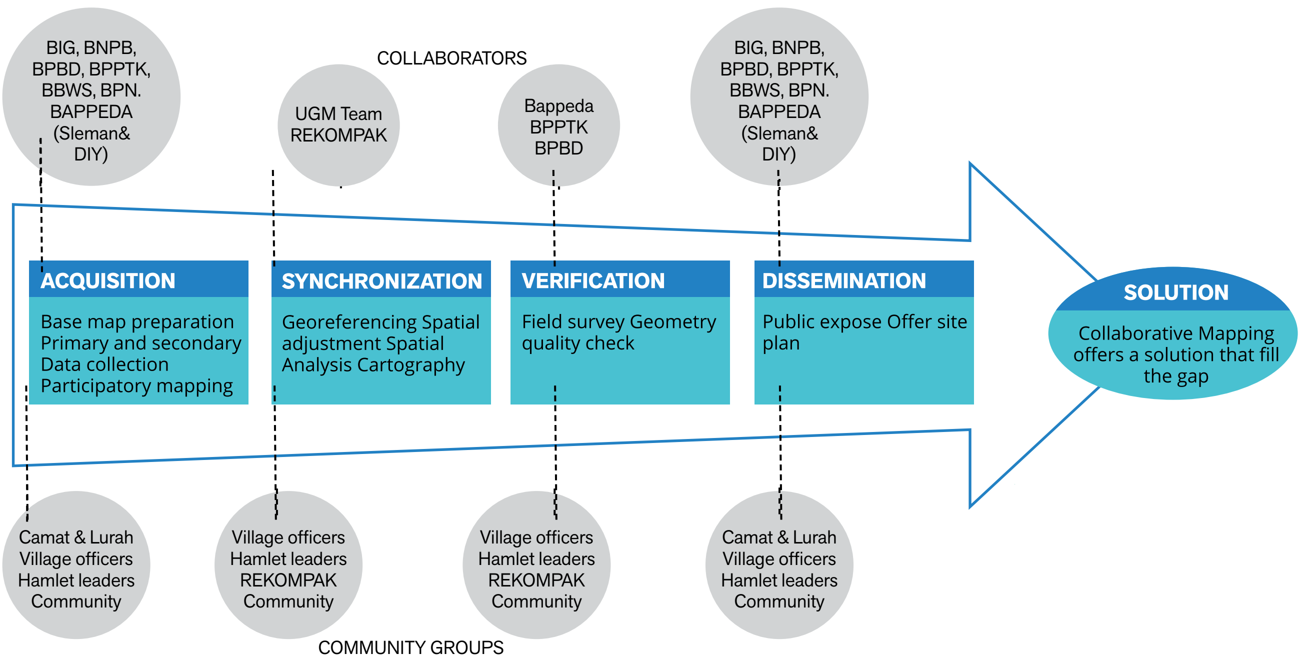
Figure 8

Stages in collaborative mapping in post merapi eruption



METHOD

The methods including :1) To collect all existing data regarding basic layers (administrative boundaries, building, land uses, infrastructures) and disaster related zones (impacted areas, hazard prone areas zonation, planning zonation) of Mt Merapi from stakeholders , 2) To make uses of latest products of large-scale mapping on Mt Merapi, i.e. LIDAR data and aerial photo maps produced by BPPTK and UGM (2012) as the reference background for collaborative mapping, 3) To convert community maps from REKOMPAK project as spatial features plotted on top of the referenced aerial photos, 4) To digitize spatial features of building and public infrastructures seen on the 2012 aerial photos as vector data, 5) To compile BPPTK maps on the potential hazards of pyroclastic flow and lahar flood, produced from LIDAR mapping and GIS modelling, 6) To develop standards and protocols for conducting joint survey involving stakeholders and community , 7) To conduct a series of precise GPS survey to delineate: administrative boundaries, past impacted areas, predictive hazard zones together with BPBD, Sleman's Technical Agencies, BPPTK, Bappeda, Village Leaders, Hamlet/Dusun Leaders, REKOMPAK, etc and 8) To discuss with the expert on the recommendation based on the result and field activities.

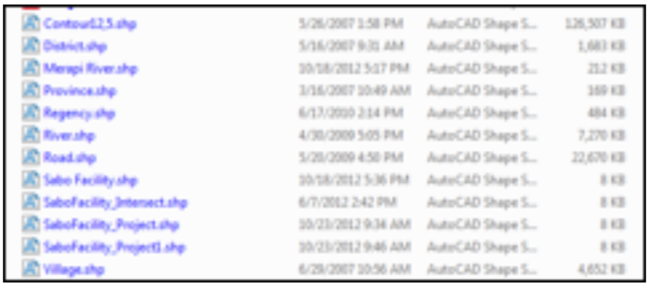
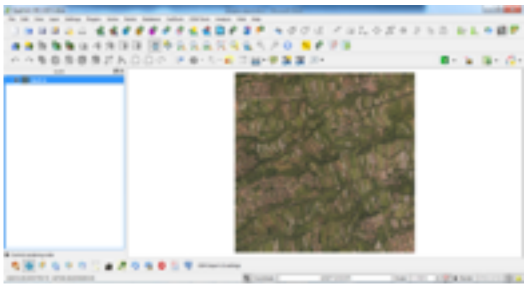
Figure 9

Field Validation activities

Figure 10

Participatory Mapping to validate the
draft of maps at hamlet level

The following layers are secondary data coming from different technical agencies are compiled on top of the basemap on which the disaster related information are plotted.

TYPE OF DATA AND FORMAT	SAMPLE OF DATA PREVIEW
Detailed Spatial Plan (RDTR/Rencana Detail Tata Ruang) from Public Works Agency (JPG) / Rencana Detil Tata Ruang dari Dinas PU (JPG)	
River and dam infrastructures from BBWS Serayu Opak (SHP)	
LIDAR and aerial photos of Merapi and Yogyakarta from BPPTK and UGM (SHP)	

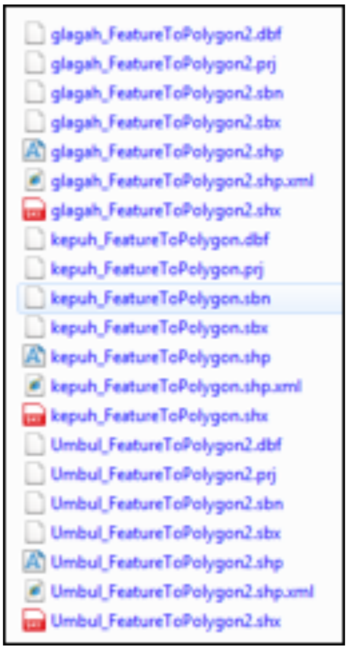
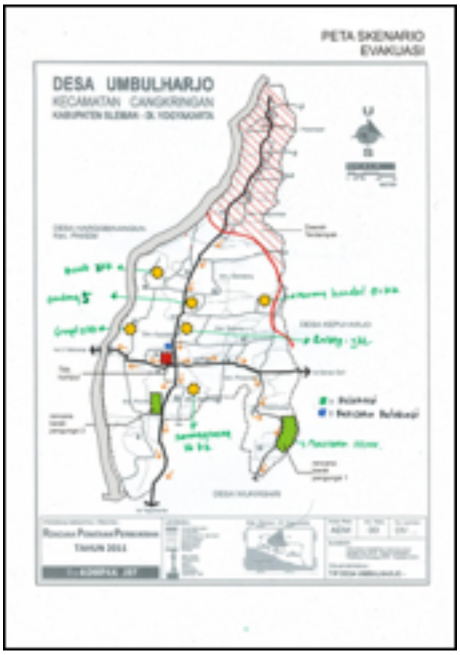
TYPE OF DATA AND FORMAT	SAMPLE OF DATA PREVIEW
Sleman District Land Controlling Department (SHP)	
Community Settlement Plan from REKOMPAK Sleman (PDF)	

Figure 11

Existing data available

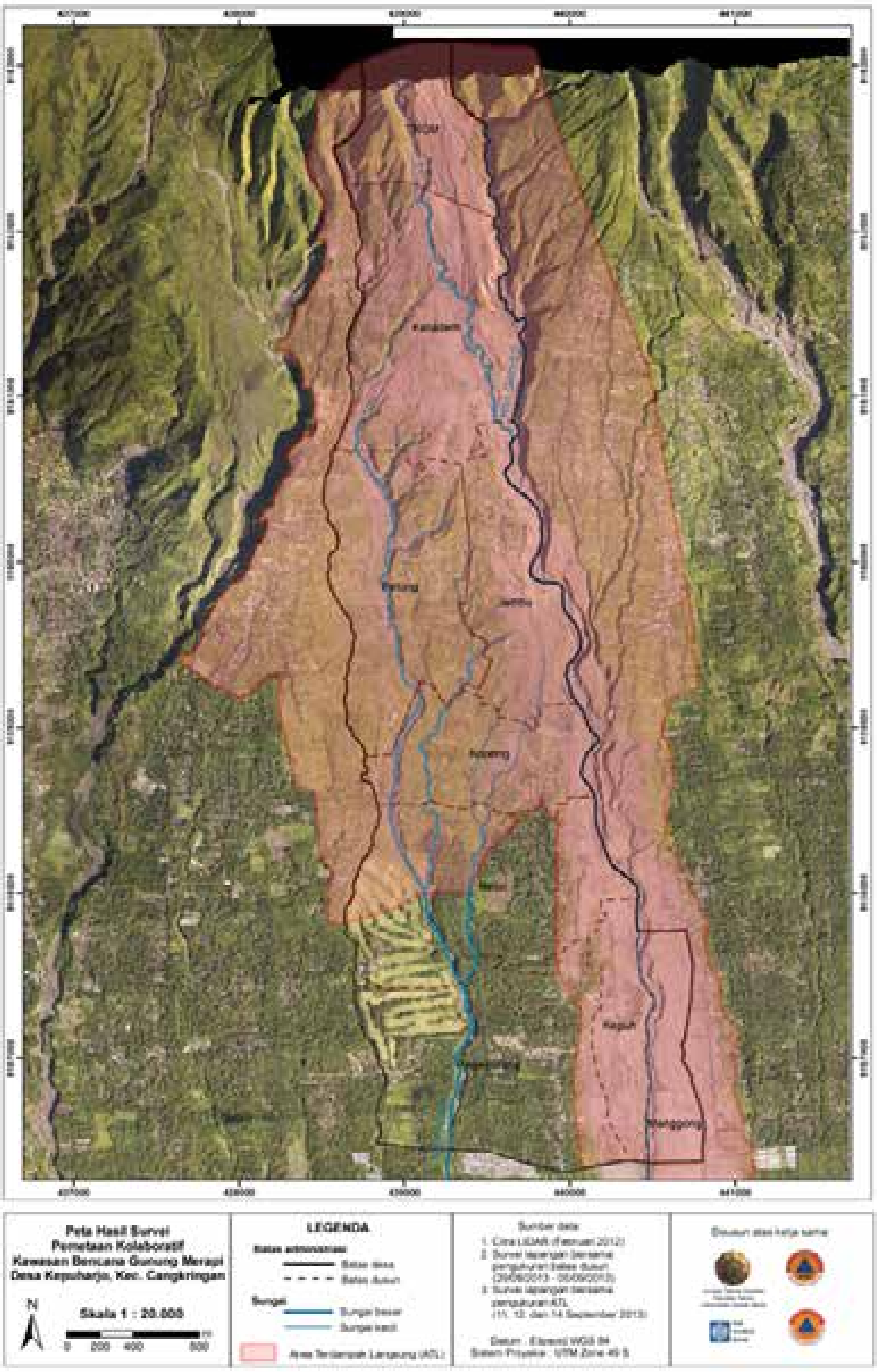


Figure 12

Sample of resulted detailed risk map

RESULTS

The collaborative mapping study of detailed risk zones in Merapi includes three villages considered to be the most villages at risk in Merapi namely Umbulharjo, Kepuharjo and Glagaharjo. The experiment resulted a detailed map of 3 villages in scale of 1:5,000 and detailed map of 27 hamlets in scale of 1:2,000 – 1: 3,000. The map depicting risk zone boundaries taken through the data integration, validation, ground truthing of the affected areas and consultation with experts.

The map comprises of georeferenced information of administrative boundaries, houses, pubic building and infrastructures. Delineation of hazard zones of pyroclastic flow, lahar, landslides as well as exposures such as houses and critical infrastructure in the area within the hazard zones was resulted by community members. The result from participatory mapping was then validated and supported with spatial analysis in combination with local leader's information and hazard expert's justification. The layers were then integrated with maps produced by PVMBG, BNPB, BPPTK, PU and REKOMPAK.

The resulted maps of risk zones were disseminated and discussed by 27 hamlet representatives. Record has been made on community agreement regarding 27 hamlet boundaries, local infrastructures and risk zones. This spatial database of Mount Merapi villages affected by disaster is disseminated to local stakeholders and managed by Yogyakarta Provincial Bappeda and BPBD.

The resulting data is converted into maps to enable local village and government to communicate the risk zones to communities and stakeholders involved in recovery activities, particularly to support the settlement plans. The maps have been used by the local government and REKOMPAK as the base information for decision-support in community-based settlement planning activities in the new area.

The availability of such detailed map have led to its use for BPN to conduct land consolidation and manage land administration for tenure out of risk zone area. As a result, families relocated to the new settlement whose land parcels directly affected by pyroclastic flow obtain certificates of ownership for their parcels.

Figure 13

New Settlement environment

IV. 2. Risk-Sensitive Urban Planning of Winongo River, Yogyakarta, Indonesia

CONTEXT

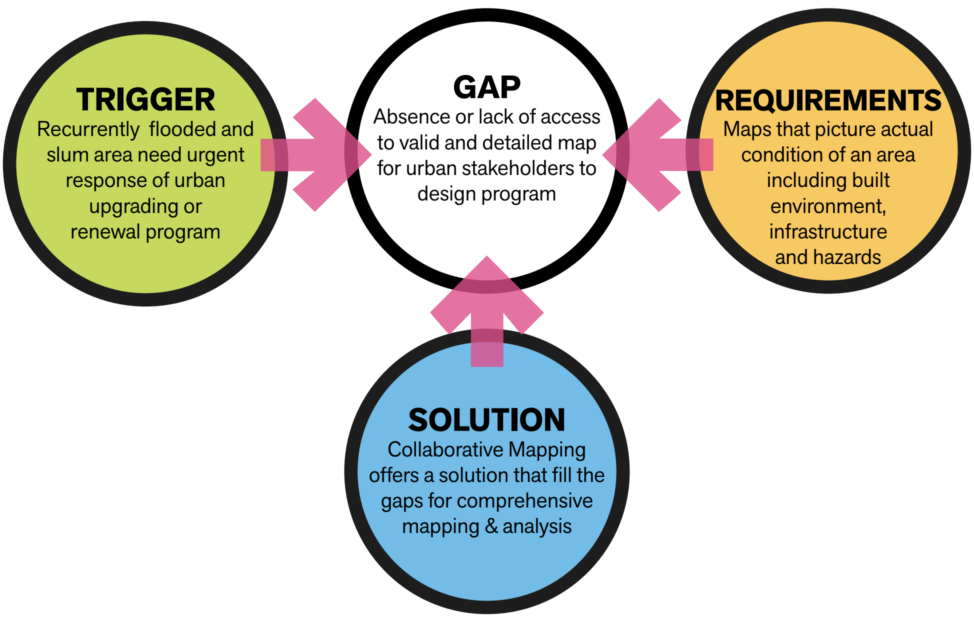
The Winongo River is one of the major streams that flow across the Javanese cultural rich city of Yogyakarta. The river holds critical roles in urban ecosystem and heritage yet it also overwhelmed with carrying capacity issues due to fast and uncontrolled development of urban settlements. River pollution, ineffective drainage system, poor domestic waste water management and lack of access to fresh water are daily problems people in the riverbanks have to deal with. Even worse, they also threatened by flood inundation, landslides, and fires that come across frequently with almost knowledgeable pattern. The relationship between trigger, gap, requirements that motivate the project is given in Figure 14.

The World Bank Disaster Risk Management (DRM) team held engagement with the city of Yogyakarta to figure out ways to address the gap. It is agreed to prioritize area that require immediate attention such as settlement that regularly flooded. The development of detailed, risk-sensitive urban spatial plans is critical for cities to adapt to and cope with uncertainty of natural hazard occurrences. However, the ability to create such plans is often constrained by the lack of available high resolution geospatial data that meet both technical and legal requirements in developing a formal block plan. Recent development in geospatial technology such as the handheld GPS, coupled with growing movement to involve citizens in local mapping activities have opened an opportunity to incorporate community-generated geospatial information into a formal planning process. The collaborative process in mapping offers solution to high resolution geospatial information that could facilitate people-oriented and risk-sensitve urban development.

The City of Yogyakarta named Winongo River as locus to deliver Detailed Risk Mapping that assesses vulnerability to flood and landslide. The selection of Winongo River represents growing area which require updates while base map is not available. Both hazards had been identified in the Bank's prior rapid risk assessment in Yogyakarta i.e. the City Risk Diagnostics which followed by the pre-feasibility study of Winongo River. The study recommends concept of "the Winongo Riverwalk" to address disasters and climate change issues that align with Yogyakarta City's vision to further develop its education, cultural tourism, and services sectors in a sustainable manner.

Figure 14

Rationale for Winongo Disaster Risk and Climate Change Mapping



As the city was keen to showcase the Winongo Riverwalk, one crucial step to realize the concept is producing Detailed Risk Map that picture segments of the river into high resolution spatial information, for instance a 1:1,000 scale of map, to allow vulnerability assessment be carried out with great detail. The resulted map can be used as basic reference to enable integrated spatial planning adhering to suitable settlements' structure and pattern in city planning to support sustainable development that taken into account hazard potentials, slums related problems (socio-economic, utilities, open space) and climate change impacts.

with the city government in terms of community building, environmental protection and disaster mitigation planning.

In the study, a local team tied to Bappeda is needed to compile and reconcile data from institutions and community. In this study, the local team role was undertaken by the UGM team, whose expertise is related to geomatics engineering (including field surveys and geospatial analytics, community mapping and communication strategy to public officials). The mapping team ensures the project carried out in high level quality in terms of process and outputs.

COLLABORATORS

The study can be seen as a business model of collaborative mapping broken-down into four steps based on input-output relationship (see Figure). Each step includes dialogue between data representative which in many occasions had lead to data conflict resolutions. In Yogyakarta, Bappeda took responsibility in leading the process. Aside from commitment of formal agencies, the study received support from the Winongo Community i.e. FKWA (Forum Komunikasi Winongo Asri) which was considered most proactive and well engaged

METHODS

The methods implemented in the Winongo study is following the general approach and methods discussed in part II on Methods. In this study, the base map was acquired by utilizing UAV imageries with additional field topographic survey survey. Field survey activities include a survey to conduct precise GPS measurement to provide control points for UAV mission and topographic mapping and a terrestrial survey to measure riverbanks' topographic profile

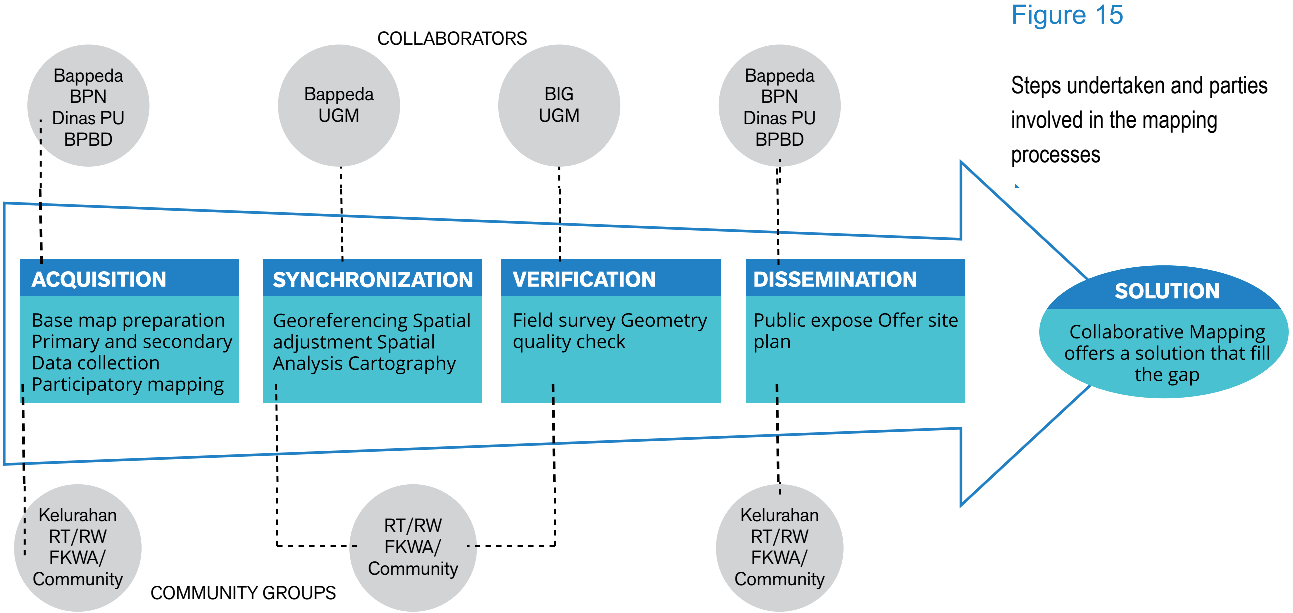


Figure 15

Steps undertaken and parties involved in the mapping processes using digital total station for improved digital terrain model. In regard to smallest unit of administrative boundaries, while the case study in Merapi post disaster recovery uses participatory mapping and joint field survey to delineate dusun boundaries, here in the Winongo Case, participatory mapping activities were used to delineate neighborhood boundaries (RT and RW boundaries).

Participatory mapping activities were attended by local representatives of 8 segments coordinated by FKWA. In total there were two sessions allocated for participatory mapping activity in each segment. Each session was attended by 10-20 local representatives. The first meeting session mainly to acquire spatial boundaries of neighborhood areas (RT, RW, block), settlement infrastructures, hazard areas and to copile spatially-referenced inputs from representatives regarding settlement quality and disaster management. The second session of participatory mapping, done in the end of the study after the final map is ready, was mainly done to disseminate the results and to accommodate corrections from the community members.

Cartographic work and spatial analysis were done iteratively to produce the base map and the thematic map of risk-sensitive urban development in riverbank areas. A ready-installed online map is also provided to the local government. The spatial analysis aims to illustrate the usefulness of the resulted map to help local government to handle possible relocation issues, land administration and urban development integration as well as to provide riverbank area upgrading scenarios to improve disaster risk infrastructure and settlement infrastructure quality.

There are at least two benefits of implementing collaborative mapping: first, it rearranges spatial governance by integrating spatial data with special thematic objectives into one georeferenced base map accessible for urban stakeholders. Various data and maps from different technical agencies are collected and integrated with community data which compiling community problems into one map. The map is a canvas to plot objects that have been built and problems that require solution. A detailed planning is created upon such canvas. The same reference allows technical agencies and community participate in planning and monitoring.

Second, it creates connection between community efforts in generating geospatial information with formal planning process. The participatory/ collaborative mapping generally serves two purposes: 1) engagement between the community and government experts on natural hazards and increase awareness of hazard exposure to community assets; and 2) updating and delineation of spatial objects to develop high resolution maps. Both processes constitute critical aspects in participatory planning, especially in the context of redefining spatial layout to mitigate future disasters (in this case flooding and localized landslide).

RESULT

The Collaborative Mapping at Winongo Yogyakarta delivers final outputs that include (1) data products both in the forms of high resolution base maps as well as the derived thematic maps from the collaborative process and (2) Module of Collaborative Mapping procedure for future use.

Risk-sensitive spatial plans can inform investment decisions including the definition of land-use designation that control new development and infrastructure layout in hazardous areas or the identification of necessary mitigation investments (e.g., including through land/spatial consolidation) to protect existing or future development. However, majority of cities in Indonesia lack of official high resolution aerial satellites and spatial database, this include Yogyakarta.

The critical point in project activities was to define the base map which is unavailable for Winongo River area. It was decided to produce high resolution aerial photos which serve as updated base maps, and to utilize the ortho-rectified aerial photos in collaborative mapping to delineate hazard zones and to map key infrastructures.

The specific products that have been completed at the end of the project are outlined below:

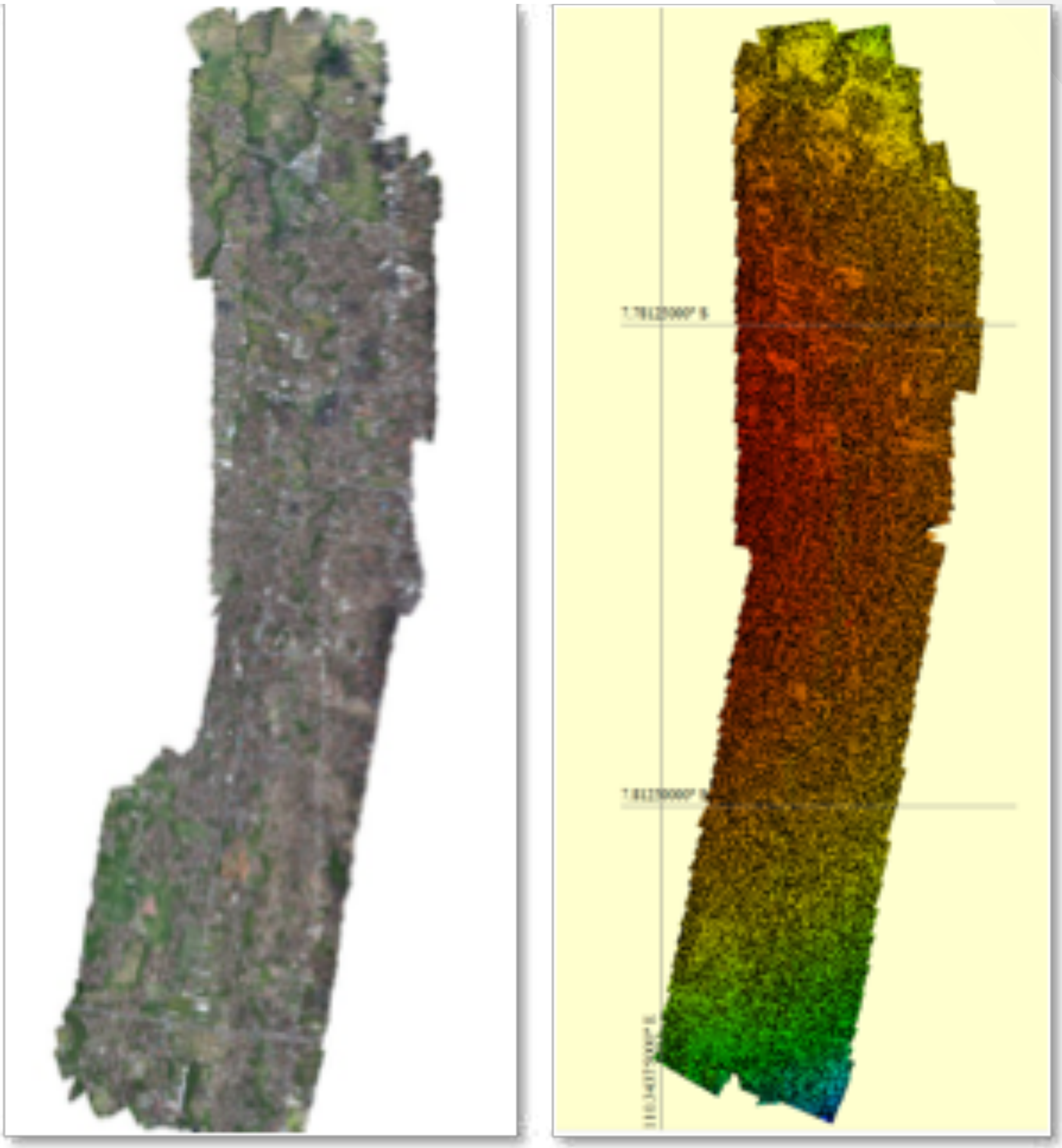


Figure 16

Mosaic orthophoto and DSM derived from UAV imagery

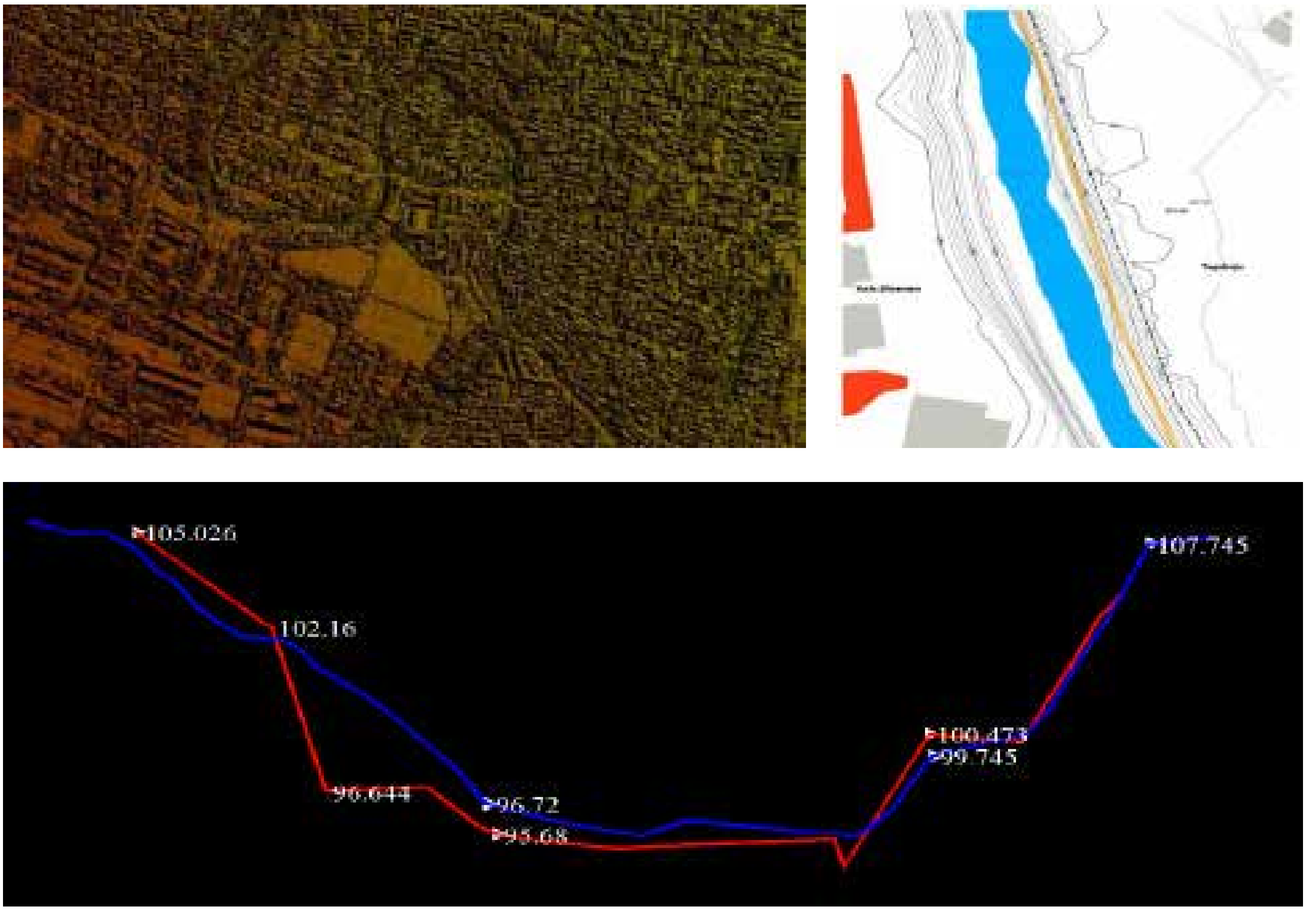


Figure 17

DSM (top left), Contour map (top right), Cross sections produced in the project (bottom)

1. Mosaic of Orthophoto and Digital Surface Model (DSM)

2. Two dimensional cross-section of the river

3. Collaborative thematic maps. There are several basic themes produced, including: settlement, environmental condition, land

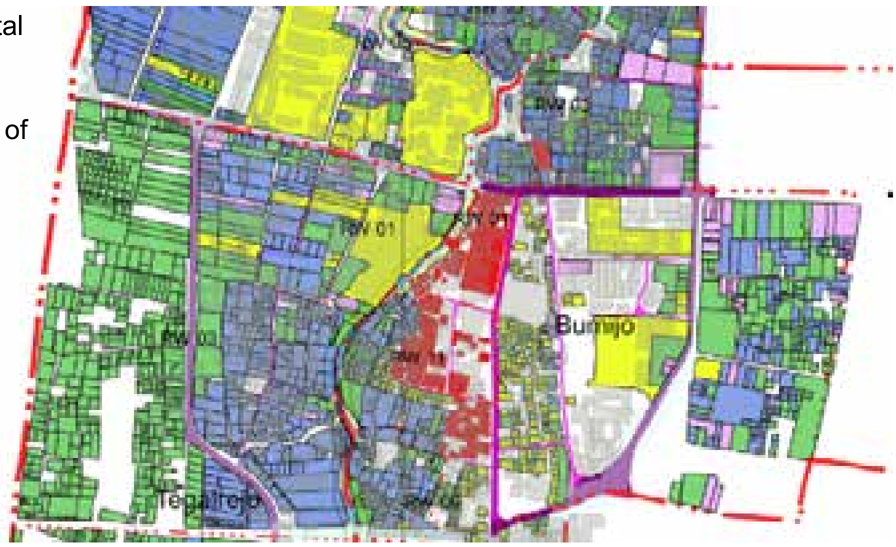


Figure 18

Land parcel by the legal status, the red one indicates blocks traditionally registered as the Sultanate Ground status, disaster response related facilities, and potential for tourism spots.

4. Spatial Analysis. The spatial analysis also constitutes as an important work and also as tool to engage stakeholders in building common understanding about hazards, risk and risk mitigation options. Several simple analyses to assess the overlap between space occupation and river buffer zone (as proxy to hazard boundary), population density of neighborhood blocks, evacuation route options, are among the examples of outputs produced by the analysisoverlap between space occupation and river buffer zone (as proxy to hazard boundary), population density of neighborhood blocks, evacuation route options, are among the examples of outputs produced by the analysis.

The thematic maps produced in this project have spatial accuracy that meets the Government's standard on provision of base map and the indicators as stipulated by the National Mapping Accuracy for the scale of 1:2,500.

Figure 19

Some spatial analyses produced from the project

Population Density Heat Map

Estimation of structures affected by applying the River buffer zone

IV. 3. Risk-Sensitive Urban Planning of Ampal River, Balikpapan

CONTEXT

Ampal River is one of the main rivers that flows through Balikpapan City, East Kalimantan. Areas surrounding the river is prone to floods and landslide due to excessive development in its upstream areas. A number of studies have demonstrated that changes in land use in the upper watershed areas of the river, from agricultural areas to settlement areas, have significantly reduced the water storage capacity of the land, thus increased the flooding intensity. A massive increase in the volume of surface runoff cannot be accommodated in Ampal River, which has already experienced severe siltation due to erosion at the upper stream. Increased concentration of suspended sediments has intensified from year to year and led to clogging in several points in Ampal River (Figure 20).

Balikpapan City Government was committed to rearrange and improve land use management in areas around the riverbank of Ampal River. For that purpose, the government needed a detailed mapping of the areas as a key instrument for spatial planning, which would need to be developed in a collaborative

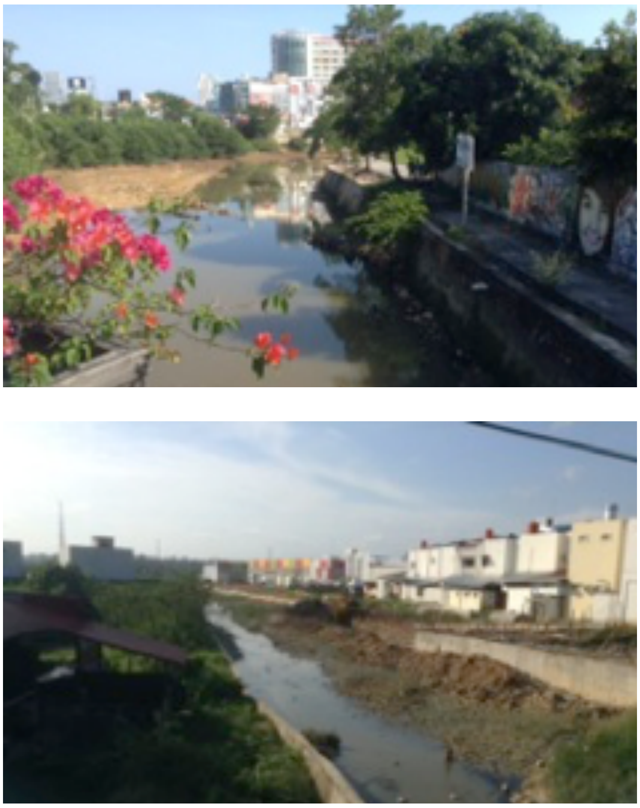


Figure 20

Condition of Ampal River riverbank that experiences rapid development

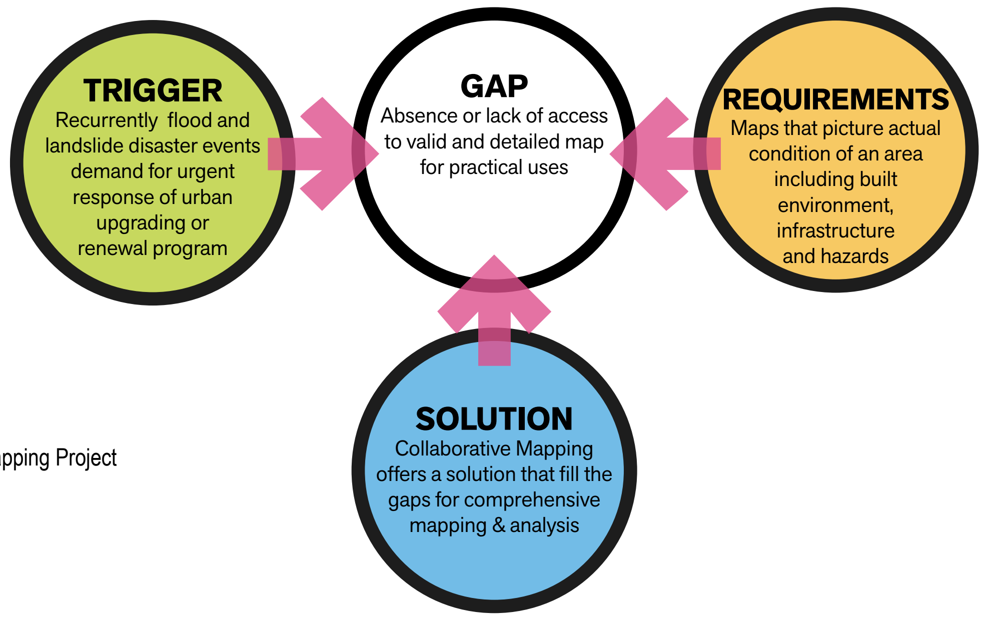


Figure 21

Rationale for Ampal Collaborative Mapping Project manner involving the relevant stakeholders. The rationale that motivates the project is given in Figure 21.

As a first step, a detailed map would be needed as a basic reference in spatial planning. Through the spatial planning the city government defined the spatial structure and settlement pattern appropriate to the city development plan, as part of the efforts to achieve sustainable development. Bappeda of Balikpapan City involved a Mapping Consultant Team from the Faculty of Civil Engineering and Planning of Balikpapan University to conduct a detailed mapping.

The goal of the pilot project in Ampal River was to build a collaboration platform among key stakeholders in the city to jointly formulate detailed risk maps and recommendations for the spatial planning of areas around the river. It was expected that the resulting detailed map could be used as a reference in the preparation of detailed spatial plan of Ampal River areas, with a view of making the areas resilient to disaster and climate change-related risks. The map would be presented in a user-friendly format that would be easy to understand, use and update by the city government.

COLLABORATORS/STAKEHOLDERS INVOLVED

AGENCY/ ORGANIZATION	ROLE
Balikpapan City Bappeda	• facilitated FGDs to identify issues related to land-use in areas around Ampal River • facilitated consultative workshops with the multi-stakeholders on the map and design of the target areas • coordinated geospatial data collection and other technical matters with the local sectoral units
Mapping Team from Faculty of Civil Engineering and Planning, Balikpapan University	• made data inventory from relevant SKPD • inter-local agencies survey • field survey • data processing and analysis
UGM mapping team	Quality assurance
Public Work Agency of Balikpapan City	prepared basic maps of Balikpapan City
Camat/Head of Sub-District	data verification and validation
Lurah/Head of Urban Ward	data verification and validation
Community	data verification and validation

METHODS

The methods implemented to complete the Ampal River case study is similar to ones implemented in Winongo and Merapi. Here the base map was produced from aerial imageries produced by BIG in 2015, thus capable in providing a better quality of geometry and radiometry aspects of imageries than the base map used in Winongo and Merapi.

While in Winongo, land parcel map representing land parcel boundaries and their corresponding ownership rights for the study area can be integrated well, here in Ampal project the land parcel map cannot be used for analysis due to data availability constraints.

RESULTS

The Ampal River pilot project had 3 outputs as the following:

a. Thematic map with a scale of 1:2,500 for the entire Ampal River areas
b. Flood Risk Map and Landslide Risk Map of Ampal River's riverbank
c. Design plan for Modern Market in Ampal River areas

THEMATIC MAP WITH A SCALE OF 1:2500 FOR THE ENTIRE AMPAL RIVER AREAS

The mapping team started to prepare detailed risk map of Ampal River areas by delineating areas that used to be affected by flood. To facilitate discussion and overlaying of the map, mapped areas were divided into seven segments. The mapping team used basic map and secondary data from Balikpapan City Bappeda and Public Works Agency in the form of aerial photos from 2014, topographical map from 2004, DED Normalization map of Ampal River from 2012, DED Coastal Road map of Balikpapan City from 2012, and Spatial Plan map of Balikpapan City from 2012.

Digitation of basic map was done by making vector data from aerial photographs of 2014, which were grouped into several layers including: street layer, building layer, land-use layer, river layer, and drainage layer.

Collaborative mapping was done after the field survey activities were done. The process involved community and government apparatuses from the urban ward/kelurahan level. Local government officers helped delineate boundaries between neighborhood and kelurahan areas, identify public and social facilities, validate these facilities, and provide missing information in the basic map such as flood and landslide affected areas, and the boundaries of these hazard-prone areas. Together with the community, they also proposed measures to reduce flood and landslide risks in their respective areas.

Stages in digital data processing from the primary and secondary data and data that came from field survey to make basic map included spatial adjustment of secondary data, survey inputs and attribute data, and spatial analysis. The subsequent process constituted validation workshop and verification of thematic maps, and compilation of data from new information obtained from the segment developed by stakeholders that would be used as pilot in the improvement of the land-use planning.

The last stage was finalization of the collaborative map by the incorporation of corrections in the form of addition of research areas, geometry of some objects, cartography, and map layout.

The large scale thematic maps contain the following information:

a. Administrative boundaries (urban wards, neighborhood areas/RT)
b. Land contour
c. River demarcation areas
d. Critical infrastructures (education, health, social and religious)
e. Land ownership status
f. Areas prone to flooding and landslide
g. Social-economic status
h. Land use classification (industry, settlement, etc.)
i. Location of control dam/water catchment
j. Potential land for consolidation

The thematic maps that had gone through the process of validation and verification were presented as a GIS database that would be used as reference by stakeholders in the planning and development of Ampal River areas in Balikpapan City.

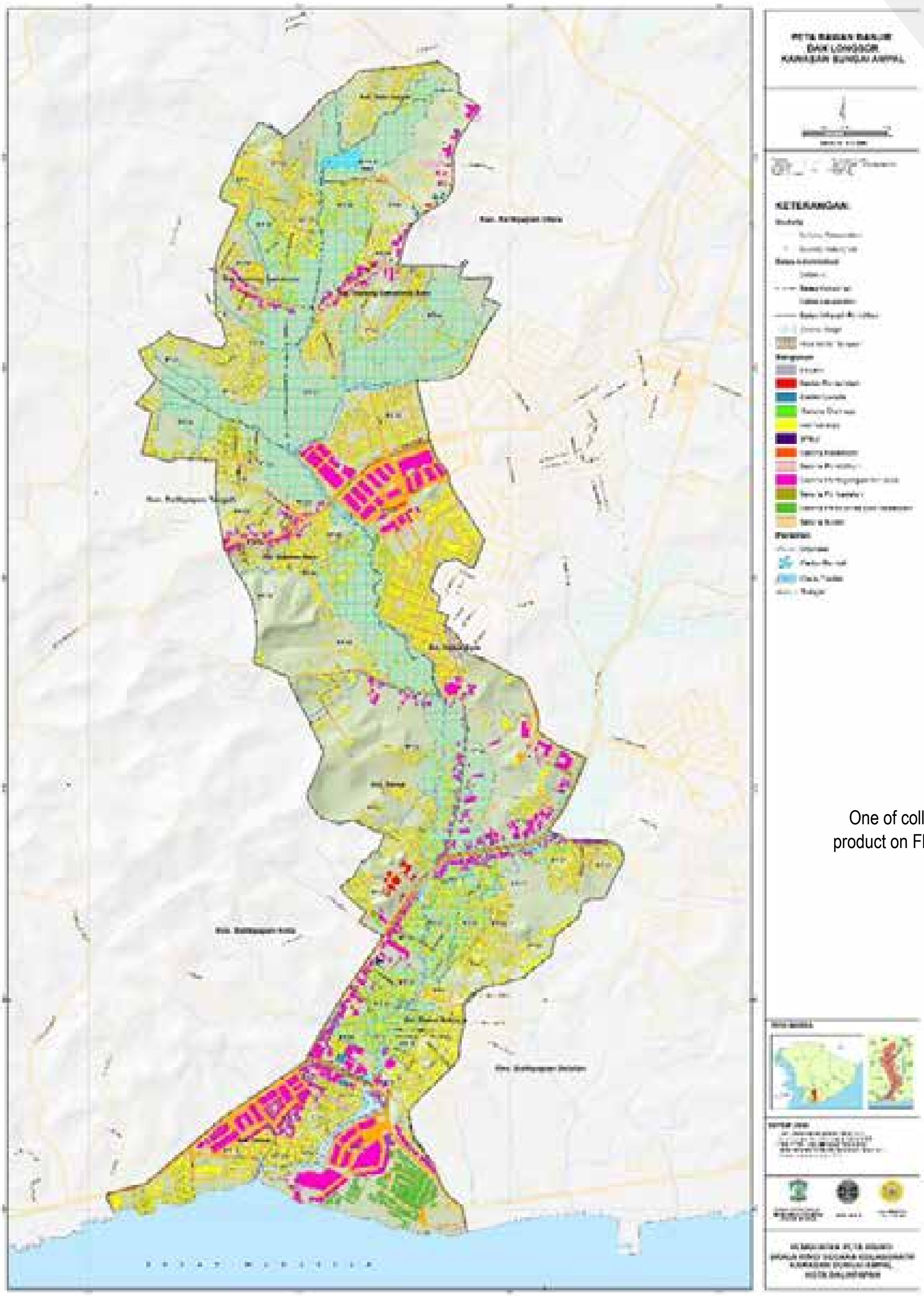


Figure 22

One of collaborative mapping product on Flood and Landslide susceptibility

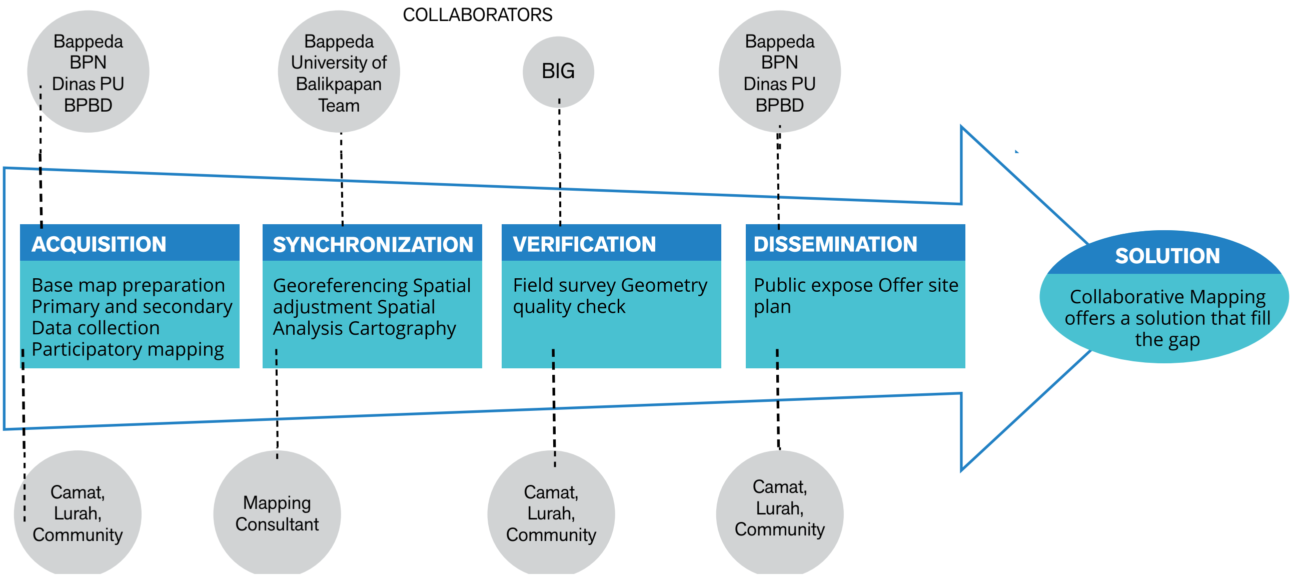


Figure 23

Steps undertaken and parties involved in collaborative mapping process

FLOOD RISK MAP AND LANDSLIDE RISK MAP FOR AREAS AROUND AMPAL RIVER

The detailed risk maps contained information about flood and landslide hazards that had been consulted with experts and community leaders. Risk analysis was generated from the analysis to determine the level of risk based on the hazard and vulnerability.

The analysis of flood-prone areas around Ampal River was done by using community data gathered from participatory mapping activities and analysis of the topographical map. The data used from participatory mapping were mainly information related to extent and intensities of historical flood events. Locations and heights of floods were plotted into collaborative map, and then overlaid with topographical map to delineate flood-prone areas. The analysis of landslide-prone areas was done by using data from the participatory mapping that were overlaid with slope elevation data. The results from the analysis of areas around Ampal River that are prone to flood and landslide hazards were elaborated in the following segments.

Segment 1

Flooding usually occurred due to sea tides, but it only affected a small section of settlement areas. The width of the river was around 30 meter.

Segment 2

Flood-affected area in this segment covered an area of 36.17 Ha with height between 0.5 and 1.5 meter. Flooding was caused by heavy rain and sea tide. Landslide was caused by erosion in the river. The width of the river was 10-18 meter.

Segment 3

Flood-affected area in this segment covered an area of 22.45 Ha. This area was lower than the surrounding streets and hence often inundated with the overflow from Ampal River. Besides rain intensity, narrowing of the river and heavy sedimentation had played a significant role in triggering floods.

Segment 4

Flood-affected area in this segment covered an area of 20.73 Ha from a total of 91.24 Ha. This segment was also prone to landslide due to its steep slope. Flooding in this segment was caused by rain intensity and silting-up of the river due to heavy sedimentation. The width of the river was 8-10 meter.

Segment 5

Flood-affected area in this segment covered an area of 59.04 Ha. This area was the meeting point of three tributaries of Ampal River, and hence the area affected by flooding was quite significant. Flooding was mostly caused by increased intensity of rain, sedimentation, and narrowing of the river in several locations. Also, in several places the river embankments had been broken.

Segment 6

Flood-affected area in this segment covered an area of 32.55 Ha. Flooding occurred during heavy rain with a duration of more than two hours. This was caused by the narrowing of the river that had greatly reduced its capacity to hold the excessive volume of rain water.

Segment 7

lFlood-affected area in this segment covered an area of 8.0 Ha. Flooding was mostly caused by rain intensity and silting up of the river. There was also an area that was prone to landslide in RT 07 of Gunung Samarinda Baru ward.

DESIGN FOR REARRANGEMENT OF AMPAL RIVER'S MODERN MARKET AREA

The proposed design for spatial rearrangement of Ampal River areas took into consideration the technical appropriateness and the economic, social, cultural and environmental feasibility. The recommendations covered issues related to land-use planning, infrastructure planning and spatial zoning.

Ampal River pilot project utilized collaborative map in analyzing the Strength, Weaknesses, Opportunity and Threat of Modern Market development in the form of Design for Spatial Rearrangement of the Segment around Modern Market areas. Some strategic policies had been suggested to be implemented, there are:

a. The realization of one-map policy or decision-making based on the same data and map was needed at city level to ensure the coherence of planning, implementation and maintenance
b. The realization of land acquisition in Modern Market/Fresh Market areas
c. The construction of control dam to contain water flow to the three secondary rivers
d. The follow up to conduct further study of the proposal to develop Fresh Market Areas.

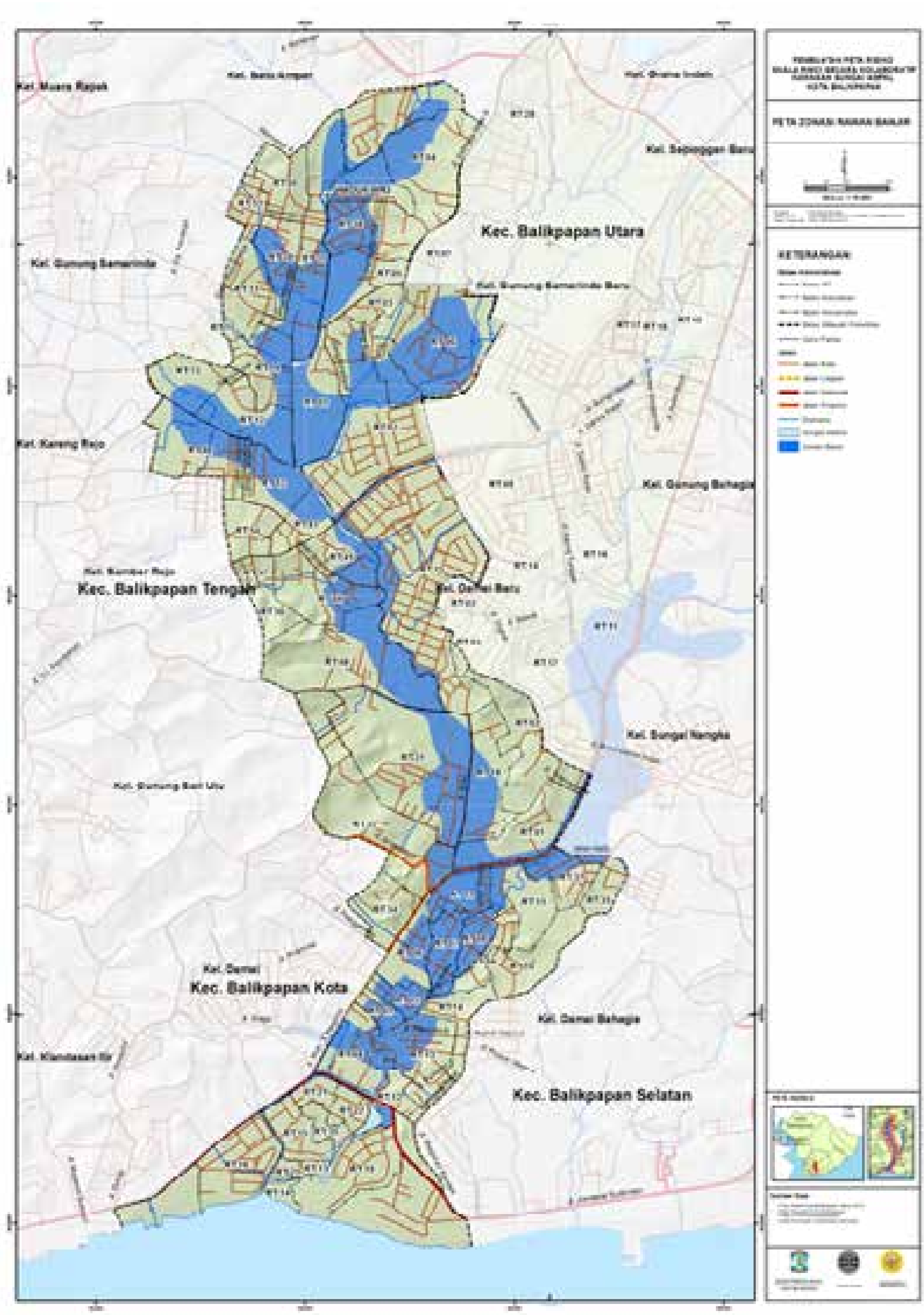


Figure 24

Flood prone areas map

V. Utilization of Collaborative Mapping Projects

From case studies elaborated in Part IV, the overall impression gained at the final workshop on the result dissemination has been the same. The collaborative maps gain positive feedback and interest from stakeholders. Mainly, stakeholders appreciate on the level of detail the map can offer and secondly on the collaborative processes in data collection and validation. Further, the potential uses of the map can be understood very well by stakeholders. As a result, the sense of belonging and ownership of the maps produced grow strong across the involved collaborators and stakeholders.

This part will focus on the use of collaborative maps produced. How the unified data and map produced can be optimally used to support local government needs in urban and rural development. Three post mapping activities will be showcases. First, the utilization of the collaborative map to support the land consolidation in Mount Merapi after the 2010's eruption. Secondly, the utilization of the collaborative map to provide decision-support for risk sensitive urban development in Winongo and Ampal rivers.

VILLAGES	HAMLET	NUMBERS OF	
		LAND PARCELS	SUBJECTS
Umbulharjo	Pangukrejo	468	350
Umbulharjo	Pelemsari	167	121
Kepuharjo	Jambu	292	172
Kepuharjo	Kaliadem	230	173
Kepuharjo	Kopeng	205	154
Kepuharjo	Petung	325	200
Total		1,687	1,170

V. 1. Land Consolidation in Mount Merapi's Post Disaster Recovery

After the Mount Merapi eruption 2010, the local government unleashed a regulation that sub-villages affected directly by the eruption must not be used as settlement areas. This means villagers that live in areas which were burnt or damaged by pyroclastic flow must be relocated to new places. Local government and REKOMPAK then launched a supporting program called community-based settlement planning activities aiming at providing new settlements to impacted residents. Meanwhile the impacted areas defined as zero settlement and building units include land parcels owned by residents.

Land consolidation is a strategy to readjust and rearrange the boundaries of land parcels and their ownerships for improved spatial plan that provide among others better access to settlement infrastructure and better preparedness for a disaster. In case of Mount Merapi, the readjustment and rearrangement were initially to also accommodate needs for evacuation routes, community cattle ranch, local roads and drainages. In Indonesia, land consolidation is a program activity that is done under auspices of BPN and DPPD (BPN 2014). The outcome of the land consolidation program is land certificates to residents in the project area (or new ones for the land parcels that have been certificated). One condition is applied in Merapi land consolidation program which is that the land certificate is an ownership right with type of nonresidential use, such as: farming land. With this certain type of certificates, residents cannot rebuild or add building objects in their land parcels. In total there were 1,687 parcels located at 6 hamlets (known as Dusun) in 2 villages certificated in December 2014 as the result of the land consolidation activity. The land certificates have been handed over to residents who are the subjects of the land parcels in December 2014.

The land consolidation project was done by Yogyakarta Province and Sleman BPN from January to December 2014. The steps undertaken during the project include (Yogyakarta BPN 2014):

- Site identification
- Socialization and community meeting
- Agreement and consensus building
- Site selection
- Subjects and objects identification
- Perimeter and boundaries' measurements
- Topographic and land use mapping
- Parcel-based block plan design
- Community discussion on land boundaries delineation
- Release and land consolidation Boundary Demarcation
- Stake-out survey to apply land consolidation design and agreed land boundaries
- Administration of land tenure process
- Certificates production and hand-over

These steps interact a lot with village officers, community leaders, and land owners. The required activity of topographic and land use mapping was not done since the project agreed to use the collaborative map. The collaborative map resulted from Mt. Merapi's Post Disaster Recovery produced a reference map at scale 1:2,500 depicting topographic layers and thematic information, used as a reference for National Land Office to do land consolidation in the area. In fact, the collaborative map resulted in 2013 was used in many steps to support site identification, subjects and objects identification and to be used as the base map in the process for parcel-based block design. The end result of land parcel map resulted from lnd consolidation project is seen as follow.

Figure 25

The resulted collaborative map of Pangukrejo, Umbulharjo

Figure 26

Using the resulted collaborative map (top), land parcels were identified and their boundaries were designed producing parcel-based block plan design in land consolidation project

From the land consolidation project implementation, it can be concluded that the base map resulted from collaborative mapping activity gave huge contribution not only for its initial purposes for settlement planning and detailed planning activities but also to support land consolidation project need for a detailed yet validated topographic map of project area. Thus, one map can serve many purposes from land administration, spatial planning up to disaster management activities. As the maps were distributed to all stakeholders, village officers and hamlet chiefs could use the collaborative map as a reference for their local references.

V. 2. Spatial Decision-Support in Risk-Sensitive Urban Development

Winongo river in Yogyakarta city and Ampal River in Balikpapan city provide perfect examples about city rivers disturbed by business and settlement areas growth in the city, creating danger and vulnerability to residents living along the river area. It is unfortunate that many settlement areas in the riverbank are prone to flood inundation and landslide events. Ampal dan Winongo projects showcases the potential uses of the collaborative map to produce spatial analysis regarding parcels and buildings to handle to support urban riverbank redevelopment for flood disaster mitigation.

Ampal riverbank area is experiencing fast settlement and business areas grow. Unfortunately the increase of houses and building objects near the river has increased the risk for wider flood inundation and more frequent landslide events (see the figure).

Figure 27

Flood inundation nearby the Ampal riverbank is frequent experience for local residents especially when heavy rain shower the city more than two hours

In fact, the local government has allocated huge budget to revitalize and improve the city drainages to make city areas less vulnerable to flood. This plan however is difficult to be implemented as many land parcels are till in disputes or in uncertain status, thus make the improvement of the city infrastructure becomes difficult. One possible solution for this is the implementation of land consolidation project. Similar to the case of Merapi land consolidation, the site identification for urban land consolidation in Ampal River can be easily developed using the collaborative map produced for Ampal river (see Figure 28).

As for Winongo case, the various technical data collected from technical agencies are valuable data that enable local government to do spatial analysis to implement risk-sensitive urban development in the riverbank areas. To illustrate the utilization of the map, here are some outcomes resulted from spatial analysis done on top of the collaborative map. The following are illustrated usefulness for city planning resulted from spatial analyses done in Winongo Case study.

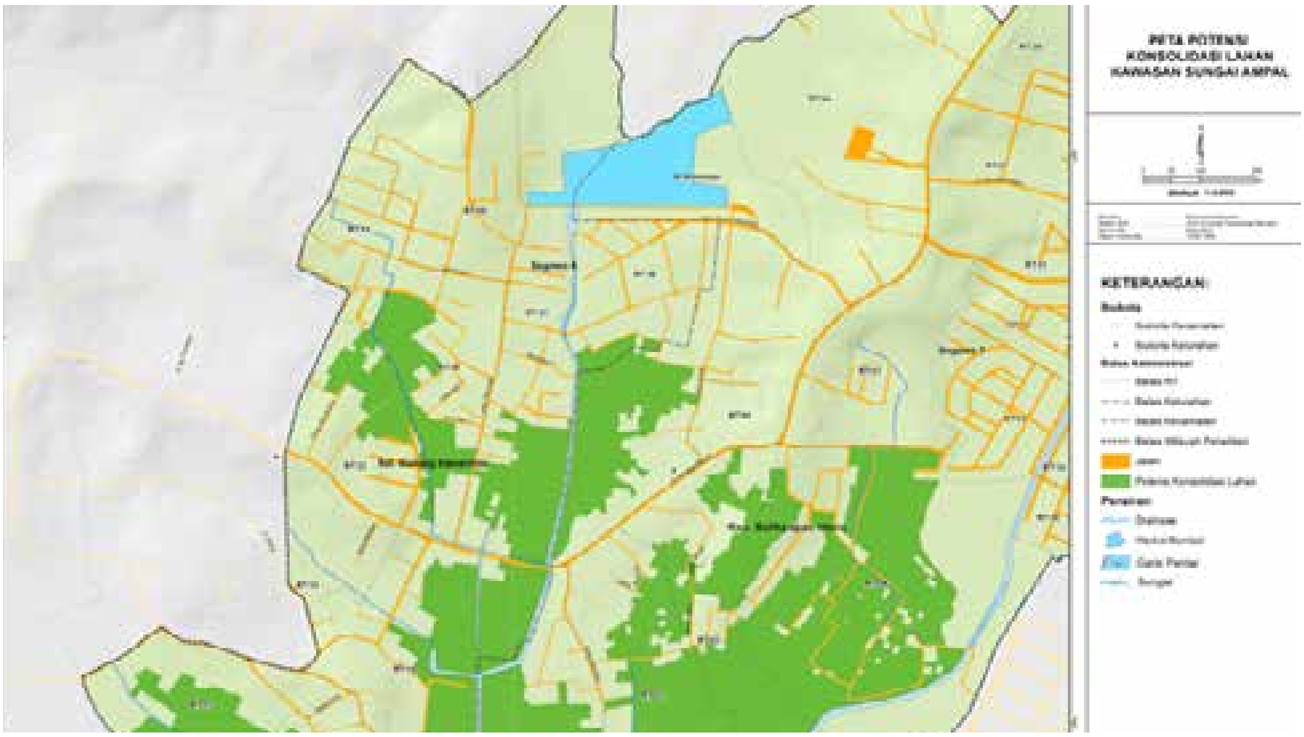


Figure 28

The green aggregated parcel blocks were identified as parcels potential to be included in land consolidation project to support city infrastructure improvement

V. 2. 1. Calculating Building density

Building density in a segment can be calculated by comparing the total area of built environments against the total area of a segment, seen as follow:

$$\textit{Buidling density} = \frac{\textit{total area of built environment}}{\textit{total segment area}} \times 100\%$$

Steps used to calculate building density are :

a. To select building using spatial query (Within) of QGIS spatial query.
b. To calculate building area.
c. To calculate segment/block area.
d. To calculate building density.

Density building is then visualized using heatmap method with radius of determined circle is using the value of individual building area. The results of heatmap visualization of building density for each Segment.

Figure 29

Density buidling heatmap of Segment 1 and 2 (left) as well as 3 and 4 (right) of Winongo River

Figure 30

The demarcation lines of 15 meters right and left from the edge of the river on segment 1 and 2 (left) as well as 3 and 4 (right).

V. 2. 2. Calculating imaginary demarcation lines on riverside areas

The government regulation on River (PP. No. 38/2011) specifies that a city river like Winongo that has depth from 3 up to 20 meters, many are without riverbank structure, should be freed from settlements and has at a free space at least 15 meters from the left and right side of the edge of the river (see Figure 30). Such imaginary demarcation lines on the riverbanks can be seen as an awakening call to simulate how the regulation would affect the riverbank areas.

From the analysis, it can be summarized that hundreds of houses need to be relocated and re-arranged (see Figure 31).

Figure 31

Buildings that virtually are fully within or partially within the 15 m of riverbanks zone

Table

Numbers of buildings that are fully or partially selected in case of urban arrangement based upon riverside zonation (15 m

SCOPE	WITHIN	INTERSECT
Segmen 1	4	67
Segmen 2	80	202
Segmen 3	16	94
Segmen 4	24	124
Segmen 5	42	137
Segmen 6	39	146
Segmen 7	37	126
Segmen 8	21	106
Total (sum)	263	1,002
Total buildings in all segments	263	1,002

Meanwhile the numbers of land parcels that need to be consolidated when urban arrangement will take place is shown in Figure 32.

Figure 32

land parcels (with various riights i.e. use rights/HP, private ownerships/HM, building use rights/HGB) that virtually are fully within or partially within (i.e. intersect) the 15 m of riverbanks zone

V. 2. 3. Identifying the location of waste water treatment infrastructures

The main concern in all segments is that the use of rain drainages is combined with waste water networks. In addition to that, there are some Waste Water Treatment Installation known as IPAL have been built and installed in the field but failed to beused. For this reason, waste water treatment seem essential to be provided in each community area. In this study, the location of IPAL is designed based upon its topographic features of each RW. The results of analysis are presented in Figure 33.

Figure 33

The proposed location of IPAL to be installed in Segment 5 and 6 (left) as well as 7 and 8 (right) based on their access and the topography

V. 2. 4. Identifying where to put hydrant

Optimal hydrants are proposed based upon community inputs and geospatial analysis considering the density of the buildings and accessibility of the local roads in the study area. Optimum hydrant locations were assumed to have a location that no later than 30 meters from the street. The hydrants should be able to reach all settlement blocks. The resulted analysis is shown in Figure 34.

Figure 34

Proposed community hydrant installation in segment 1 and 2 (left) as well as 3 and 4 (right).

V. 2. 5. Calculting best evacuation routes

Optimum evacuation routes were generated utilising tools road planning using GIS software. The destination of the evacuation routes is main public facilities and open space environment.

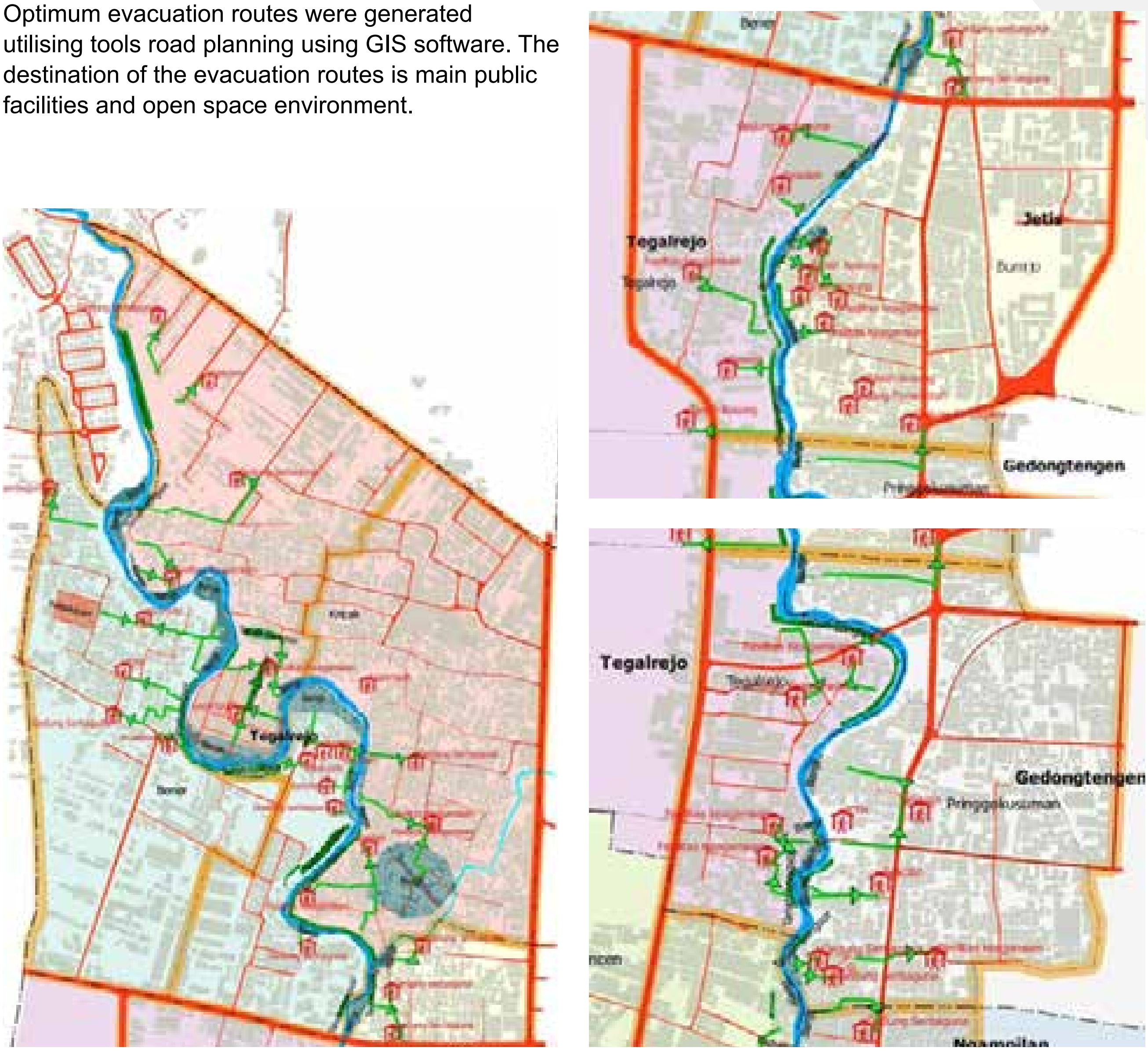


Figure 35

Best evacuation routes for Segments 1 and 2 (left) as well as 3 and 4 (right)

The proposed routes for residents to move from settlements areas to targeted evacuation points in all segments were based upon the existing condition of flood and landslide prone areas. All prone areas were successfully identified based upon historical data gathered during participatory mapping activities and based upon flood discharge estimation from previous study (i.e. Feasibility Study of Winongo River by AECOM 2014). From the map it can then be calculated numbers of buildings either fully or partially threatened by landslide and floods. Figure 36 show the results.

The corresponding numbers of buildings that are constantly threatened by flood events are 431 buildings.

V. 2. 6. Identifying land ownership

In regard to riverbank zonation, the existing condition of land ownership in the study areas shows that major types of rights are private ownerships (*Hak Milik)* and utilization right (*Hak Pakai*), the others are Building Use (*HGB*) and not registered. There are actually many Sultanate Ground land ownerships in the study area but mostly are not registered to BPN. The complete situation of land ownership in the study area can be calculated based upon the collaborative map produced.

Figure 36

Flood extent and threatened houses

Table. Composition of land tenureships based on their right types in the study area

SEG MENT	LAND WITHOUT DEED	PRIVATE OWNERSHIPS (HAK MILIK)	USE (HAK PAKAI)	BUILDING USE (HGB)	LAND WITH NO DEED (%)	HM (%)	HAK PAKAI (%)	HGB (%)
1	2005	1990	54	142	4191	47.84	47.48	1.28
2	1568	2230	46	88	3932	39.87	56.71	1.169
3	517	684	229	61	1491	34.67	45.87	15.36
4	426	625	30	20	1101	38.69	56.76	2.72
5	103	706	120	16	945	10.89	74.70	12.69
6	86	649	134	50	919	9.35	70.62	14.58
7	437	1062	353	59	1911	22.86	55.57	18.47
8	451	824	57	72	1404	32.12	58.69	4.06

In order to illustrate the composition of the land ownerships as presented in Figure 37 shows the situation of land tenureships surrounding the Winongo river. The types of ownerships can be not registered (*belum terdaftar*), private ownership (*hak milik*), building use (*hak guna bangunan*), use right (*hak pakai*).

Figure 37

Land ownership situation in Winongo river

VI. Lesson Learned

From the showcases on the development of collaborative maps (Chapter IV) and their usefulness the lessons learned on advantages and challenges of collaborative mapping projects can be identified. These lessons learnt are expected to create awareness and comprehension to assess opportunities in applying collaborative mapping projects for supporting detailed spatial planning and risk zonation for disaster management.

VI. 1. Advantages

VI. 1. 1. EFFICIENT WAY TO GATHER GOOD QUALITY DATA

A significant advantage of this approach is that it offers lower budget and shorter time of actions than conventional mapping approaches. Government and local government mapping projects require more budget to hire experts and professionals that are not from the area. Using conventional implementation, consultants need more time to get to know the local area and more resources to mobilize the team, whereas in the collaborative mapping approach, the consultants are the community, local leaders, village officers, technical agency leaders and staff with scientist and students are installed as facilitators. Merapi project that required 4 months of actions spent about 330 millions rupiah or 110 million rupiah for each village, Winongo project that covered about 500 ha of corridor mapping areas spent about 250 million rupiah or 700 thousand rupiah per ha to get complete geospatial features of contours, building footprints, neighbourhood infrastructures, hazard areas, etc. In summary, the advantages of the mapping approach include:

- It offers faster and cost efficiently map products
- It offers better ownership values to stakeholders

VI. 1. 2. STRENGTHENING SPATIAL AWARENESS

In addition to the rapidness to derive the outcome and the reduced cost for data acquisition, the outcome of the collaborative mapping creates a better ownership to stakeholders involved in the process. Through participatory mapping activities at the community level and stakeholders meeting involved local agencies, data sharing and data validation become more familiar to stakeholders. Good quality product can be offered as it requires the quality assurance from BPN and the level of detailed of the content is validated by all parties.

In participatory mapping sessions and stakeholder workshop, environmental problems related disaster and their proposed solutions are expressed and documented in the draft map. It combines top-down and bottom approaches, so more than just participatory mapping activities. In this regard, community and local staff become more familiar with maps and geospatial information on their niche.

The resulting map is, at the same time, an effective tool for program planning and monitoring. First, once the problems and drawbacks are all spatially represented and documented, local community used the map as a base to propose community-based plans to be submitted to sub district office. From the government perspective, those spatially referenced problems and drawbacks will be straightforward resources to develop priority actions. Interestingly, the current planning system endorse bottom-up planning programs.

Monitoring and evaluation on land developments and permit issuance could be very effective to be done on top of the collaborative map. The challenge will be on the institution support and resource allocation to make sure that the useful information resources gained from the collaborative map is used for planning and decision-support. Here are the opportunities it can offer:

- Basis for well targetted public investments, regulate land use, and increase resiliency
- Unlimited themes: high adaptability and interoperability
- System and data base integration by vertical and horizontal

VI. 1. 3. EXTENDING POSSIBILITIES AND OUTREACH

The collaborative map can also be easily turned into a “living spatial canvas” to present field developments’ updates and to gather community feedback. The Web 2.0 technology has opened up possibilities to mash up the web collaborative map (WebGIS) with social media as a crowd application, even to be accessed through Mobile Apps. This has been exemplified by many smartcity applications (e.g. QLUE in Jakarta) where human sensors are employed to support city services’ improvement. Connecting the web collaborative map application with field sensors and human sensors is a huge potential to offer.

VI. 2. Real challenges

It must be acknowledged, that the challenges to produce a collaborative map of an area are difficult and complex. Not only on the data availability, quality, but also on the heterogeneity of the data format. Here is the summary:

ITEMS	CHALLENGE	RESPONSE
Base Map	Availability of physical and digital map of national standard	Practical regulation to accelerate base map generation
Data source	Not spatially adjusted format, out of date, low resolution, misplaced, confidentiality	Triangulation with primary data, build consensus and understanding
Thematic model	Lack of guidance about thematic data model on attributes taken into account include layer, class and category	Sectors to decide and prepare guideline for each and every thematic map
Data sharing	Disconnection of local and national data management	Introduce platform of national data management
Human resource	Varied capacity of local consultants	Promote training, advisory, knowledge sharing and networking with national pool of talents

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Abbreviations & Acronyms

BPBD DIY	Yogyakarta Provincial Disaster Management Agency
BAPPEDA	Badan Perencanaan Pembangunan Daerah/Regional Development Planning Agency
BBWS	Balai Besar Wilayah Sungai/River Basin Development Agency
BIG	Badan Informasi Geospasial/Geospatial Information Agency
BNPB	Badan Nasional Penanggulangan Bencana/National Disaster Management Authority
BPN	Badan Pertanahan Nasional /National Land Agency
BPN	Badan Pertanahan Nasional/National Land Agency
BPPTK	Badan Pengkajian dan Pengembangan Kegunungapian /Agency for Technological Development and Research of Volcanology
BPPTKG	Balai Penyelidikan dan Pengembangan Teknologi Kebencanaan Geologi/Research and Technology Development of Geological Disaster
DED	Detailed Engineering Design
DEM	Digital Elevation Model
DIY	Daerah Istimewa Yogyakarta/Yogyakarta Special Region
DPPD	Dinas Pengendalian Pertanahan Daerah/Regional Land Control Department
DRM	Disaster Risk Management
FKWA	Forum Komunikasi Winongo Asri/Winongo Community
GCP	Ground Control Points
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographic Information Systems
GPS	Global Positioning Systems
IPAL	Instalasi Pengolahan Air Limbah/Waste Water Treatment Installation
LAPAN	Lembaga Penerbangan dan Antariksa Nasional/National Institute of Aeronautics and Space
PPK GPS	Post Processing Kinematic GPS
PU	Pekerjaan Umum/Public Works
PU ESDM	Pekerjaan Umum, Energi dan Sumber Daya Mineral/Public Works, Energy and Natural Resources Agency
PVMBG	Pusat Vulkanologi dan Mitigasi Bencana Geologi/Center of Volcanology and Disaster Mitigation
RDTR	Rencana Detail Tata Ruang/Detailed Spatial Plan
REKOMPAK	Rehabilitasi dan Rekonstruksi Berbasis Masyarakat/Community-based Settlement Rehabilitation and Reconstruction
RT and RW	Rukun Tetangga and Rukun Warga/Neighborhood areas
UAV	Unmanned Aerial Vehicle

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