Geoinformational Support

Geo4IRBM

for Integrated River Basins Management

European Space Agency

Land Cover Mapping

Przemysław Turos (Topologic)

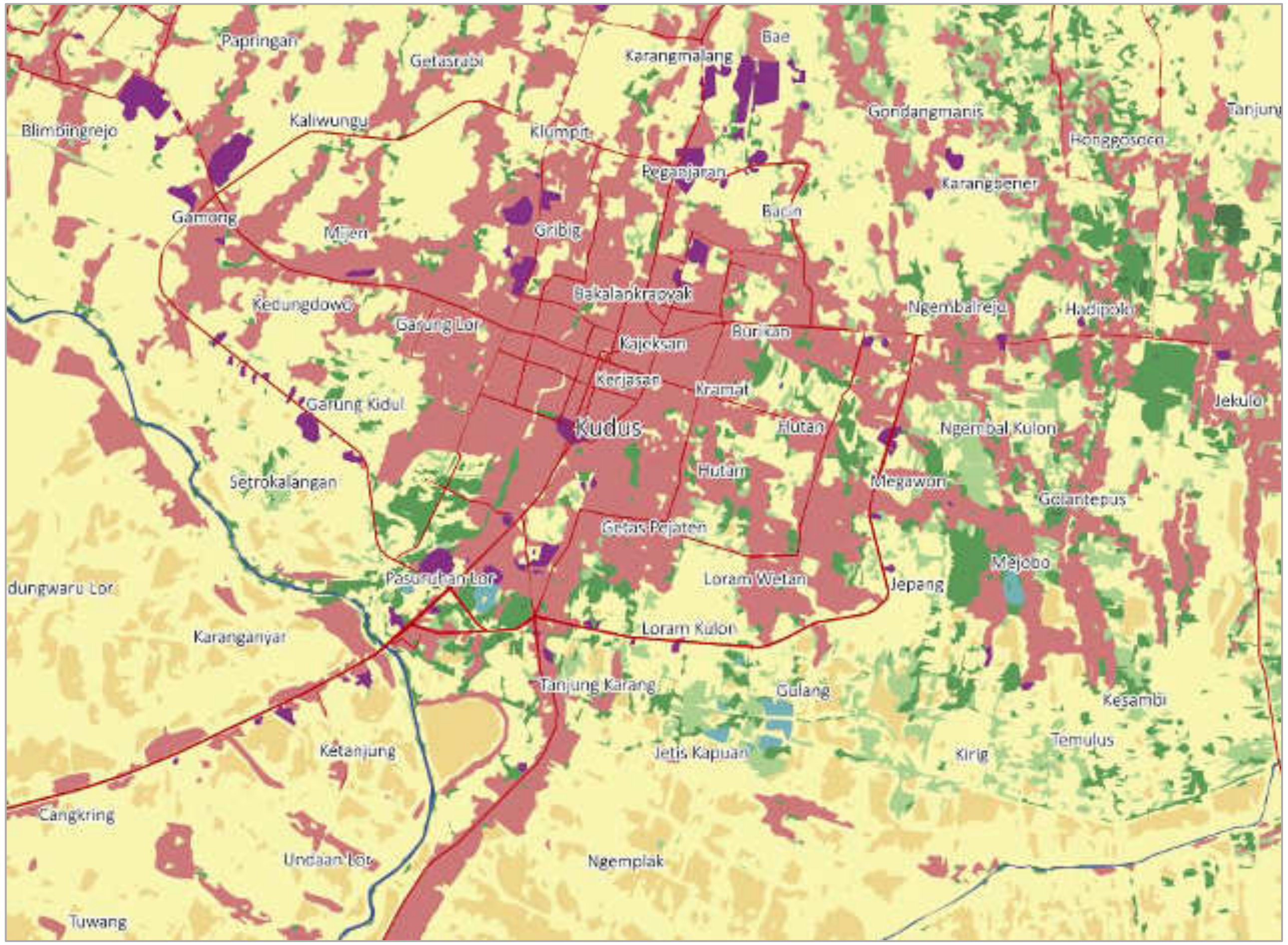
Land Cover Mapping – Definitions

Proposed resource provides complex and comprehensive information on Earth surface in given area. It consists of several thematic data scopes characteristic for typical maps:

Land Cover - physical material at the surface of the earth. Land covers include grass, asphalt, trees, bare ground, water, etc. or observed physical and biological cover of the earth's land, as vegetation or man-made features (IPCC).

Land Use - total of arrangements, activities, and inputs that people undertake in a certain land cover type (IPCC).

Topographical map - detailed and accurate graphic representation of cultural and natural features on the ground.



Land Cover Mapping – Background

Enhanced Water Security Investment Project *(source: EWSIP Project Concept Paper)*

Outputs

1. Planning for water resources optimized

    1a. Water monitoring equipment installed as per rationalization plans.

    1b. River basin wide hydrological and hydrodynamic models calibrated.

    1d. Asset management information system for river assets established.

    1e. Knowledge and skills in climate resilient infrastructure design/planning of RBO staff

Key Activities with Milestones

1. Planning for water resources optimized

    1.2 Install and calibrate expanded networks of hydro-meteorological stations. (Q4 2020)

    1.3 Run hydrological and hydrodynamic models to optimize water management for DMI, irrigation and energy needs taking into account land use change and climate change scenarios. (Q2 2020)

    1.5 Upgrade the river asset management information system to an online GIS based system. (Q2 2020)

Proposed application scenarios of Geo4IRBM services

Land Cover Maps applied for the needs of flood risks and flood hazard (the Polish case IMGW/Polish Waters/Ministry of Inland Navigation and Water Management).

Crops Intensity Maps for water demand assessment.

Surface Waters Monitoring historical data could contribute to climate change analysis and historical floods delimitation – frequency of water coverage

Land Cover Mapping – Background

Enhanced Water Security Investment Project *(source: EWSIP Project Concept Paper)*

Outputs

2. Raw water supply infrastructure and services improved

    2a. Water storage is increased

    2c. Additional groundwater wells built or upgraded worse than expected ground conditions may cause implementation delays)

Key Activities with Milestones

2. Raw water supply infrastructure and services improved

    2.4 Construct or upgrade bulk water facilities (reservoirs, ponds, bunded reservoirs, groundwater wells, conveyance) including climate resilient design features. (Q1 2022)

Proposed application scenarios of Geo4IRBM services

Land Cover Maps applied for the needs of investments strategic planning

Surface Water Monitoring service inputs for the reservoirs effectiveness and responsiveness evaluation.

Ground conditions analysis could be supported with interferometric analysis of ground subsidence.

Land Cover Mapping – Background

PPTA requirements *(source: PPTA task force)*

Objective

- To evaluate historical changes in Water/flood extent, Land Use and Land cover in 4 basins in Indonesia; Cimanuk, Seluna, Mahakam, and Belewan.

Processes

- Evaluation of Water inflows to reservoirs in Raw Water Supply (RWS) subprojects,
- Evaluation of Water/flood extent in Flood Risk Management (FRM) subprojects.

Data sets requested

- Cross analysis of flood events on the base of existing reports and as detected by historical surface water monitoring (1-month before and 1-month after the date)
- (i) Water/flood extent – also for the period before S1 mission (ii) Land cover and (iii) Land Use (if available) through Landsat-8 and Sentinel-1 images at the basin scale.
- Products for assessments along the coast-line.
- Information on cropping intensity

Proposed application scenarios of Geo4IRBM services

Land Cover Maps and Land Cover Changes maps applied for the needs of EWSIP focusing

Coastline changes elaborated on the base of Land Cover Changes maps. Indicators of coastline length variations in reference network.

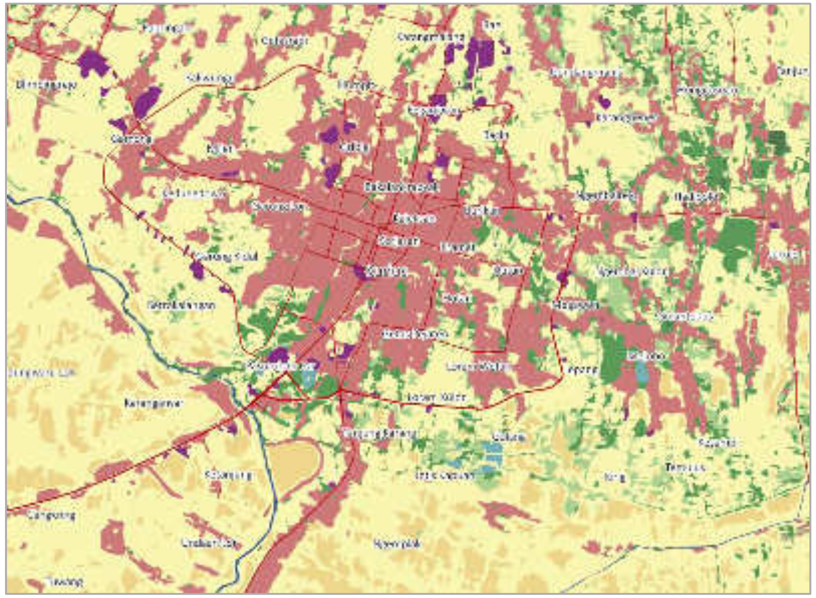
Surface deformation / subsidence along the coastline, cross analysis of coastline changes.

Surface deformation for the needs of landslides detection and erosion assessment useful for floods forecasting.

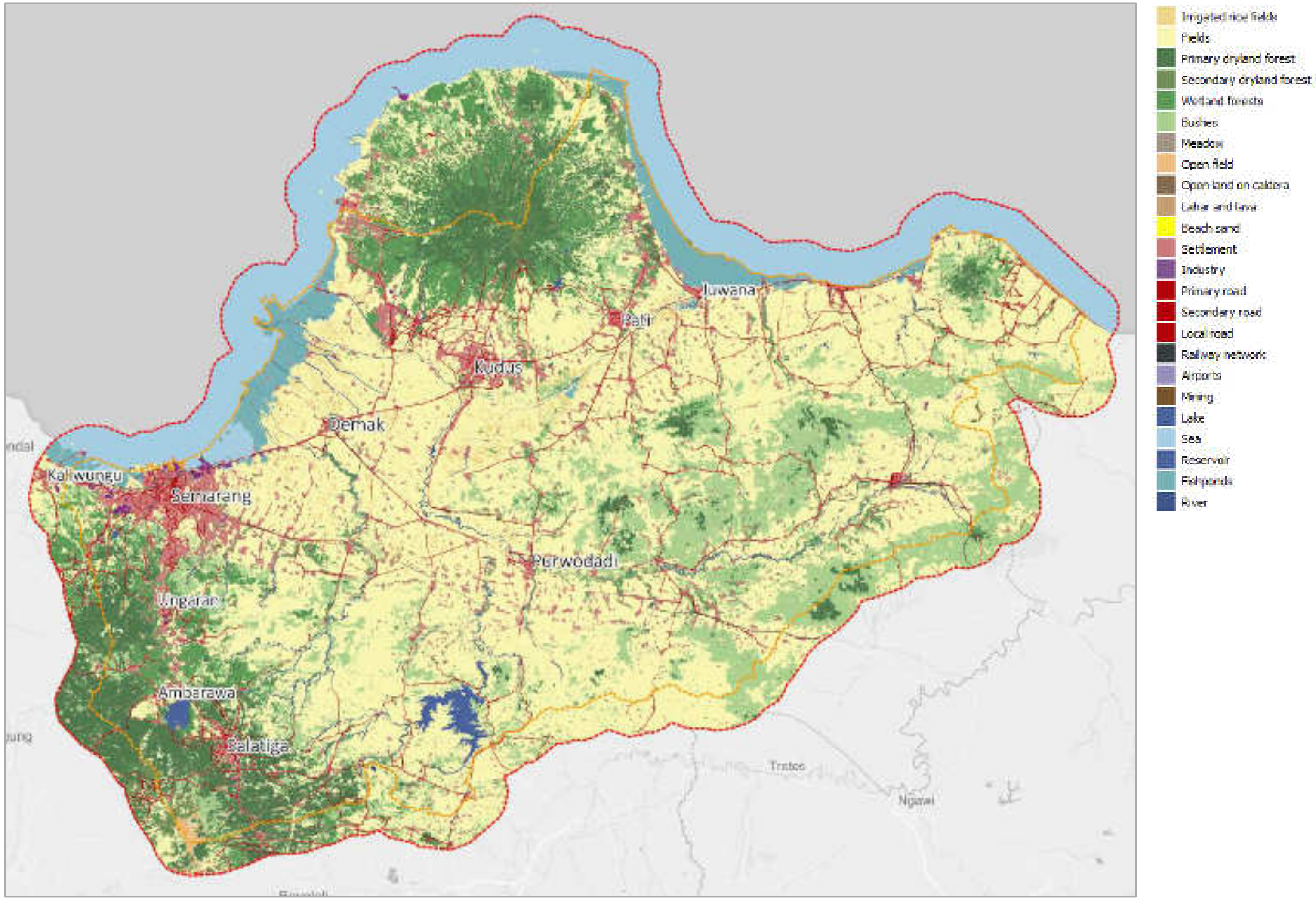
Surface waters monitoring historical data could contribute to historical floods delimitation and as information on frequency of water coverage, proposed extension of the period before S1 operation.

Proposition of extension of AOIs was rejected due to resources limitation (proposed extension area was 5 times bigger than the original)

Land Cover Mapping – Objectives

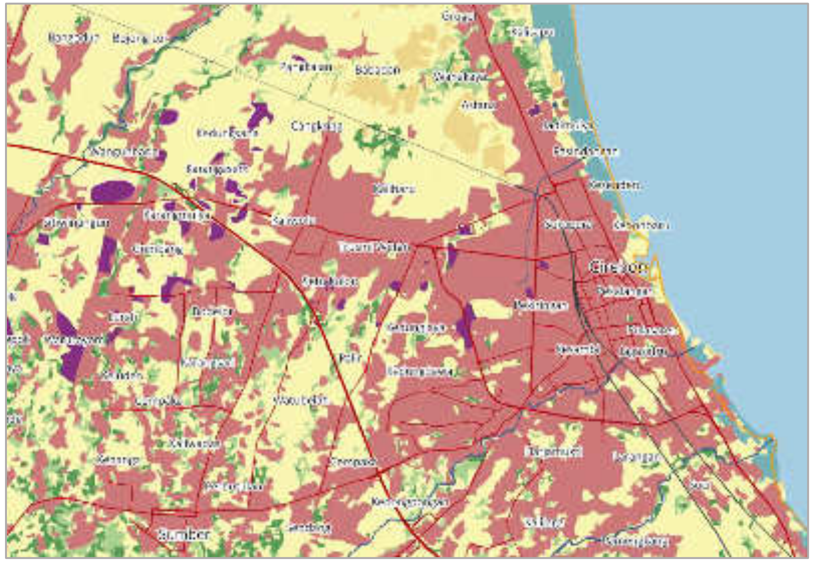


Subset of Land Cover map for Jratunseluna river watershed, Central Java, Indonesia, covering surroundings of the city of Kudus.

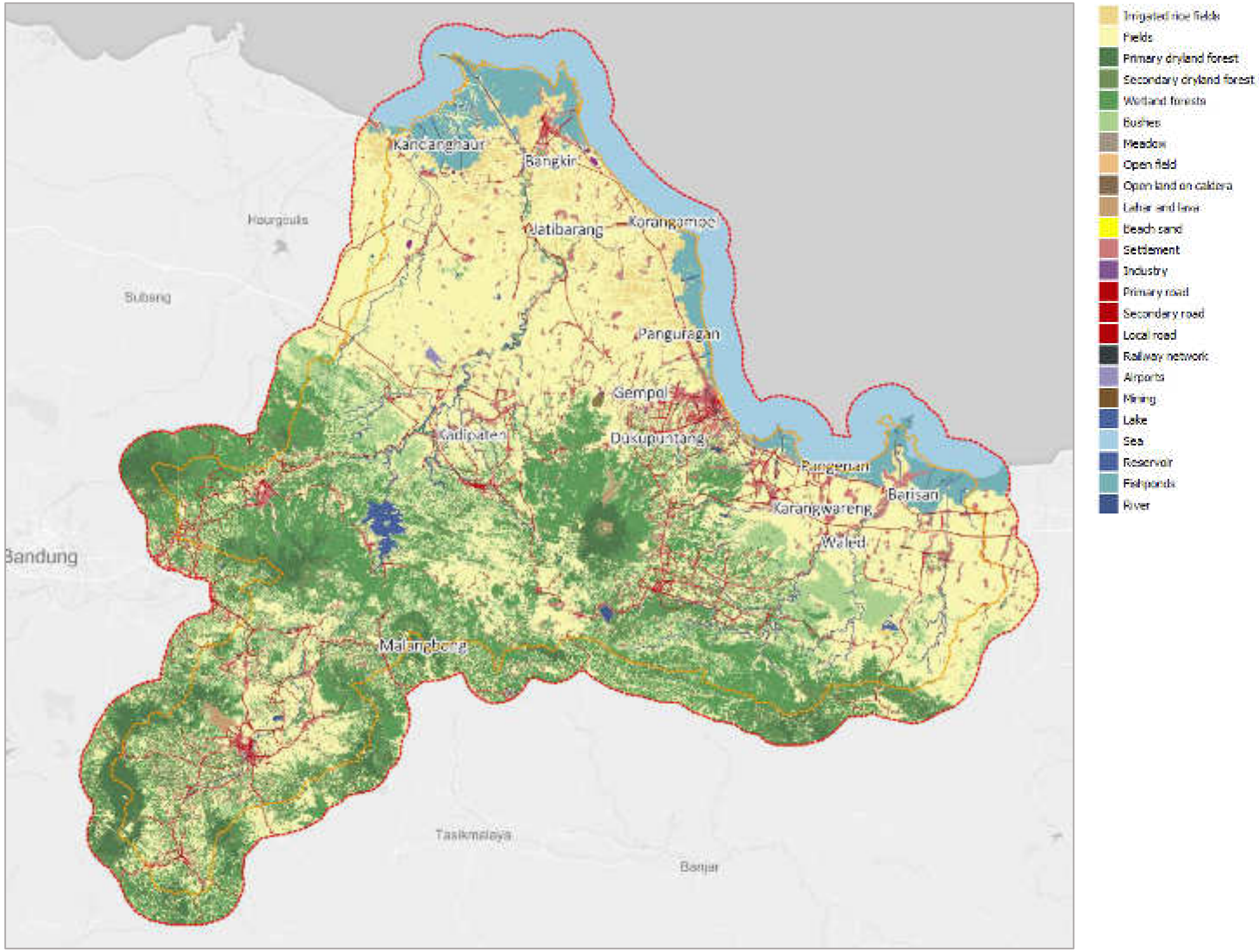


Land Cover map for Jratunseluna river watershed, Central Java, Indonesia (area of the watershed: 9 367 sqkm, area with 5 km buffer: 12 706 sqkm).

Land Cover Mapping – Objectives



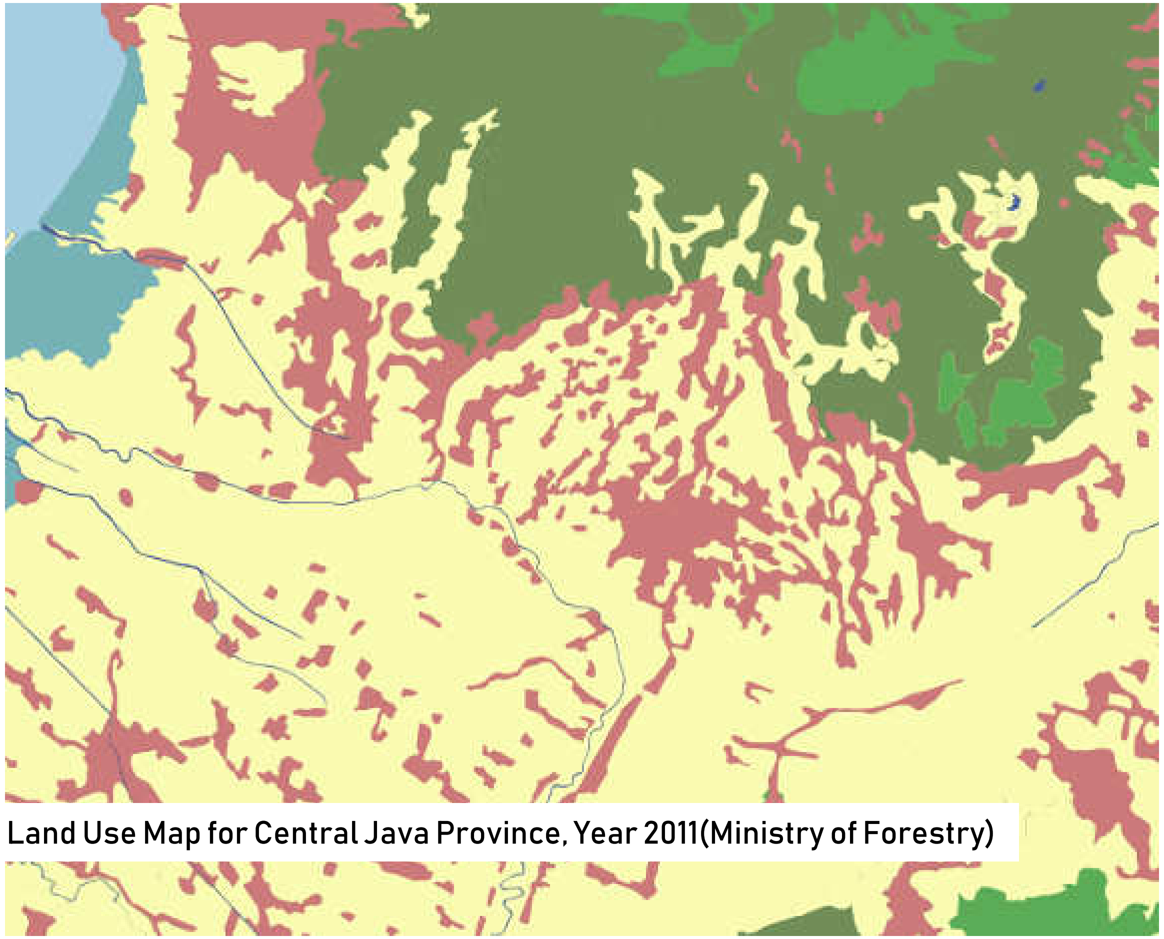
Subset of Land Cover map for Jratunseluna river watershed, Central Java, Indonesia, covering north-western neighbourhood of the city of Cirebon.



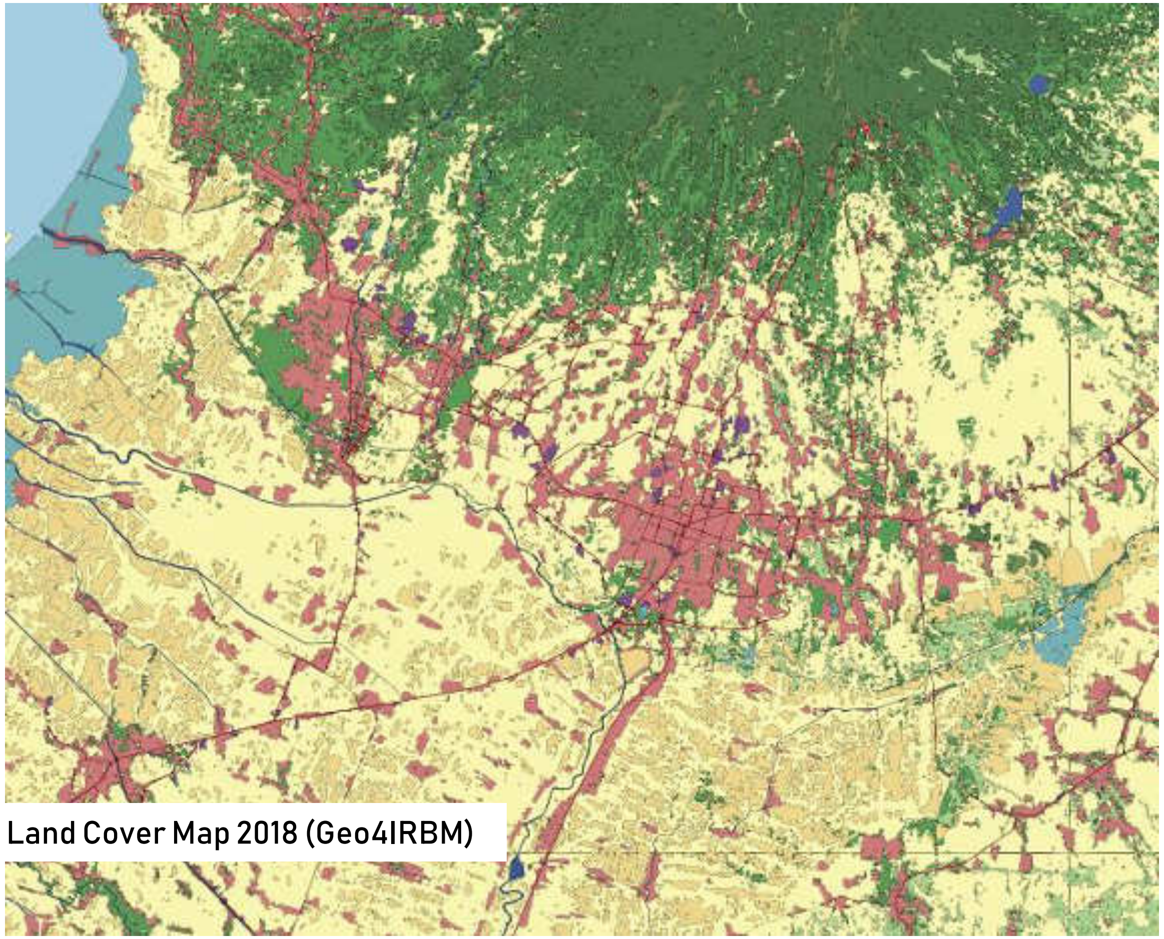
Land Cover map for Cimanuk-Cisanggarung, Central Java, Indonesia (area of the watershed: 7 795 sqkm, area with 5 km buffer: 10 575 sqkm).

Land Cover Mapping – Objectives

Main general objective – to improve awareness of the actual up-to-date status of the AOI surface coverage. As the reference point – identified and made available by the end-user datasets were taken.

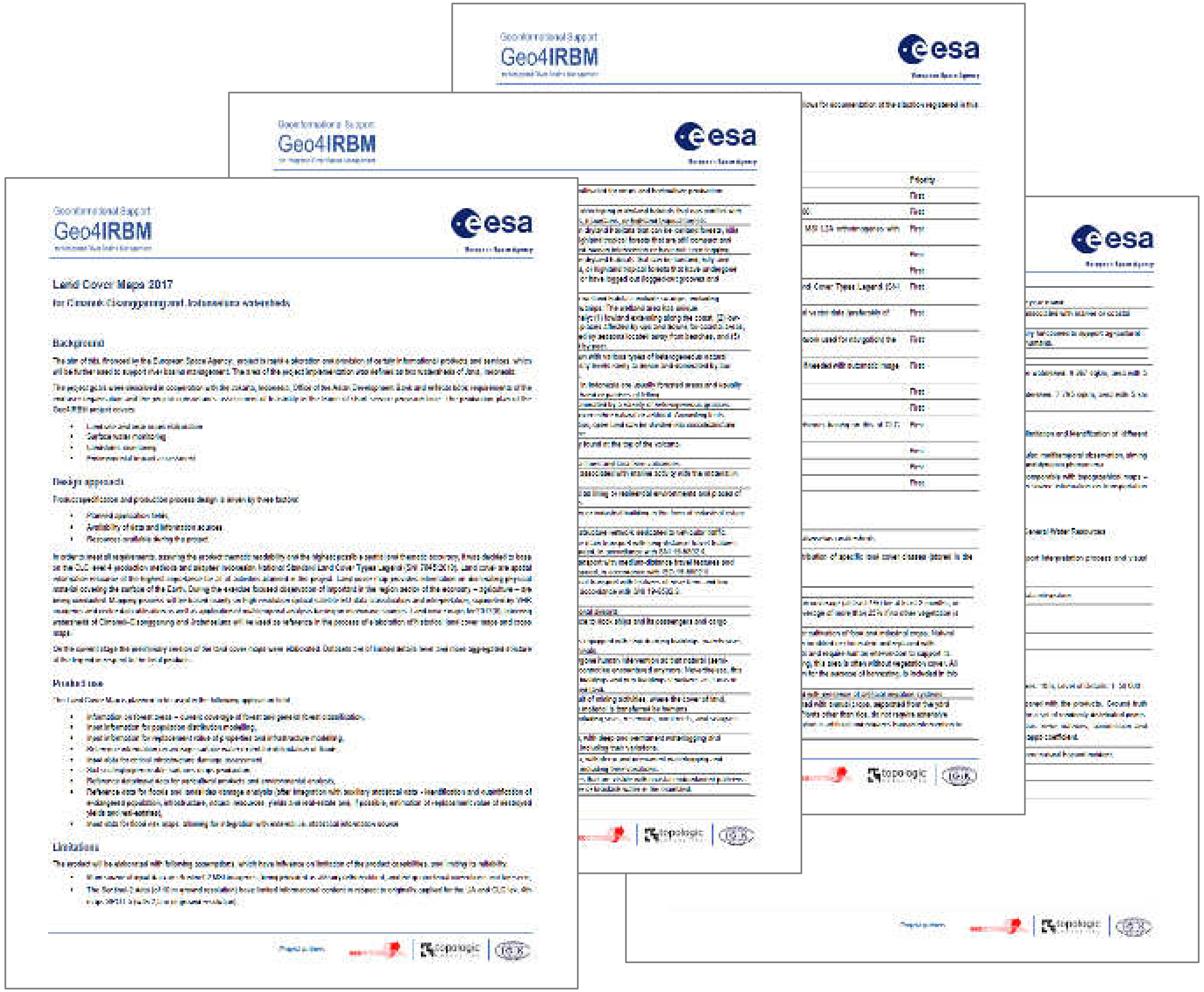


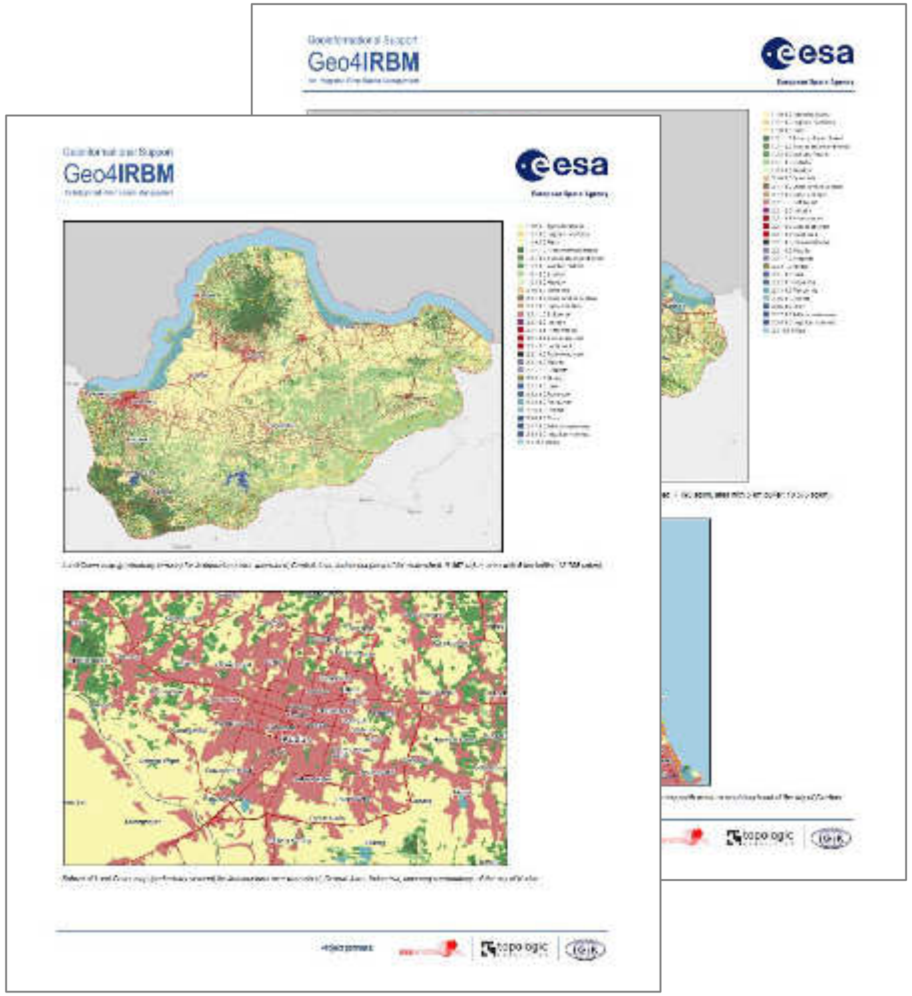
Land Use Map for Central Java Province, Year 2011(Ministry of Forestry)



Land Cover Map 2018 (Geo4IRBM)

Land Cover Mapping – Objectives

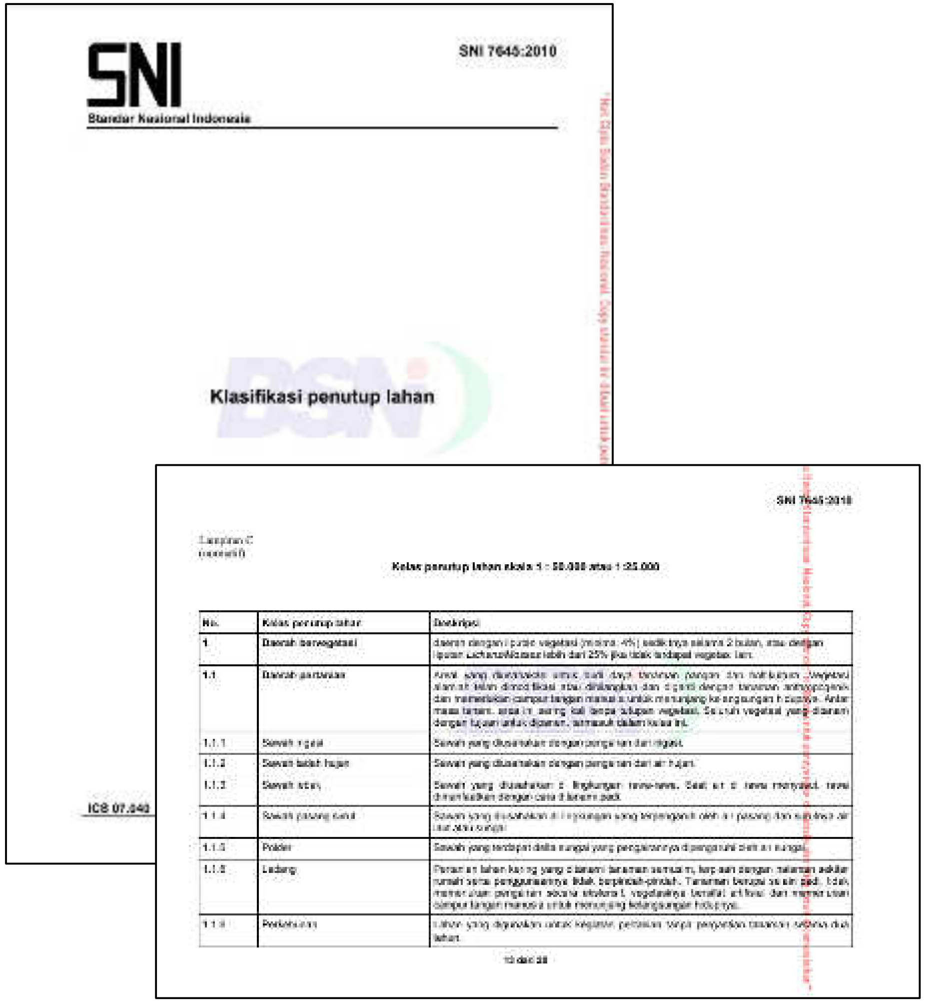




Land Cover Mapping – Design approach

Product specification and production process design is driven by three factors:

- Planned application fields,
- Availability of data and information sources,
- Resources available during the project.



In order to meet all requirements, assuring the product thematic readability and the highest possible spatial and thematic accuracy, it was decided to base on the adapted Indonesian National Standard Land Cover Types Legend (SNI 7645:2010).

Focused analysis of important in the region sector of the economy – agriculture – are being conducted. Mapping process will be based mainly on high resolution optical satellite EO data classification and interpretation, supported by VHR imageries and vector data utilisation as well as application of multitemporal analysis basing on microwave sources.

Land cover are spatial information resource of the highest importance for all of activities planned in the project. Land Cover Maps 2018 are being used as reference in the process of elaboration of historical land cover maps and cropping intensity maps, potential erosion analysis and more.

Land Cover Mapping – Product Use

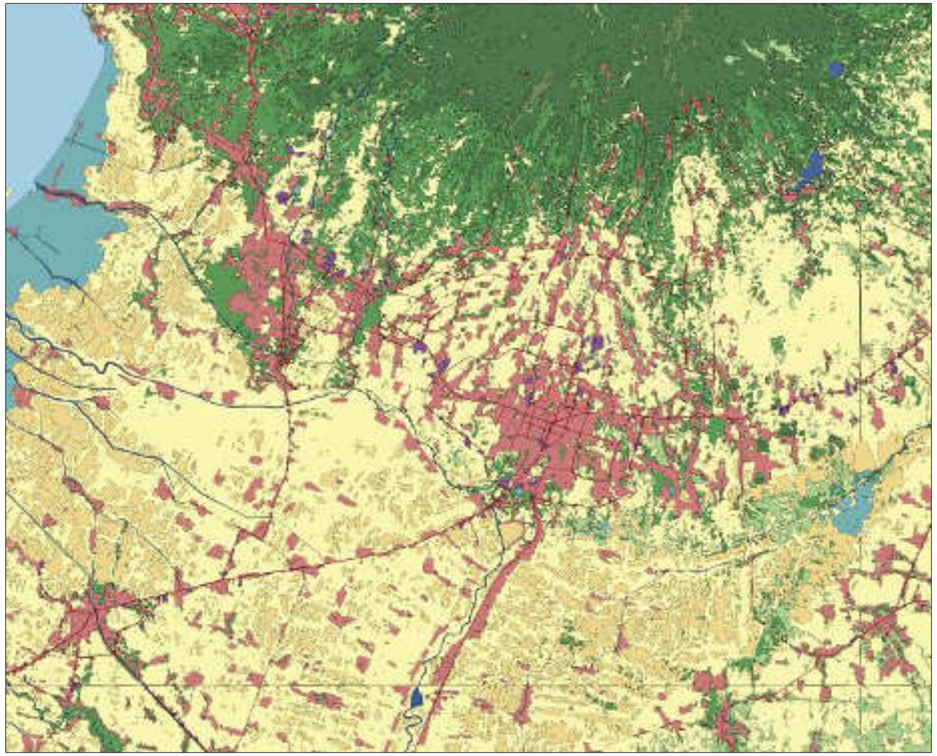
The Land Cover Map is planned to be used in the following application fields:

- Information on forest areas – current coverage of forest and general forest classification,
- Input information for population distribution modelling,
- Input information for replacement value of properties and infrastructure modelling,
- Reference information on average surface water extent for delimitation of floods,
- Input data for critical infrastructure damage assessment,
- Soil sealing/impermeable surfaces maps production,
- Reference data/input data for agricultural products and environmental analysis,
- Reference data for floods and landslides damage analysis (after integration with auxiliary statistical data - identification and quantification of endangered population, infrastructure, natural resources, yields and real-estate and, if possible, estimation of replacement value of destroyed yields and real-estates),
- Input data for flood risk maps, allowing for integration with external i.e. statistical information source

Land Cover Mapping – Limitations

Features limiting product's reliability, applicability and level of details:

- Satellite remote sensing (Sentinel-2 data of 10 m ground resolution) does not allow to reflect fully the requirements of 1: 50000 Indonesian National Standard Land Cover Types Legend (SNI 7645:2010) – adaptation applied,
- EO data used for the production was acquired in 2018 and allows for documentation of the situation registered in this year,
- The region of interest is very cloudy what limits access to the terrain – no valuable EO data for specific location for a very ling time.
- Very limited access to reference data (ground truth) during the products elaboration.



Land Cover Mapping – Requirements

ID	Requirement	Priority
LCM01	Maps should cover areas defined by the end-user (See section 1.6).	First
LCM02	Maps should be elaborated with the level of details proper for the scale of 1: 50 000.	First
LCM03	The major source of the information should be the most up-to-date Sentinel-2 MSI L2A orthoimageries with topographic normalization.	First
LCM04	Minimum mapping unit should be 1ha	First
LCM05	Minimum distance between lines should be 10m	First
LCM06	The legend of the map should be based on Indonesian National Standard Land Cover Types Legend (SNI 7645:2010).	First
LCM07	Land cover classes related to transportation networks should be based on external vector data (preferably of equal quality with those used for navigation).	First
LCM08	In the case of limited access to valuable local topographic data (transportation network used for navigation) the map should be enriched with information from the OpenStreetMap (OSM) project.	First
LCM09	Map should be elaborated using visual image interpretation techniques, supported if needed with automatic image analysis techniques (i.e. object based classification).	First
LCM10	Map should be elaborated as vector dataset.	First
LCM11	Map should be stored as vector dataset as well as a raster.	First
LCM12	Map in both vector and raster formats should be equipped with color-coding schemes basing on this of CLC maps.	First
LCM13	Map should be stored in UTM coordination system.	First
LCM14	Thematic accuracy of the map should be higher than 90%.	First
LCM15	Planimetric accuracy of the map should be higher than 30m.	First

Land Cover Mapping – Specification: Content

LC Code	LC Class	Description
1.1.0.0.0	Agricultural area	Areas designated for cultivation of food and industrial crops. Natural vegetation has been modified or eliminated and replaced with anthropogenic plants and require human intervention to support its survival. Inter-planting, this area is often without vegetation cover. All the vegetation grown for the purpose of harvesting, is included in this class.
1.2.1.0.0	Dryland forest	Forest growing and developing in dryland habitats that can conflict with lowland forests, hills, mountains, or highland tropical forests.
1.2.1.1.0	Primary dryland forest	Developed forests in dryland habitats that can be lowland forests, hills and mountains or highland tropical forests that are still compact and have not experienced human intervention or have not seen logging.
1.2.1.2.0	Secondary dryland forest	Developed forests in dryland habitats that can be lowland, hilly and mountainous forests, or highland tropical forests that have undergone human intervention or have logged out (logged-out grooves and patches).
1.2.2.0.0	Wetland forests	Forests that grow in wetland habitats include swamps, including swamps and peat swamps. The wetland area has unique characteristics, namely: (1) lowland extending along the coast, (2) low-elevation areas, (3) places affected by ups and downs for coastal areas, (4) regions influenced by seasons located away from beaches, and (5) most areas covered by peat.
1.5.1.0.0	Bushes	Dry land is overgrown with various types of heterogeneous natural vegetation with density levels rarely to dense and dominated by low (natural) vegetation. NOTE: The bushes in Indonesia are usually forested areas and usually not reveals second-hand or patches of felling.
1.5.3.0.0	Meadow	The open area is dominated by a variety of heterogeneous grasses.
2.1.0.0.0	Open field	Land without land cover either natural or artificial. According to its surface characteristics, open land can be divided into consolidated and unconsolidated surface.
2.1.1.0.0	Open land on caldera	The crater is usually found at the top of the volcano.
2.1.2.0.0	Lahar and lava	Open ground of lava flows and lava from volcanoes.
2.1.3.0.0	Beach sand	Open land which is associated with marine activity with the material in the form of sand.

Land Cover Mapping – Specification: Content

LC Code	LC Class	Description
2.2.1.1.0	Settlement	Areas or lands used as living or residential environments and places of life support activities.
2.2.1.2.0	Industry	Area used for factory or industrial building in the form of industrial estate or company.
2..2.1.3.1	Primary road	Roads that serve the main transport with long-distance travel features and high average speed, in accordance with SNI 19-6502.4.
2.2.1.3.2	Secondary road	Roads that serve transport with medium-distance travel features and moderate average speed, in accordance with ISO 19-6502.4.
2.2.1.3.3	Local road	Roads that serve local transport with features of near-term and low-speed trajectory, in accordance with SNI 19-6502.3.
2.2.1.4.0	Railway network	Railway or lorry.
2.2.1.6.0	Airports	Domestic / international airports
2.2.1.7.0	Seaports	Place used as a place to dock ships and its passengers and cargo related activities. NOTE: Port facilities equipped with ship docking buildings, warehouses, and passenger terminals.
2.2.2.1.0	Mining	Open land as a result of mining activities, where the cover of land, stone or other earth material is transferred by humans.
2.3.0.0.0	Waters	All visible waters, including seas, reservoirs, coral reefs, and seagrass beds.
2.3.1.0.0	Lake	Natural water areas, with deep and permanent waterlogging and shallow inundation, including their variations.
2.3.2.0.0	Reservoir	Artificial waters area, with deep and permanent waterlogging and shallow inundation, including their variations.
2.3.3.0.0	Fishponds	Activities for fisheries that are visible with coastal embankment patterns.
2.3.5.0.0	Swamp	Extensive freshwater or brackish water in the mainland.
2.3.6.0.0	River	Natural watering place. NOTE: Streams can be seasonal or year-round.
2.3.8.0.0	Irrigation channels	Artificial water flow places and usually functioned to support agricultural activities or fisheries conducted by humans.
2.3.11.0.0	Sea	Sea water

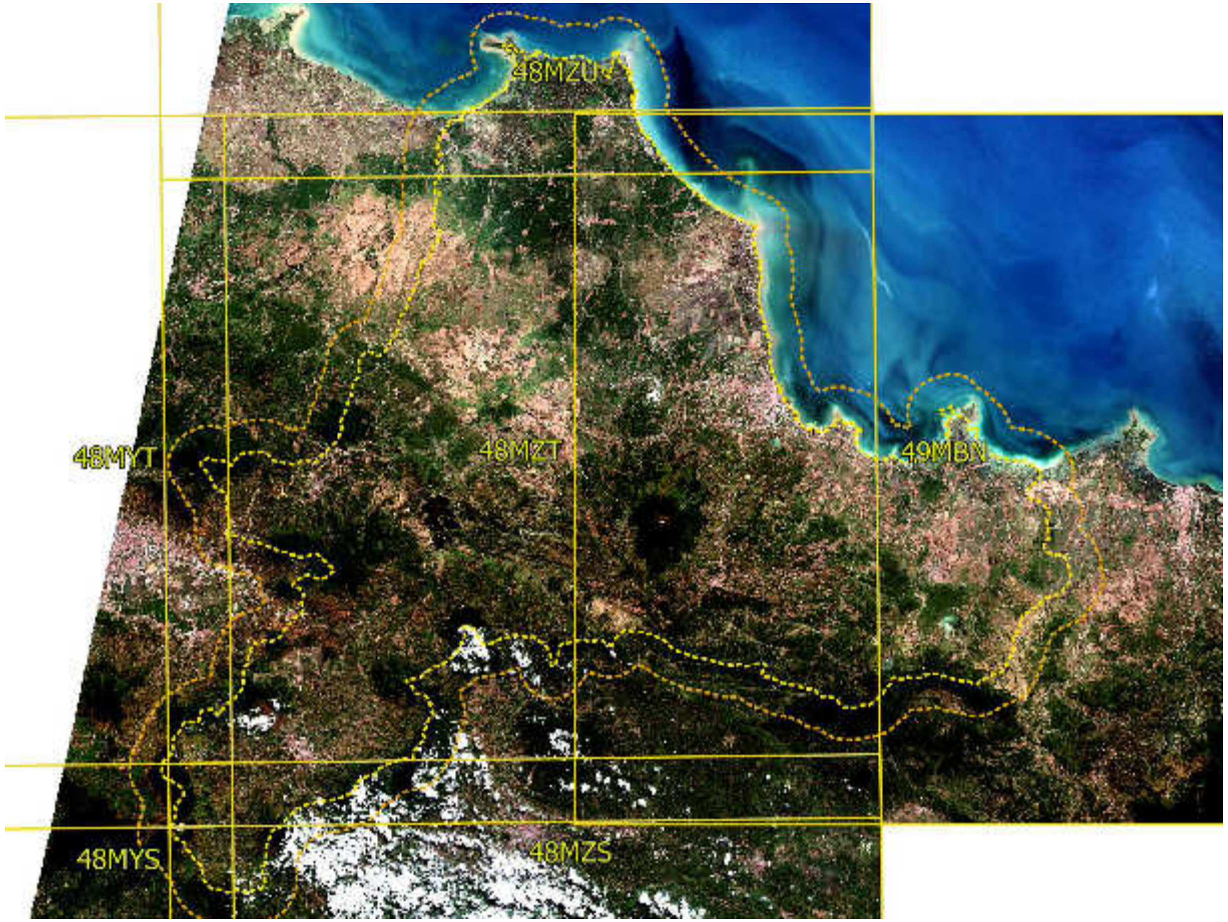
Land Cover Mapping – Specification

Feature	Value / description
Geographic Coverage	AOI 1.: Jratunseluna river watershed, Central Java, Indonesia (area of the watershed: 9 367 sqkm, area with 5 km buffer: 12 706 sqkm). AOI 2.: Cimanuk-Cisanggarung, Central Java, Indonesia (area of the watershed: 7 795 sqkm, area with 5 km buffer: 10 575 sqkm).
Input data sources	Input data: 1. Sentinel-2 MSI satellite orthophotos - image enables for the delimitation and identification of different land cover classes (like forests, settlements or waterbodies), 2. OpenStreetMap vector databases are of information content comparable with topographical maps – during the final products development will be used as the main source information on transportation network and for other linear features layer, Input data provided by End-user: Land use map (2011), Ministry of Forestry, scale 1: 250 000 Hydrographic map, Ministry of Public Works & Housing, Directorate General Water Resources Ancillary input data: 1. High resolution satellite and aerial orthophotos - used to support interpretation process and visual classification enhancement. 2. Unstructured information sources.

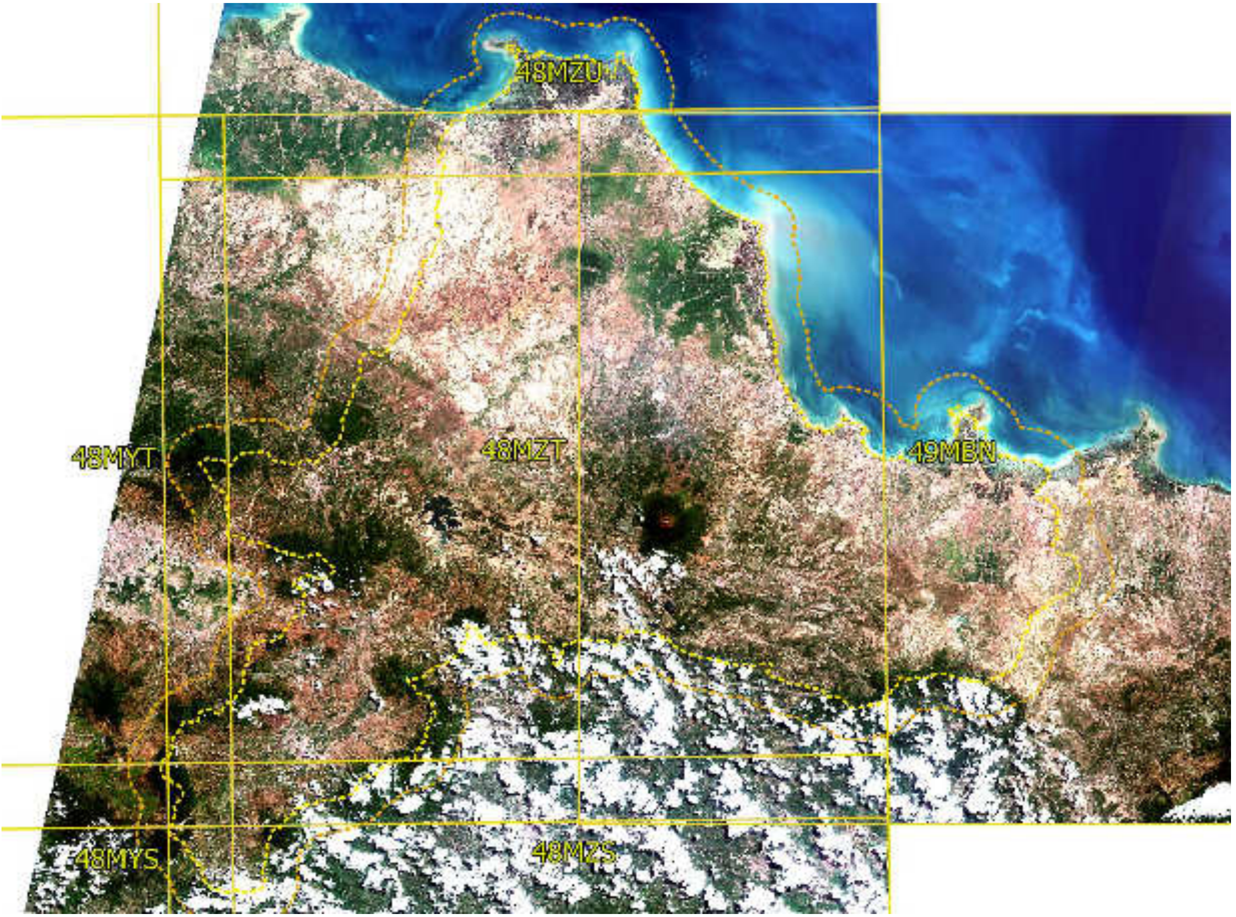
Land Cover Mapping – Specification: Input data sources

Major satellite input data

Cimanuk-Cisanggarung rivers watershed



Sentinel-2A MSI 20180706



Sentinel-2A MSI 20180904

Land Cover Mapping – Specification: Input data sources

Major satellite input data

Jratunseluna river watershed

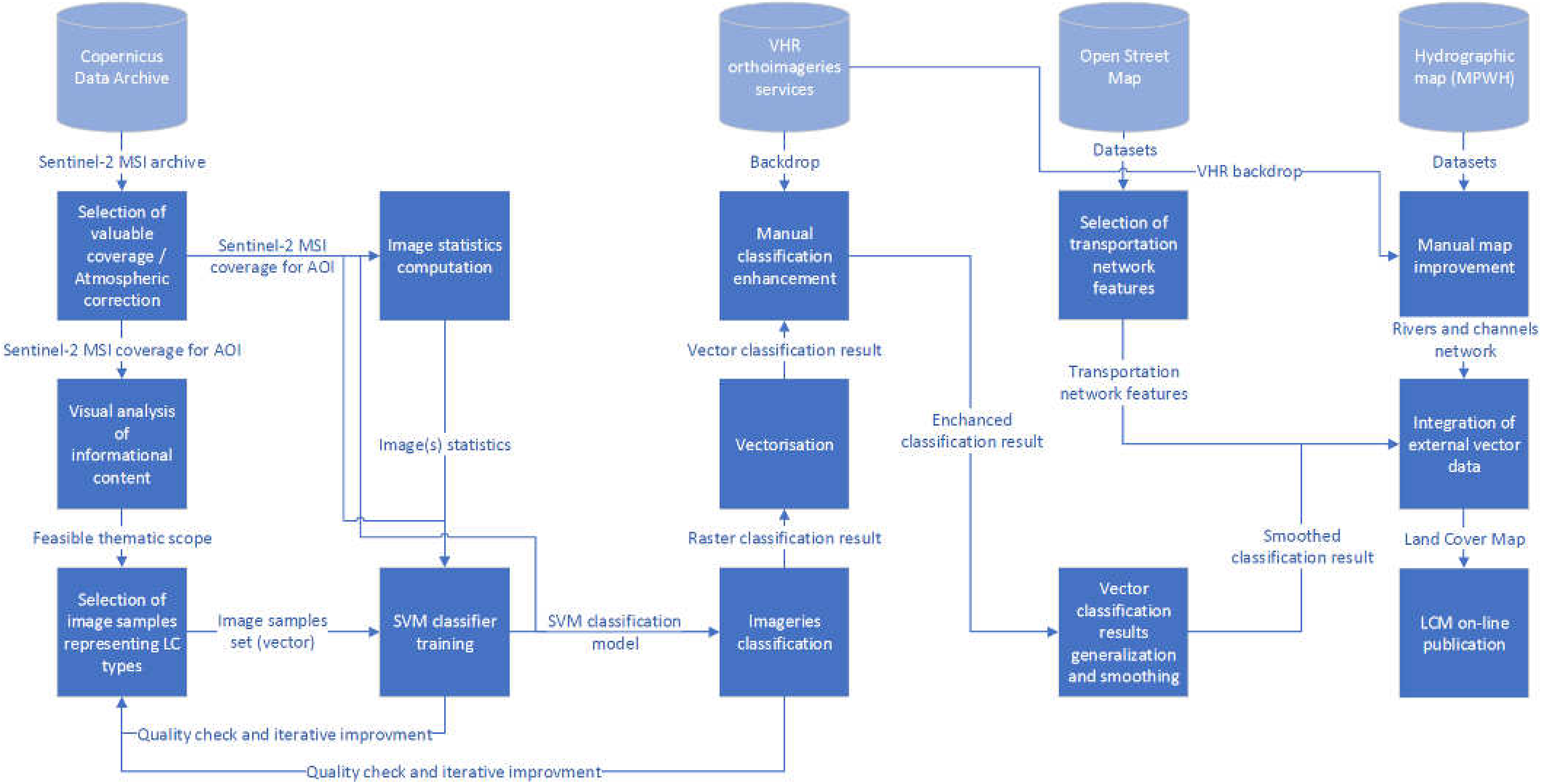
Sentinel-2A MSI 20170807

Sentinel-2A MSI 20181011

Land Cover Mapping – Specification

Feature	Value / description
Methodology of Classification	Object-oriented classification, image interpretation (manual refinement), data integration.
Spatial Resolution and Coverage	Not applicable.
Coordinate Reference System	WGS 84 (EPSG: 4326)
Accuracy, Constraints	Thematic accuracy: > 90% Geometric accuracy: < 30m Constraints: Minimum Mapping Unit: 1ha, Minimum Width of Linear Features: 10m, Level of Details: 1: 50 000
Accuracy Assessment Approach	For each land cover type at least 10 ground truth samples will be compared with the products. Ground truth samples will be simulated by independently interpreted land cover types for a set of randomly distributed points. Accuracy assessment results will be expressed using following statistics: error matrices, commission and omission errors, user's accuracy, producer's accuracy, overall accuracy, kappa coefficient.
Frequency	It is suggested to update the map every 3 years, or locally, after every severe natural hazard incident.
Availability	2018
Delivery / Output Format	Shapefile (on demand any other form and format)

Land Cover Mapping – Specification: Methodology



Schema of applied analysis and processing procedures in course of LCM elaboration

THANK YOU

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esa

European Space Agency

Land Cover Change Mapping

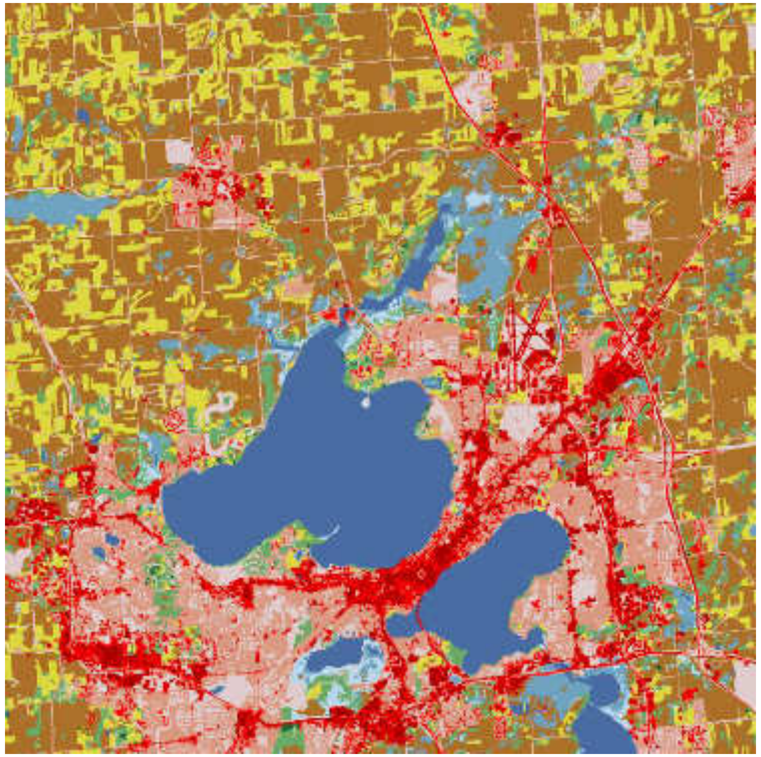
Rafal Dabrowski (GEOSYSTEMS)

Land Cover Change Mapping – Definitions

WIKIPEDIA
The Free Encyclopedia

Land cover is the physical material at the surface of the earth. Land covers include grass, asphalt, trees, bare ground, water, etc.
There are two primary methods for capturing information on land cover: field survey and analysis of remotely sensed imagery. Land change models can be built from these types of data to assess future shifts in land cover.

One of the major land cover issues [...] is that every survey defines similarly named categories in different ways. For instance, there are many definitions of "forest"—sometimes within the same organisation—that may or may not incorporate a number of different forest features (e.g., stand height, canopy cover, strip width, inclusion of grasses, and rates of growth for timber production). Areas without trees may be classified as forest cover "if the intention is to re-plant" (UK and Ireland), while areas with many trees may not be labelled as forest "if the trees are not growing fast enough" (Norway and Finland).

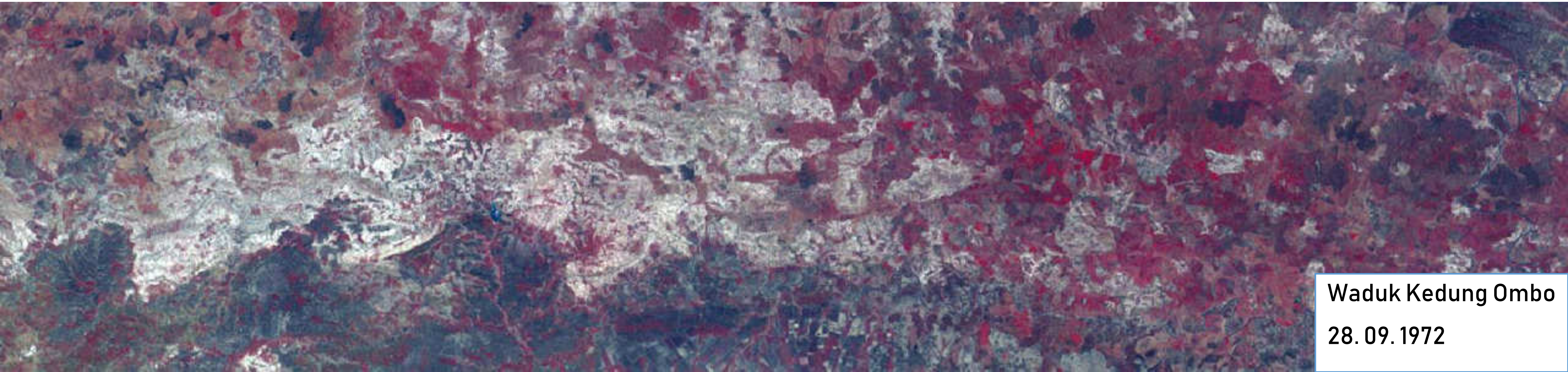


Land Cover Change Mapping – Background

The aim of this, financed by the European Space Agency, project is rapid elaboration and provision of certain informational products and services, which will be further used to support river basins management. The area of the project implementation was defined as two watersheds of Java, Indonesia.

[…] During the project it is planned to elaborate also historic maps, illustrating changes in land use status since the beginning of operational satellite EO missions of 1970s. This will give opportunity of analysis of land use change trends as well as its mutual influences with the economy and natural phenomena of the region. […]

from: Geo4IRBM Proposal



Waduk Kedung Ombo
28.09.1972

Land Cover Change Mapping – Objectives

[…]Land Cover Change phenomena imapcts on biodiversity and aquatic ecosystems (affects water quality and supply) […]

M.G. Turner, R.H. Gardner, R.V. O'Neill
Landscape Ecology in Theory and Practice Pattern and Process
Springer-Verlag, New York (2001)

[…] the assessment of land use patterns and their changes at the watershed level is crucial to planning and management of water resources and land use of the particular watershed. […]

M.G. Turner, R.H. Gardner, R.V. O'Neill
Landscape Ecology in Theory and Practice Pattern and Process
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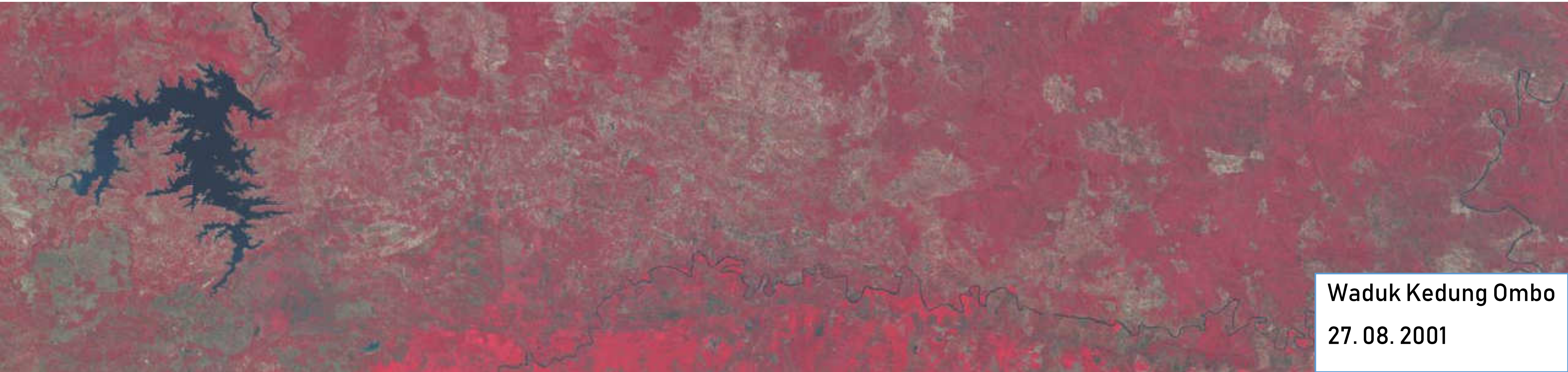


Land Cover Change Mapping – Design approach

Product specification and production process design is driven by three factors:

- Planned application fields,
- Availability of data and information sources,
- Resources available during the project.

Ability of provision of information on changes of land cover, the physical material covering terrain surface, allows for complex analysis of trends of phenomena active over time in the region of interest.

Numerous mutual influences could be observed analysing multitemporal land cover data covering timespan of decades. To properly address challenges of such research Land Cover Changes Map should cover as long as possible period of time. Time limitations of the project, however, allows for elaboration the product with limited interval between acquisitions. Elaboration of historical land cover maps required selection historical EO data acquired by the following sensors: Landsat MSS, TM, ETM+ and OLI starting from 1972, when the first available imagery of Java Island was acquired. Landsat archives give unprecedented capability of reconstruction of processes transforming landscape and the land cover over decades.

1975 (1972-1978)	**1990** (1989-1991)	**2000** (1991-2001)	**2017**
Landsat-1/3 MSS	Landsat-5 TM	Landsat-7 ETM+	Sentinel -2 MSI

Main EO data sources selected from USGS satellite historical data archive – Landsat imageries and reflecting the current status source data of Land Cover Map 2017 – Sentinel-2 operated by ESA

Land Cover Change Mapping – Design approach

Analysis of changes of land cover requires reliable reference. In this case previously elaborated Land Cover Map 2017 is used as reference information. Since not all historical imageries are orthorectified with precision assuring geometric consistency with the newest EO data, important stage of geometric corrections has been applied. Taking the land cover 2017 map as a starting point, operators will detect differences in land cover categories geographic range applying both: automated image classification methods and visual interpretation.
Image interpretation process will be followed by the accuracy assessment and possible products refinement.
Integration of final products time series in vector and raster formats will finish the production process of historical land-cover maps.

Land Cover Change Mapping – Product Use

The Land Cover Change Map is planned to be used in the following application fields:

- Analysis of deforestation and its connection with limitation of water retention and increase of surface runoff
- Analysis of urban sprawl and indirectly - population distribution
- Analysis of changes of surface water coverage i.e. construction of dams and reservoirs
- Analysis of development of agriculturally cultivated lands and their influence on ecosystems
- Research on influence of deforestation and introduction of agriculture to deforested land on landslides and floods occurrence
- Research on seashore variability (erosion, sea level growth)
- Carbon stock modelling and modelling of carbon stock balance

Land Cover Change Mapping – Limitations

The product will be elaborated with following assumptions, which have influence on limitation of the product applicability, and limiting its reliability:

- The product is based on regularly acquired EO imageries of different satellite systems characterized by various spatial, spectral and radiometric resolution, which results in noticeable limitation of their information content. Due to that thematic scope overall accuracy of products is limited compared to similar achieved only with use of current means.
- EO data archives contain only selected historical satellite imageries usually not allowing for observation seasonal changes what decreases accuracy and thematic content of final product.
- Lack of valuable reference data for historical land cover maps is also a factor limiting products accuracy and reliability

Requirements for Land Cover Change Maps 1976-2017

ID	Requirement	Priority	Y/N
LCC01	Maps should cover areas defined by the end-user (See section 1.6).	First	Y
LCC02	Historic land cover maps should be elaborated in reference to the Land Cover Maps 2017 (2018) to assure geometric consistency of delimited features and their thematic consistency.	First	Y
LCC03	Maps should be elaborated with the level of details proper for the scale of 1: 50 000.	First	Y
LCC04	The major source of the information should be the most up-to-date Landsat MSS, TM, ETM+, and OLI orthoimageries.	First	Y
LCC05	Minimum mapping unit should be 1ha	First	Y
LCC06	Minimum distance between lines should be 10m	First	Y
LCC07	The legend of the map should be based on CORINE Land Cover legend, but on level achievable to be interpreted on the base of the imageries of the lowest parameters.	First	Y
LCC08	Land cover classes related to transportation networks should be based on external data or information allowing for reconstruction of these networks development over time.	First	?
LCC09	Map should be elaborated using supervised classification supported by visual image interpretation techniques.	First	Y
LCC10	Map should be elaborated as vector dataset.	First	Y
LCC11	Map should be stored as vector dataset as well as a raster.	First	Y
LCC12	Map in both vector and raster formats should be equipped with color-coding schemes basing on this of CLC maps.	First	Y
LCC13	Map should be stored in UTM coordination system.	First	Y
LCC14	Thematic accuracy of the map should be higher than 90%.	First	Y
LCC15	Planimetric accuracy of the mapshould be higher than 90m.	First	Y

Land Cover Change Mapping – Specification: Content, Spatial resolution, Coverage

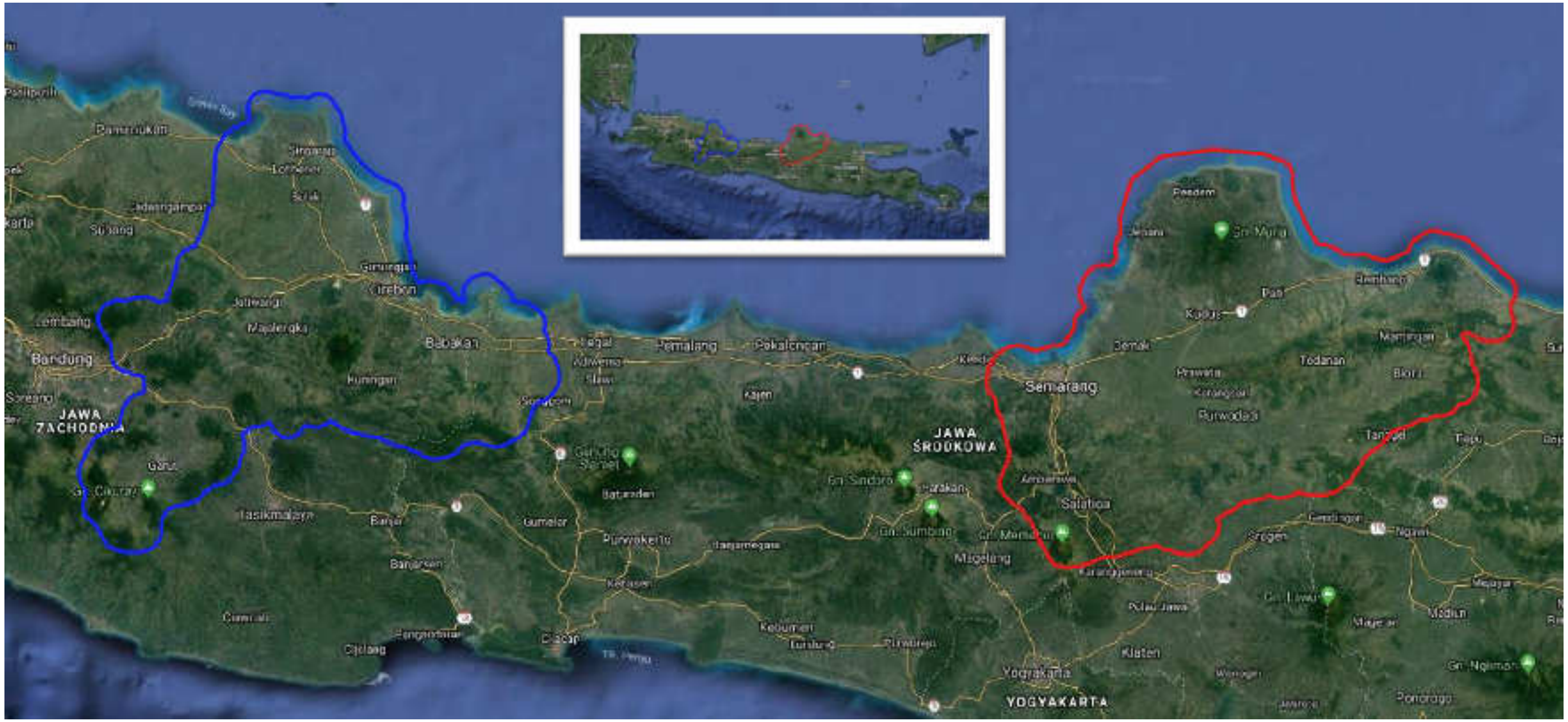
Content	The Land Cover Changes Map contains information of spatial distribution of specific land cover classes (stored in the lc attribute)of vector datasets representing subsequent land cover maps, for 1975, 1990 and 2000.Additionally the Land Cover Changes Maps shows changes during particular time period, information is stored in two complementary attributes describing each change pattern with before (i.e. lc_1990) and after (i.e. lc_2000) land cover information. • Lc1000 Artificial surfaces (urban fabric, Industrial, commercialand transport units) • Lc2000 Agricultural areas (arable land, permanent crops, pastures, heterogenous agricultural areas) • Lc3000 Forests and semi natural areas (forests, scrub and/or herbaceous vegetation associations) • Lc 5000 Water bodies(inland water, marine waters)

Land Cover Change Mapping – Specification: Spatial resolution

Spatial Resolution	Raster Product will be sampled to the lowest resolution of input data – 60m Vector product – not applicable

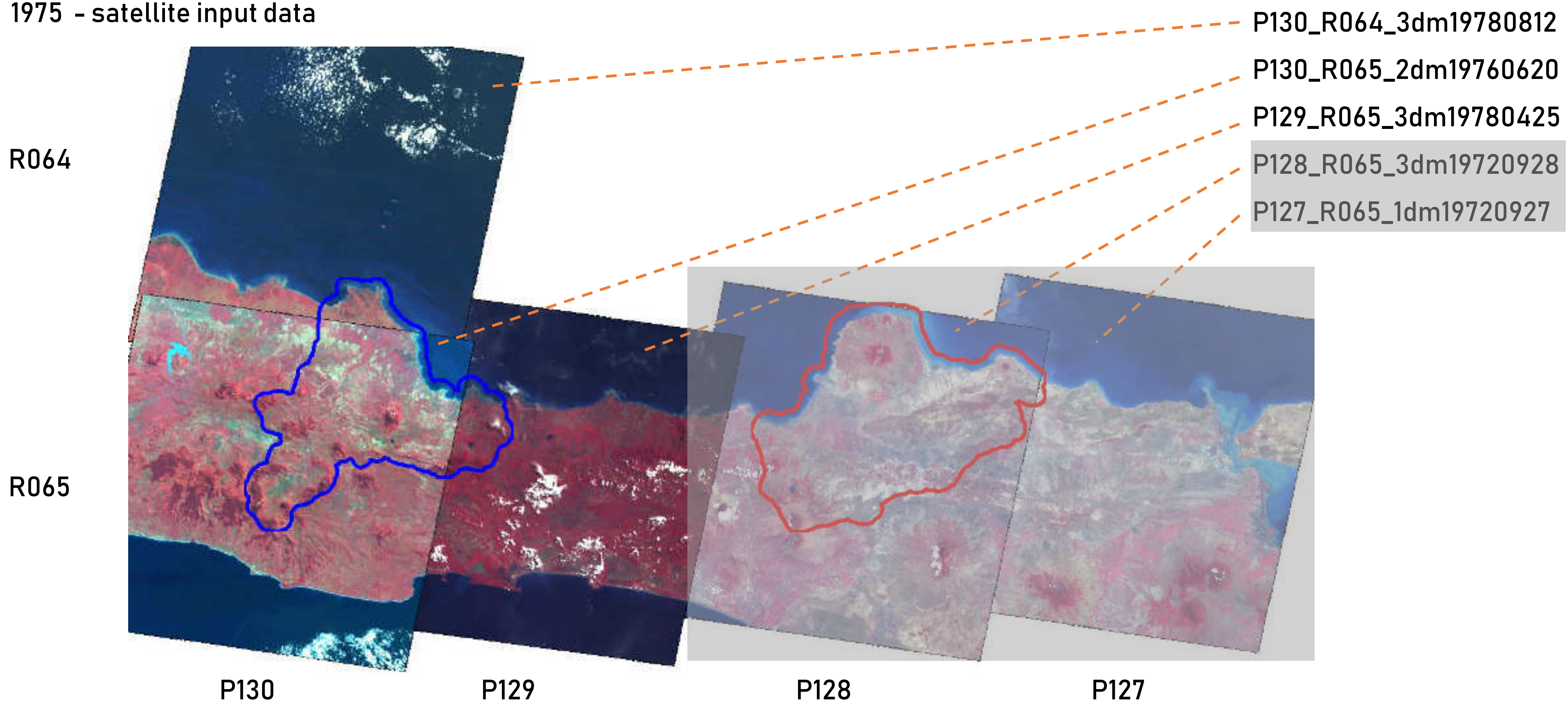
Land Cover Change Mapping – Specification: Geographic Coverage

Geographic Coverage	• AOI 1.: Jratunseluna river watershed, Central Java, Indonesia (area: 9 367 sqkm, area with 5 km buffer: 12 706 sqkm). • AOI 2.: Cimanuk-Cisanggarung, Central Java, Indonesia (area: 7 795 sqkm, area with 5 km buffer: 10 575 sqkm).



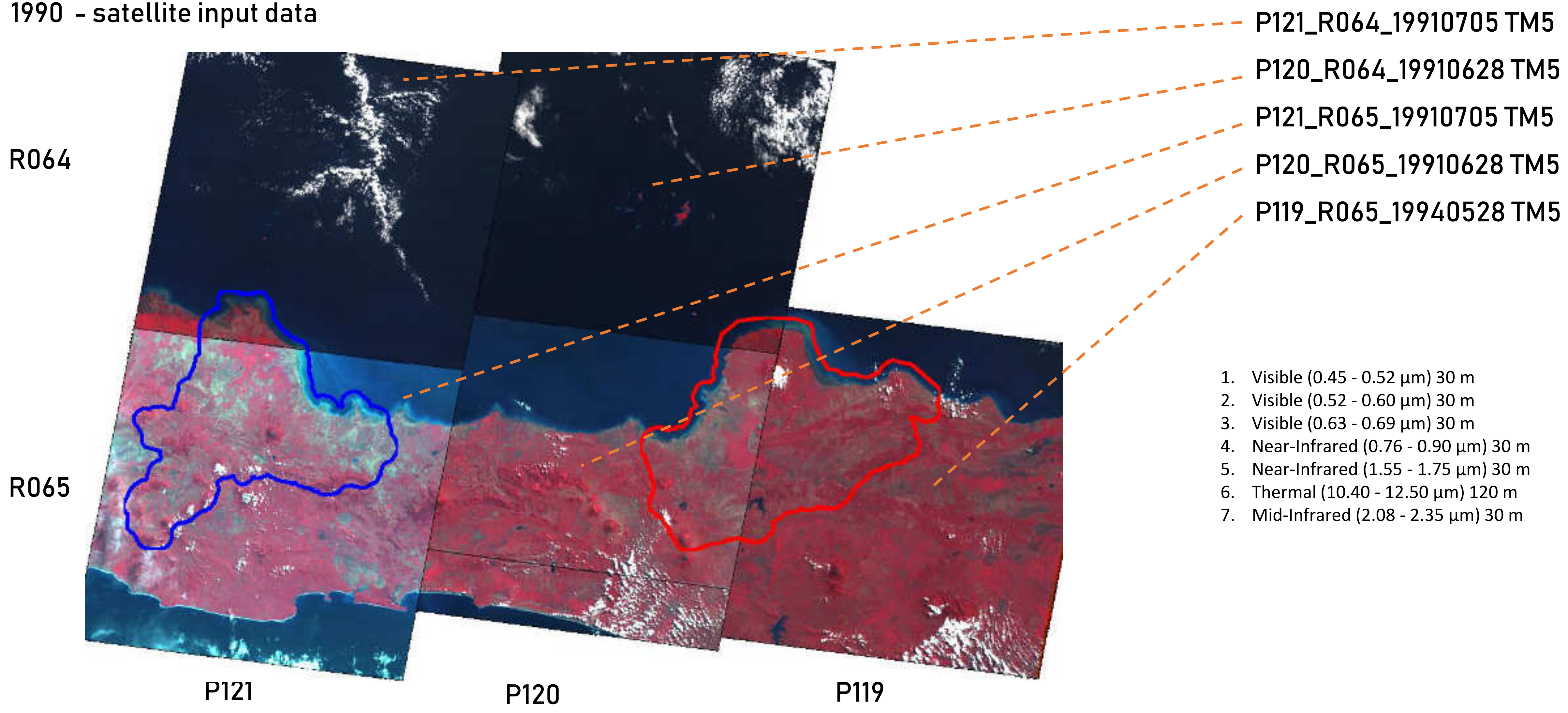
Land Cover Change Mapping – Specification: Input data sources

1975 - satellite input data



Land Cover Change Mapping – Specification: Input data sources

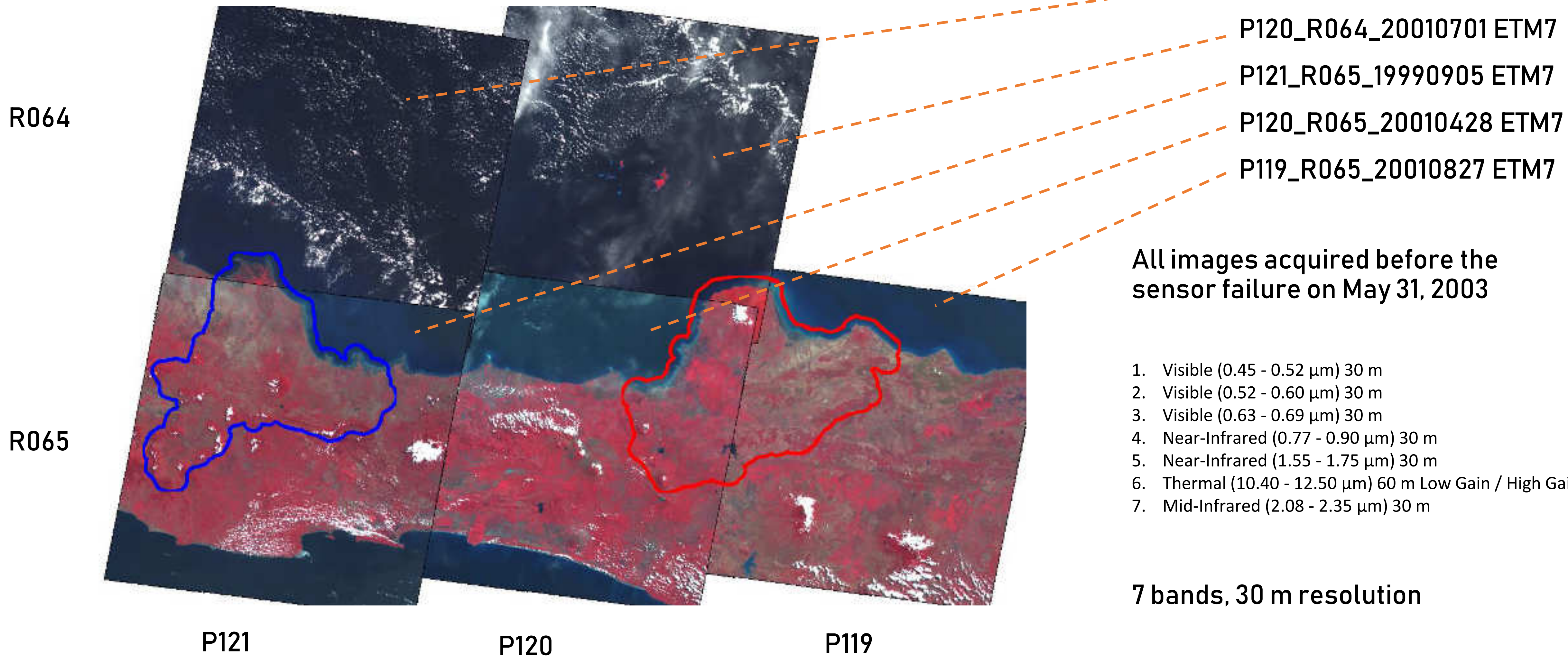
1990 - satellite input data



1. Visible (0.45 - 0.52 µm) 30 m
2. Visible (0.52 - 0.60 µm) 30 m
3. Visible (0.63 - 0.69 µm) 30 m
4. Near-Infrared (0.76 - 0.90 µm) 30 m
5. Near-Infrared (1.55 - 1.75 µm) 30 m
6. Thermal (10.40 - 12.50 µm) 120 m
7. Mid-Infrared (2.08 - 2.35 µm) 30 m

Land Cover Change Mapping – Specification: Input data sources

2000 - satellite input data



All images acquired before the sensor failure on May 31, 2003

1. Visible (0.45 - 0.52 µm) 30 m
2. Visible (0.52 - 0.60 µm) 30 m
3. Visible (0.63 - 0.69 µm) 30 m
4. Near-Infrared (0.77 - 0.90 µm) 30 m
5. Near-Infrared (1.55 - 1.75 µm) 30 m
6. Thermal (10.40 - 12.50 µm) 60 m Low Gain / High Gain
7. Mid-Infrared (2.08 - 2.35 µm) 30 m

7 bands, 30 m resolution

Land Cover Change Mapping – Specification: Methodology

Classification method: Object based approach, manual refinement

Software tools: eCognition Developer, QGIS

Classification metodology:

Image segmentation → Samples selection → Model train & apply → Cleanup → Results export → Visual check

Bayesian ML

SVM ML

Merge, reclassify

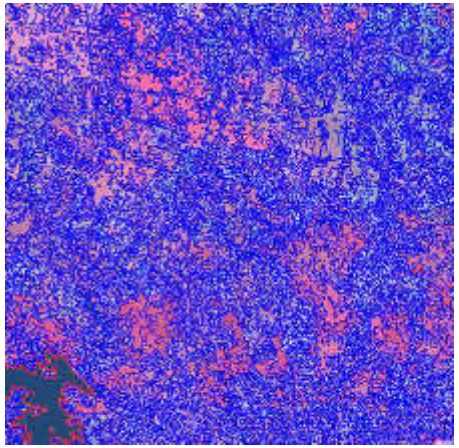


Image objects level

Vector layer

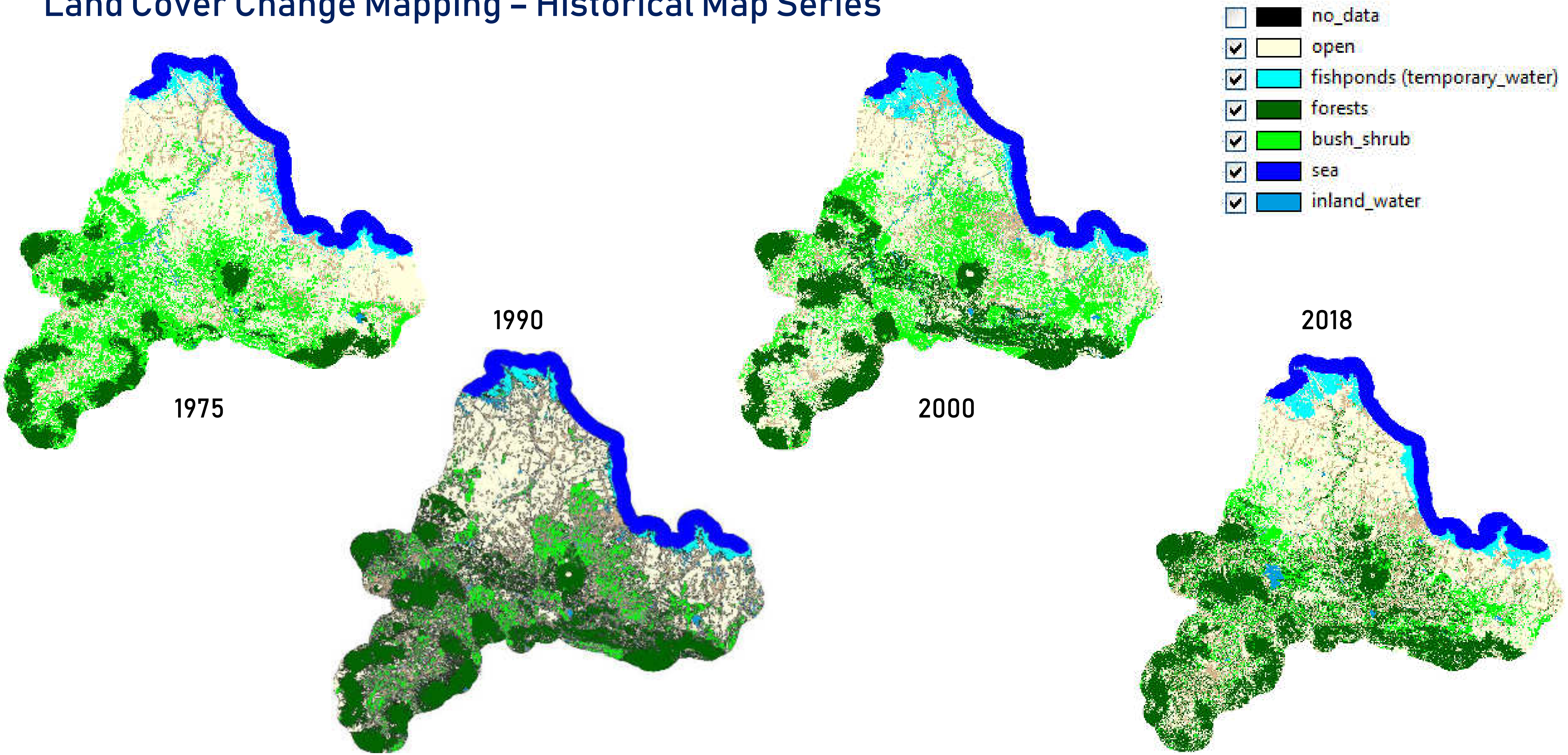
Land Cover Change Mapping – Specification: Frequency, Availability, Delivery (mean, formats, coding)

Frequency
3 years (or after every severe natural hazard incydent)

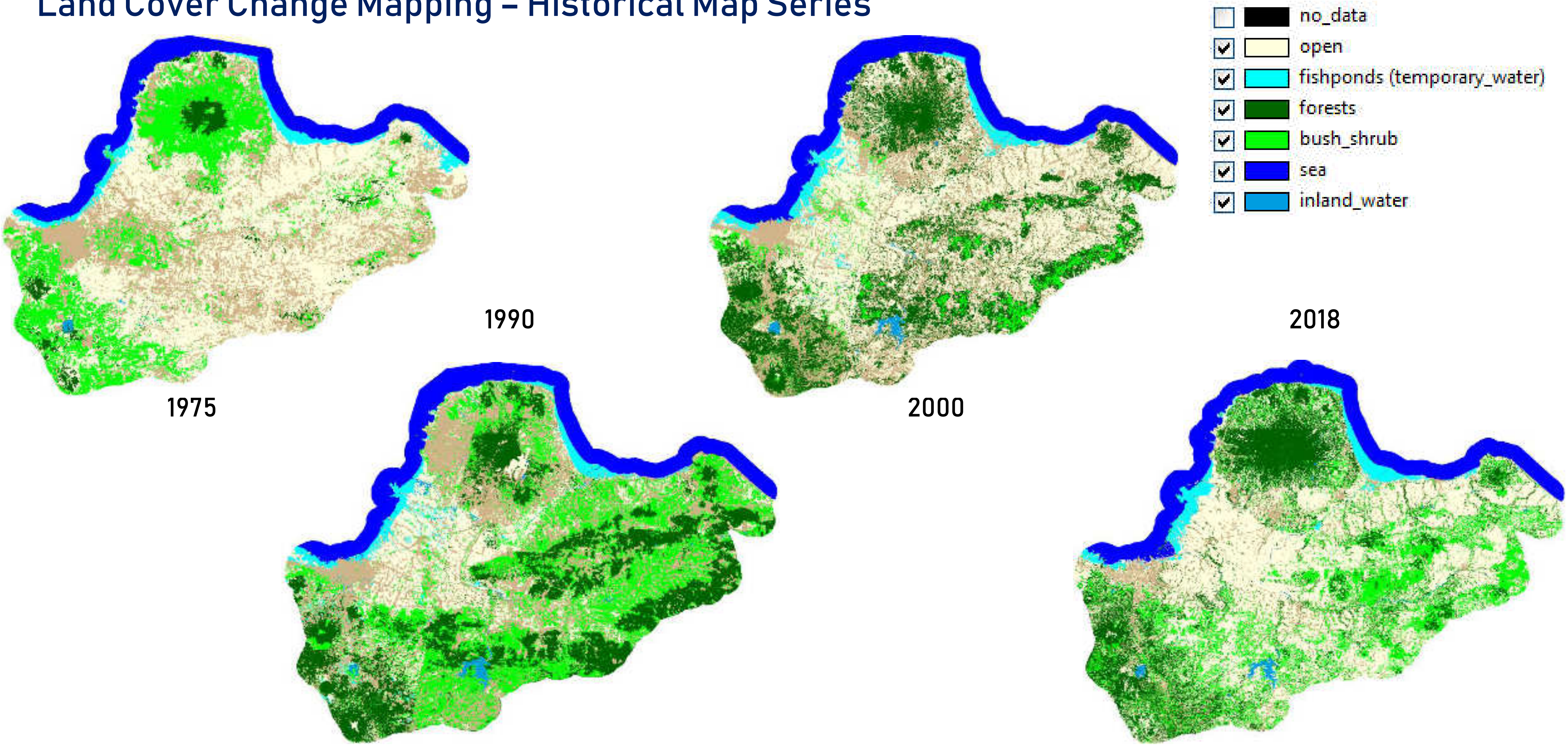
Availabile products
Historic Land Cover Maps 1975/1990/2000 and 2018 as a reference

Delivery
60 m thematic raster

Land Cover Change Mapping – Historical Map Series



Land Cover Change Mapping – Historical Map Series



Geoinformational Support

Geo4IRBM

for Integrated River Basins Management

European Space Agency

Cropping Intensity Mapping

Przemysław Turos (Topologic)

Cropping Intensity Mapping – Background

PPTA requirements *(source: PPTA task force)*

Objective

- To evaluate historical changes in Water/flood extent, Land Use and Land cover in 4 basins in Indonesia; Cimanuk, Seluna, Mahakam, and Belewan.

Processes

- Evaluation of Water inflows to reservoirs in Raw Water Supply (RWS) subprojects,
- Evaluation of Water/flood extent in Flood Risk Management (FRM) subprojects.

Data sets requested

- *Cross analysis of flood events on the base of existing reports and as detected by historical surface water monitoring (1-month before and 1-month after the date)*
- *(i) Water/flood extent – also for the period before S1 mission (ii) Land cover and (iii) Land Use (if available) through Landsat-8 and Sentinel-1 images at the basin scale.*
- *Products for assessments along the coast-line.*
- Information on cropping intensity

Proposed application scenarios of Geo4IRBM services

- *Land Cover Maps and Land Cover Changes maps applied for the needs of EWSIP focusing*
- *Coastline changes elaborated on the base of Land Cover Changes maps. Indicators of coastline length variations in reference network.*
- *Surface deformation / subsidence along the coastline, cross analysis of coastline changes.*
- *Surface deformation for the needs of landslides detection and erosion assessment useful for floods forecasting.*
- *Surface waters monitoring historical data could contribute to historical floods delimitation and as information on frequency of water coverage, proposed extension of the period before S1 operation.*
- Crops Intensity Maps for water demand assessment.

Proposition of extension of AOIs was rejected due to resources limitation (proposed extension area was 5 times bigger than the original)

Cropping Intensity Mapping – Background

Enhanced Water Security Investment Project *(source: EWSIP Project Concept Paper)*

Outputs

1. Planning for water resources optimized
   - 1a. Water monitoring equipment installed as per rationalization plans.
   - 1b. River basin wide hydrological and hydrodynamic models calibrated.
   - 1d. Asset management information system for river assets established.
   - 1e. Knowledge and skills in climate resilient infrastructure design/planning of RBO staff

Key Activities with Milestones

1. Planning for water resources optimized
   - 1.2 Install and calibrate expanded networks of hydro-meteorological stations. (Q4 2020)
   - 1.3 Run hydrological and hydrodynamic models to optimize water management for DMI, irrigation and energy needs taking into account land use change and climate change scenarios. (Q2 2020)
   - 1.5 Upgrade the river asset management information system to an online GIS based system. (Q2 2020)

Proposed application scenarios of Geo4IRBM services

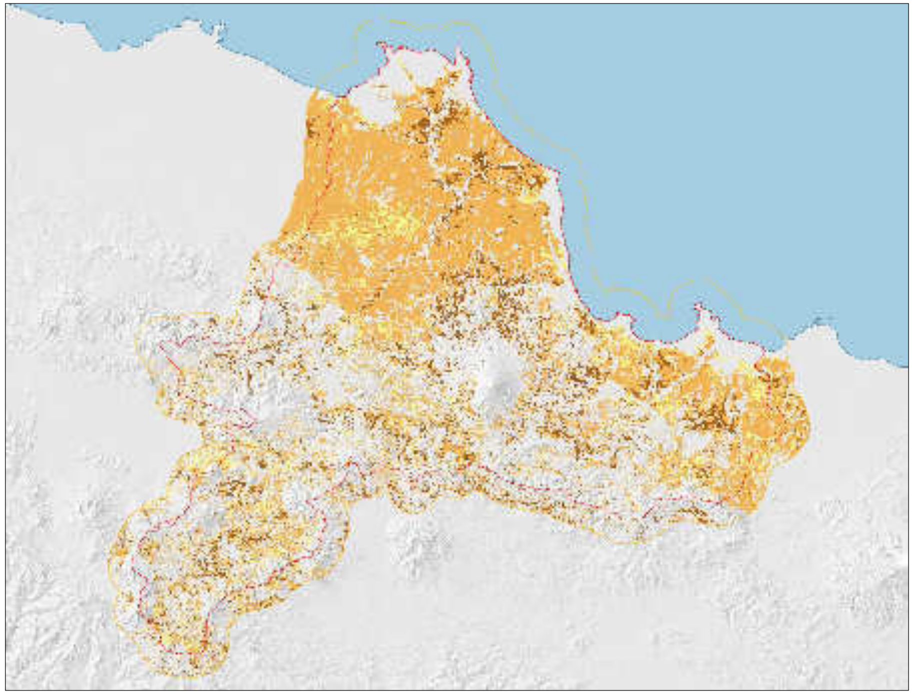
Land Cover Maps applied for the needs of flood risks and flood hazard (the Polish case IMGW/Polish Waters/Ministry of Inland Navigation and Water Management).

Cropping Intensity Maps for water demand assessment.

Surface Waters Monitoring historical data could contribute to climate change analysis and historical floods delimitation – frequency of water coverage

Cropping Intensity Mapping – Definitions

Proposed resource provides information on number of crops/harvest cycle during a year.



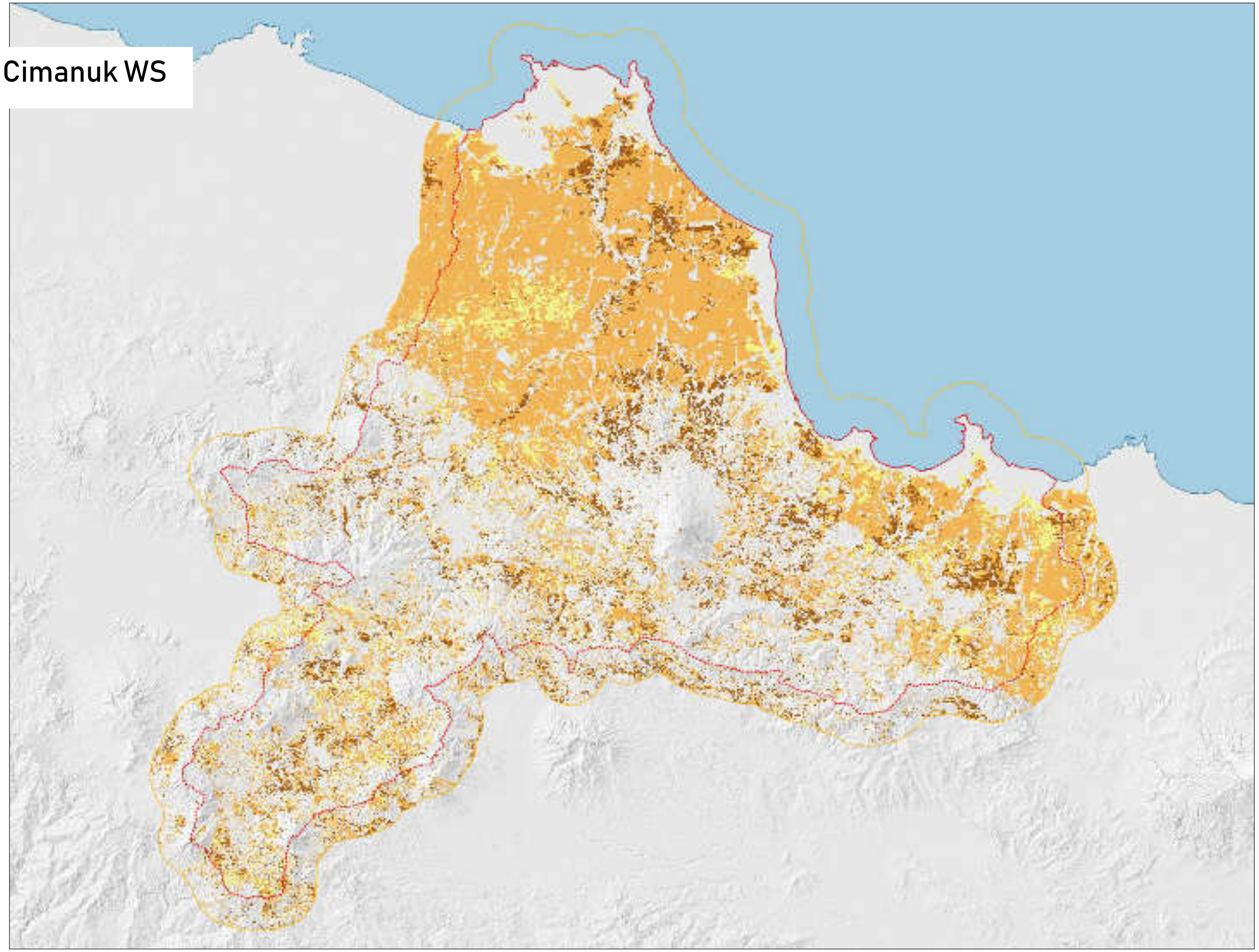
Harvest/Harvesting is the process of gathering a ripe crop from the fields.

Maps of indexes used usually for analysis of status of environment elements (i.e. plans development stage).

NDVI - Normalized Difference Vegetation Index – quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).

Statistics mean non-spatial information, which refers to particular area (i.e. permanent crops area in municipality) or particular location.

Cropping Intensity Mapping – Objectives

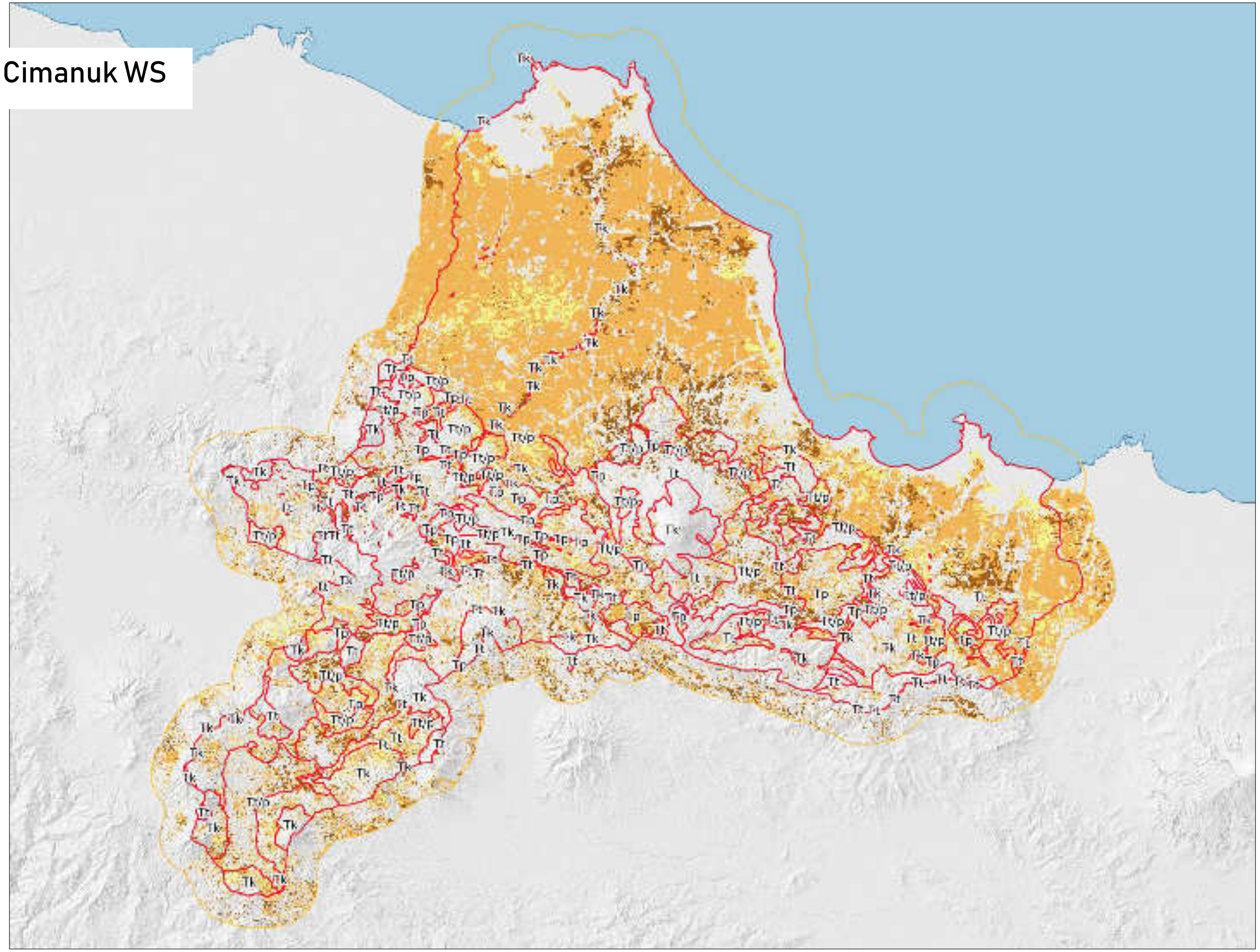


Cropping intensity – number of annual harvests

3
2
1

Analysis conducted only for agricultural lands as classified in course of Geo4IRBM project

Cropping Intensity Mapping – Objectives



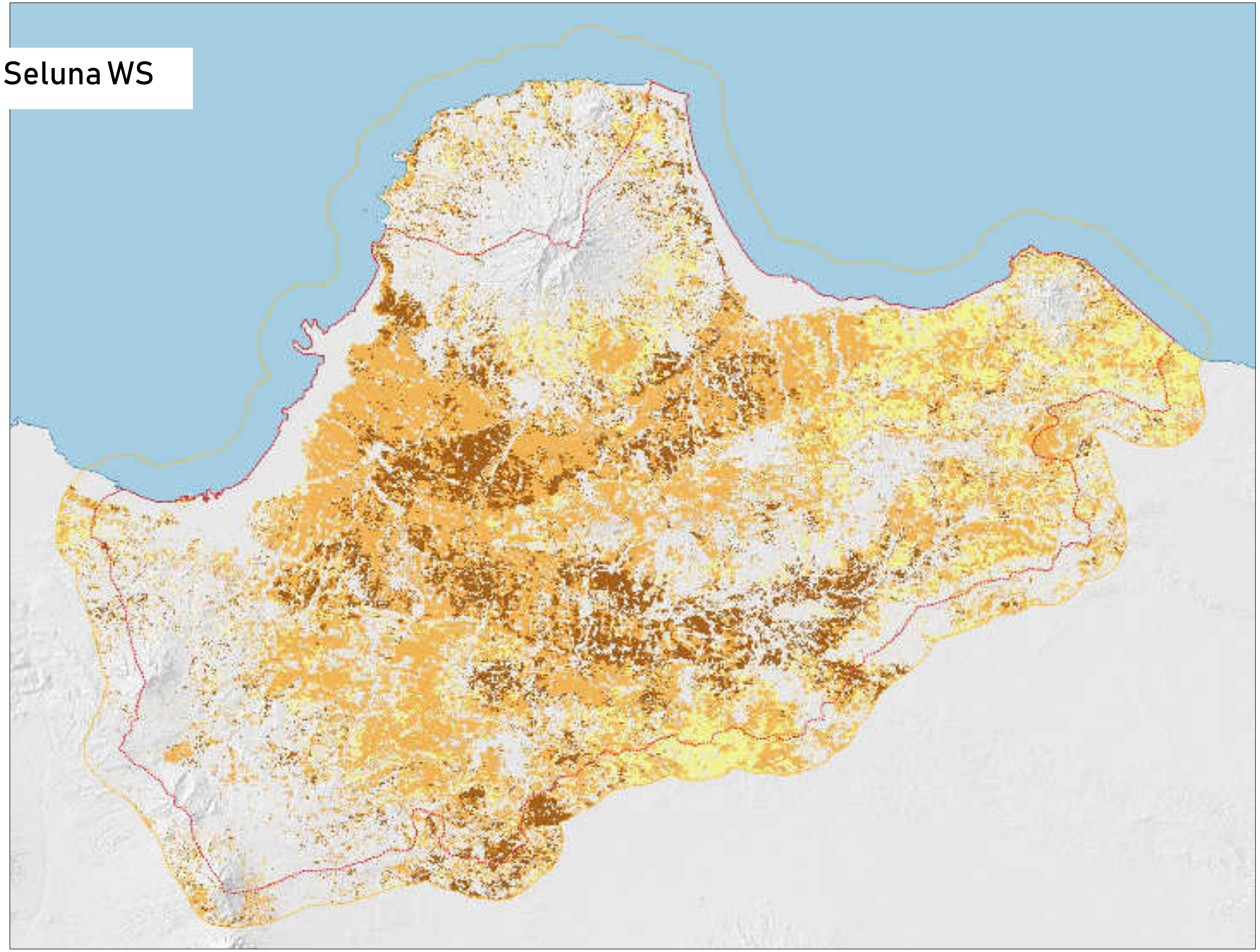
Cropping intensity – number of annual harvests

3
2
1

		Number of annual harvests - percentage of total area		
Sistem (System)	***Abr.***	***1***	***2***	***3***
Tanaman kehutanan (Forestry)	Tk	24.01	59.13	16.86
Tanaman pangan (Crops)	Tp	10.29	77.5	12.21
Tanaman tahunan (Annual crops)	Tt	17.36	62.56	20.08
Tanaman tahunan/pangan (Annual crops / food)	Tt/p	13.64	59.48	26.88

Analysis conducted only for agricultural lands as classified in course of Geo4IRBM project

Cropping Intensity Mapping – Objectives

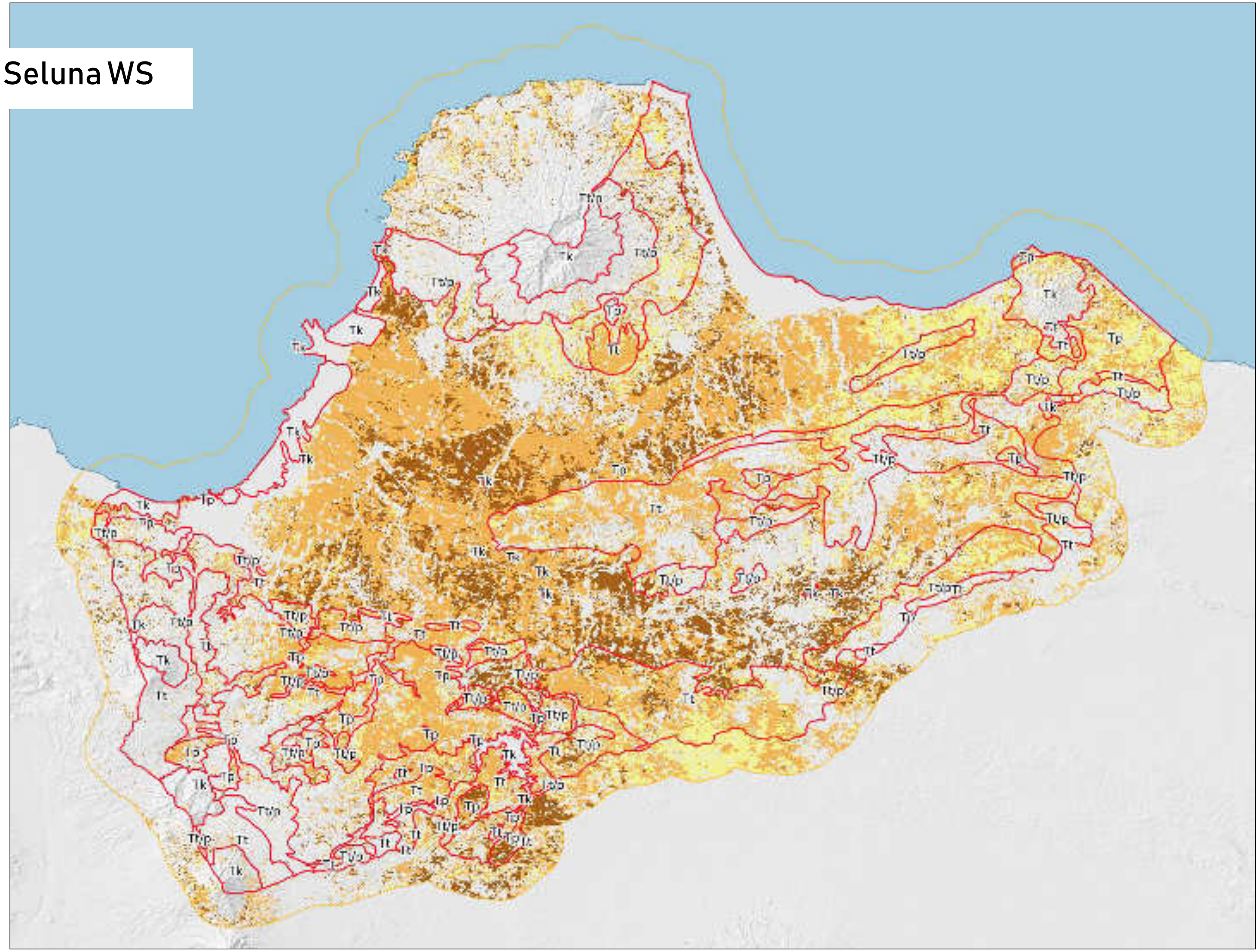


Cropping intensity – number of annual harvests

- 3
- 2
- 1

Analysis conducted only for agricultural lands as classified in course of Geo4IRBM project

Cropping Intensity Mapping – Objectives



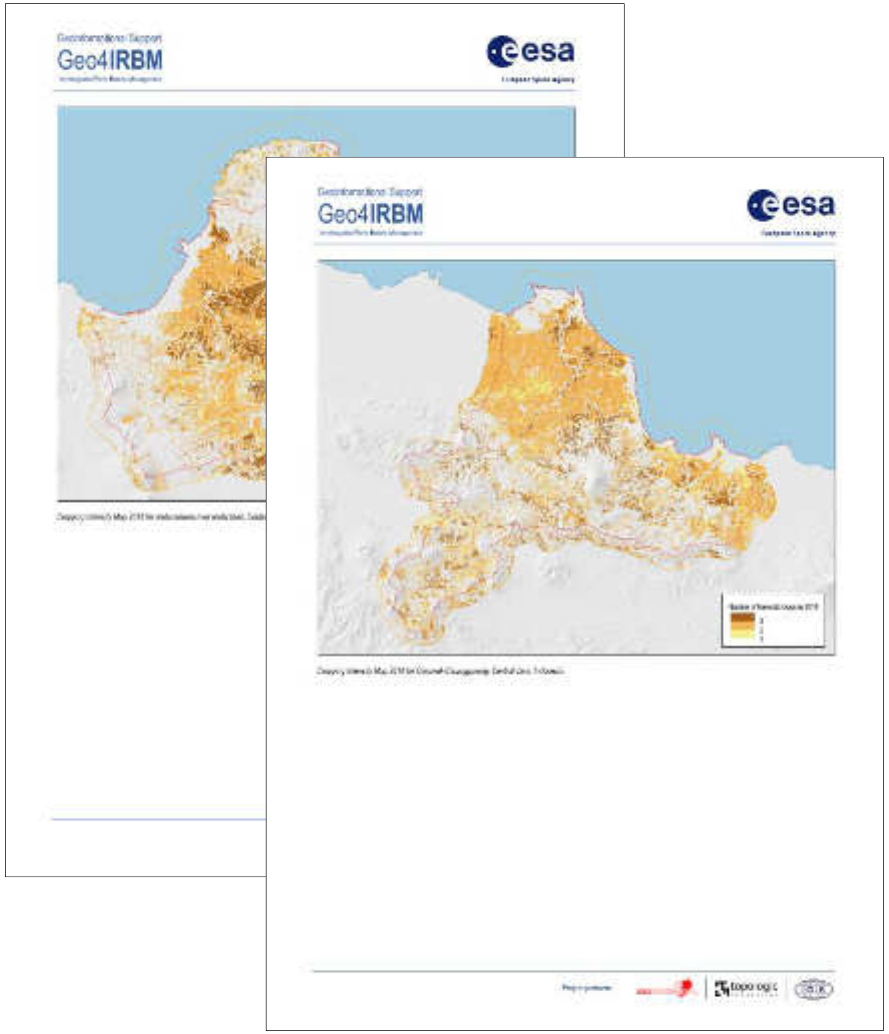
Cropping intensity – number of annual harvests

3
2
1

Sistem (System)	***Abr.***	***Number of annual harvests - percentage of total area*** 1	2	3
Tanaman kehutanan (Forestry)	Tk	36.37	54.3	9.34
Tanaman pangan (Crops)	Tp	13.82	60.05	26.13
Tanaman tahunan (Annual crops)	Tt	20.09	74.1	5.81
Tanaman tahunan/pangan (Annual crops / food)	Tt/p	33.29	55.18	11.54

Analysis conducted only for agricultural lands as classified in course of Geo4IRBM project

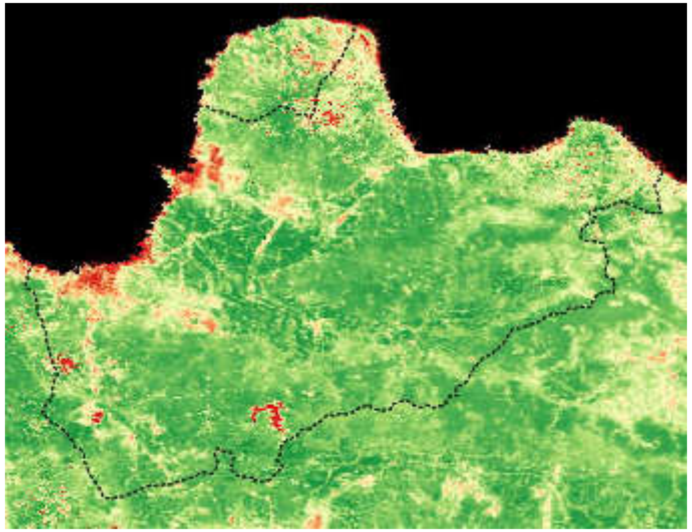
Cropping Intensity Mapping – Objectives

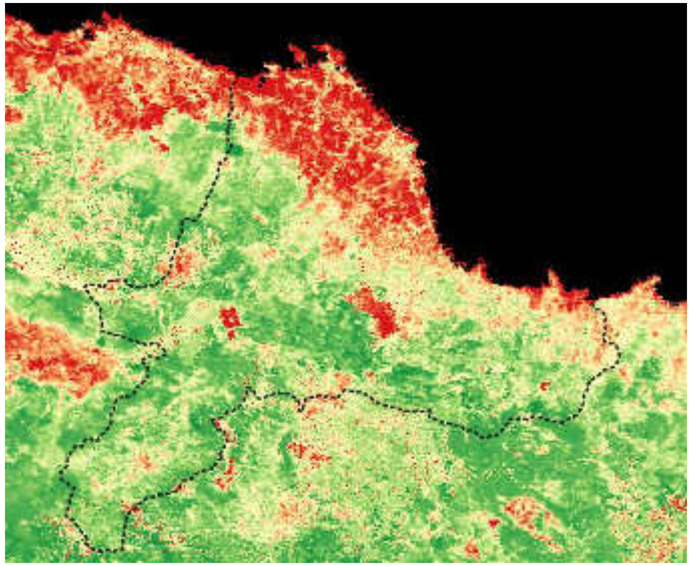


Cropping Intensity Mapping– Design approach

Product specification and production process design is driven by three factors:

- Planned application fields,
- Availability of data and information sources,
- Resources available during the project.





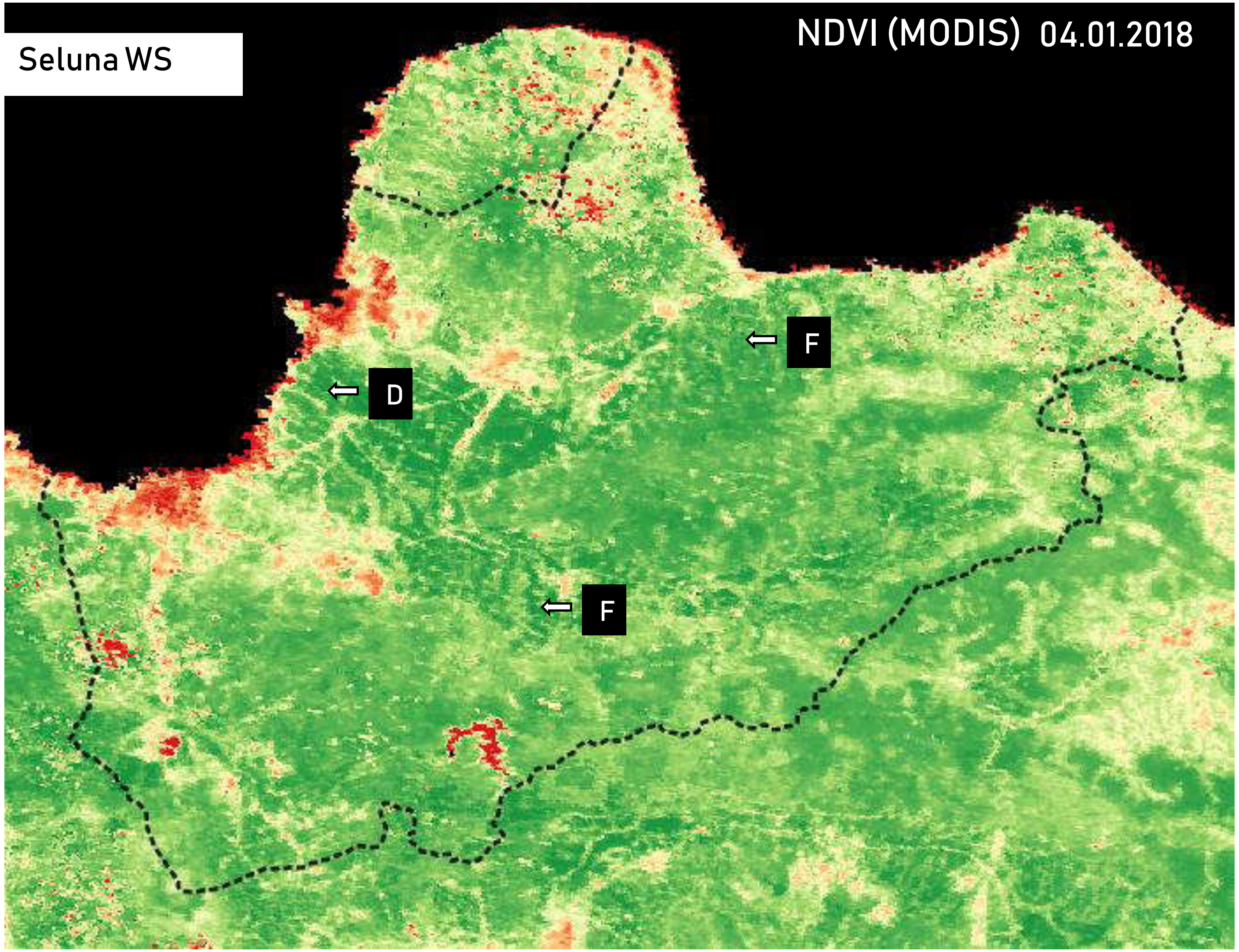
Due to necessity of conducting analysis in highly clouded area there was a necessity of application of data from satellite sensor of high temporal resolution, allowing for frequent access to terrain. High temporal resolution is usually achiever with very wide swath and limited ground resolution of imageries. To simplify and accelerate the process it was decided to use MODIS sensor based derivatives. Products selected to be applied in the analysis was MODIS Vegetation Indices 16-Day L3 Global 250m. Time series of data for 2018 was collected and preprocesses.

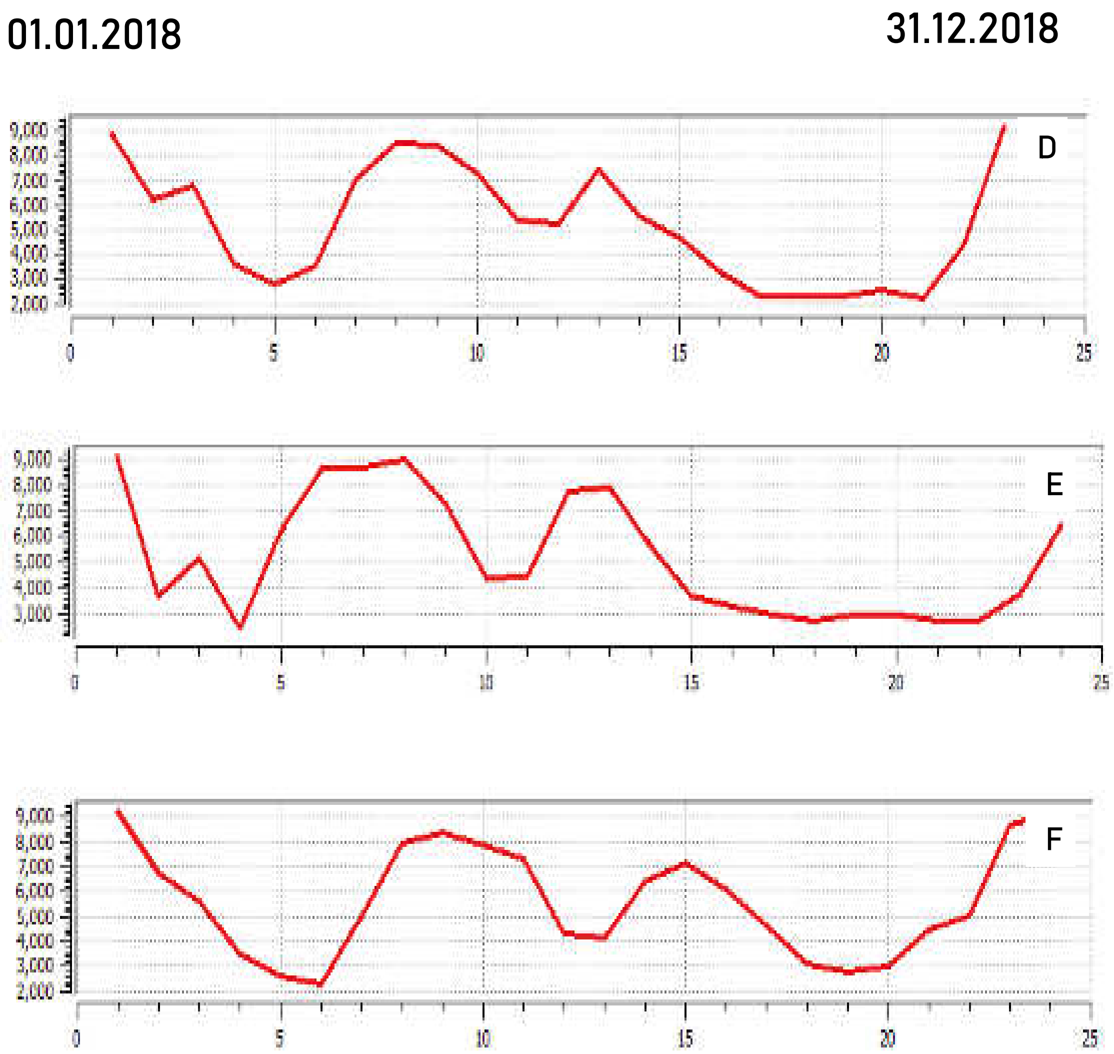
The actual analysis was concentrated on temporal variability of NDVI values in a network of cells of 250m resolution. Assumptions on highest (intensive vegetation) and lowest (no vegetation) values of the index was made on the base of contextual analysis of input data. Important assumption was made also in reference to minimal periods between cropping.

The last stage of Cropping Intensity Mapping process is oriented on focusing the analysis on areas identified as agriculturally cultivated land. This stage is being conducted with use of Land Cover Map 2018 elaborated in course of the project by masking non-agriculturally cultivated land in the spatial information datasets. Only agriculturally cultivated lands will contribute to CIM based statistics

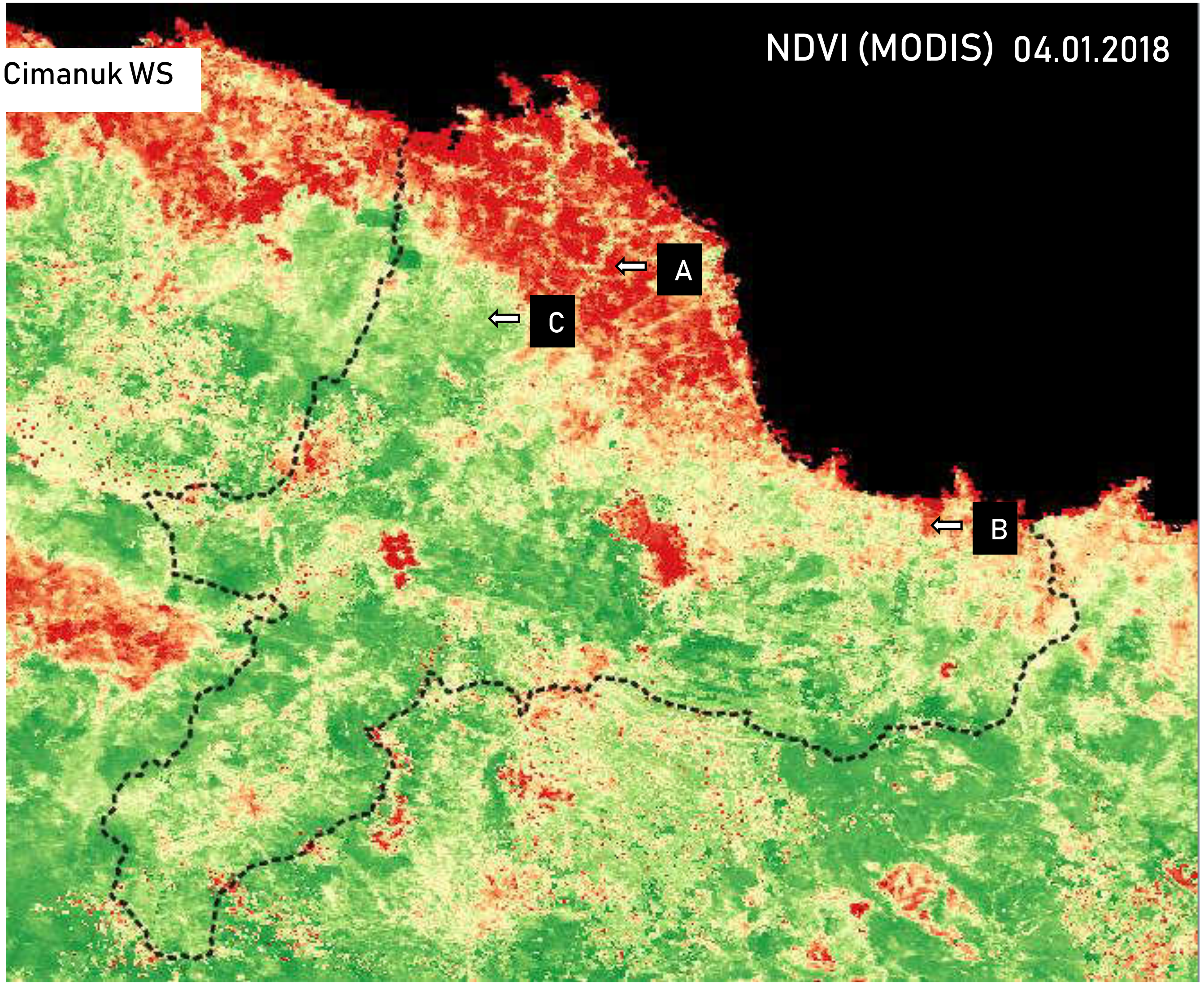
Cropping Intensity maps 2018

MODIS NDVI 16 days composites 2018

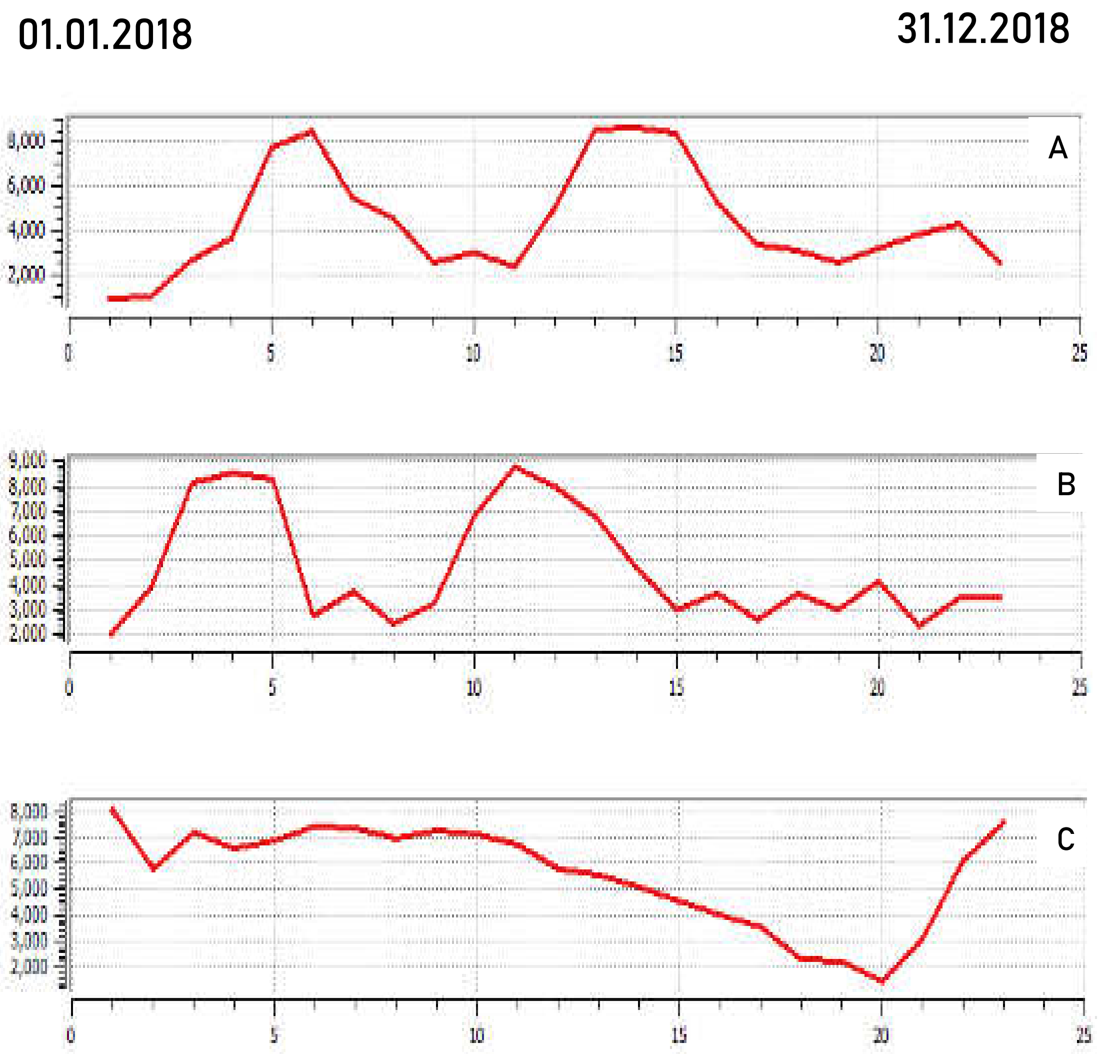




Cropping Intensity maps 2018



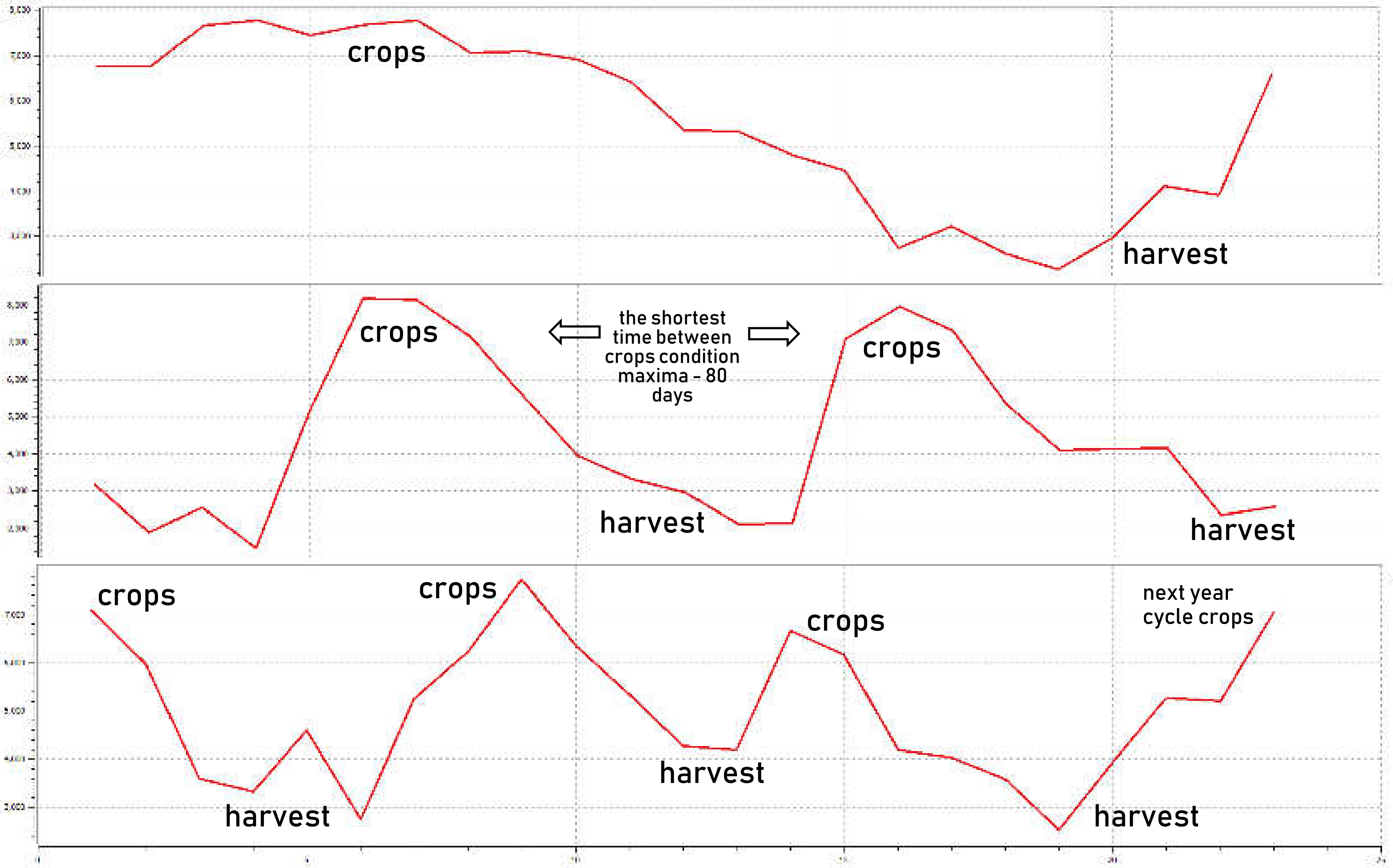
MODIS NDVI 16 days composites 2018



Cropping Intensity maps 2018

Interpretation basics of MODIS NDVI 16 days composites 2018

01.01.2018 31.12.2018



1 — 1 year long NDVI time series curve interpreted as one harvest annually (when refers to seasonal crops)

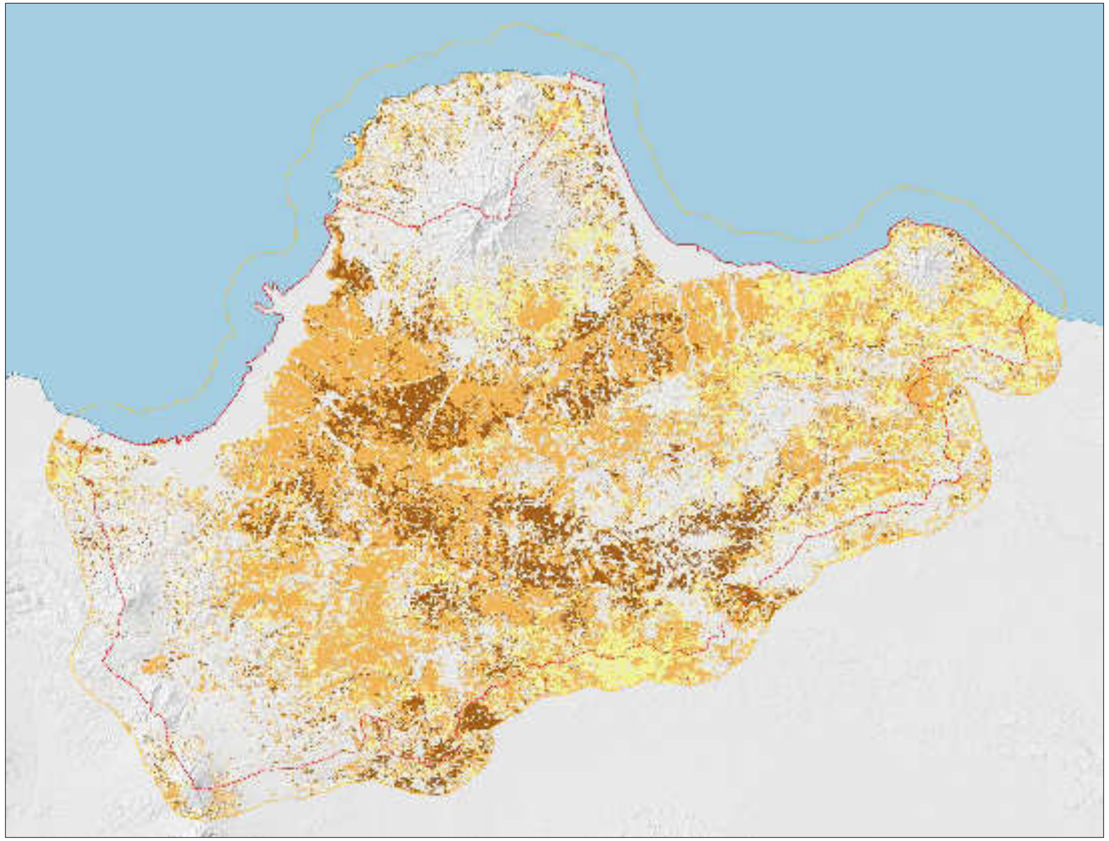
2 — 1 year long NDVI time series curve interpreted as two harvests annually (when refers to seasonal crops)

3 — 1 year long NDVI time series curve interpreted as three harvests annually (when refers to seasonal crops)

Cropping Intensity Mapping– Product Use

Cropping Intensity Maps are planned to be used in the following application field:

- Elaboration of statistics on cropping intensity structure,
- Basis for continuous cropping intensity monitoring,
- Reference for other sources of agricultural statistics,
- Climate changes impact assessment,
- Evaluation of impact of investments in water management supporting infrastructure,
- Evaluation of impact of potential of agricultural practices development,
- Reference data/input data for productivity modelling,
- Environmental impact analysis.



Cropping Intensity Mapping– Limitations

Features limiting product's reliability, applicability and level of details:

- Planned major source of EO based data is of moderate resolution of 250m, which leads to existence of pixels representing mixed land cover not allowing for detailed analysis.
- The products does not provide information on the actual crop type, only information od changes of Normalized Differential Vegetation Index, which could be interpret as chances of vegetation canopy – in the case of agriculturally cultivated land – with crop/harvest cycle.
- The products reflect the cropping intensity – number of crop/harvest cycle – in reference to the calendar year 2018.
- Thematic accuracy of the product is strongly dependent on reference data on crops types and cropping intensity. During the production access to reference data of required character was strongly limited.
- Ability of conducting reliable accuracy assessment is also strongly dependent on accessibility of reference data.

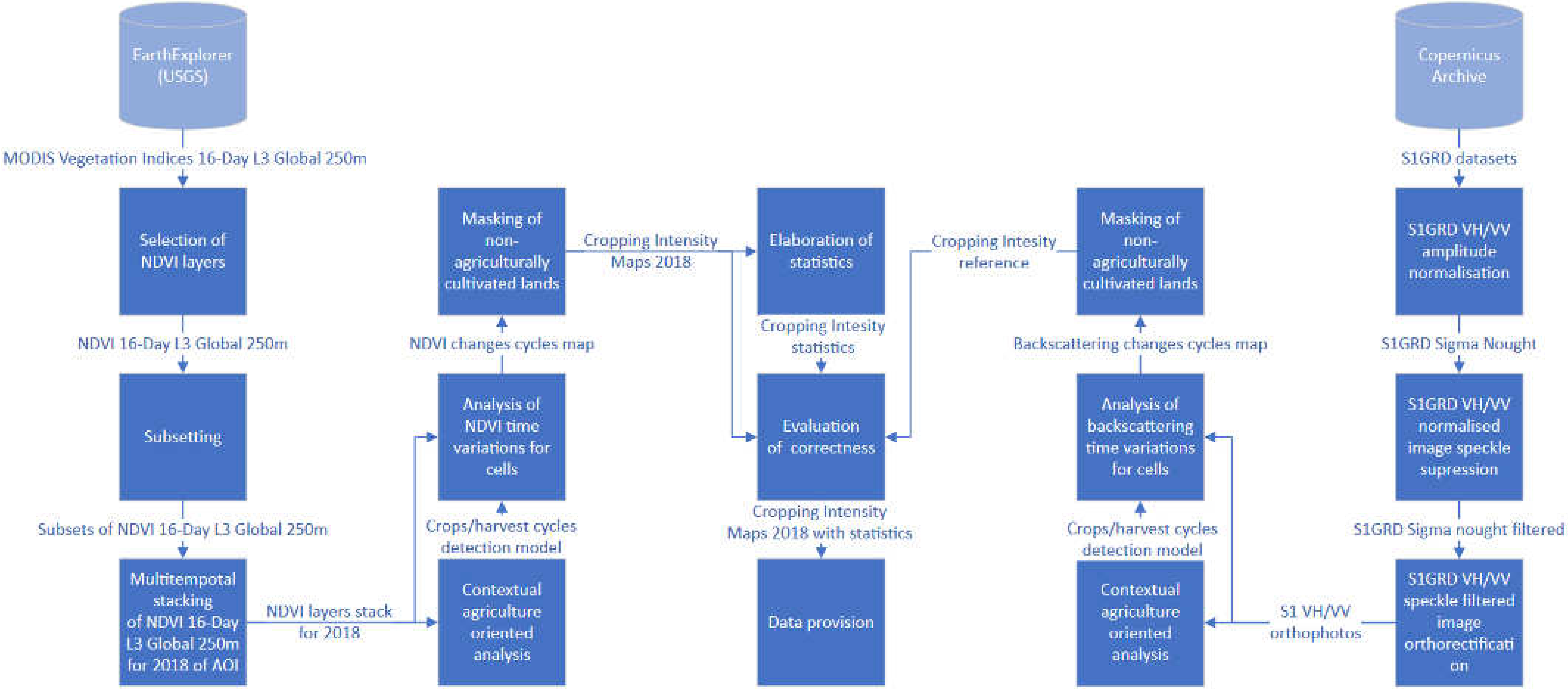
Cropping Intensity Mapping– Requirements

ID	Requirement	Priority
CIM01	Maps should cover areas defined by the end-user	First
CIM02	Maps should be elaborated with the level of details proper for the scale of 1: 50 000.	First
CIM03	The major source should be moderate resolution MODIS products reflecting Vegetation Indices time series for the entire 2018	First
CIM04	Due to necessity of multitemporal analysis and expected intense cloud coverage multitemporal composites basing on multiply observations should be applied.	First
CIM05	Minimum mapping unit should be equal to the resolution of input data	First
CIM06	Legend should reflect the number of number of harvests/crops for agriculturally cultivated land (with crops types not differentiated) during the year of monitoring.	First
CIM07	Map should be stored as a raster GIS format.	First
CIM08	Map should be stored in UTM coordination system.	First
CIM09	Thematic accuracy of the map should be higher than 75%.	First

Long-term Surface Water Coverage Mapping – Specification

Feature	Value / description
Content	The Cropping Intensity Maps 2018 provides information indicating number of harvests/crops for agriculturally cultivated land (with crops types not differentiated) during the year of monitoring. *DN*1 1 harvest/crop *DN*2 2 harvest/crop *DN*3 3 harvest/crop
Geographic Coverage	AOI 1.: Jratunseluna river watershed, Central Java, Indonesia (area of the watershed: 9 367 sqkm, area with 5 km buffer: 12 706 sqkm). AOI 2.: Cimanuk-Cisanggarung, Central Java, Indonesia (area of the watershed: 7 795 sqkm, area with 5 km buffer: 10 575 sqkm).
Input data sources	*Input data:* MODIS Vegetation Indices 16-Day L3 Global 250m time series for 2018 (23 datasets for h28v09 tile and 23 datasets for h28v09 tile) Land Cover Map 2018 elaborated in course of Geo4IRBM project *Input data provided by End-user:* Reference data on crops types of limited thematic scope and geographic extent
Methodology	Multitemporal Normalised Differential Vegetation Index analysis
Spatial Resolution and Coverage	Not applicable.
Coordinate Reference System	UTM zone 49S / EPSG: 32749
Accuracy, Constraints	Thematic accuracy: > 75% (assumed, not fully verified)
Accuracy Assessment Approach	Attempt of accuracy assessment basing on application of Sentinel-1 Sentinel-1 SAR GRD timeseries for 2018 (Seluna WS – orbit 076, Cimanuk WS – orbit WS 149) undertaken.
Frequency	It is suggested to update – annually
Availability	1972-2018
Delivery / Output Format	Shapefile

Cropping Intensity Mapping – Specification: Methodology



Schema of applied analysis and processing procedures in course of CIM elaboration

THANK YOU

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Geoinformational Support

Geo4IRBM

for Integrated River Basins Management

Surface Water Monitoring Service

Przemysław Turos (Topologic)

Surface Water Monitoring Service – Definitions

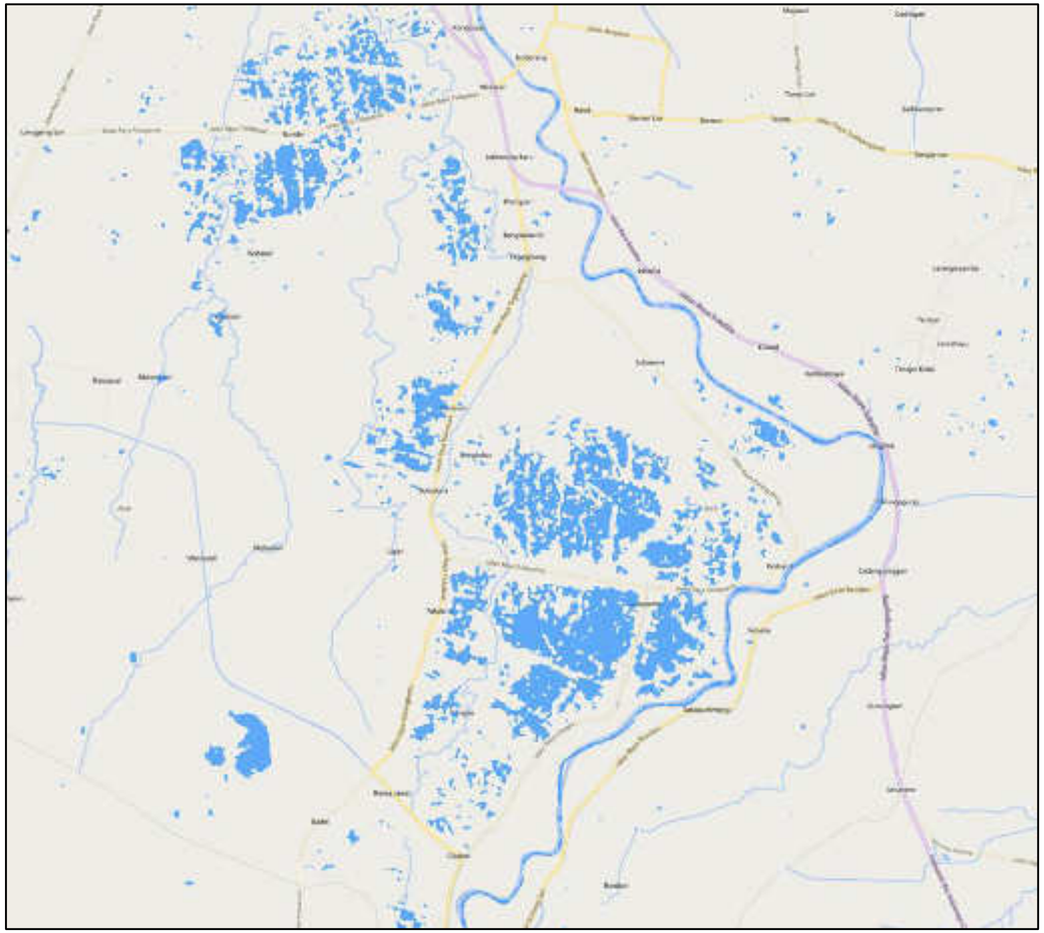
Surface Water Monitoring is being provided continuously as an automatic online service allowing for access to the newest map products as well as to historic water extent statuses over the AOI

Product - static information reflecting i.e. the environment's components' status in particular time, in this case - surface water extent.

Monitoring service is systematic provision of dynamic information allowing for changes detection and analysis of trends of changes. This service is satellite EO observation based monitoring.

Surface water is any natural water that has not penetrated under the surface of the ground underneath.

- Rivers, lakes, wetlands are commonly known bodies of surface water.
- Surface water is lost through evaporation and regained through precipitation (rain) or recruited from ground-water sources.
- The service maps also flooded rise fields, inundations and floods.
- No attempt of categorisation is introduced in the service itself.



Surface Water Monitoring Service – Background

PPTA requirements *(source: PPTA task force)*

Objective

To evaluate historical changes in Water/flood extent, Land Use and Land cover in 4 basins in Indonesia; Cimanuk, Seluna, Mahakam, and Belewan.

Processes

Evaluation of Water inflows to reservoirs in Raw Water Supply (RWS) subprojects,

Evaluation of Water/flood extent in Flood Risk Management (FRM) subprojects.

Data sets requested

Cross analysis of flood events on the base of existing reports and as detected by historical surface water monitoring (1-month before and 1-month after the date)

(i) Water/flood extent – also for the period before S1 mission (ii) Land cover and (iii) Land Use (if available) through Landsat-8 and Sentinel-1 images at the basin scale.

Products for assessments along the coast-line.

Information on cropping intensity

Proposed application scenarios of Geo4IRBM services

Land Cover Maps and Land Cover Changes maps applied for the needs of EWSIP focusing

Coastline changes elaborated on the base of Land Cover Changes maps. Indicators of coastline length variations in reference network.

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Surface deformation for the needs of landslides detection and erosion assessment useful for floods forecasting.

Surface waters monitoring historical data could contribute to historical floods delimitation and as information on frequency of water coverage, proposed extension of the period before S1 operation.

Proposition of extension of AOIs was rejected due to resources limitation (proposed extension area was 5 times bigger than the original)

Surface Water Monitoring Service – Background

Enhanced Water Security Investment Project *(source: EWSIP Project Concept Paper)*

Outputs

1. Planning for water resources optimized

   1a. Water monitoring equipment installed as per rationalization plans.

   1b. River basin wide hydrological and hydrodynamic models calibrated.

   1d. Asset management information system for river assets established.

   1e. Knowledge and skills in climate resilient infrastructure design/planning of RBO staff

Key Activities with Milestones

1. Planning for water resources optimized

   1.2 Install and calibrate expanded networks of hydro-meteorological stations. (Q4 2020)

   1.3 Run hydrological and hydrodynamic models to optimize water management for DMI, irrigation and energy needs taking into account land use change and climate change scenarios. (Q2 2020)

   1.5 Upgrade the river asset management information system to an online GIS based system. (Q2 2020)

Proposed application scenarios of Geo4IRBM services

Land Cover Maps applied for the needs of flood risks and flood hazard (the Polish case IMGW/Polish Waters/Ministry of Inland Navigation and Water Management).

Crops Intensity Maps for water demand assessment.

Surface Waters Monitoring historical data could contribute to climate change analysis and historical floods delimitation - frequency of water coverage

Surface Water Monitoring Service – Background

Enhanced Water Security Investment Project *(source: EWSIP Project Concept Paper)*

Outputs

2. Raw water supply infrastructure and services improved

   2a. Water storage is increased

   2c. Additional groundwater wells built or upgraded worse than expected ground conditions may cause implementation delays)

Key Activities with Milestones

2. Raw water supply infrastructure and services improved

   2.4 Construct or upgrade bulk water facilities (reservoirs, ponds, bunded reservoirs, groundwater wells, conveyance) including climate resilient design features. (Q1 2022)

Proposed application scenarios of Geo4IRBM services

Land Cover Maps applied for the needs of investments strategic planning

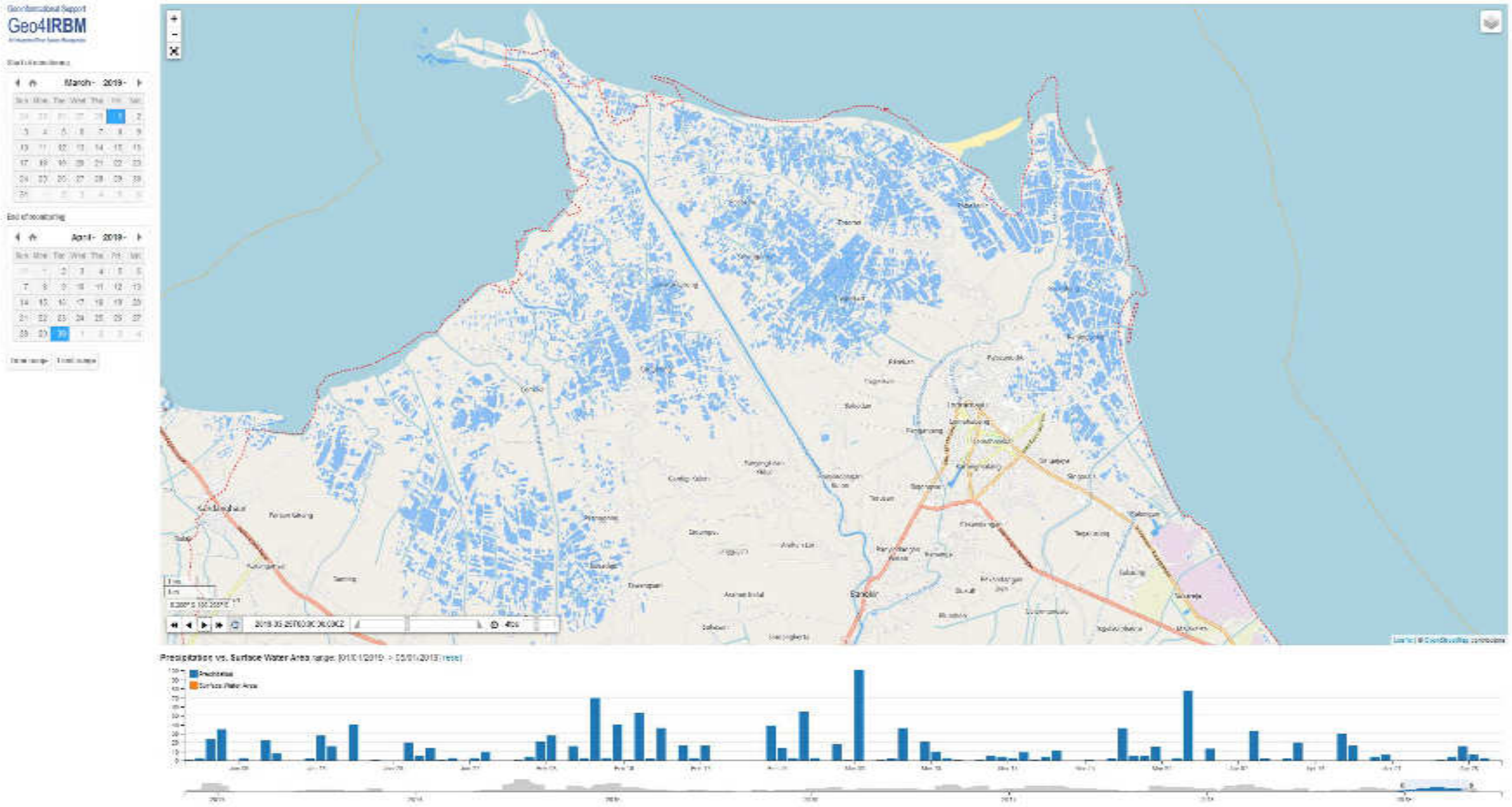
Surface Water Monitoring service inputs for the reservoirs effectiveness and responsiveness evaluation.

Ground conditions analysis could be supported with interferometric analysis of ground subsidence.

Surface Water Monitoring Service – Objectives

Geoportal dedicated for Surface Water Monitoring Service

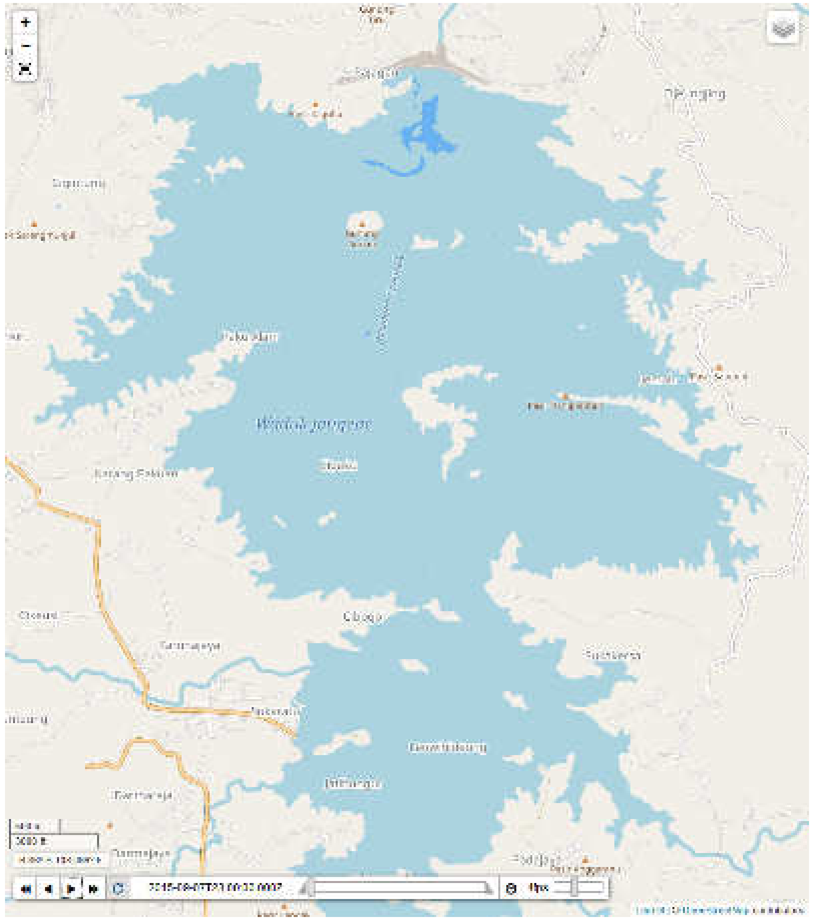
Series of surface water masks made available as WMS-T (time support)



Surface Water Monitoring Service portal – subsequent surface water masks were made available as WMS with time support, on the bottom of the portal daily precipitation sums are presented as a bar chart. North coast of Cimanuk-Cisanggarung river watershed, Central Java, Indonesia with visible fishponds and temporarily inundated rice fields – SWM maps generated on the base of Sentinel-1 SAR data.

Surface Water Monitoring Service – Objectives

Operation of the initial filling of Jatigede Reservoir on Cimanuk river – characteristic stages reflected on SWM maps generated on the base of Sentinel-1 SAR data



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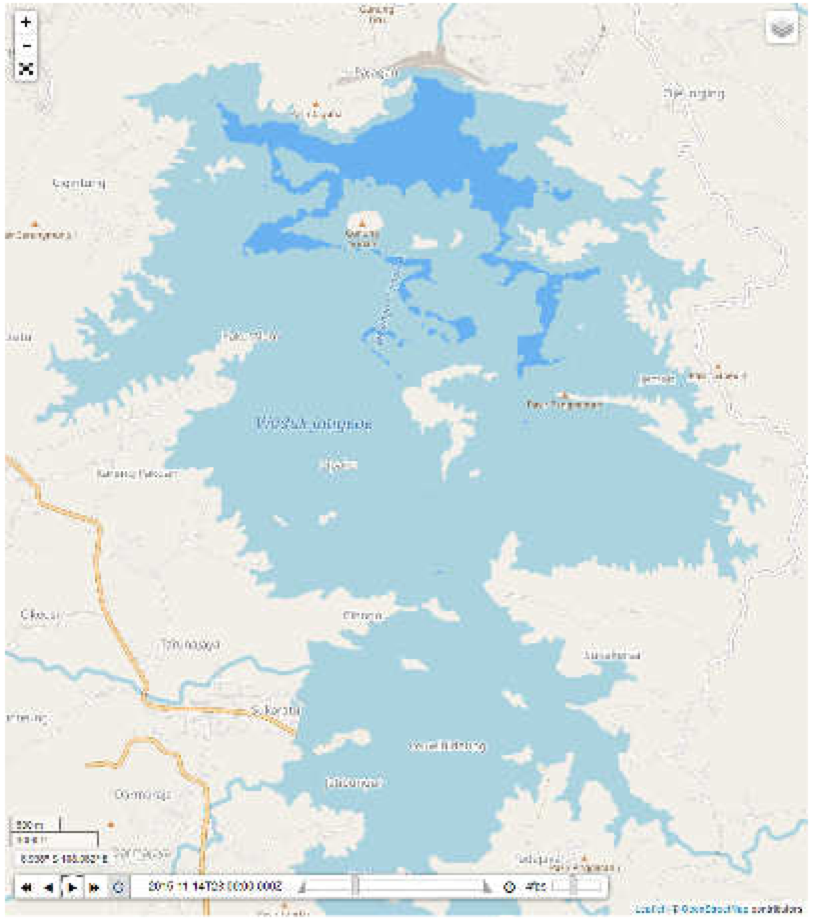
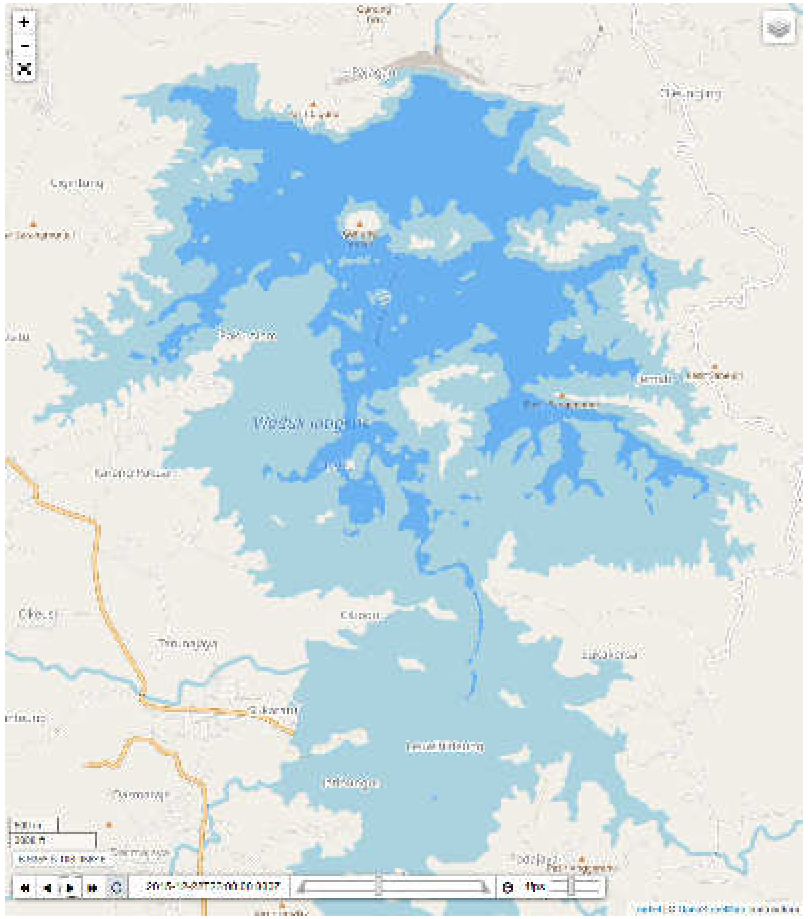


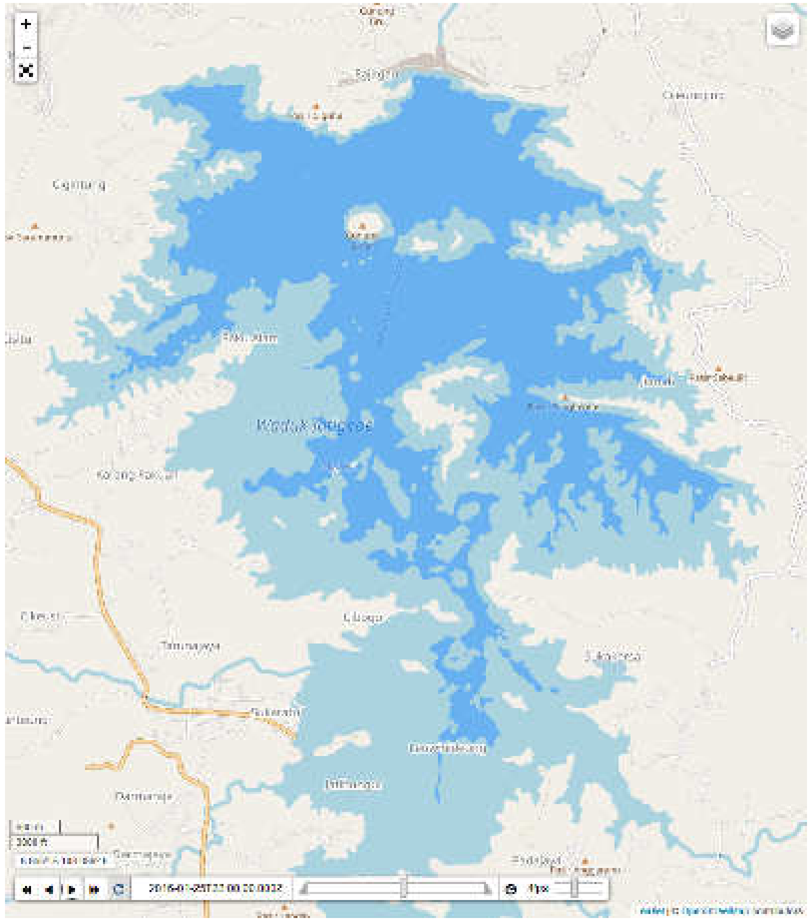
2015-11-14



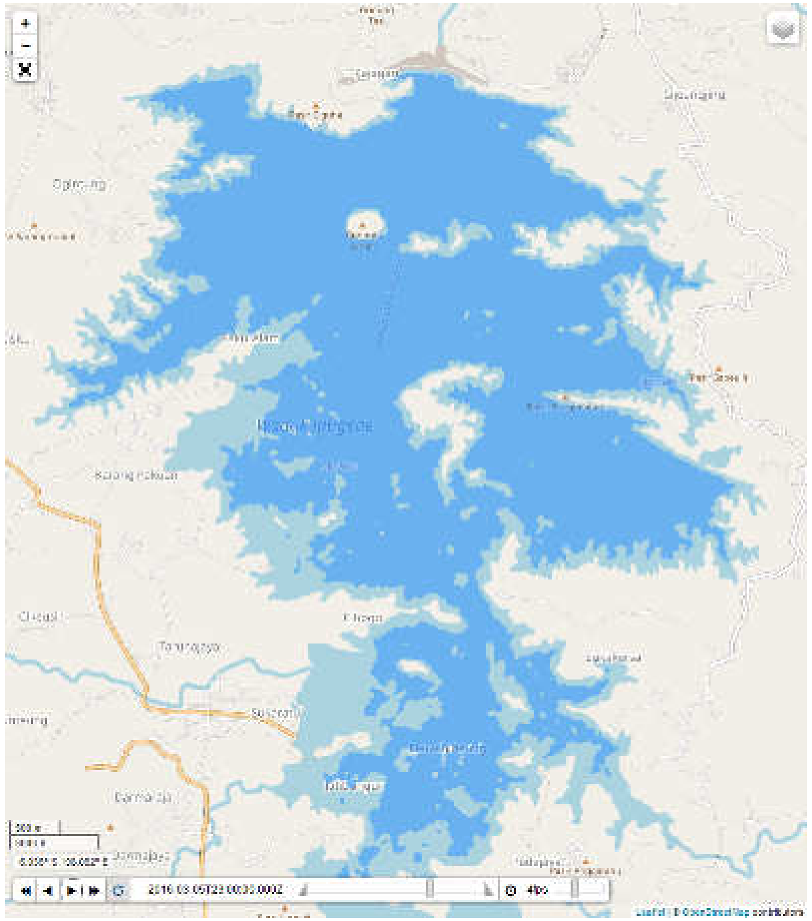
2015-12-22

Surface Water Monitoring Service – Objectives

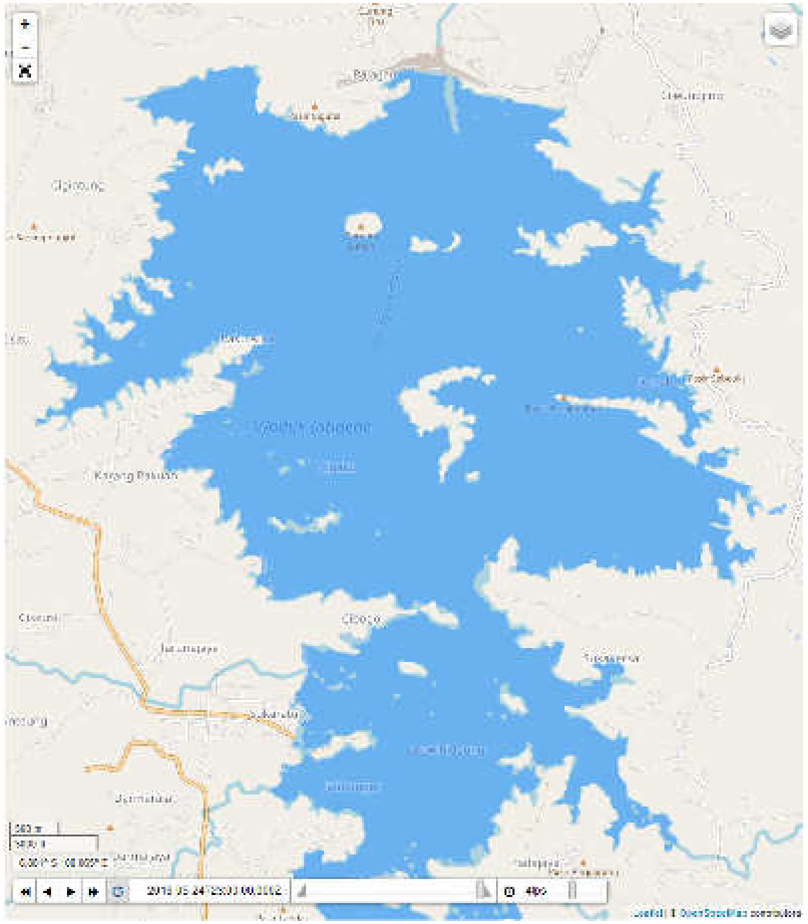
Operation of the initial filling of Jatigede Reservoir on Cimanuk river – characteristic stages reflected on SWM maps generated on the base of Sentinel-1 SAR data



2016-01-25



2016-03-05



2016-05-24

Surface Water Monitoring Service – Objectives

Geoinformational Support
Geo4IRBM

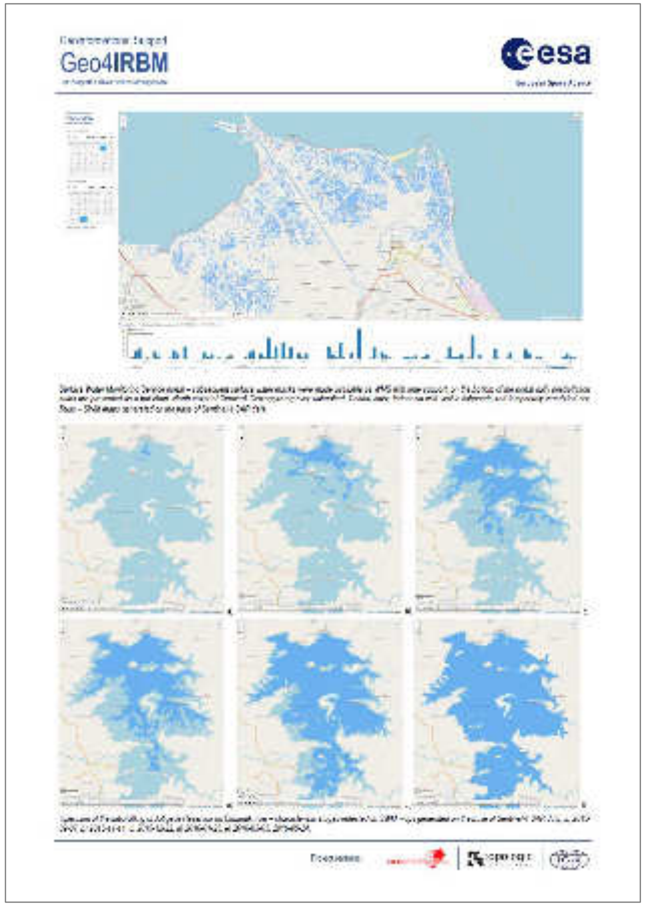
Surface Water Monitoring Service

Background

Design approach

Product use

Limitations



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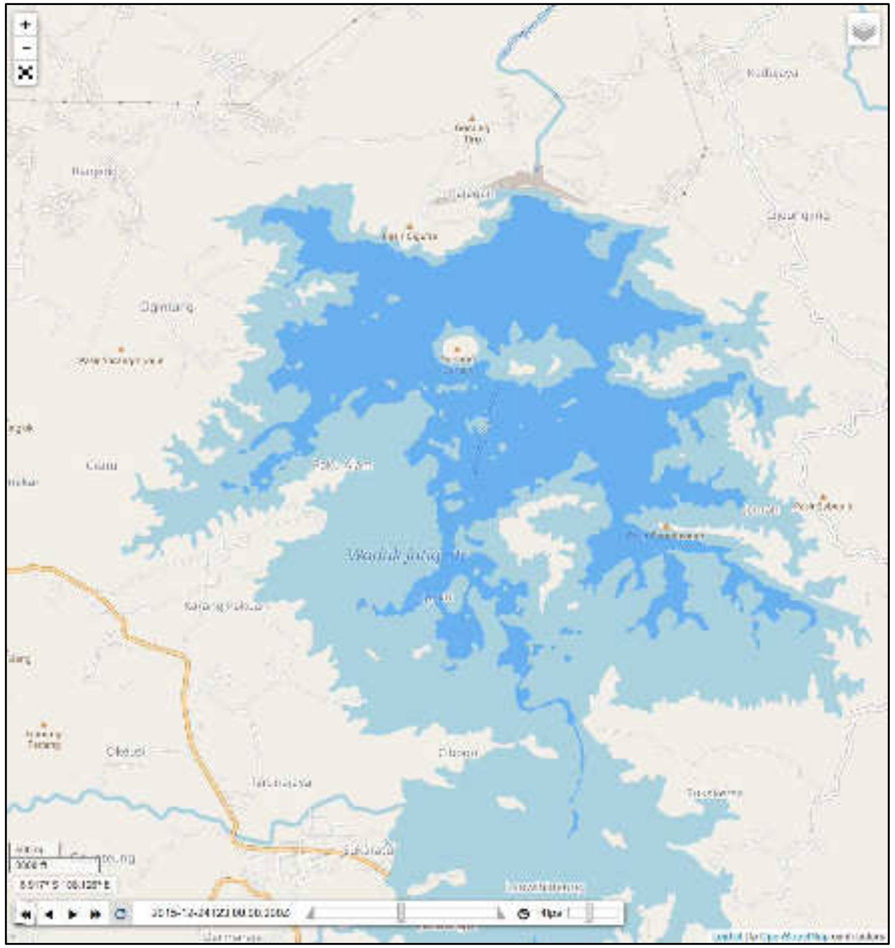
Surface Water Monitoring Service – Design approach

Product specification and production process design is driven by three factors:

- Planned application fields,
- Availability of data and information sources,
- Resources available during the project.

Service utilized historical data – satellite images of appropriate resolution available in the archive catalogues, and on the operational stage - newly acquired data which will have been collected during the project timespan. Information on surface water extent will be derived by automatic analysis of the imagery.

Service execution is based on Sentinel-1 microwave satellites monitoring capabilities utilization. Such solution provides flexibility given by regular acquisition of SAR data and ensures weather-independent service capacity. Preliminary data of the monitoring service are being used for calibration of the algorithms of water discrimination aiming at limitation of errors in the process.



Surface Water Monitoring Service – Product Use

The Land Cover Map is planned to be used in the following application fields:

- Agriculture oriented water management,
- Analysis of fields inundation extent and time schema,
- Identification of flood impact for given period / flood event (current or historical),
- Observation of evolution of flood hazard by assessment of multiple historic flood events,
- Input into calibration of flood modelling, which represents different type of hazard estimation,
- Support risk assessment - in combination with structural or socio-economic vulnerability hazard map represents crucial input into flood risk assessment aiming at identification of areas with the highest risks,
- Damage assessment,
- Correlation of floods events with land cover changes,
- Preparation of rescue and evacuation training scenarios.

Surface Water Monitoring Service – Limitations

The product will be elaborated with following assumptions, which have influence on limitation of the product capabilities, and limiting its reliability:

- Main source of input data are Sentinel-1 IW default orthorectification applied
- Effective ground resolution of the Sentinel-1 is 10 m which affects level of detail provided by the output product.
- Acquisition frequency of Sentinel-1 constellation at best 6 days. Data cannot be acquired between set acquisition dates.
- The Sentinel-1 data archive spans back to October 2014. For covering of events before acquisition period alternative data sources with (usually) much lower and irregular acquisition frequency must be considered.
- SAR data such as Sentinel-1 are not affected by cloud coverage, but they have limited interpretability of flood inundation in certain areas or under certain conditions:
    - omission errors – connected with problematic detection of water surface under dense trees crowns cover, in radar shadow, wavy water),
    - errors of commission – caused by annexation of shadowed or due to other reasons similar to water surface to the actual flooded area, or merging the flooded area with normally existing rivers or reservoirs (especially in urban or complex backscattering areas).

Surface Water Monitoring Service – Requirements

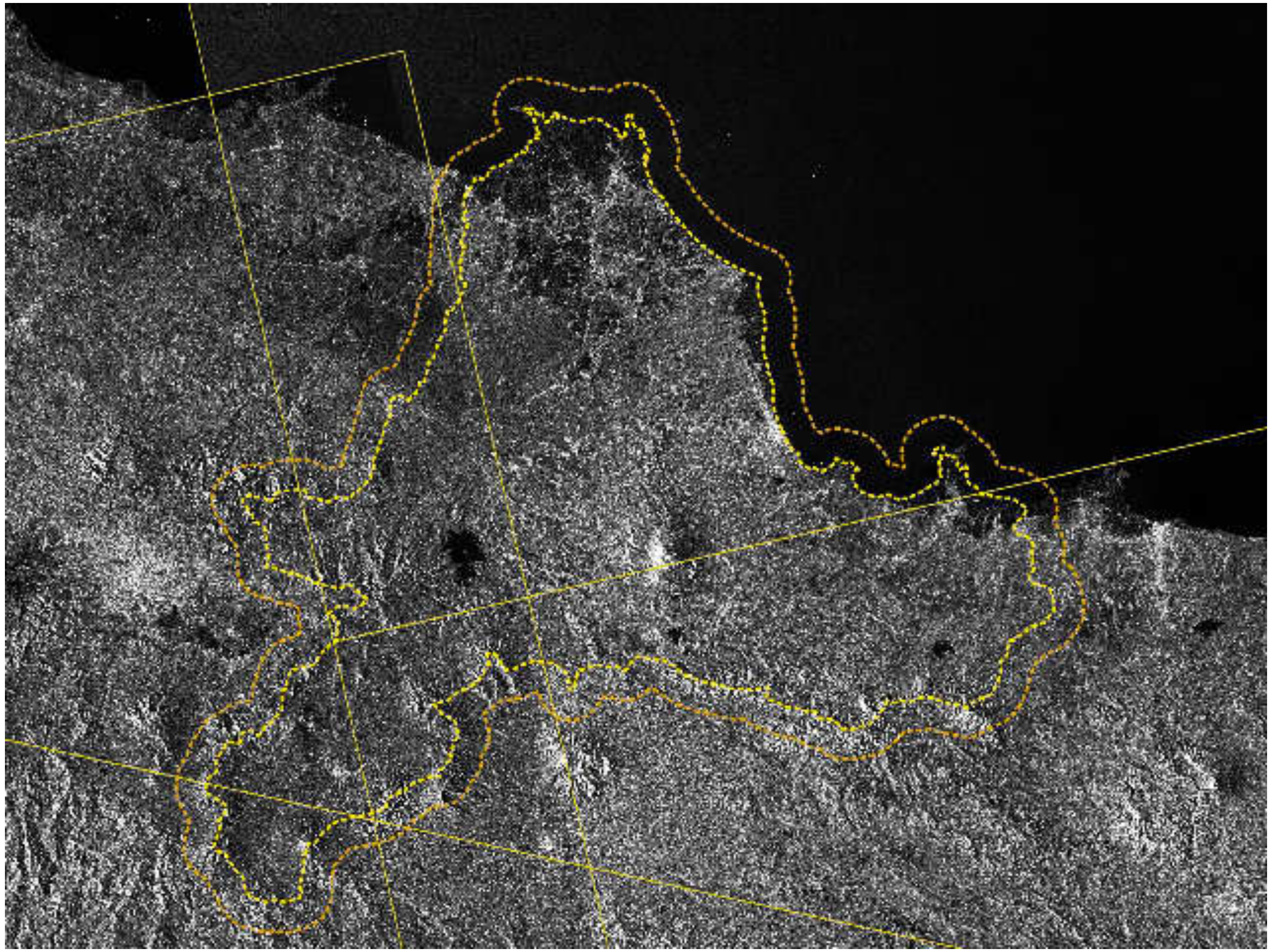
ID	Requirement	Priority
SWM01	Maps should cover areas defined by the end-user (See section 1.6).	First
SWM02	The major source of the information should be the most up-to-date Sentinel-2 SAR on GRD processing level, orthorectified and topographically normalized	First
SWM03	The result of surface water detection should contain two classes water and background	First
SWM04	Minimum mapping unit should be 1ha	First
SWM05	The map should be derived automatically originally as raster output	First
SWM06	The flood and inundation delimitation process should be conducted on the base of Land Cover Map 2017.	First
SWM07	The original classification result should be an object of refinement – removing normally appearing errors, due to radar shadows and high, dense vegetation.	First
SWM08	Map should be stored as vector dataset as well as a raster.	First
SWM09	Map in both vector and raster formats should be equipped with color-coding schemes.	First
SWM10	Map should be stored in UTM coordination system.	First
SWM11	Thematic accuracy of the map should be higher than 80%.	First

Surface Water Monitoring Service – Specification

Feature	Value / description
Content	Spatial representation of detected surface water extent. *DN* 1 Surface water
Geographic Coverage	AOI 1.: Jratunseluna river watershed, Central Java, Indonesia (area of the watershed: 9 367 sqkm, area with 5 km buffer: 12 706 sqkm). AOI 2.: Cimanuk-Cisanggarung, Central Java, Indonesia (area of the watershed: 7 795 sqkm, area with 5 km buffer: 10 575 sqkm).
Input data sources	*Input data:* Sentinel-1 SAR satellite data – microwave data allowing for regular, multitemporal observation, aiming at identification of delimitation of typical status of waterbodies and dynamic phenomena, SRTM (Shuttle Radar Topography Mission) DSM

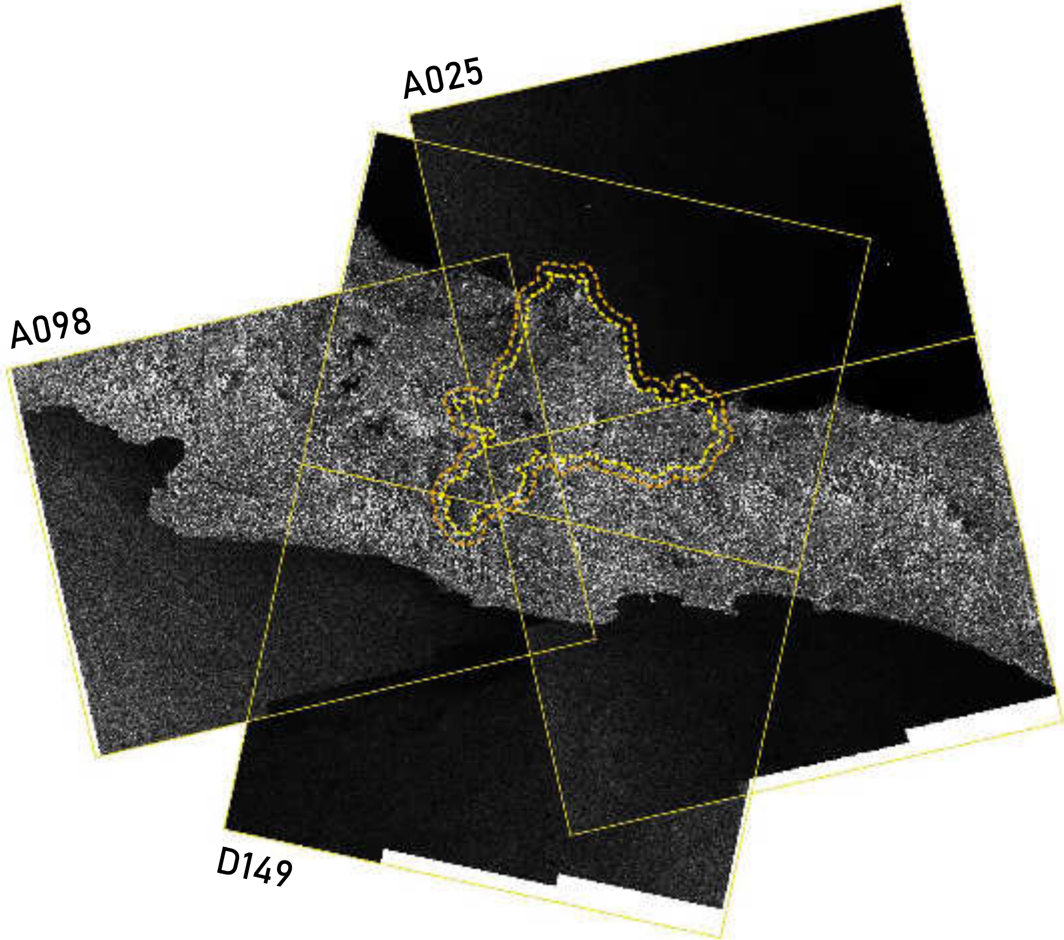
Surface Water Monitoring Service – Specification: Input data sources

Major satellite input data



Sentinel-1A/B SAR (VV) 20141007 - now

Cimanuk-Cisanggarung rivers watershed

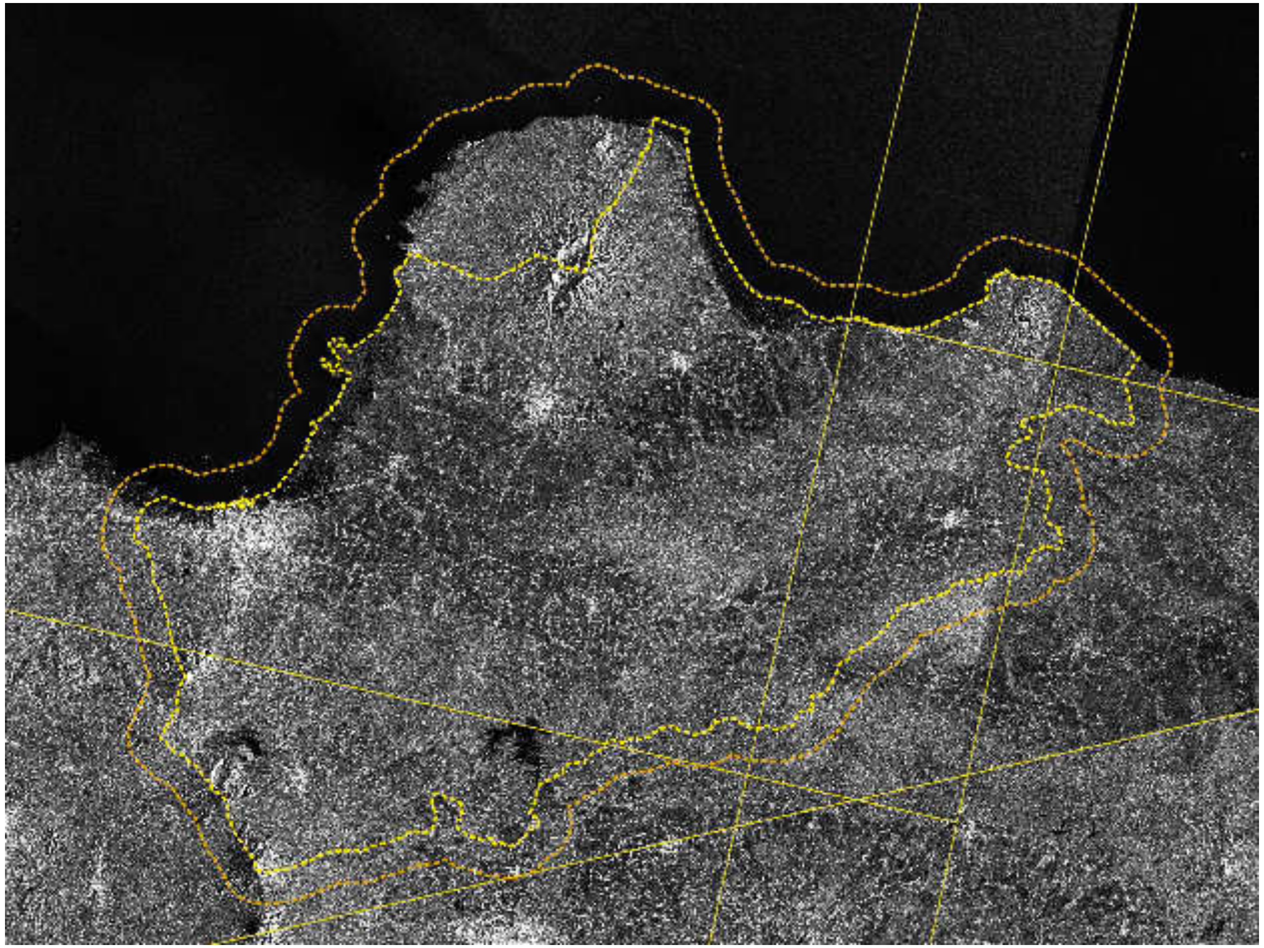


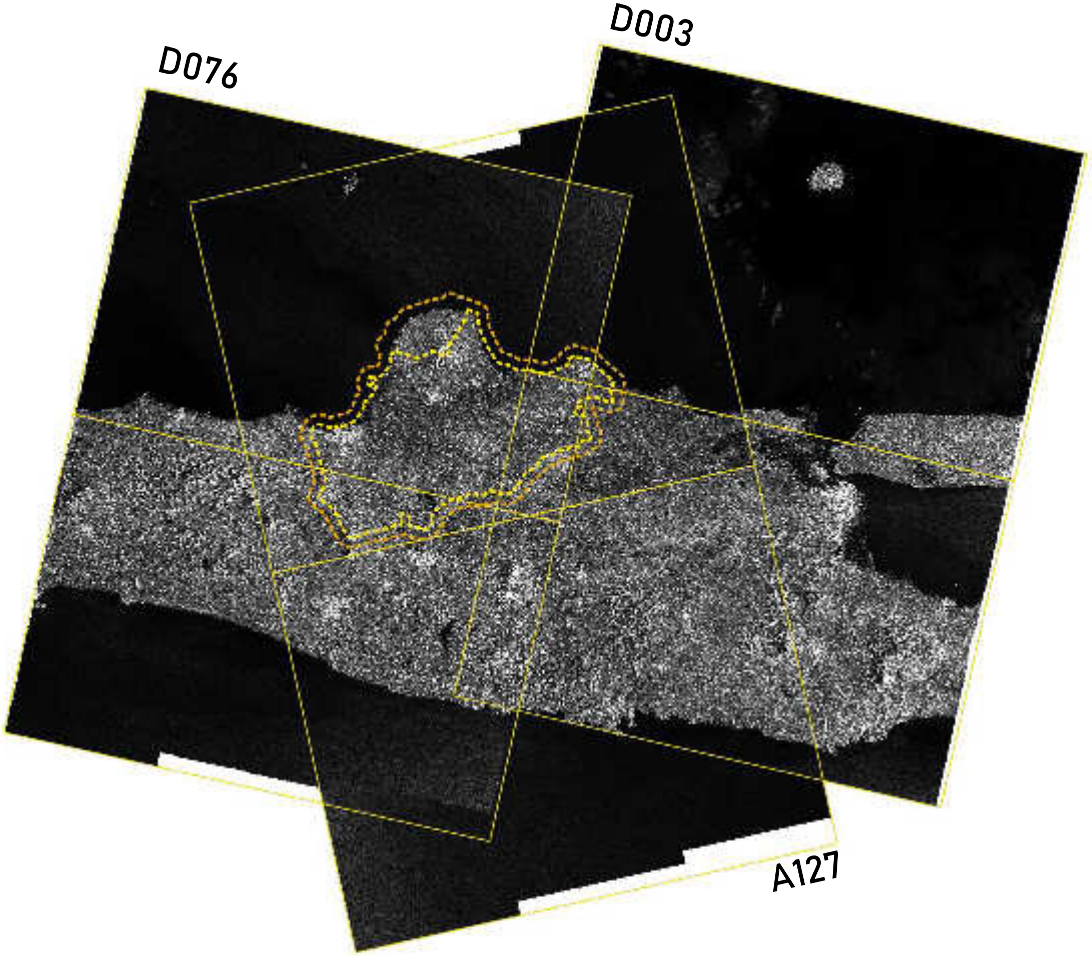
Orbits selection

Surface Water Monitoring Service – Specification: Input data sources

Major satellite input data

Jratunseluna river watershed





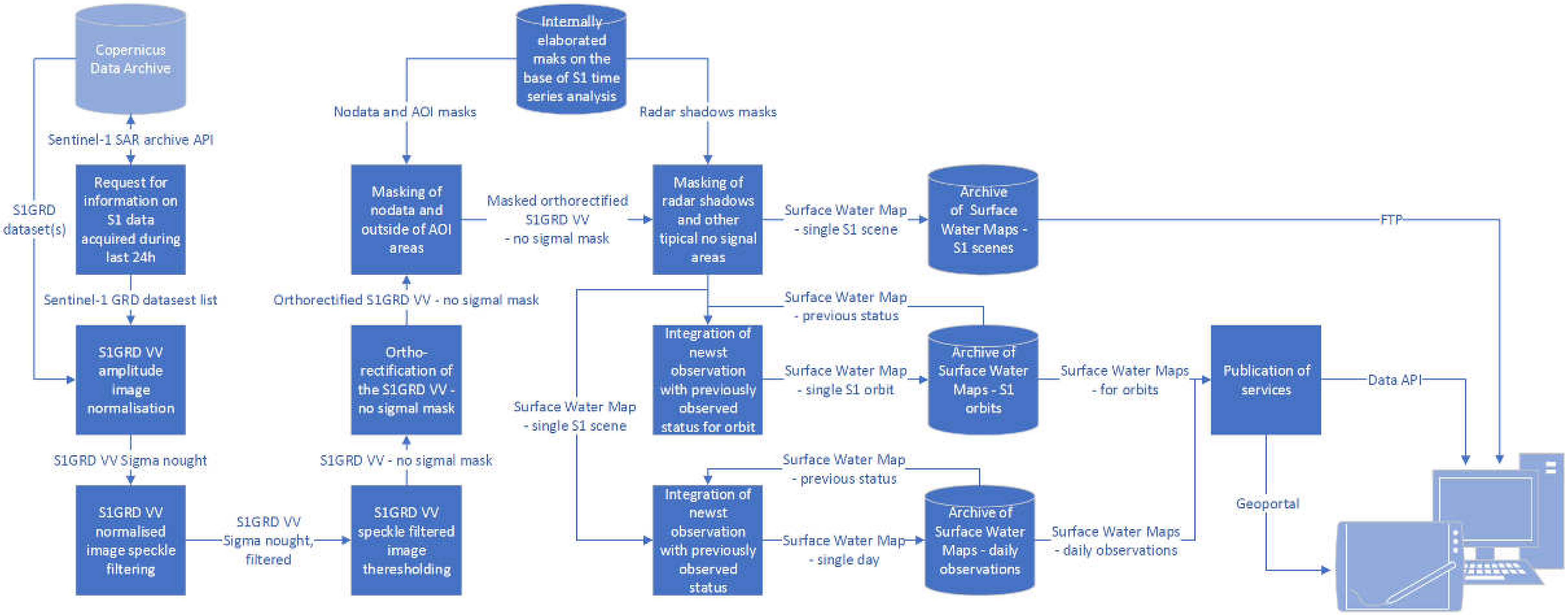
Sentinel-1A/B SAR (VV) 20141007 - now

Orbits selection

Surface Water Monitoring Service – Specification

Feature	Value / description
Methodology of Classification	SAR amplitude data thresholding, data integration (preliminary data).
Spatial Resolution and Coverage	10m
Coordinate Reference System	UTM zone 49S / EPSG: 32749
Accuracy, Constraints	Thematic accuracy: > 80% Geometric accuracy: < 20m (dependent on Sentinel-1 scenes automatic orthorectification, noticed very rare incidences of misregistration in the initial phase of Sentinel-1 satellites operation) Constraints: Each product covers entire area of one of the AOIs, however the information on surface water is provided only basing on a source satellite scene that could not cover entire AOI. Each product has sored in the file name information on date and time of the end of acquisition, information on satellite delivering data and the relative orbit number (example: *20150509T220929_S1A_003.tif*). This information allows for identification of particular input scene and definition of the swath extent from given orbit (see below).
Accuracy Assessment Approach	The accuracy assessment is based on comparative analysis of selected surface water maps based on Sentinel-1 data with reference data elaborated with use of the Sentinel-2 imageries. These analysis are possible only for selected dates and for limited extent due to extensive cloud coverage in the region.
Frequency	1 month in 2014 to 3 to 8 days in October 2018 (dependently on location).
Availability	October 2014 - October 2018 (archive monitoring data)
Delivery / Output Format	GeoTIFF, 1-bit

Surface Water Monitoring Service – Specification: Methodology



Schema of entirely automatic analysis and processing chain in course of SWM service provision

THANK YOU

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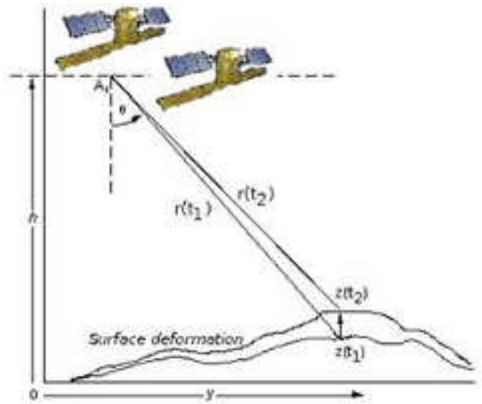
Surface deformation monitoring

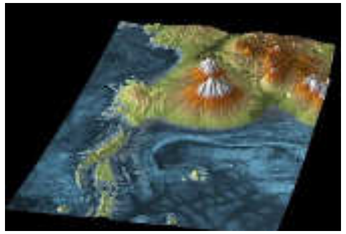
Dariusz Ziółkowski (Institute of Geodesy and Cartography, Remote Sensing Centre)

Surface Deformation Monitoring – Definitions: Radar Interferometry

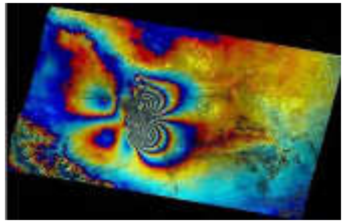


Radar interferometry can be broadly defined by use of phase measurements to precisely measure the relative distance to an object when imaged by synthetic aperture radar from two or more observations separated either in time or space.
– **Interferometric phase** is simply another means of measuring (relative) distance.

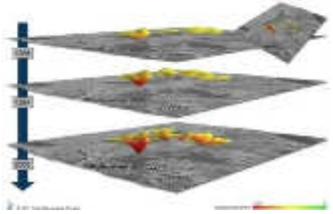
Interferometry (InSAR) for topography. Generally two observations are made from different locations in space so the interferometric phase is proportional to topography



Differential Interferometry - When two observations are made from the same location in space but at different times, the interferometric phase is proportional to any change in the range of a surface feature directly



Multitemporal interferometry (usually more than 20 images) rely on studying pixels which remain coherent over a sequence of interferograms
– **Persistemt scatters interferometry , distributed scatters interferometry**



Surface Deformation Monitoring – Definitions: Surface Deformation

Surface Deformation - **slow** movements (uplift or subsidence) of the terrain or objects (e.g. Infrastructure) located on it which results in small changes of the distance between the sattelites and the terrain and can be measured by radar interferometry

There are many possible **sources of deformation** which can be measured by radar interferometry:

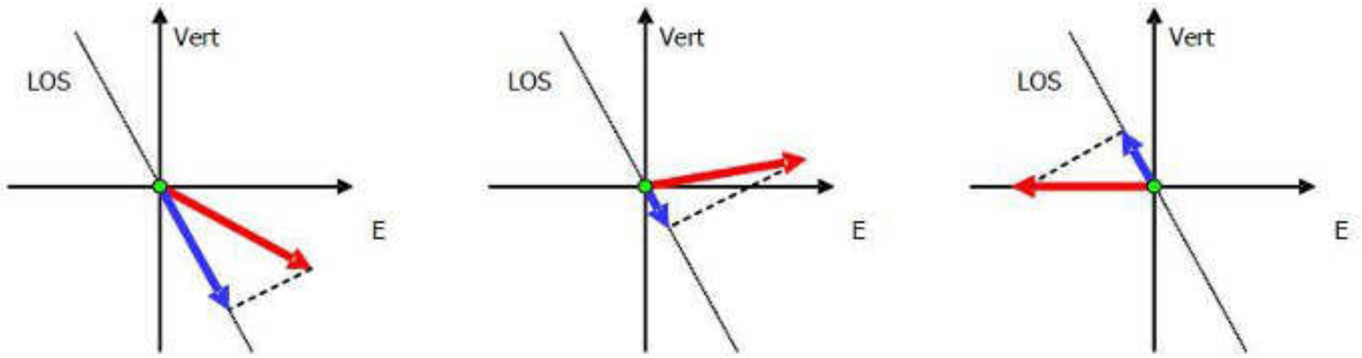
- Earthquakes
- Tectonic processes(faults)
- Volcanos
- Landslides
- Soil erosion
- Water extraction
- New infrastructure
- etc...

All these types of deformation take place in Indonesia

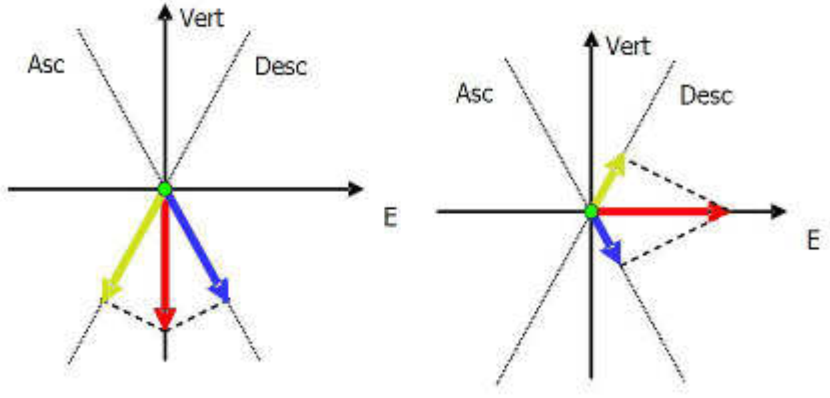
Radar interferometry can be used for **historical analysis** or **ongoing monitoring**

Surface Deformation Monitoring– Background

Radar Interferometrty measures surface deformation with millimeter accuracy



Radar Interferometry measures the **surface deformation** in Line of Sight direction



Reconstruction of **vertical** and **horizontal** (East – West) **displacement** is possible when the radar data from both ascending and descending orbits are available

Surface Deformation Monitoring – Objectives

Products scope:

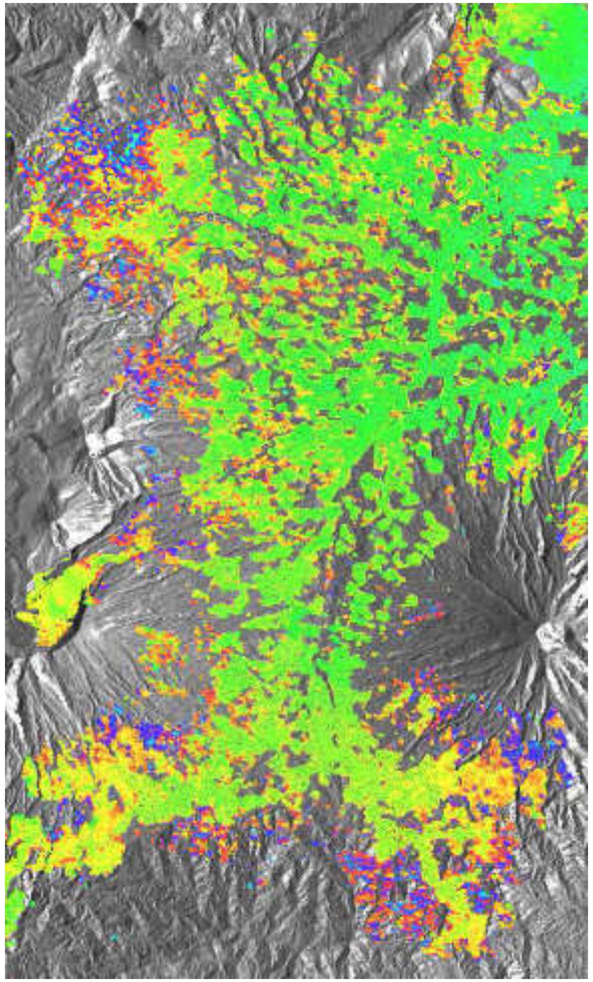
- Analysis of applicability of the potential service (delimitation of areas with Persistent and Distributed scatters, assessment of type of deformations possible to detect and monitor) and expected accuracy for particular movements within the study area.
- Detection of deformations within the study area (frequency of the measurements dependent on input data provision and frequency of the updating of the deformation maps every 3 – 4 months).

Content:

- Detection and monitoring of deformations triggered by various reasons like geology, hydrology or landslides

Input data sources and methods:

- Multitemporal Interferometric Techniques (MTInSAR) like Persistent Scatterer Interferometry and Distributed Scatterer Interferometry basing on satellite microwave data.



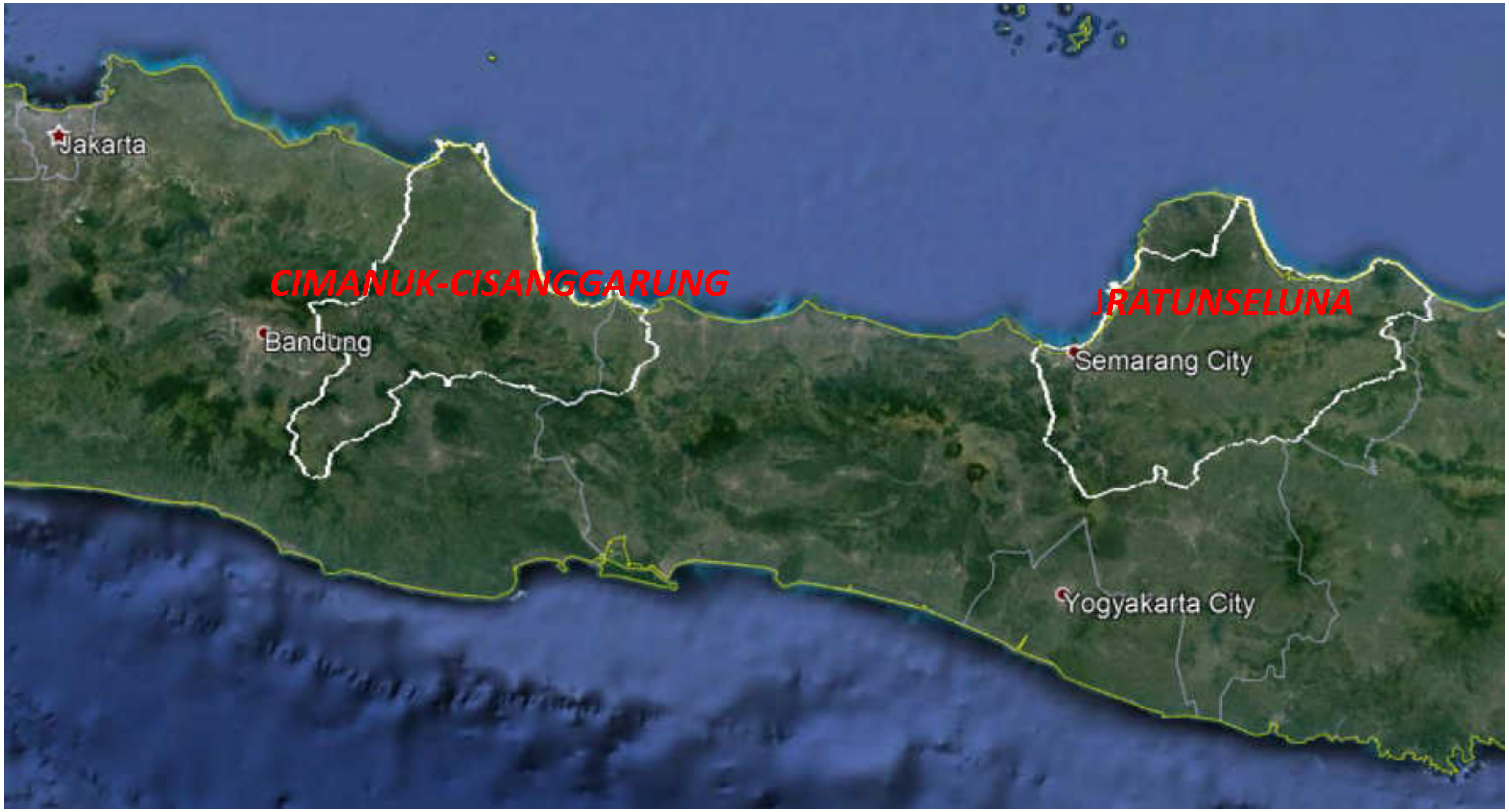
Example of deformation map based on Sentinel-1 data (southern part of Cimanuk Catchment

Surface Deformation Monitoring – Objectives

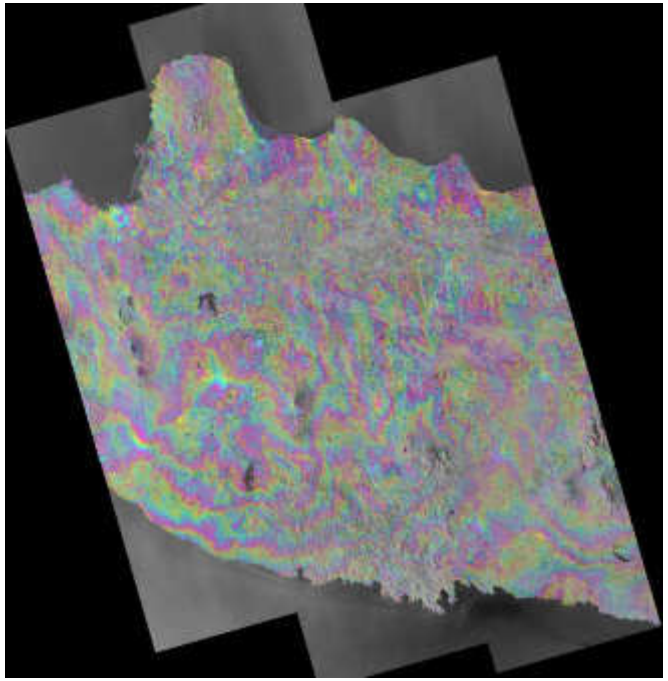
Application fields

- Identification of areas where efficient detection of deformations of various genesis is possible with application of MTInSAR technique,
- Identification of extent and magnitude of historic and currently observed movements,
- Observation of evolution of deformations on the base multiple historic events,
- Correlation of acceleration of deformations with other events like e.g. extreme rainfalls and flood episodes, earthquakes, buildings subsidence,
- Support risk assessment - in combination with structural or socio-economic vulnerability hazard map represents crucial input into landslides risk assessment aiming at identification of areas with the highest risk,
- Damage assessment,
- Preparation of rescue and evacuation training scenarios,

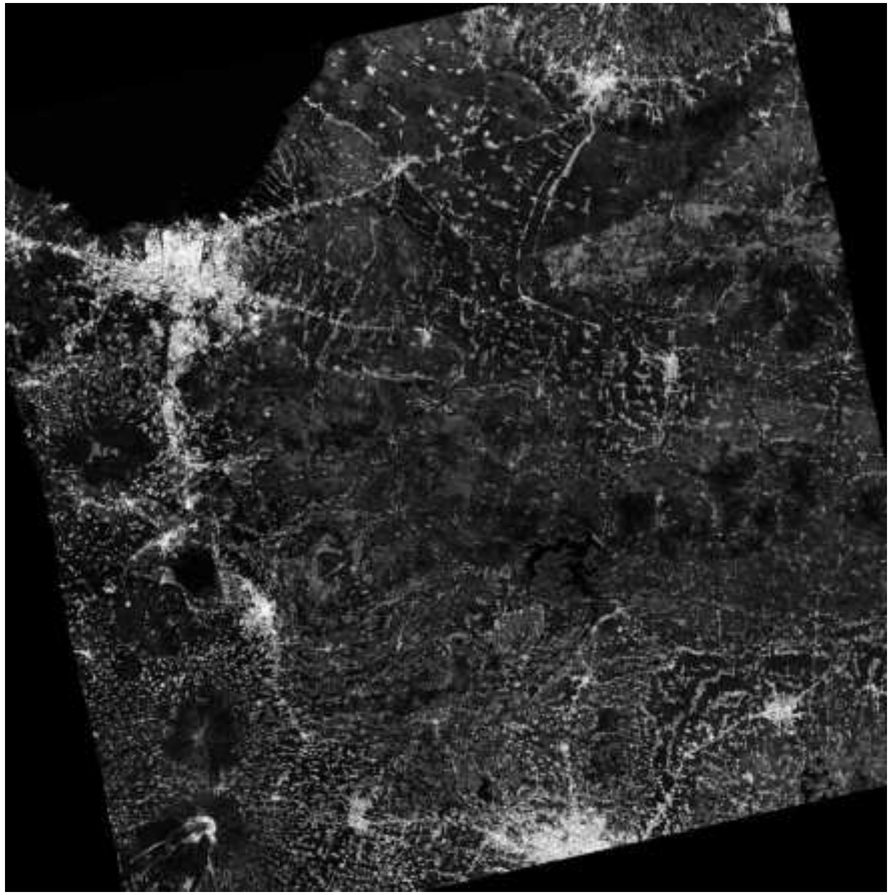
Surface Deformation Monitoring– Objectives: Surface deformation maps



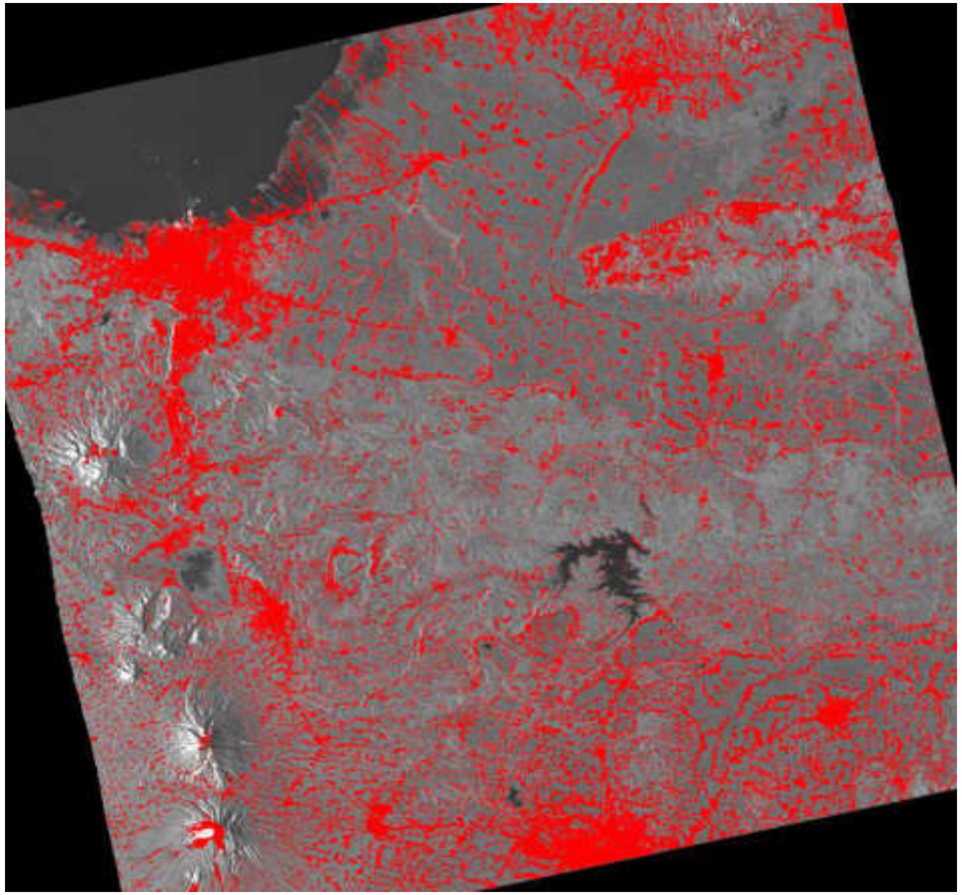
- ➢ **Landslides and soil erosion**
- ➢ **Deformation maps outside the build-up area**



Surface Deformation Monitoring – Product applicability: coherence

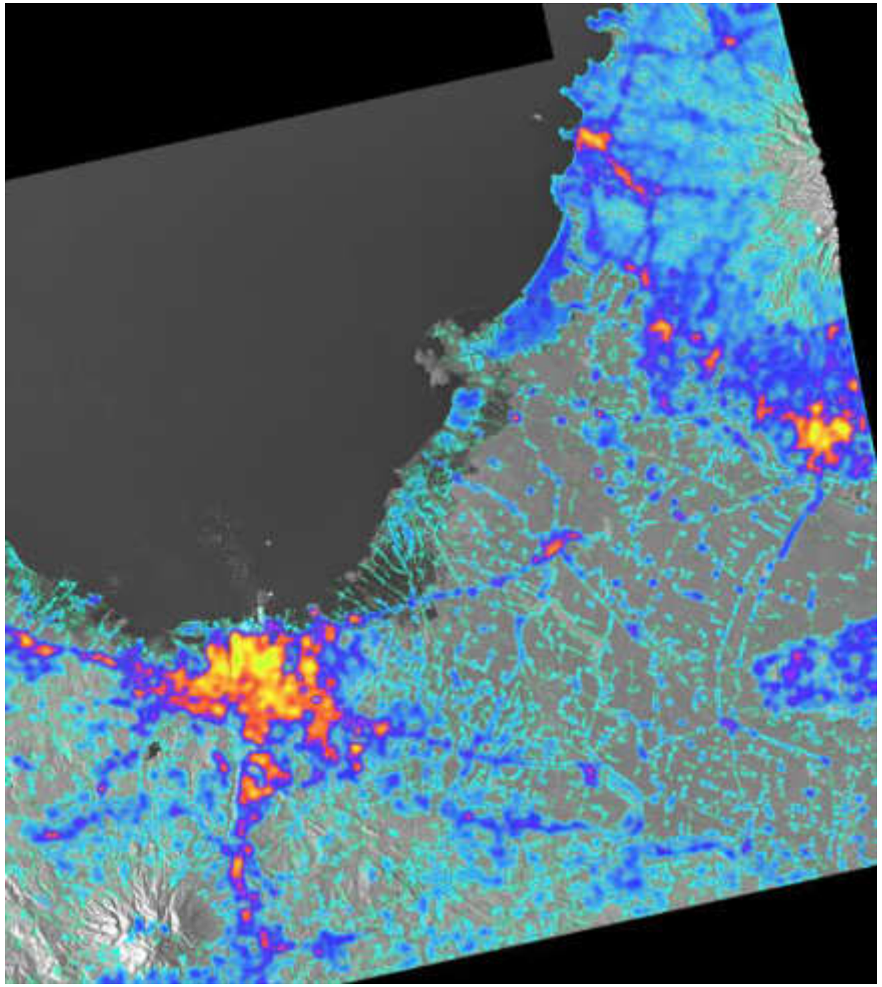


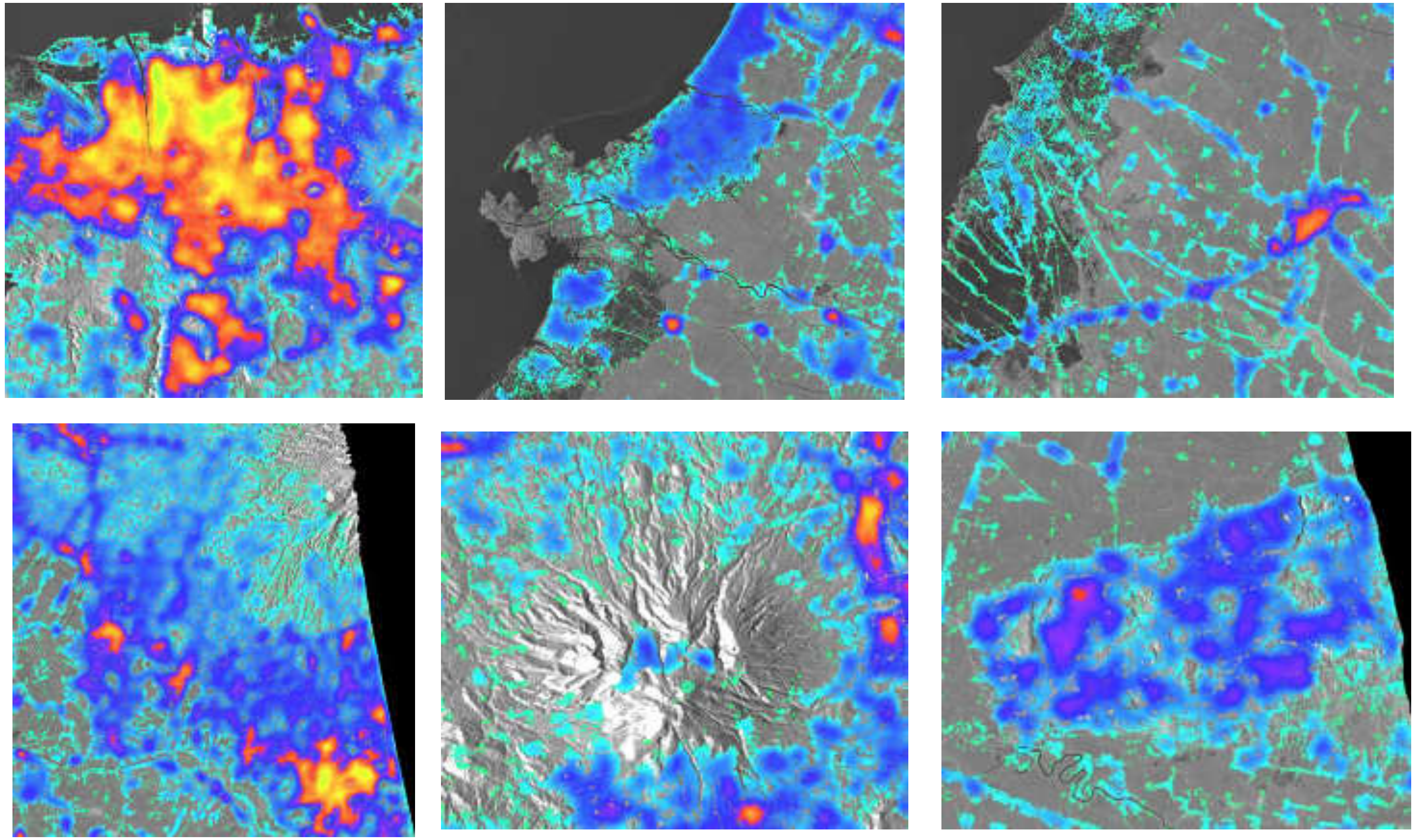
Average coherence for the part of the Jratunseluna catchment based on 6-days Sentinel-1A and B dataset (August 2017 – January 2018)



The mask of the areas with the average coherence above 0.3 (red areas). Based on 6-days Sentinel-1A and B dataset (August 2017 – January 2018)

Surface Deformation Monitoring – Product applicability: spatial distribution of persistent and distributed scatters





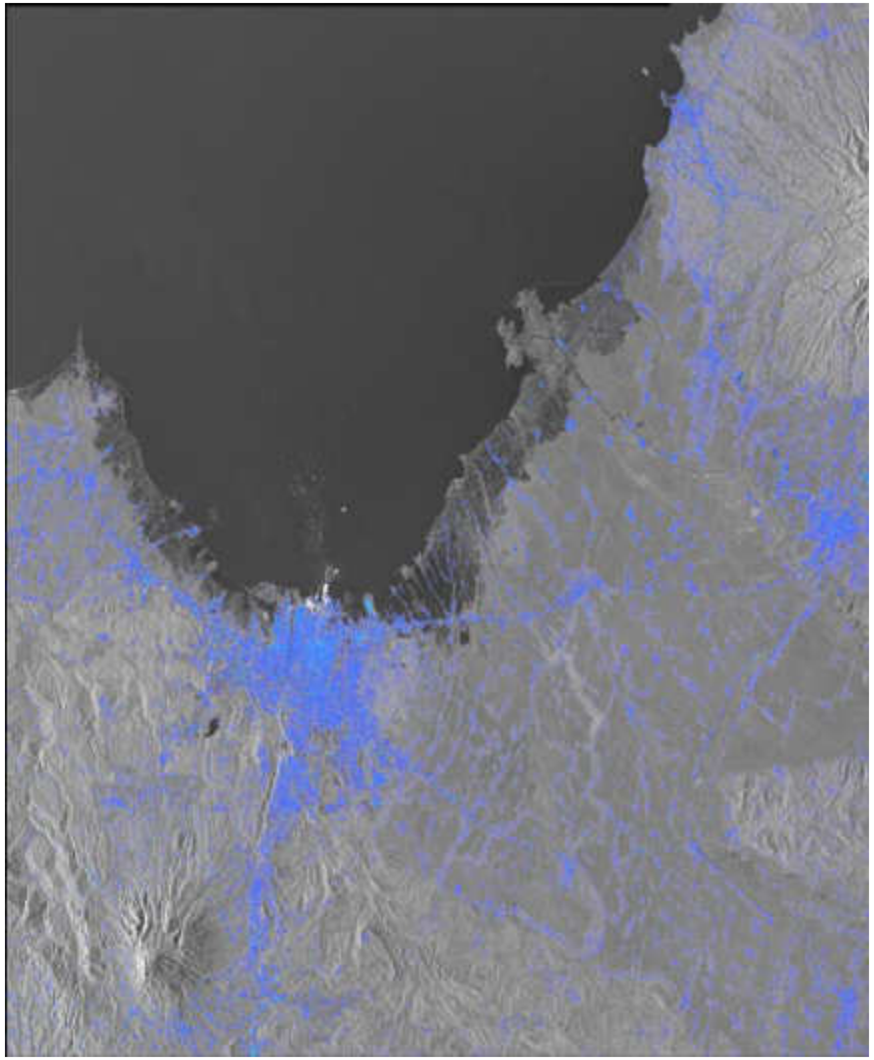
The density of Distributed Scatters outside of built-up areas is generally higher in the case of longer 6-days Sentinel-1 A and B dataset

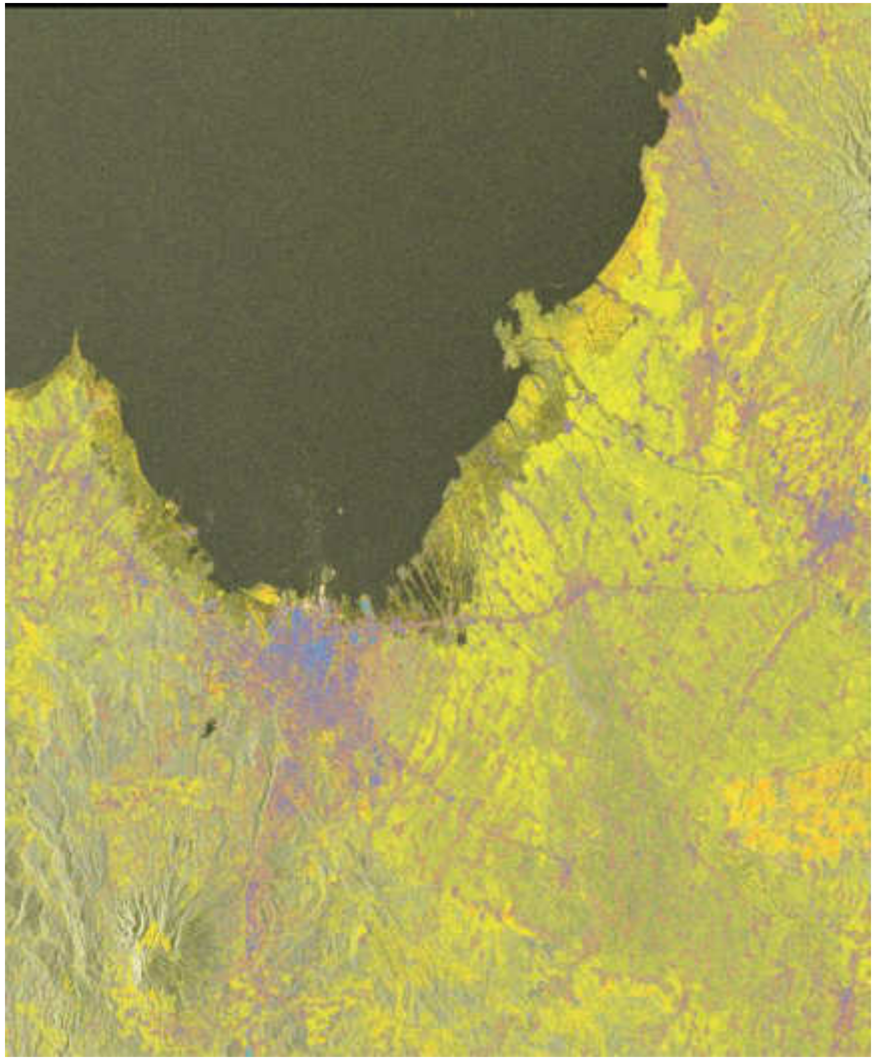
There is no signal from forests and temporary flooded flat agricultural areas (rice fields)

Surface Deformation Monitoring – Work logic, main steps of work

- **Data preparation: import, co-registration of the images and creation of data stacks for 5 different orbits**
- **Development of the method of combined analysis of Persistent and Distributed Scatters.**
- **Analysis of spatial distribution of Persistent and Distributed Scatters; Service applicability analysis**
- **Recreation of deformation history, production of the deformation maps**
- **Product validation**
- **Analysis of detected deformations, analysis of possible interpretations of the results**

Surface Deformation Monitoring – Methods: selection of PS and DS candidates



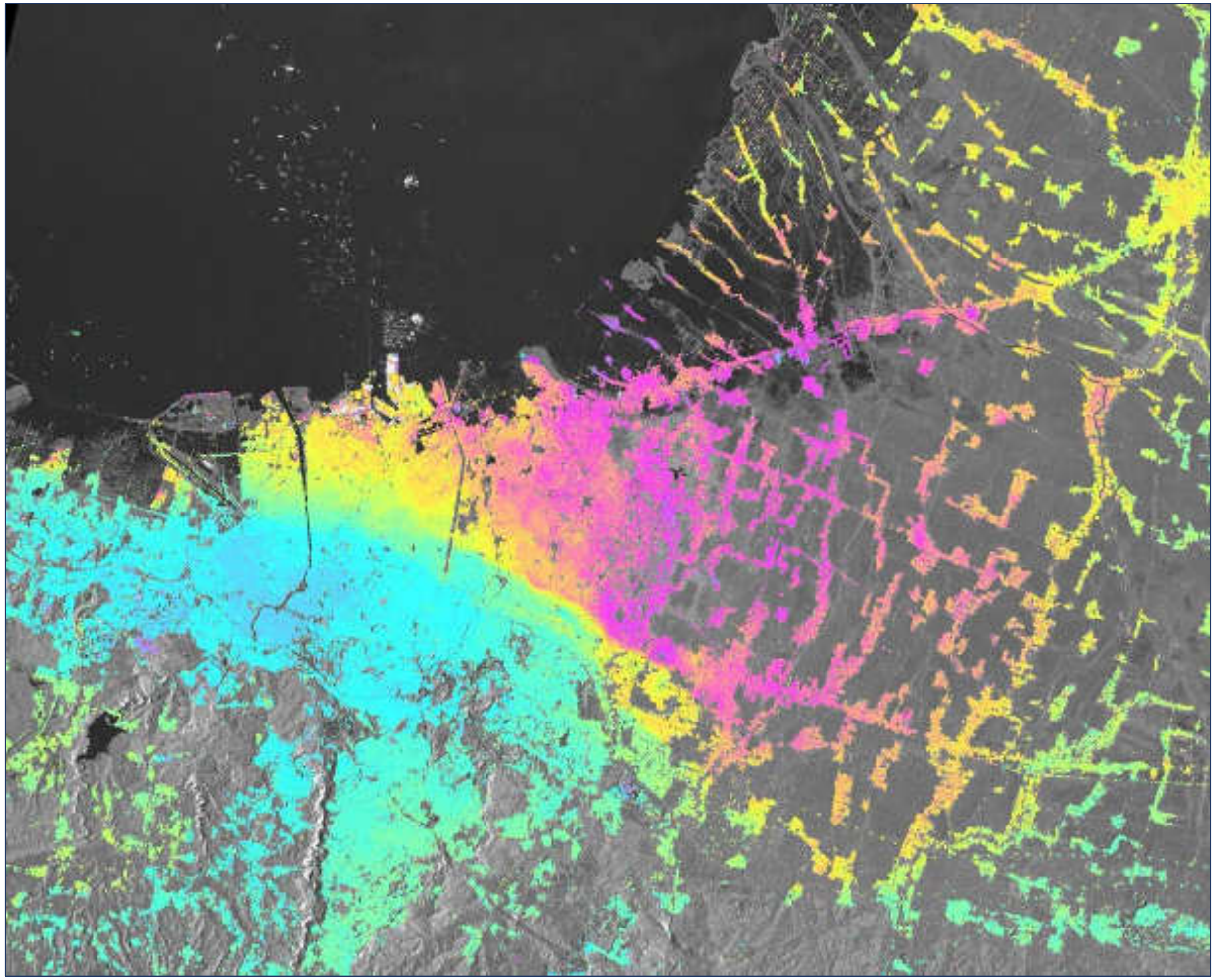


Problems:

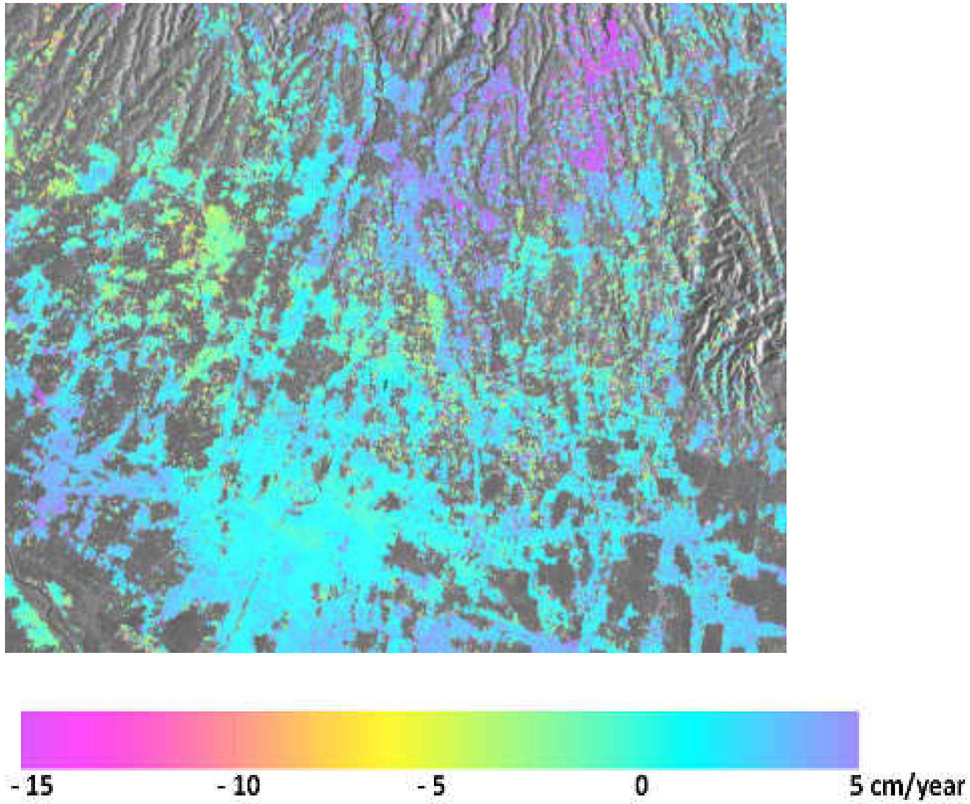
- High quality points exist only in build-up areas
- Spatial discontinuity of high quality scatters
- The use of lower quality distributed scatters is needed. It results in many phase unwrapping errors and make the processing chine very time consuming
- The final accuracy will be worse than the theoretical accuracy of the results

Surface Deformation Monitoring

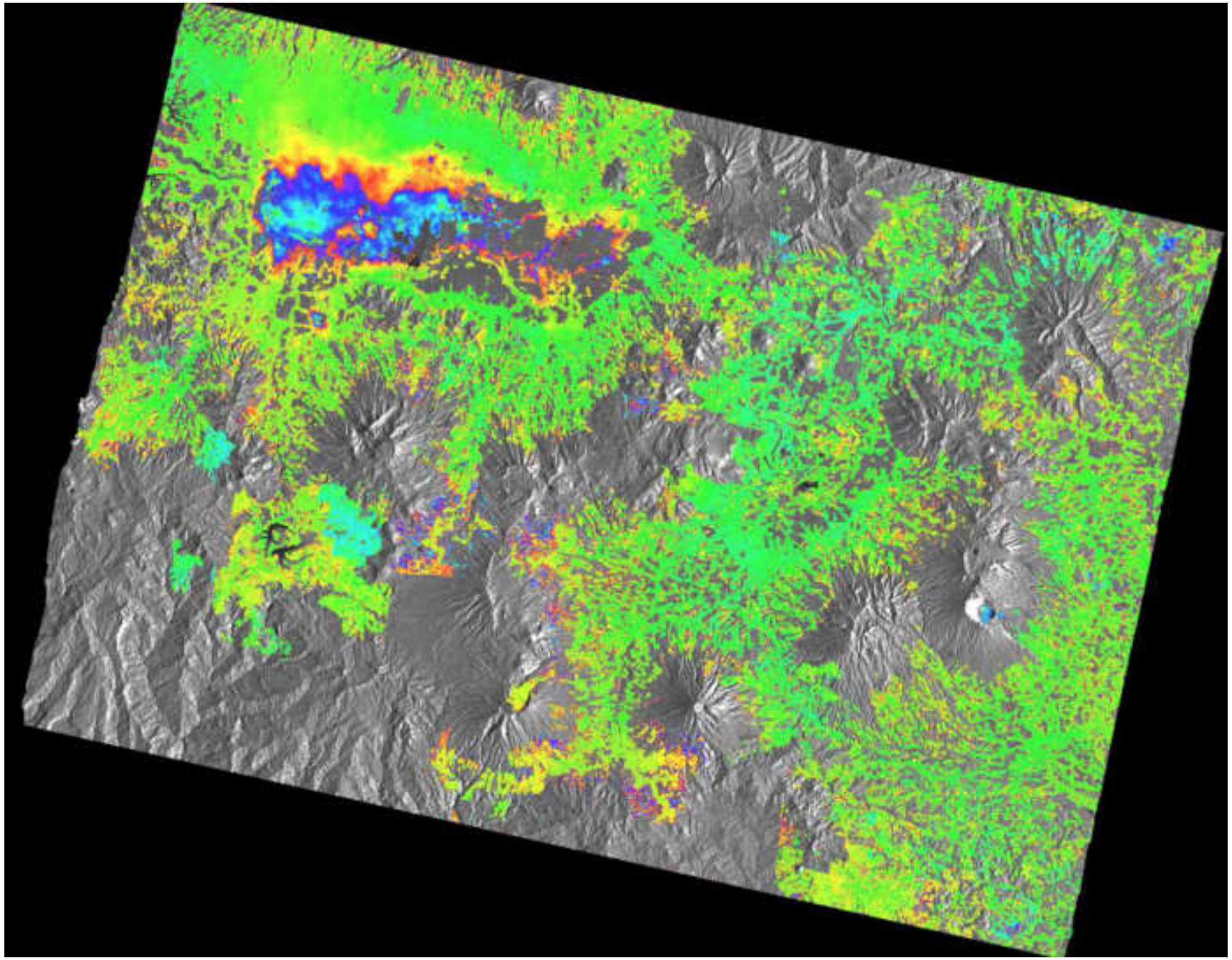
Examples of results: deformation maps – first results



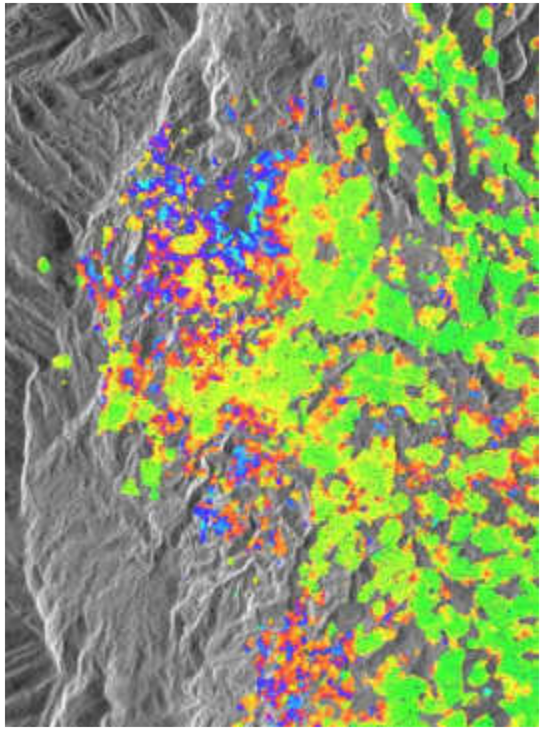
The deformation map of the part of Jratunseluna watershed (Semarang City and surroundings) based on the Sentinel-1 data registered from January 2017 to January 2018 from descending orbit D76.



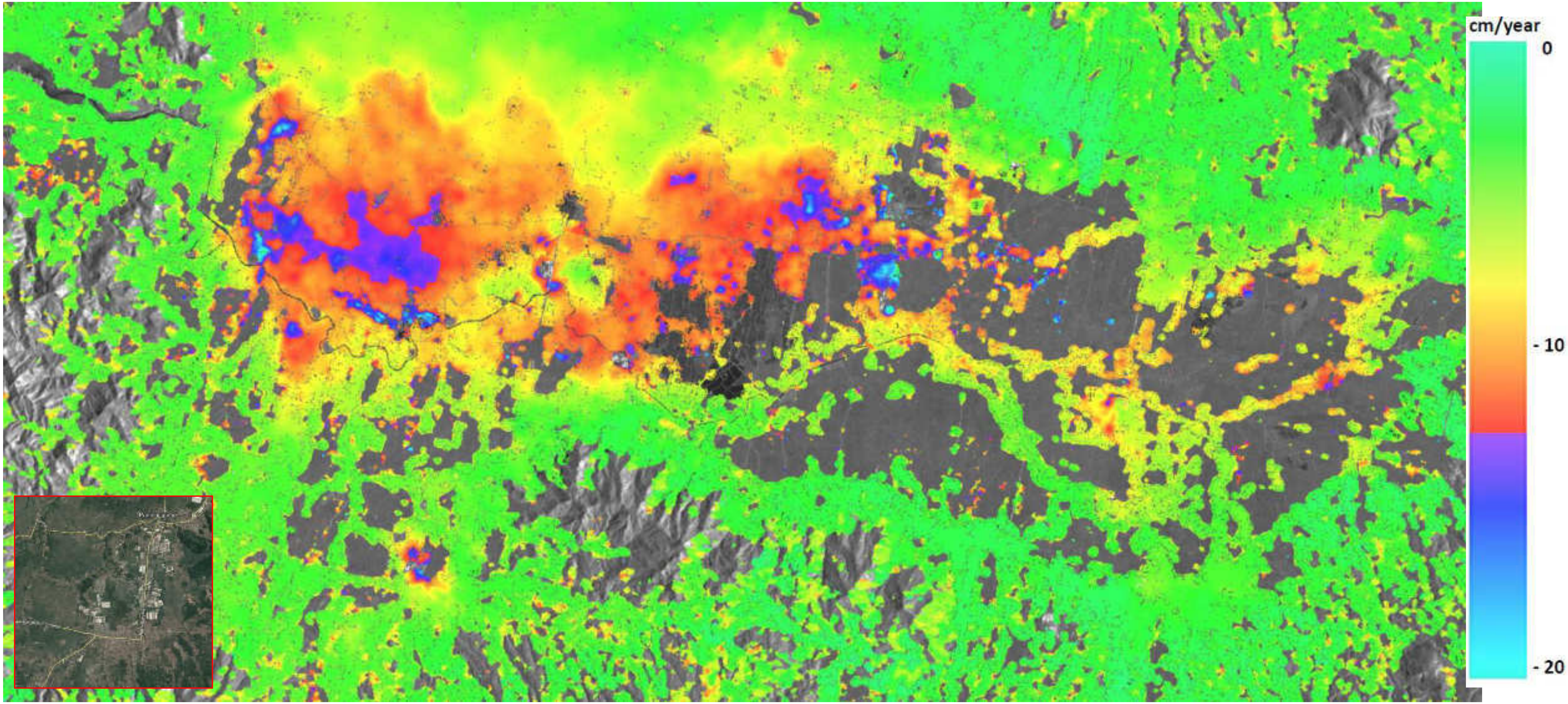
Surface Deformation Monitoring



Examples of results: deformation maps –results based on the data acquired till the end of September 2018



Surface Deformation Monitoring – Example of results



Surface Deformation Monitoring – Product validation

Possible sources of validation data:

- Permanent GNSS measurements – point validation over large distances (not available yet)
- Precise leveling – point validation, small distances (not available – processing of the archived data)
- Checking the reality of the product (careful and detailed anlysis of the results in the context of DTM, landcover, hydrographic network etc.
- Comparison to the results obtained during the other past or ongoing projects

Surface Deformation Monitoring – analysis of the results, validation

- The highest deformations are observed in the area of Semarang city (Jratunseluna catchment) and Bandung City (close to the Cimanuk-Cisangarung Catchment). In some areas **deformation exceeds 20 cm/year**.
- **Possible explanation:** underground water extraction, building new infrastructure. The obtained results are similar to the results obtained during other past or ongoing projects
- There are many local subsidence areas (agricultutal land) located on flat terrain close to the coast or on the volcano slopes
- **Possible explanation:** combination of landslides and soil erosion
- On flat terrains the local subsidence is generally higher in more humid areas located to the water channels (Google Earth, Street View)
- In the case of the more rough terrain, local diferences in deformation are visible according to the changes of slop angle and orientation (Google Earth, Street View)
- Many landslides are concentrated in southern part of Cimanuk catchment
- The results obtained for the agricultural land can be affected by changes of soil humidity over time or changes of vegetation

Surface Deformation Monitoring – limitations and continuous service provision

- the signal can be obtained for the majority of the study area except for the flat temporary flooded agriculture land (mainly rice fields) and forested areas
- The accuracy of the product can be lower than the theoretical one due to the combination of many unfavorable conditions like: low quality of PS and DS points in many regions, the discontinuity of high quality points, phase unwrapping problems, strong atmospheric signal and large non-linear deformations
- Additionally the accuracy on agricultural areas can be lowered by effect of changes in vegetation and soil humidity over time
- The process is very time and labour consuming due to the use of combined set of Persistent an Distributed scatters (to obtain the signal outside the buit up areas) and unfavorable conditions (many phase unwrapping errors), it results also in problems with automation of the process.
- The continuous service provison is possible
- The frequency of product upgreade strongly depends on the size of the study area

Surface Deformation Monitoring

Thank you for the attention !

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Geoinformational Support

Geo4IRBM

for Integrated River Basins Management

European Space Agency

Potential Soil Erosion and Sediment Yield Modelling

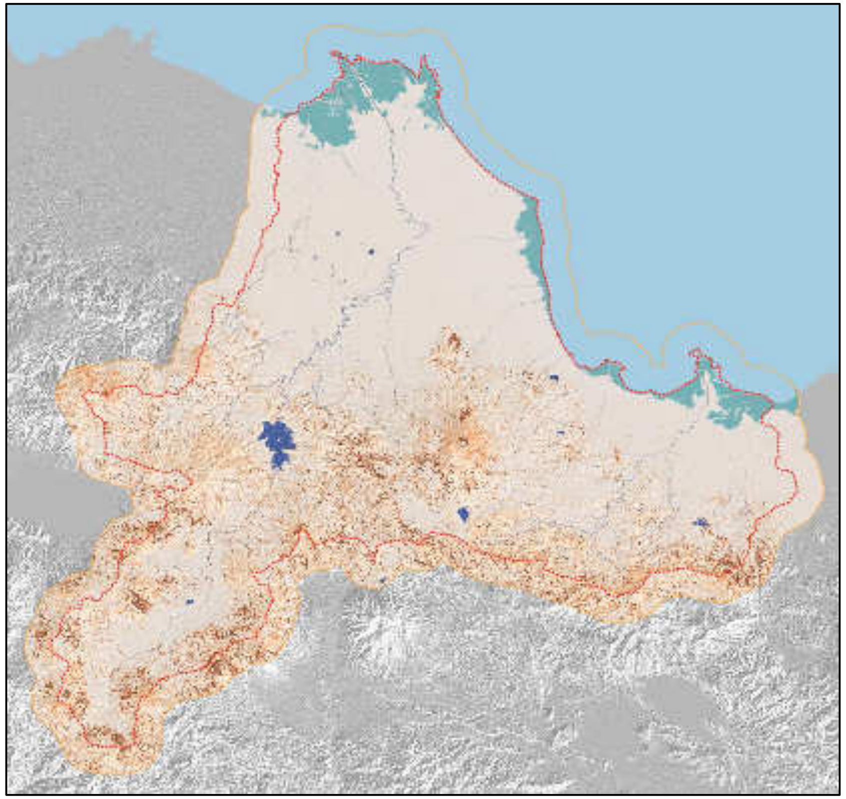
Przemysław Turos (Topologic)

Potential Soil Erosion and Sediment Yield Modelling – Definitions

Potential Soil Erosion and Sediment Yield Modelling is a set of methods applicable in environmental, agriculture oriented research as well as water management.

Soil erosion is the displacement of the upper layer of soil, it is one form of soil degradation. This natural process is caused by the dynamic activity of erosive agents, that is, water, ice (glaciers), snow, air (wind), plants, animals, and humans. In accordance with these agents, erosion is sometimes divided into water erosion, glacial erosion, snow erosion, wind (aeolean) erosion, zoogenic erosion, and anthropogenic erosion.[1] Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing a serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality and damaged drainage networks.

Sedimentation – the tendency for particles in suspension to settle out of the fluid in which they are entrained and come to rest against a barrier. This is due to their motion through the fluid in response to the forces acting on them: these forces can be due to gravity, centrifugal acceleration, or electromagnetism. In geology, sedimentation is often used as the opposite of erosion, i.e., the terminal end of sediment transport.



Potential Soil Erosion and Sediment Yield Modelling – Background

Enhanced Water Security Investment Project *(source: EWSIP Project Concept Paper)*

Outputs

3. Flood risks management enhanced

    3a. Early flood warning systems operational.

    3c. Coast protection infrastructures rehabilitated or upgraded and climate proofed.

Key Activities with Milestones

3. Flood risks management enhanced

    3.4 Construct or upgrade flood infrastructure, coast protection and urban drainage systems including climate resilient design features. (Q1 2022)

    3.5 Design and conduct gender-inclusive awareness raising campaigns (Q4 2020)

    3.6 Develop flood warning systems and raise awareness of floodplains communities through gender inclusive approach and outreach strategy. (Q4 2020)

Proposed application scenarios of Geo4IRBM services

Surface water monitoring as an element NRT of real time data acquisition at basin level.

Coastline changes maps elaborated on the base of Land Cover Changes maps. Indicators of coastline length variations in reference network.

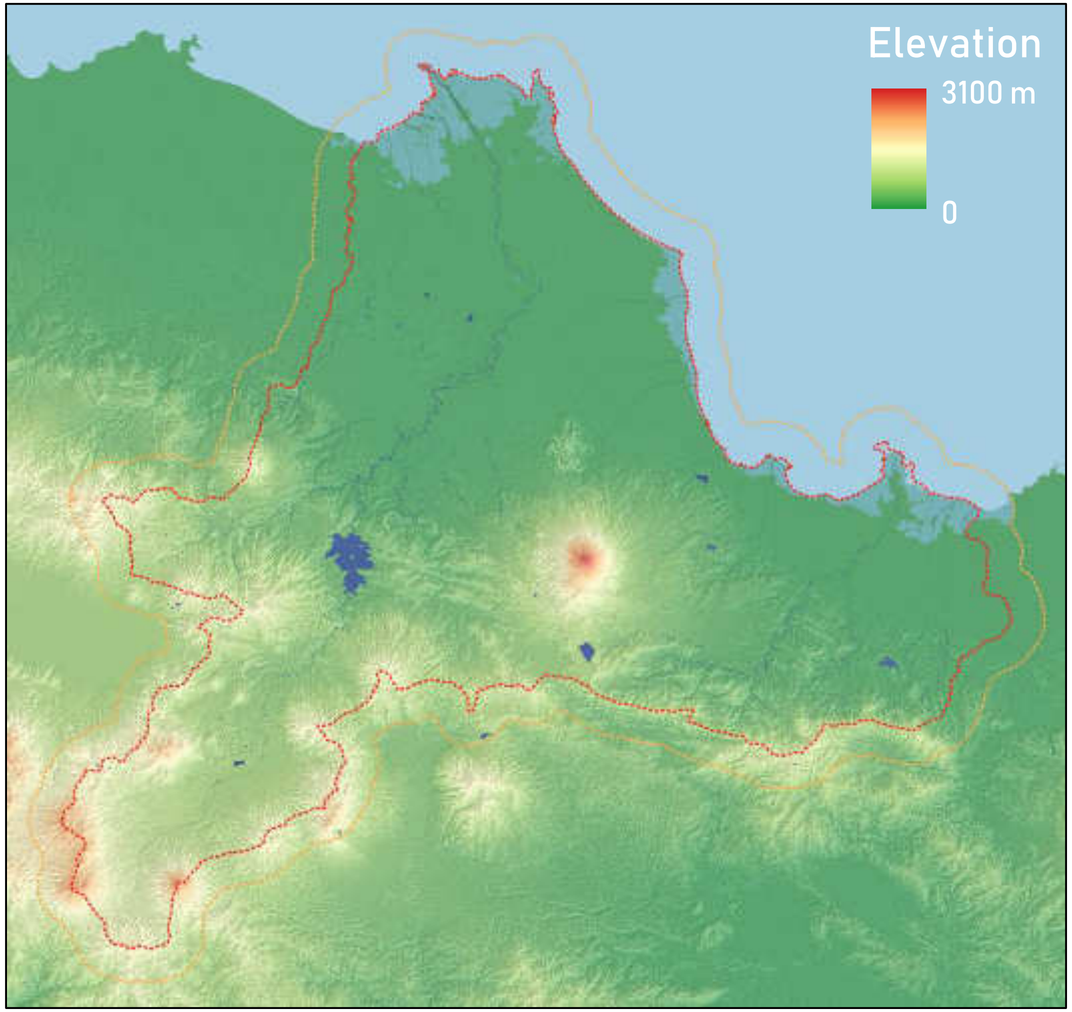
Surface deformation / subsidence along the coastline, cross analysis of coastline changes.

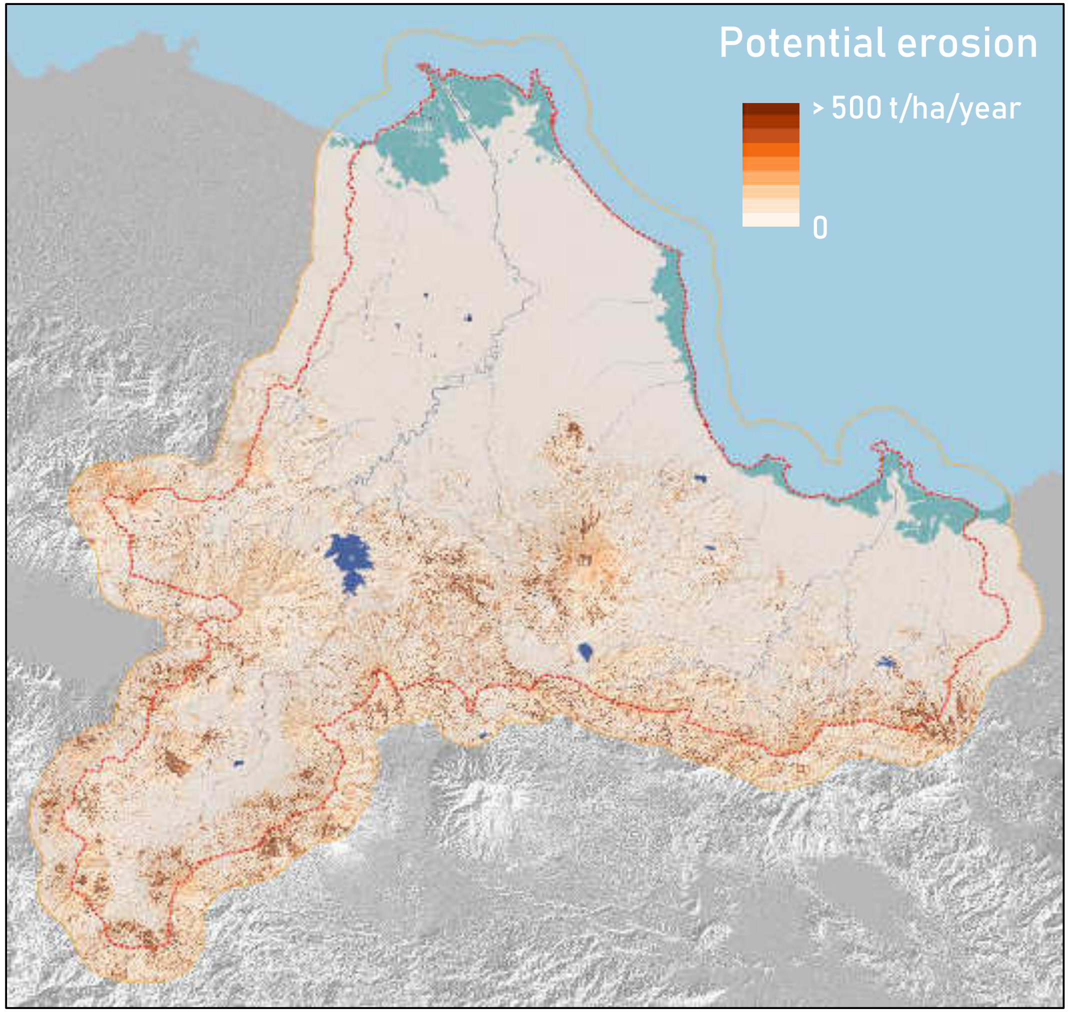
Surface deformation for the needs of landslides detection and erosion assessment useful for floods forecasting.

Soil erosion modelling applicable for floods forecasting.

Potential Soil Erosion and Sediment Yield Modelling – Objectives

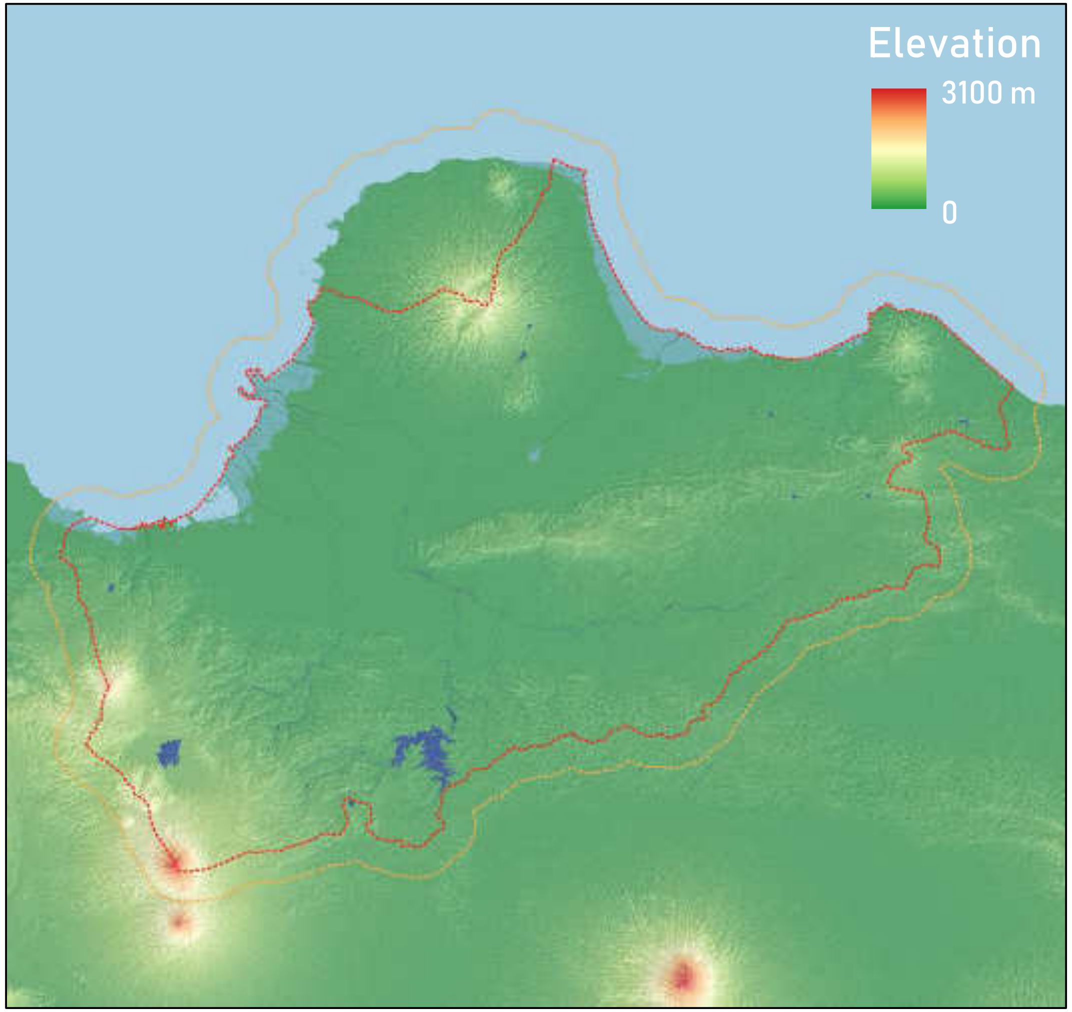
Cimanuk-Cisanggarung watershed

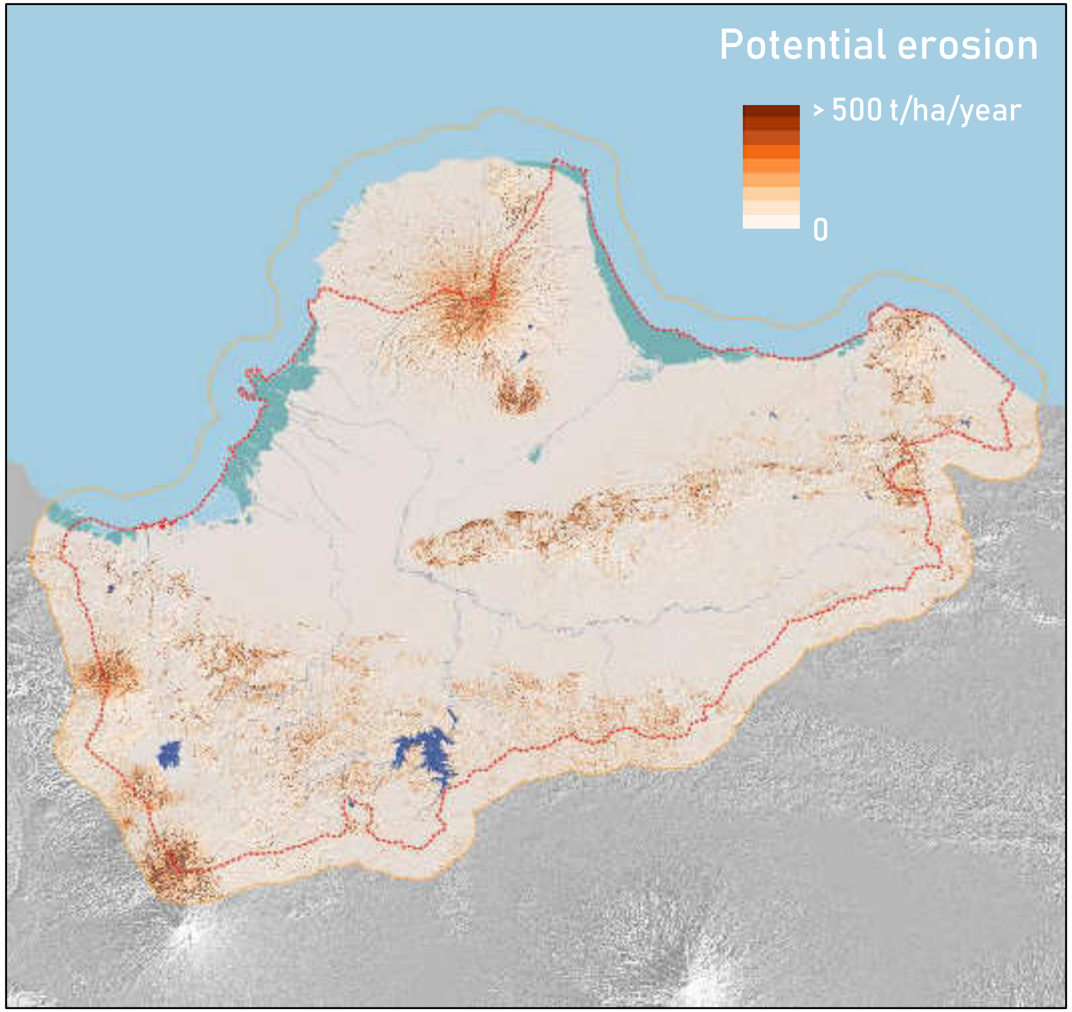




Potential Soil Erosion and Sediment Yield Modelling – Objectives

Jratunseluna watershed





Coastline Changes Mapping – Objectives

Erosion intensity increase due to expected precipitation growth

Cimanuk-Cisanggarung watershed

	Current annual precipitation		5% precipitation increase		10% precipitation increase		15% precipitation increase	
Erosion level*	Area km^2	Area %	Area km^2	Area %	Area km^2	Area %	Area km^2	Area %
Very light	3625.96	46.52	3557.88	45.64	3494.89	44.83	3438.89	44.12
Light	2019.62	25.91	2005.59	25.73	1990.50	25.54	1972.54	25.30
Moderate	1535.48	19.70	1564.78	20.07	1588.87	20.38	1608.37	20.63
Heavy	481.20	6.17	519.55	6.67	559.11	7.17	598.99	7.68
Very heavy	132.85	1.70	147.31	1.89	161.74	2.07	176.32	2.26

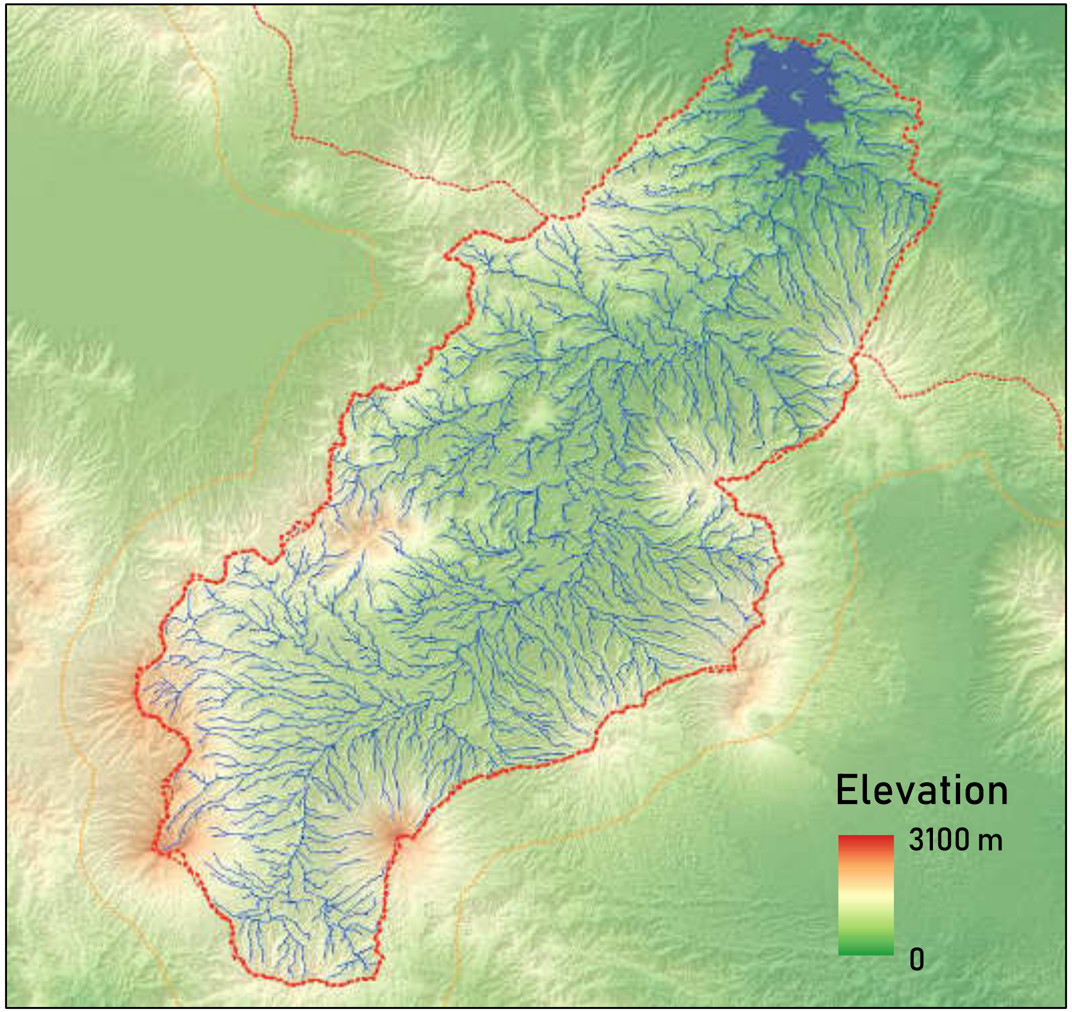
Jratunseluna watershed

	Current annual precipitation		5% precipitation increase		10% precipitation increase		15% precipitation increase	
Erosion level*	Area km^2	Area %	Area km^2	Area %	Area km^2	Area %	Area km^2	Area %
Very light	5289.48	56.50	5195.32	55.50	5106.55	54.55	5022.38	53.65
Light	2390.11	25.53	2409.13	25.73	2424.89	25.90	2438.13	26.04
Moderate	1128.77	12.06	1166.09	12.46	1201.27	12.83	1235.43	13.20
Heavy	465.77	4.98	491.20	5.25	515.73	5.51	538.64	5.75
Very heavy	87.48	0.93	99.87	1.07	113.16	1.21	127.02	1.36

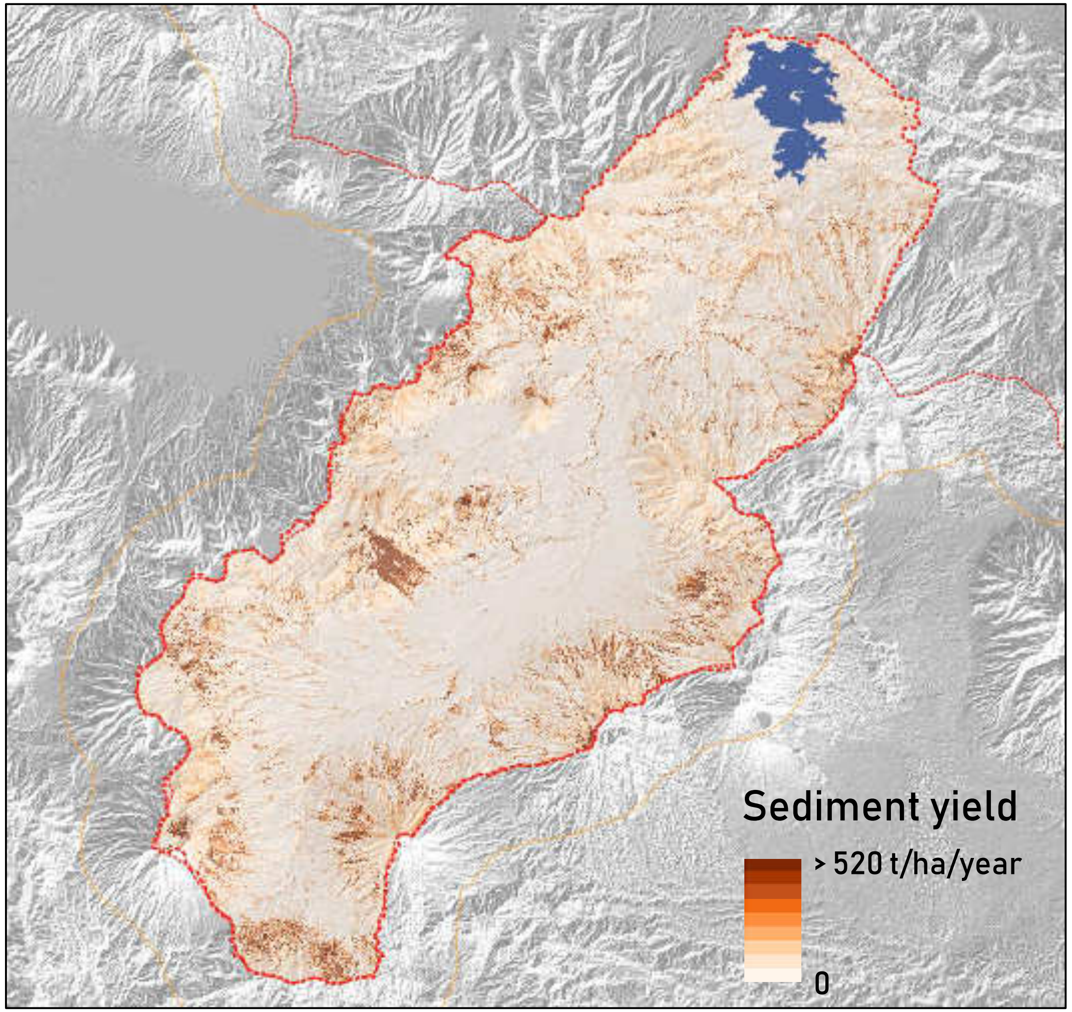
* Erosion levels: very light: < 15 ton/ha/year, light: 15 – 60, moderate: 60 -180, heavy: 180-480, very heavy > 480.

Potential Soil Erosion and Sediment Yield Modelling – Objectives

Jatigede Reservoir basin

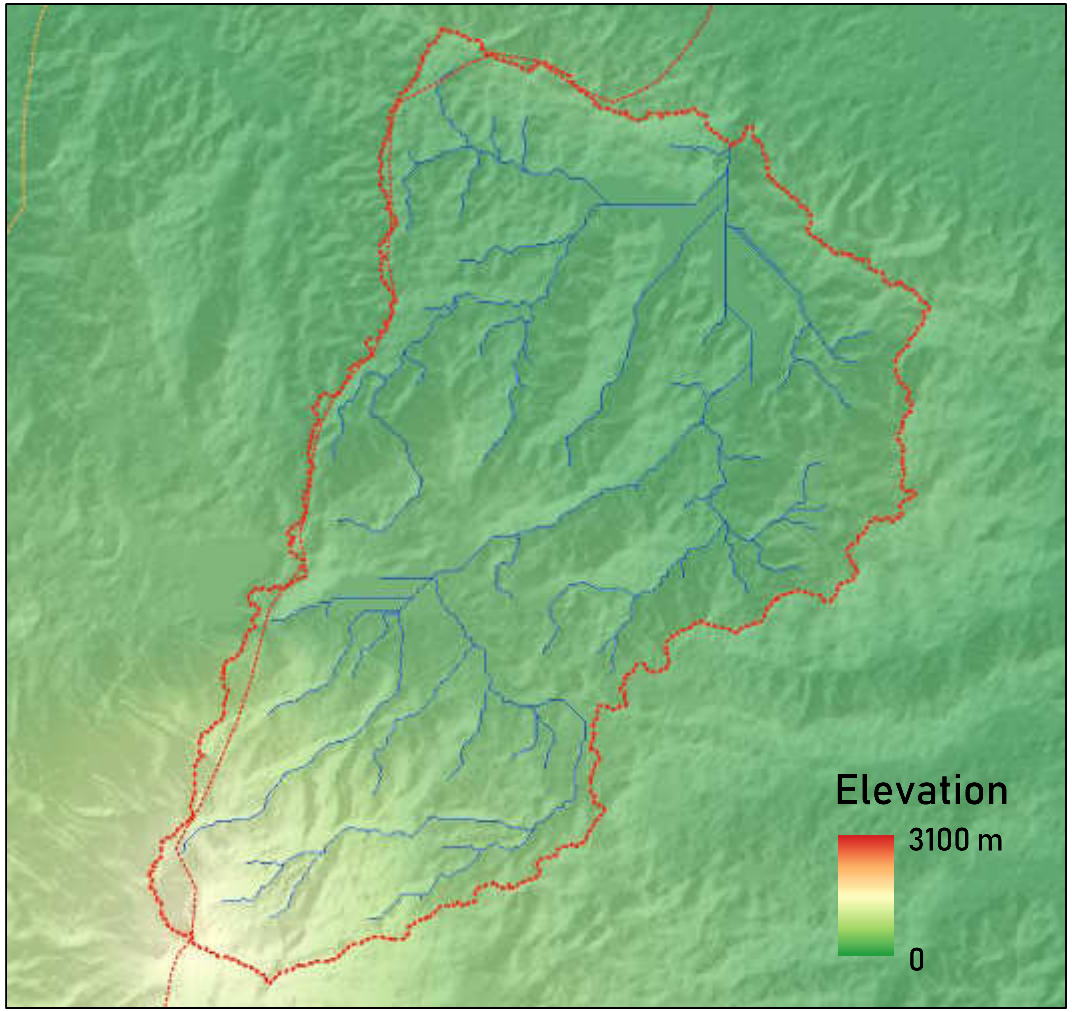


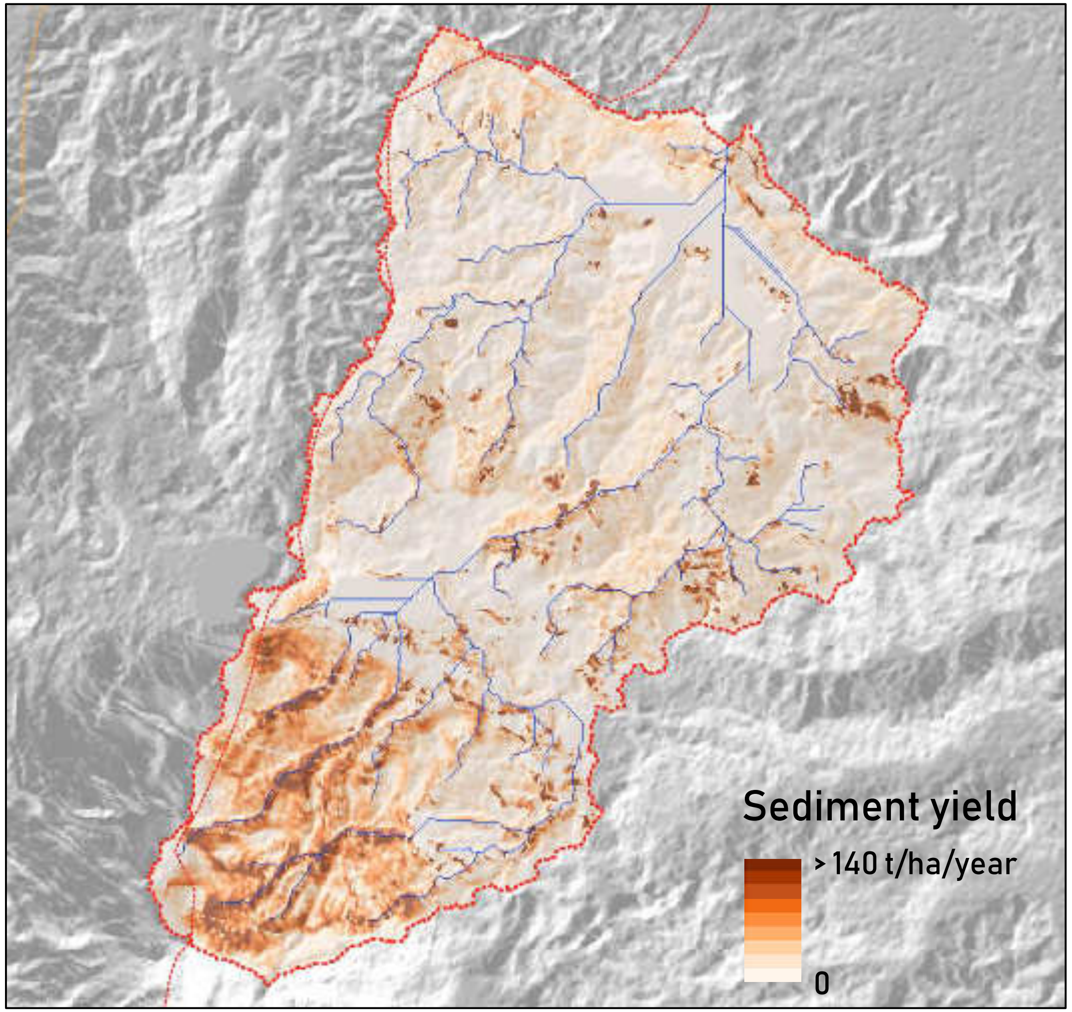
Sediment yield maps



Potential Soil Erosion and Sediment Yield Modelling – Objectives

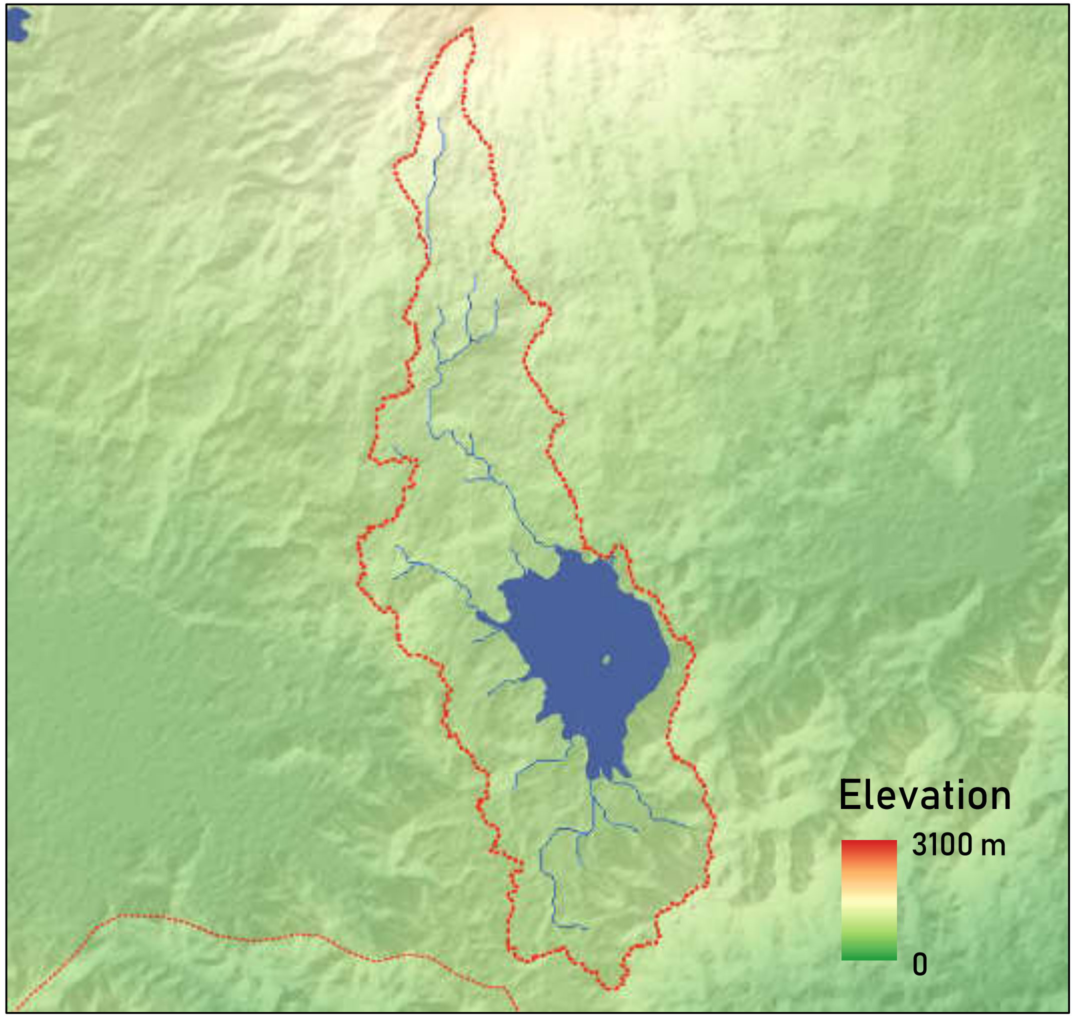
Cipanas Reservoir basin

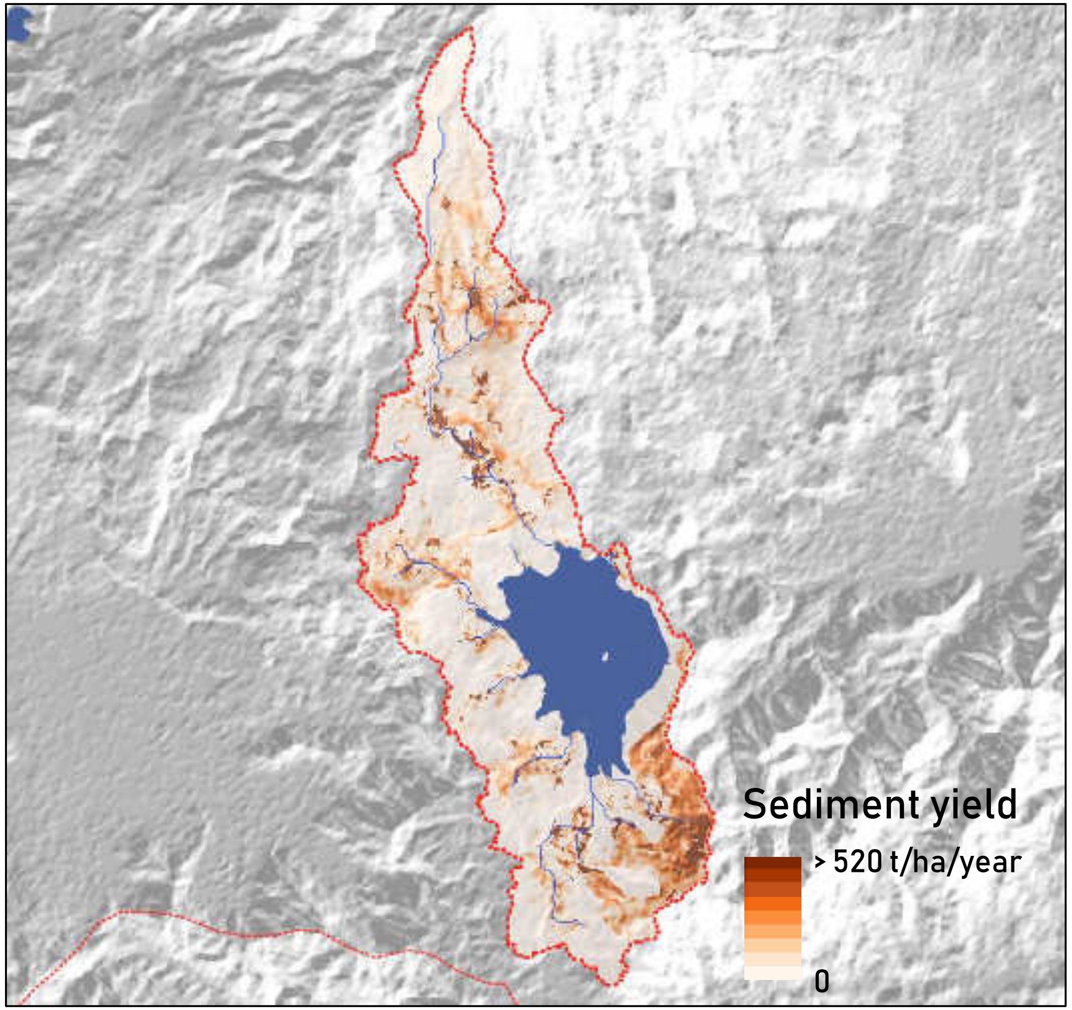




Potential Soil Erosion and Sediment Yield Modelling – Objectives

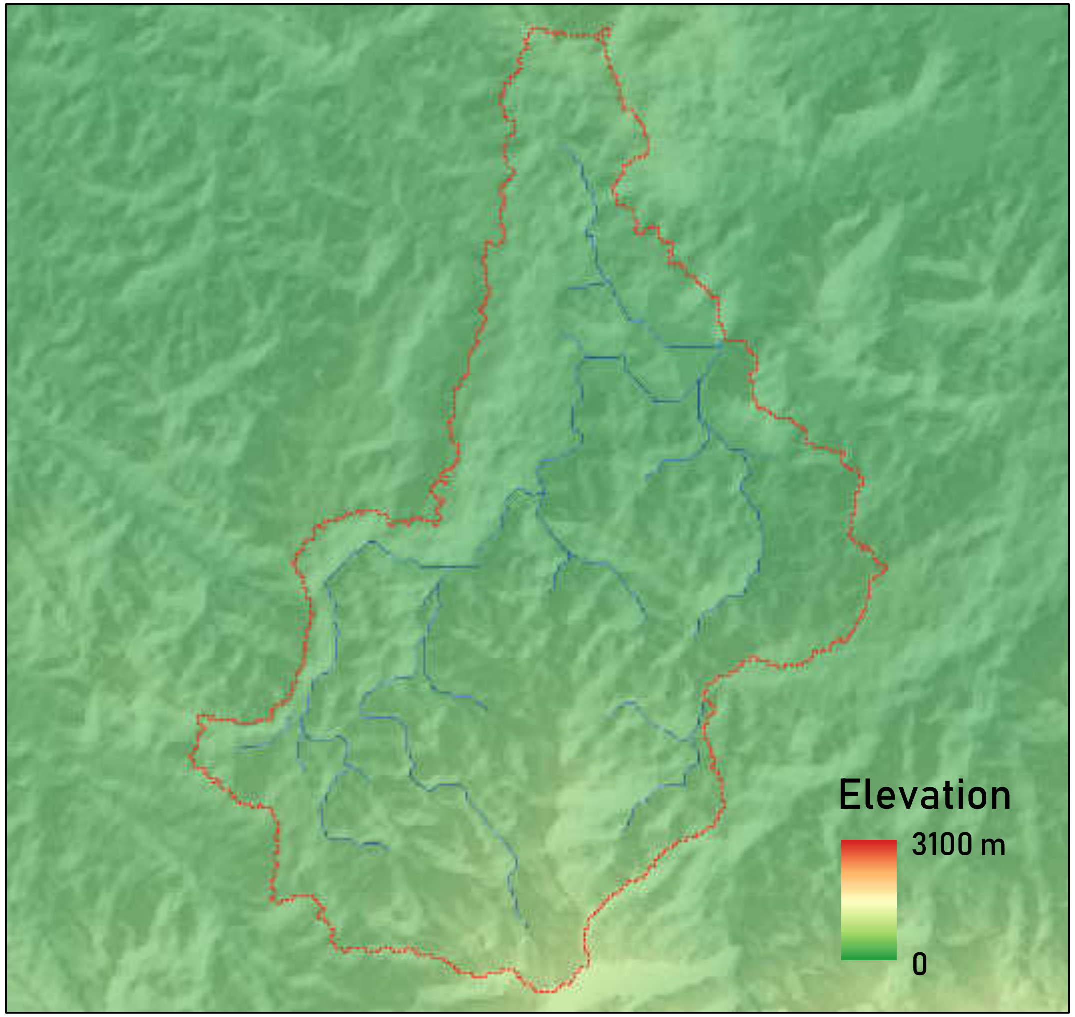
Darma-Kuningan Reservoir basin

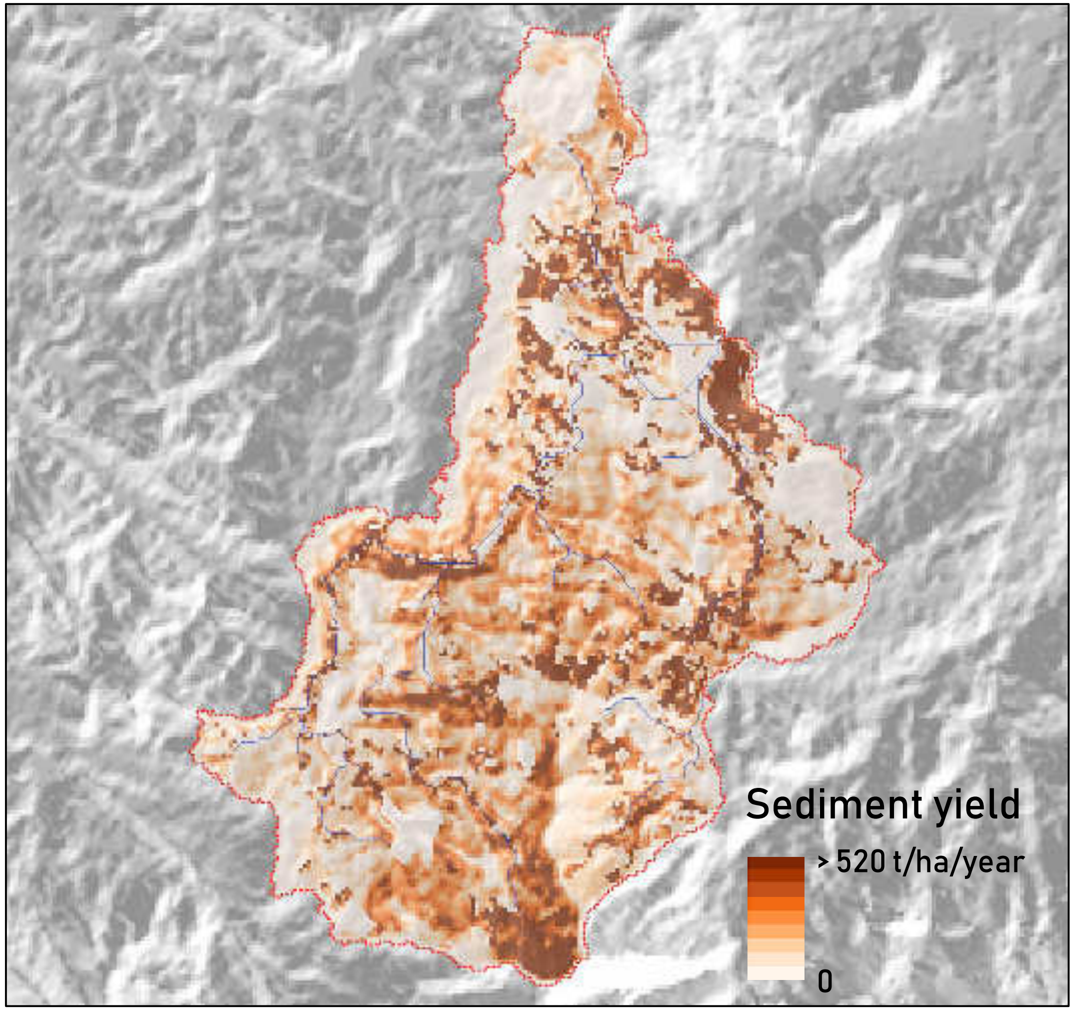




Potential Soil Erosion and Sediment Yield Modelling – Objectives

Kuningan Reservoir basin





Potential Soil Erosion and Sediment Yield Modelling – Objectives

Sediment yield analysis for selected reservoirs

Jatigede Reservoir

Capacity: 800Mm^3
Basin area: 1490.59km^2

Scenario	Sediment yield t/year	Sediment yield m^3/year*	Reservoir fill time years
Current annual precipitation	12,300,000.94	10,271,439.12	95.41
5% precipitation increase	12,988,612.14	10,823,843.45	90.54
10% precipitation increase	13,663,773.87	11,386,478.22	86.07
15% precipitation increase	14,342,117.80	11,951,764.83	82

Cipanas Reservoir

Capacity: 63Mm^3
Basin area: 73.08km^2

Scenario	Sediment yield t/year	Sediment yield m^3/year*	Reservoir fill time years
Current annual precipitation	195,431.41	162,859.51	399.12
5% precipitation increase	205,851.65	171,543.05	378.91
10% precipitation increase	216,558.91	180,465.76	360.18
15% precipitation increase	227,310.07	189,425.06	343.14

Darma-Kuningan Reservoir

Capacity: 39Mm^3
Basin area: 26.29km^2

Scenario	Sediment yield t/year	Sediment yield m^3/year*	Reservoir fill time years
Current annual precipitation	34,912.51	29,093.76	1,340.49
5% precipitation increase	36,722.01	30,601.68	1,274.44
10% precipitation increase	38,632.09	32,193.41	1,211.43
15% precipitation increase	40,549.99	33,791.66	1,154.13

* Bulk density: 1200kg/m^3

Potential Soil Erosion and Sediment Yield Modelling – Objectives

Sediment yield analysis for selected reservoirs

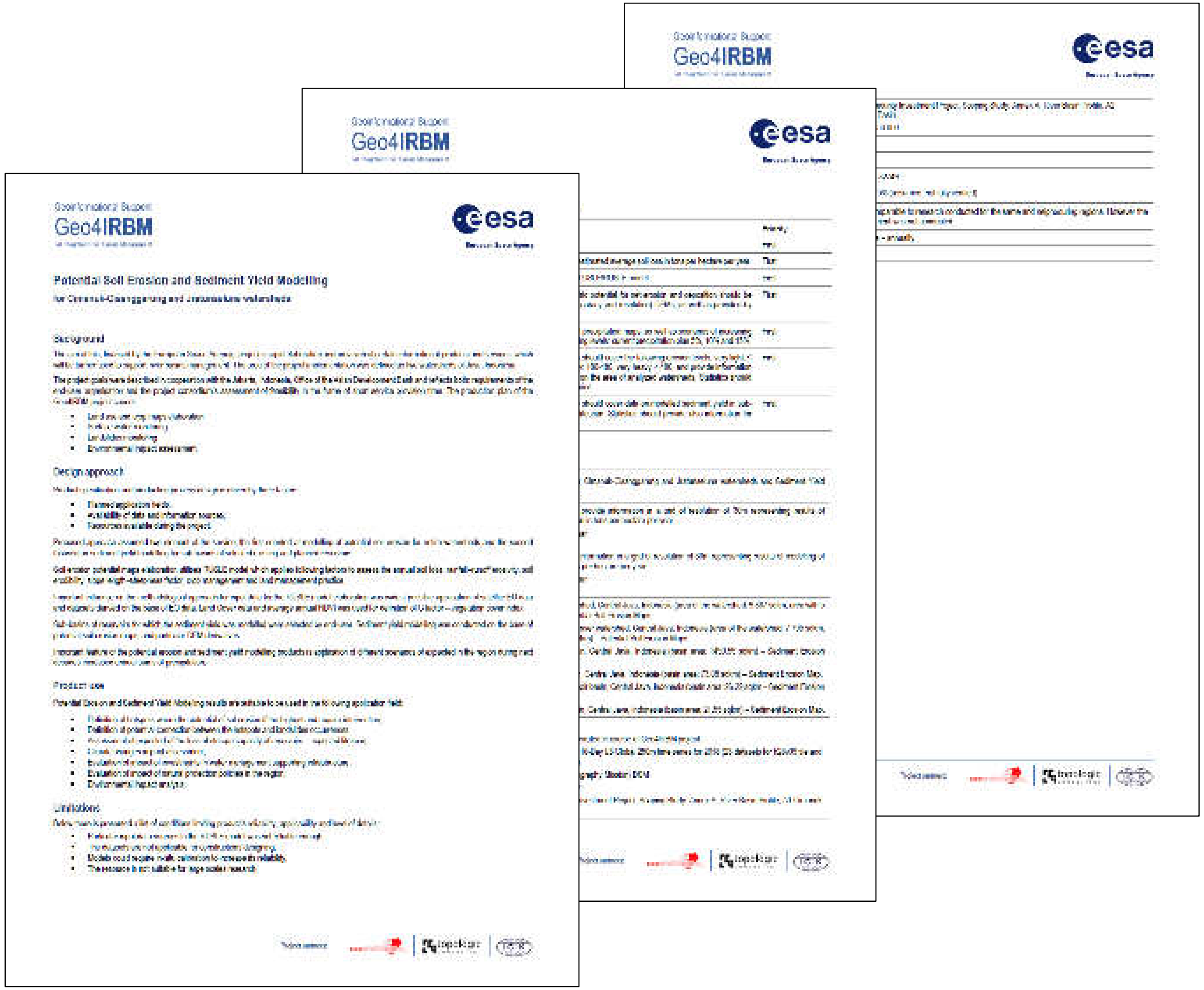
Kuningan Reservoir

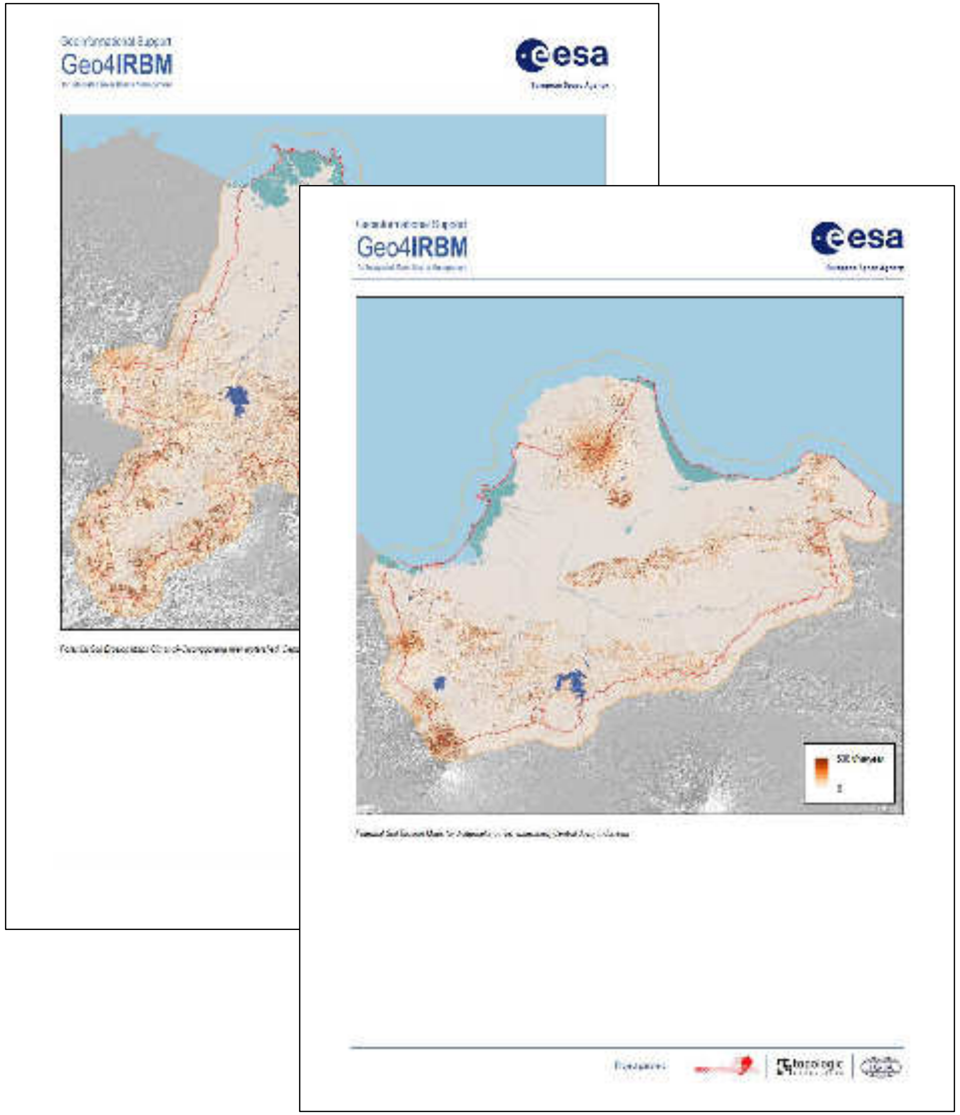
Capacity: $30Mm^3$
Basin area: $21.55km^2$

	Sediment yield		Reservoir fill time
Scenario	t/year	m^3/year*	years
Current annual precipitation	15,931.37	13,276.14	2,259.69
5% precipitation increase	16,584.38	13,820.32	2,170.72
10% precipitation increase	17,447.01	14,539.17	2,063.39
15% precipitation increase	18,313.17	15,260.98	1,965.80

* Bulk density: $1200kg/m^3$

Potential Soil Erosion and Sediment Yield Modelling – Objectives





Potential Soil Erosion and Sediment Yield Modelling – Design approach

Product specification and production process design is driven by three factors:

- Planned application fields,
- Availability of data and information sources,
- Resources available during the project.

Proposed approach assumed two element of the service, the first oriented at modelling of potential soil erosion for entire watersheds and the second focused on sediment yield modelling for sub-basins of selected existing and planned reservoirs.

Soil erosion potential maps elaboration utilises RUSLE model which applies following factors to assess the annual soil loss: rainfall–runoff erosivity, soil erodibility, slope length–steepness factor, crop management and land management practice.

Important influence on the methodological approach for input data for the RUSLE model elaboration was widest possible application of satellite EO data and datasets derived on the base of EO data. Land Cover data and average annual NDVI was used for definition of C factor – vegetation cover index.

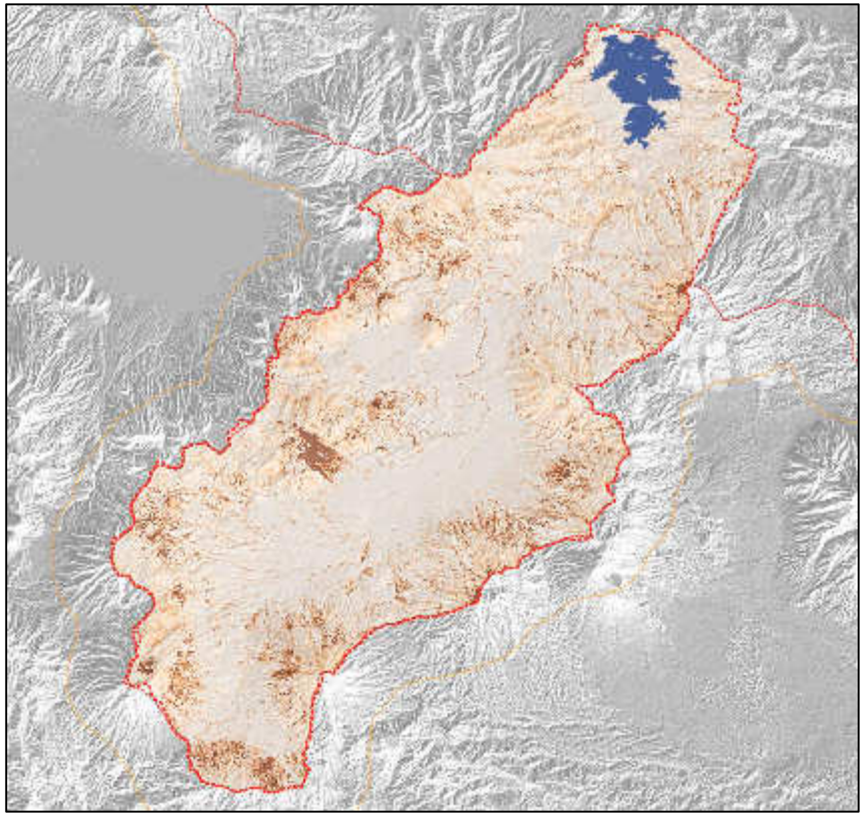
Sub-basins of reservoirs for which the sediment yield was modelled were selected by end-user. Sediment yield modelling was conducted on the base of potential soil erosion maps, and particular DEM derivatives.

Important feature of the potential erosion and sediment yield modelling products is application of different scenarios of expected in the region during next decades increased annual sums of precipitation.

Potential Soil Erosion and Sediment Yield Modelling – Product Use

Specific, identified application fields are:

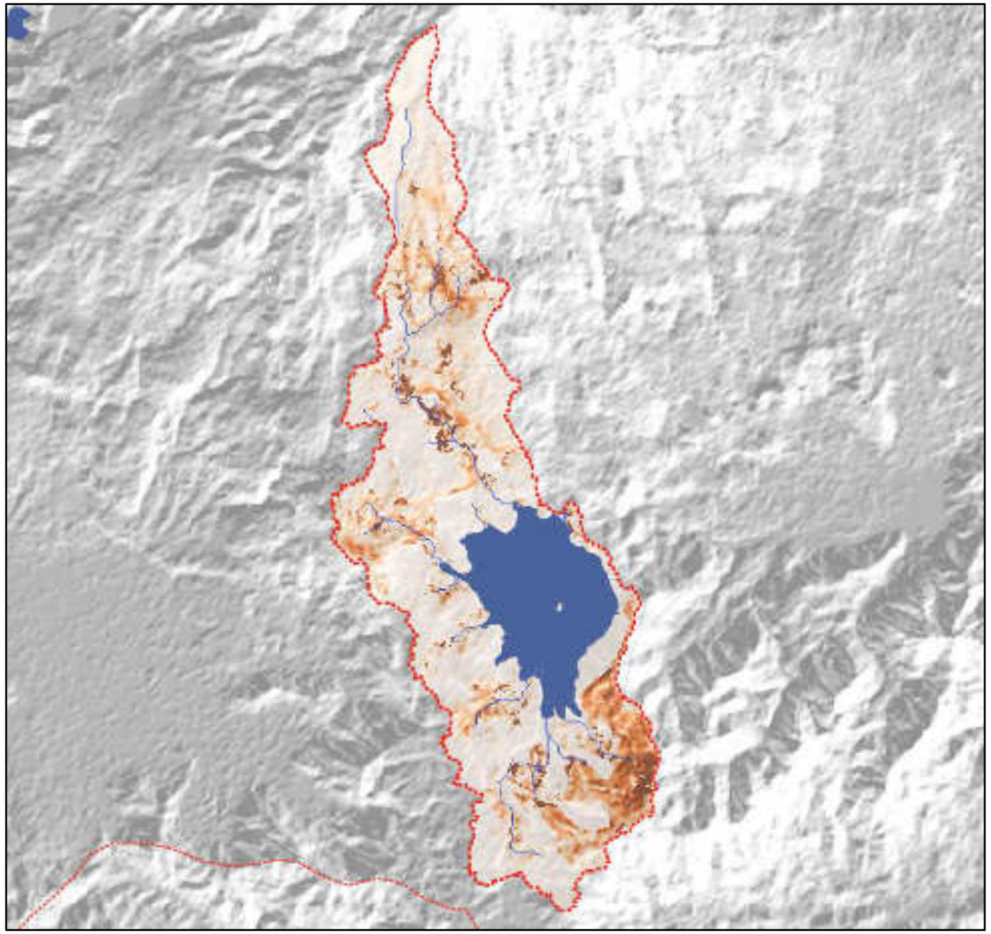
- Definition of hotspots where the potential of soil erosion if the highest and require intervention,
- Definition of potential connection between the hotspots and landslides occurrences,
- Assessment of expected of the loss of storage capacity of reservoirs – expected lifespan,
- Climate changes impact assessment,
- Evaluation of impact of investments in water management supporting infrastructure,
- Evaluation of impact of natural protection policies in the region,
- Environmental impact analysis.



Potential Soil Erosion and Sediment Yield Modelling – Limitations

Features limiting product's reliability, applicability and level of details:

- Particular input data sources to the RUSLE model was not reliable enough,
- The datasets are not applicable for constructions designing,
- Models could require in-situ calibration to increase its reliability,
- The resource is not suitable for large scales research.



Potential Soil Erosion and Sediment Yield Modelling – Requirements

ID	Requirement	Fulfilment
PES01	Maps should cover areas defined by the end-user.	Yes
PES02	The soil erosion risk map should provide information on estimated average soil loss in tons per hectare per year.	Yes
PES03	The soil erosion risk map should be derived o the bas of USLE/RUSLE model.	Yes
PES04	The soil erosion risk map should include the topographic potential for net erosion and deposition should be derived using the best available (of highest possible accuracy and resolution) DEMs, as well as provided by local partners information on soils characteristics.	Yes
PES05	Models should apply currently observed average annual precipitation maps, as well as scenarios of increasing as expected precipitation sums accordingly to the following levels: current precipitation plus 5%, 10% and 15%.	Yes
PES06	Statistics derived on the base of potential erosion maps should cover the following erosion levels: very light: < 15 ton/ha/year, light: 15 – 60, moderate: 60 -180, heavy: 180-480, very heavy > 480, and provide information on area, and percentage of share of individual classes on the area of analyzed watersheds. Statistics should provide also information for increase precipitation scenarios.	Yes
PES07	Statistics derived on the base of potential erosion maps should cover data on modelled sediment yield in sub-basins of selected reservoirs and expected reservoirs lifespan. Statistics should provide also information for increase precipitation scenarios.	Yes

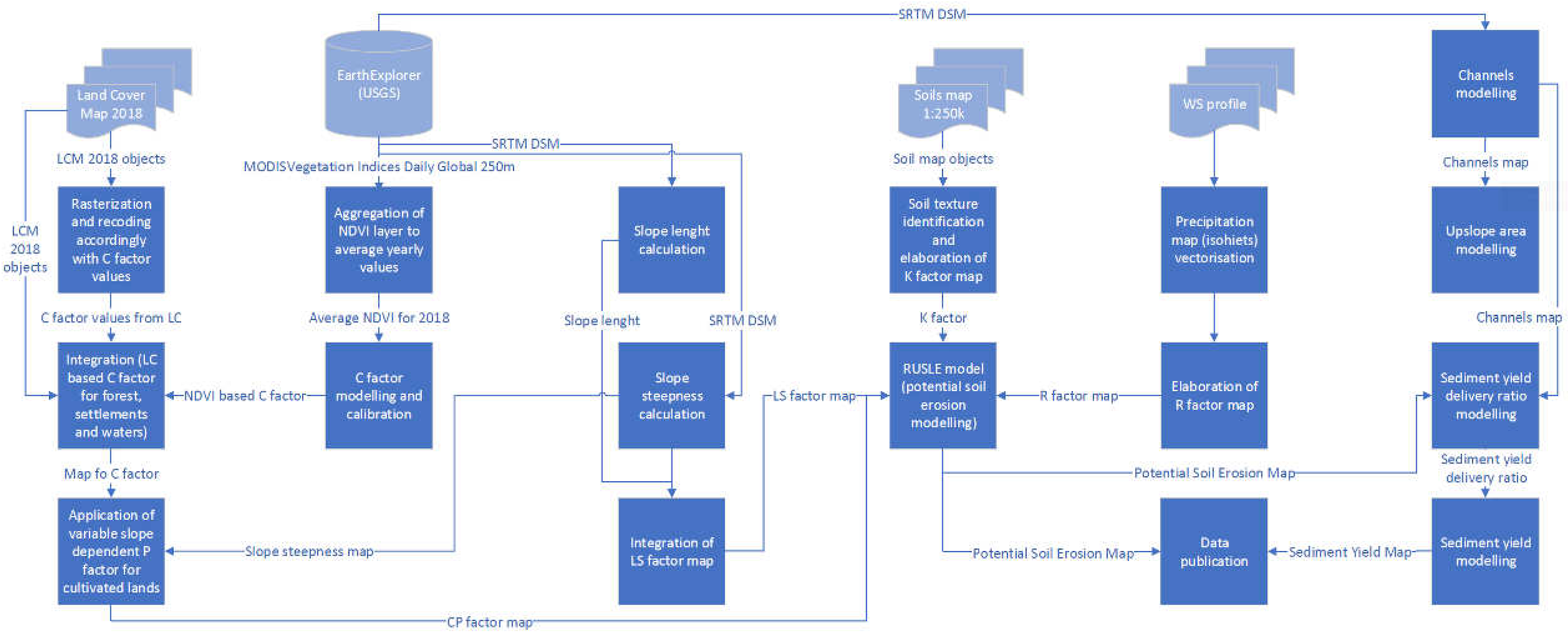
Potential Soil Erosion and Sediment Yield Modelling – Specification

Feature	Value / description
Content	Potential Soil Erosion Maps provide information in a grid of resolution of 30m representing results of modelling of potential soil erosion in tons per hectare per year. *DN* value in t/ha/year Sediment Yield Maps provide information in a grid of resolution of 30m representing results of modelling of sediment yield modelling in tons per hectare per year. *DN* value in t/ha/year
Geographic Coverage	AOI 1.: Jratunseluna river watershed, Central Java, Indonesia (area of the watershed: 9 367 sqkm, area with 5 km buffer: 12 706 sqkm) – Potential Soil Erosion Maps. AOI 2.: Cimanuk-Cisanggarung river watershed, Central Java, Indonesia (area of the watershed: 7 795 sqkm, area with 5 km buffer: 10 575 sqkm) – Potential Soil Erosion Maps. AOI 3.: Jatigede Reservoir basin, Central Java, Indonesia (basin area: 1490.59 sqkm) – Sediment Erosion Map. AOI 4.: Cipanas Reservoir basin, Central Java, Indonesia (basin area: 73.08 sqkm) – Sediment Erosion Map. AOI 5.: Darma-Kuningan Reservoir basin, Central Java, Indonesia (basin area: 26.29 sqkm – Sediment Erosion Map. AOI 6.: Kuningan Reservoir basin, Central Java, Indonesia (basin area: 21.55 sqkm) – Sediment Erosion Map.

Potential Soil Erosion and Sediment Yield Modelling – Specification

Feature	Value / description
Input data sources	*Input data:* Land Cover Map 2018 elaborated in course of Geo4IRBM project MODIS Vegetation Indices 16-Day L3 Global 250m time series for 2018 (23 datasets for h28v09 tile and 23 datasets for h28v09 tile) SRTM (Shuttle Radar Topography Mission) DSM *Input data provided by End-user:* Enhanced Water Security Investment Project, Scoping Study: Annex A, River Basin Profile, A1 Cimanuk River Basin Enhanced Water Security Investment Project, Scoping Study: Annex A, River Basin Profile, A2 Jratunseluna River Basin Soil types map 1: 250 000
Methodology	RUSLE model
Spatial Resolution and Coverage	30m
Coordinate Reference System	UTM zone 49S / EPSG: 32749
Accuracy, Constraints	Thematic accuracy: > 75% (assumed, not fully verified)
Accuracy Assessment Approach	Achieved results are comparable to research conducted for the same and neighbouring regions. However the actual accuracy assessment was not conducted.
Frequency	It is suggested to update – annually
Availability	1972-2018
Delivery / Output Format	Shapefile

Potential Erosion and Sediment Yield Modelling – Specification: Methodology



Schema of applied analysis and processing procedures in course of PES elaboration

THANK YOU

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Geoinformational Support

Geo4IRBM

for Integrated River Basins Management

European Space Agency

Coastline Changes Mapping

Przemysław Turos (Topologic)

Coastline Changes Mapping – Definitions

Coastline Changes Mapping is a simple, yet powerful tool for analysis of historical dynamics of:

Coastal erosion – lost and displacement of land along the coast due to influence of sea waters – waves, currents, tides. It might be also understand as sediment long-term removal of sediment.

Sedimentation – the tendency for particles in suspension to settle out of the fluid in which they are entrained and come to rest against a barrier. This is due to their motion through the fluid in response to the forces acting on them: these forces can be due to gravity, centrifugal acceleration, or electromagnetism. In geology, sedimentation is often used as the opposite of erosion, i.e., the terminal end of sediment transport.

Surface subsidence - is the sudden sinking or gradual downward settling of the ground's surface with little or no horizontal motion. The definition of subsidence is not restricted by the rate, magnitude, or area involved in the downward movement. It may be caused by natural processes or by human activities.

Sea level rise - since at least the start of the 20th century, the average global sea level has been rising. Between 1900 and 2016, the sea level rose by 16–21 cm (6.3–8.3 in).[2] More precise data gathered from satellite radar measurements reveal an accelerating rise of 7.5 cm (3.0 in) from 1993 to 2017,[3]:1554 which is a trend of roughly 30 cm (12 in) per century.

Coastline Changes Mapping – Background

PPTA requirements *(source: PPTA task force)*

Objective

- To evaluate historical changes in Water/flood extent, Land Use and Land cover in 4 basins in Indonesia; Cimanuk, Seluna, Mahakam, and Belewan.

Processes

- Evaluation of Water inflows to reservoirs in Raw Water Supply (RWS) subprojects,
- Evaluation of Water/flood extent in Flood Risk Management (FRM) subprojects.

Data sets requested

- Cross analysis of flood events on the base of existing reports and as detected by historical surface water monitoring (1-month before and 1-month after the date)
- (i) Water/flood extent – also for the period before S1 mission (ii) Land cover and (iii) Land Use (if available) through Landsat-8 and Sentinel-1 images at the basin scale.
- Products for assessments along the coast-line.
- Information on cropping intensity

Proposed application scenarios of Geo4IRBM services

Land Cover Maps and Land Cover Changes maps applied for the needs of EWSIP focusing

Coastline changes elaborated on the base of Land Cover Changes maps. Indicators of coastline length variations in reference network.

Surface deformation / subsidence along the coastline, cross analysis of coastline changes.

Surface deformation for the needs of landslides detection and erosion assessment useful for floods forecasting.

Surface waters monitoring historical data could contribute to historical floods delimitation and as information on frequency of water coverage, proposed extension of the period before S1 operation.

Proposition of extension of AOIs was rejected due to resources limitation (proposed extension area was 5 times bigger than the original)

Coastline Changes Mapping – Objectives

Ground subsidence, sea level rise and anthropogenic structures development (sea port infrastructure).

East of Semarang between 1974 and 2018

1975
1990
2000
2018

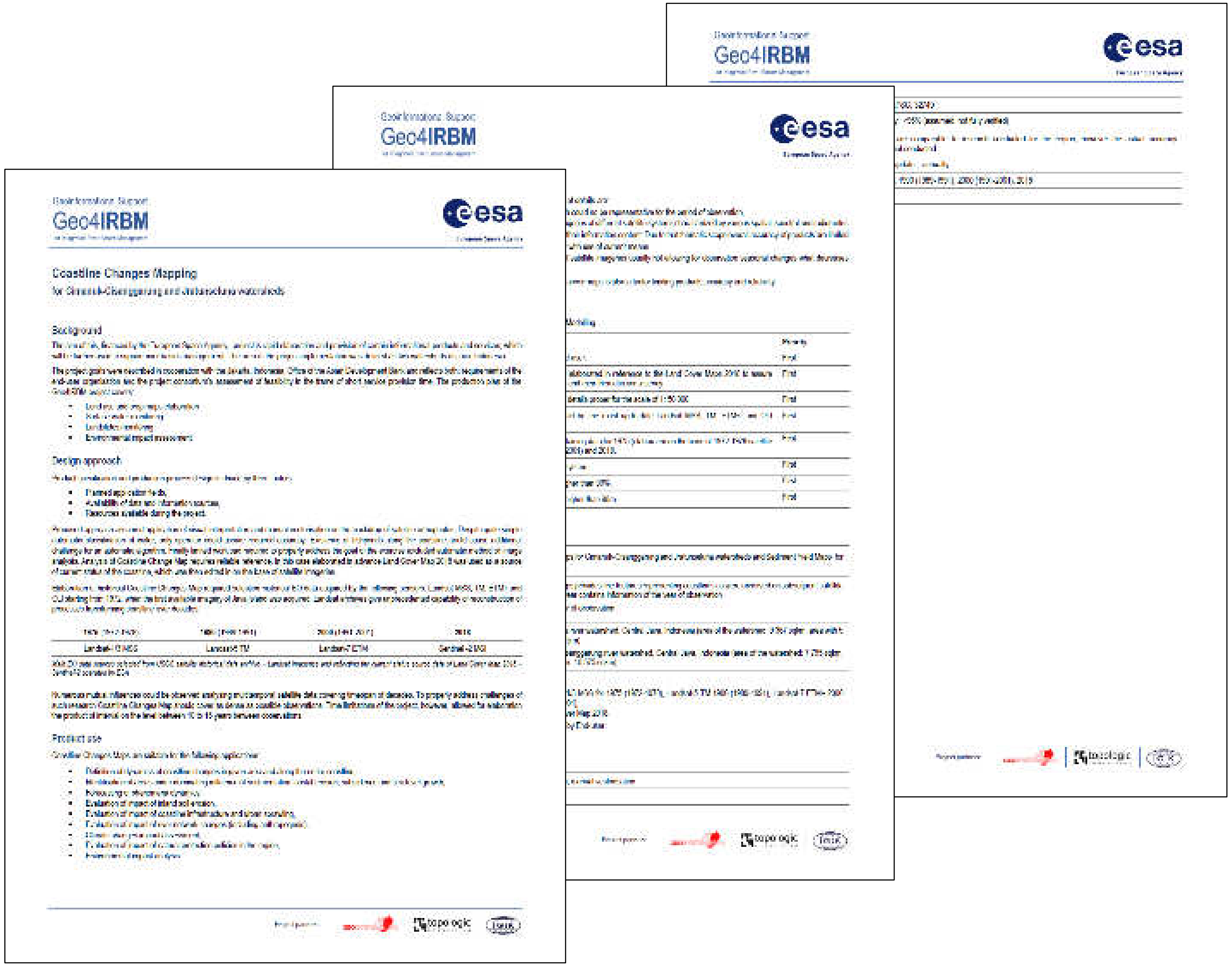
Coastline Changes Mapping – Objectives

Sedimentation dynamics in Cimanuk Anyar estuary (measured along the river)

1975-1990	770m	51 m/yr
1990-2000	1450m	145 m/yr
2000-2018	2350m	130 m/yr

1975
1990
2000
2018

Coastline Changes Mapping – Objectives



Long-term Surface Water Coverage Mapping – Design approach

Product specification and production process design is driven by three factors:

- Planned application fields,
- Availability of data and information sources,
- Resources available during the project.

Service utilized historical data – satellite images of appropriate resolution available in the archive catalogues, and on the operational stage - newly acquired data which will have been collected during the project timespan. Information on surface water extent will be derived by automatic analysis of the imagery.

Service execution is based on Sentinel-1 microwave satellites monitoring capabilities utilization. Such solution provides flexibility given by regular acquisition of SAR data and ensures weather-independent service capacity.

The product is an example analysis utilising monitoring products of the Surface Water Monitoring Service – water masks generated on the base of selected orbits data. Approach allows for strait forward analysis of frequency of detection of surface water in given period of monitoring. Frequency is represented by number of water detections over time.

Coastline Changes Mapping – Specification: Input data

Landsat-4 MSS
19720928

Ground subsidence and development of settlements – East of Semarang

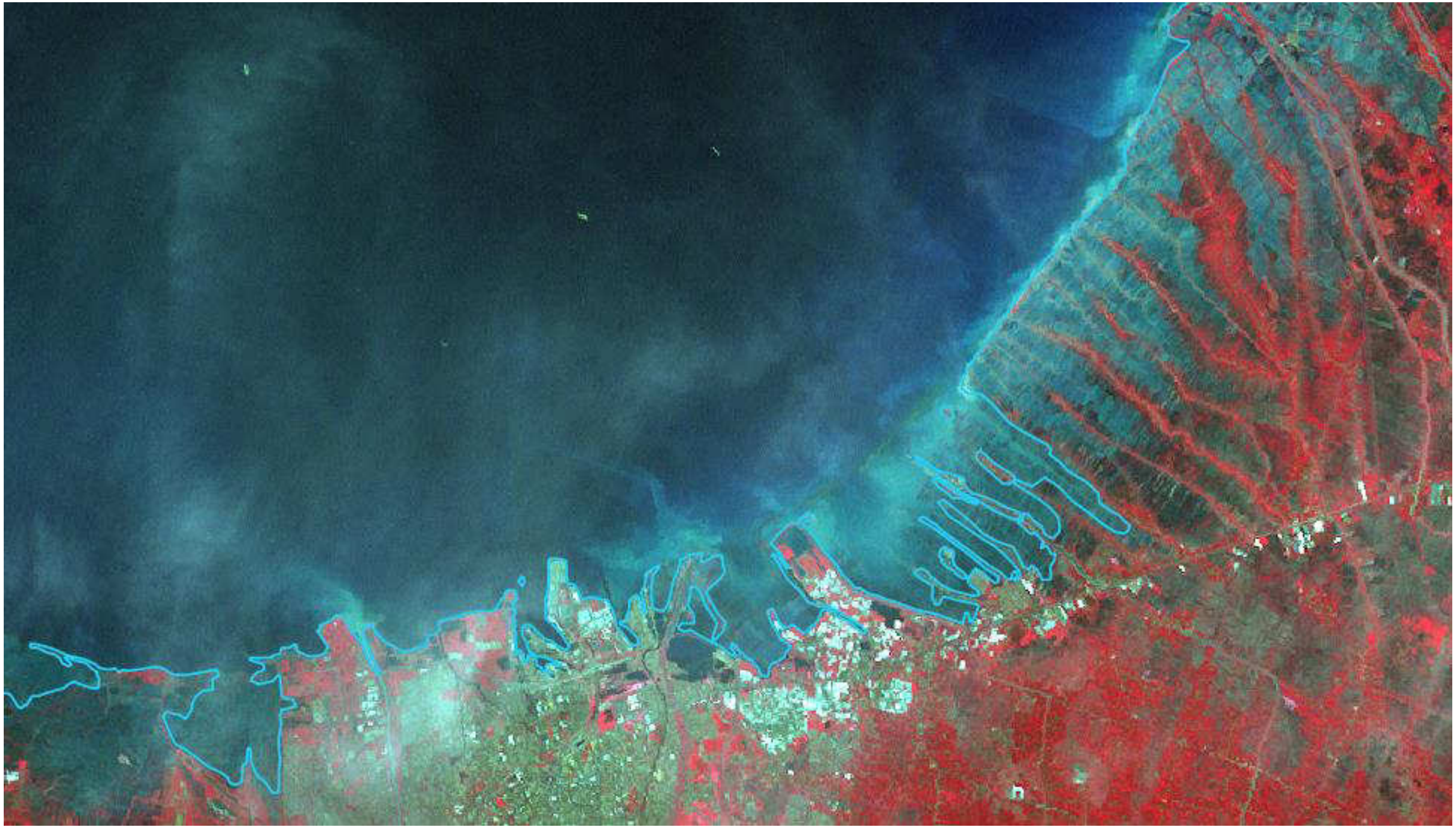
Coastline Changes Mapping – Specification: Input data

Landsat-5 TM
19910628

Ground subsidence and development of settlements – East of Semarang

Coastline Changes Mapping – Specification: Input data

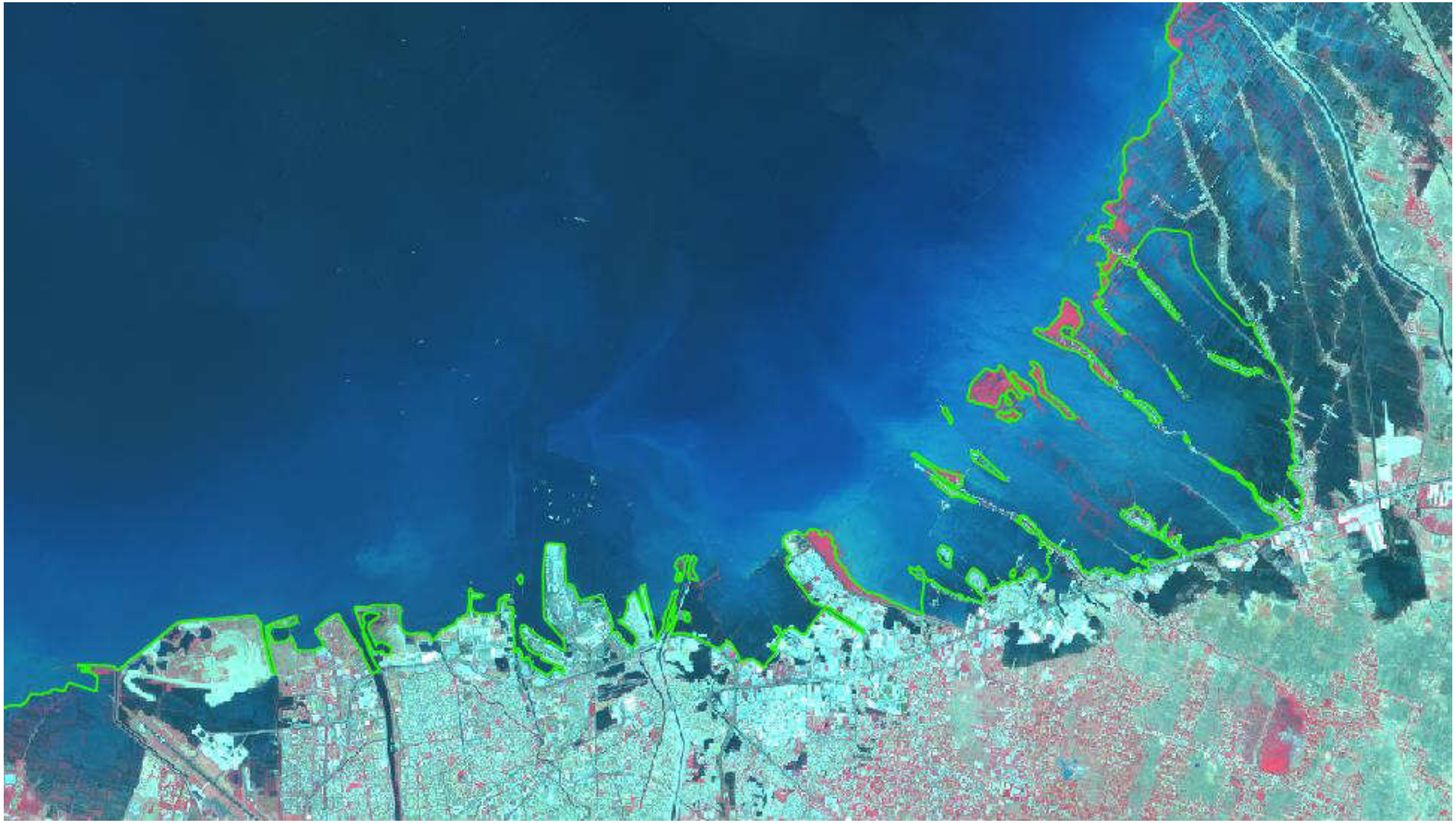
Landsat-7 ETM+
20010428



Ground subsidence and development of settlements – East of Semarang

Coastline Changes Mapping – Specification: Input data

Sentinel-2A MSI
20180807



Ground subsidence and development of settlements - East of Semarang

Long-term Surface Water Coverage Mapping – Product Use

Specific, identified application fields are:

- Agriculture oriented water management thanks to seasonal analysis,
- Analysis of fields inundation extent and time schema,
- Identification of flood risk and hazard for given period / flood event (current or historical),
- Observation of evolution of flood hazard by assessment of multiple historic flood events,
- Input into calibration of flood modelling, which represents different type of hazard estimation,
- Support risk assessment - in combination with structural or socio-economic vulnerability hazard map represents crucial input into flood risk assessment aiming at identification of areas with the highest risks,
- Damage assessment,
- Correlation of floods events with land cover changes,
- Preparation of rescue and evacuation training scenarios.

Long-term Surface Water Coverage Mapping – Limitations

Below there is presented a list of conditions limiting product's reliability, applicability and level of details:

- Main source of input data are Sentinel-1 IW and Sentinel-2 MSI imagery with default orthorectification applied
- Effective ground resolution of the Sentinel-1 and Sentinel 2 MSI data is 10 m which affects level of detail provided by the output product.
- Acquisition frequency of Sentinel-1 constellation and Sentinel-2 is at best 6 days. Data cannot be acquired between set acquisition dates.
- The Sentinel-1 data archive spans back to October 2014. For covering of events before acquisition period alternative data sources with (usually) much lower and irregular acquisition frequency must be considered.
- SAR imaging is sensitive to waves on water surface, which could limit ability of water detection.
- SAR data of Sentinel-1 resolution could not be sufficient for detection of inundation in densely built-up areas.
- SAR data such as Sentinel-1 are not affected by cloud coverage, but they have limited interpretability of flood inundation in certain areas or under certain conditions:
    - omission errors – connected with problematic detection of water surface under dense trees crowns cover, in radar shadow, wavy water),
    - errors of commission – caused by annexation of shadowed or due to other reasons similar to water surface to the actual flooded area, or merging the flooded area with normally existing rivers or reservoirs (especially in urban or complex backscattering areas).
- To avoid misinterpretation datasets from one orbit per watershed was selected, which have influence on the monitoring interval.

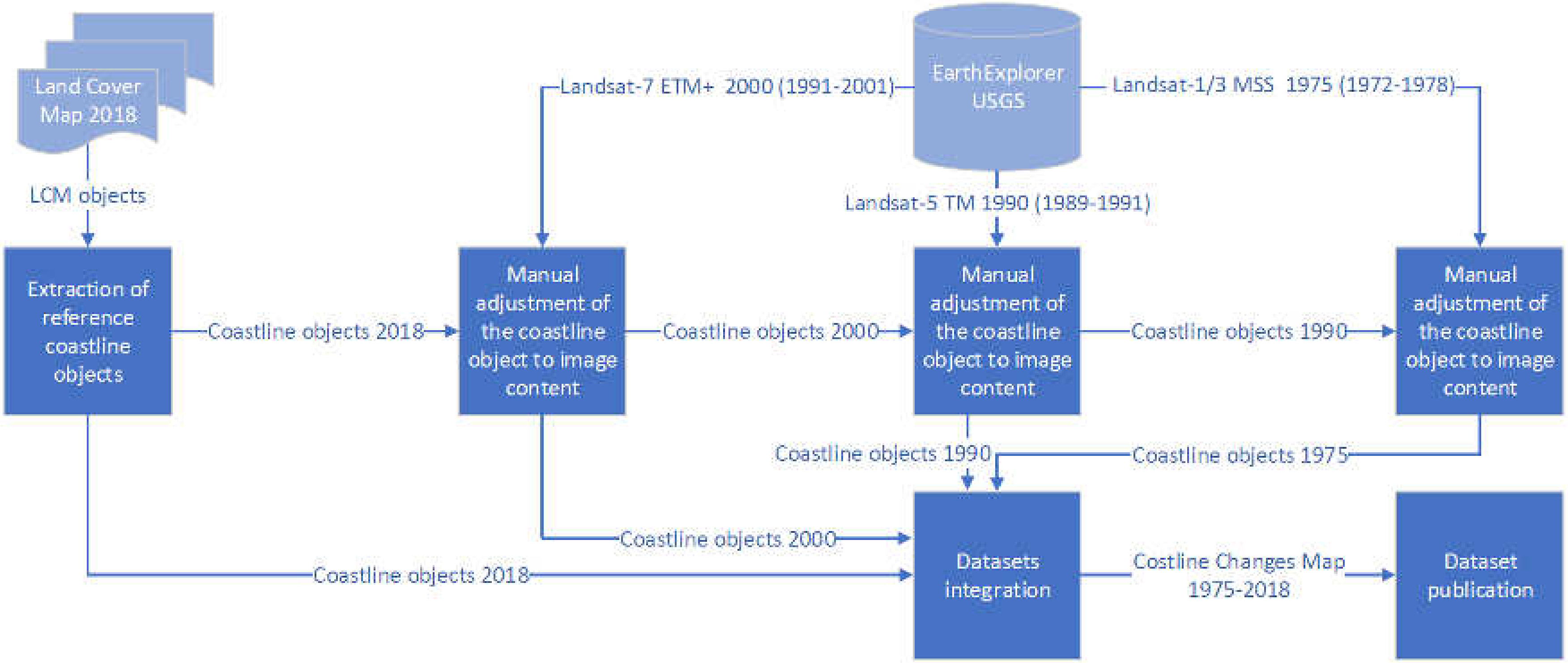
Long-term Surface Water Coverage Mapping – Requirements

ID	Requirement	Fulfilment
SWC01	Maps should cover areas defined by the end-user.	Yes
SWC02	The major source of the EO data should be Sentinel-1SAR imageries on GRD processing level, orthorectified and normalized.	Yes
SWC03	As direct input to the analysis monitoring products of the Surface Water Monitoring Service should be utilised – water masks generated on the base of selected orbits data.	Yes
SWC04	As direct input to the analysis monitoring products of the Surface Water Monitoring Service from particular orbits should be utilised – 076 for Seluna WS and 149 for Cimanuk WS.	Yes
SWC05	The map should be derived automatically originally as raster output.	Yes
SWC06	The original classification result should be an object of refinement – removing normally appearing errors, due to radar shadows and high, dense vegetation.	Yes
SWC07	Analysis should provide information on frequency of detection of surface water in given period of monitoring, which should be represented by number of water detections over time.	Yes
SWC08	Map should be stored in UTM coordination system.	Yes
SWC09	Thematic accuracy of the map should be higher than 80%.	Yes

Long-term Surface Water Coverage Mapping – Specification

Feature	Value / description
Content	Spatial representation of frequency of detection of surface water. *DN* Value – number of surface water detection in a cell during monitoring period
Geographic Coverage	AOI 1.: Jratunseluna river watershed, Central Java, Indonesia (area of the watershed: 9 367 sqkm, area with 5 km buffer: 12 706 sqkm). AOI 2.: Cimanuk-Cisanggarung, Central Java, Indonesia (area of the watershed: 7 795 sqkm, area with 5 km buffer: 10 575 sqkm).
Input data sources	*Input data:* Sentinel-1 SAR satellite data SRTM (Shuttle Radar Topography Mission) DSM
Methodology	SAR amplitude data thresholding, multitemporal data integration.
Spatial Resolution and Coverage	Not applicable.
Coordinate Reference System	UTM zone 49S / EPSG: 32749
Accuracy, Constraints	Thematic accuracy: > 80% Geometric accuracy: < 20m (dependent on Sentinel-1 scenes automatic orthorectification, noticed very rare incidences of misregistration in the initial phase of Sentinel-1 satellites operation)
Accuracy Assessment Approach	The accuracy assessment is based on comparative analysis of selected surface water maps based on Sentinel-1 data with reference data elaborated with use of the Sentinel-2 imageries. These analysis are possible only for selected dates and for limited extent due to extensive cloud coverage in the region and highly variable .
Frequency	1 month in 2014 to 3 to 8 days in October 2018 (dependently on location).
Availability	1972-2018
Delivery / Output Format	Shapefile

Coastline Changes Mapping – Specification: Methodology



Schema of applied analysis and processing procedures in course of CCM elaboration

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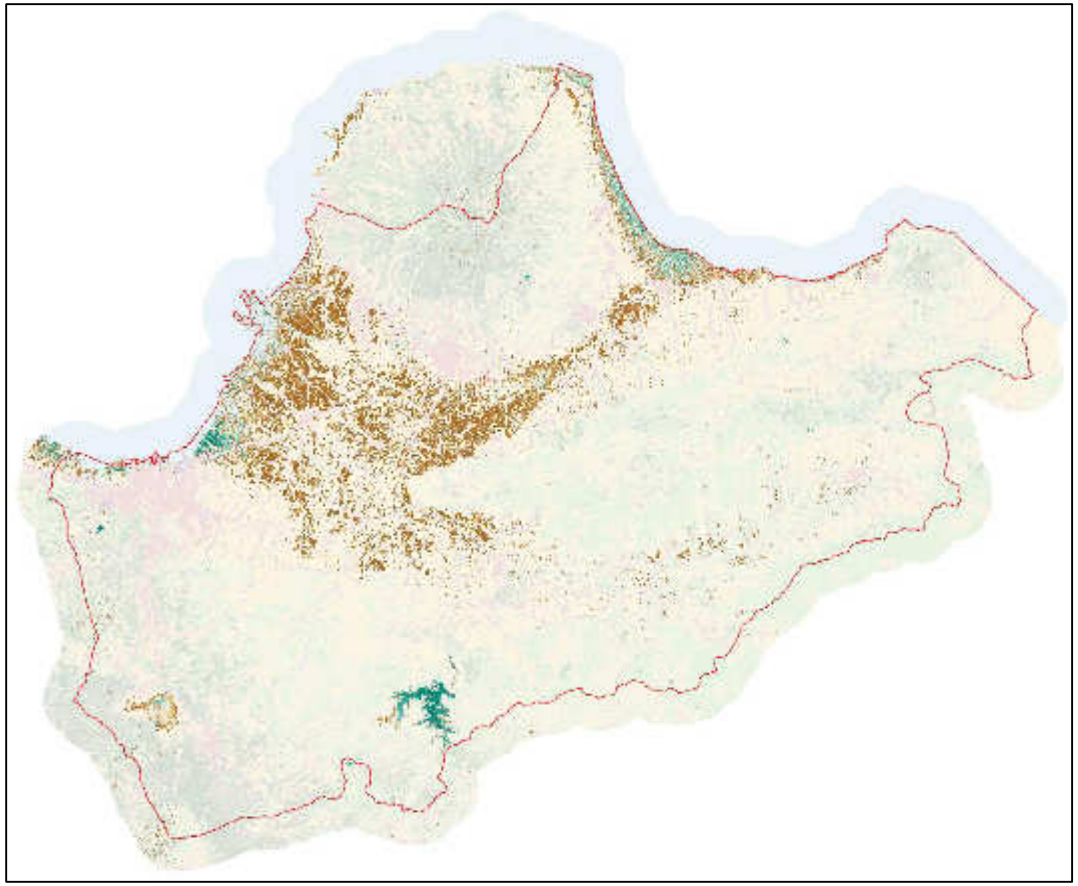
European Space Agency

Long-term Surface Water Coverage Mapping

Przemysław Turos (Topologic)

Long-term Surface Water Coverage Mapping – Definitions

Surface Water Monitoring, operating continuously as an automatic online service, allows for various aggregation of surface water masks and create Long-term Surface Water Coverage Mapping for a period of choice.



Water detection frequency - number of surface water detection in a cell during monitoring period

Surface water is any natural water that has not penetrated under the surface of the ground underneath.

- Rivers, lakes, wetlands are commonly known bodies of surface water.
- Surface water is lost through evaporation and regained through precipitation (rain) or recruited from ground-water sources.
- The service maps also flooded rise fields, inundations and floods.
- No attempt of categorisation is introduced in the service itself.

Long-term Surface Water Coverage Mapping – Background

PPTA requirements *(source: PPTA task force)*

Objective

To evaluate historical changes in Water/flood extent, Land Use and Land cover in 4 basins in Indonesia; Cimanuk, Seluna, Mahakam, and Belewan.

Processes

Evaluation of Water inflows to reservoirs in Raw Water Supply (RWS) subprojects,

Evaluation of Water/flood extent in Flood Risk Management (FRM) subprojects.

Data sets requested

Cross analysis of flood events on the base of existing reports and as detected by historical surface water monitoring (1-month before and 1-month after the date)

(i) Water/flood extent – also for the period before S1 mission (ii) Land cover and (iii) Land Use (if available) through Landsat-8 and Sentinel-1 images at the basin scale.

Products for assessments along the coast-line.

Information on cropping intensity

Proposed application scenarios of Geo4IRBM services

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Proposition of extension of AOIs was rejected due to resources limitation (proposed extension area was 5 times bigger than the original)

Long-term Surface Water Coverage Mapping – Background

Enhanced Water Security Investment Project *(source: EWSIP Project Concept Paper)*

Outputs

1. Planning for water resources optimized

   1a. Water monitoring equipment installed as per rationalization plans.

   1b. River basin wide hydrological and hydrodynamic models calibrated.

   1d. Asset management information system for river assets established.

   1e. Knowledge and skills in climate resilient infrastructure design/planning of RBO staff

Key Activities with Milestones

1. Planning for water resources optimized

   1.2 Install and calibrate expanded networks of hydro-meteorological stations. (Q4 2020)

   1.3 Run hydrological and hydrodynamic models to optimize water management for DMI, irrigation and energy needs taking into account land use change and climate change scenarios. (Q2 2020)

   1.5 Upgrade the river asset management information system to an online GIS based system. (Q2 2020)

Proposed application scenarios of Geo4IRBM services

Land Cover Maps applied for the needs of flood risks and flood hazard (the Polish case IMGW/Polish Waters/Ministry of Inland Navigation and Water Management).

Crops Intensity Maps for water demand assessment.

Surface Waters Monitoring historical data could contribute to climate change analysis and historical floods delimitation - frequency of water coverage

Long-term Surface Water Coverage Mapping – Background

Enhanced Water Security Investment Project *(source: EWSIP Project Concept Paper)*

Outputs

2. Raw water supply infrastructure and services improved

   2a. Water storage is increased

   2c. Additional groundwater wells built or upgraded worse than expected ground conditions may cause implementation delays)

Key Activities with Milestones

2. Raw water supply infrastructure and services improved

   2.4 Construct or upgrade bulk water facilities (reservoirs, ponds, bunded reservoirs, groundwater wells, conveyance) including climate resilient design features. (Q1 2022)

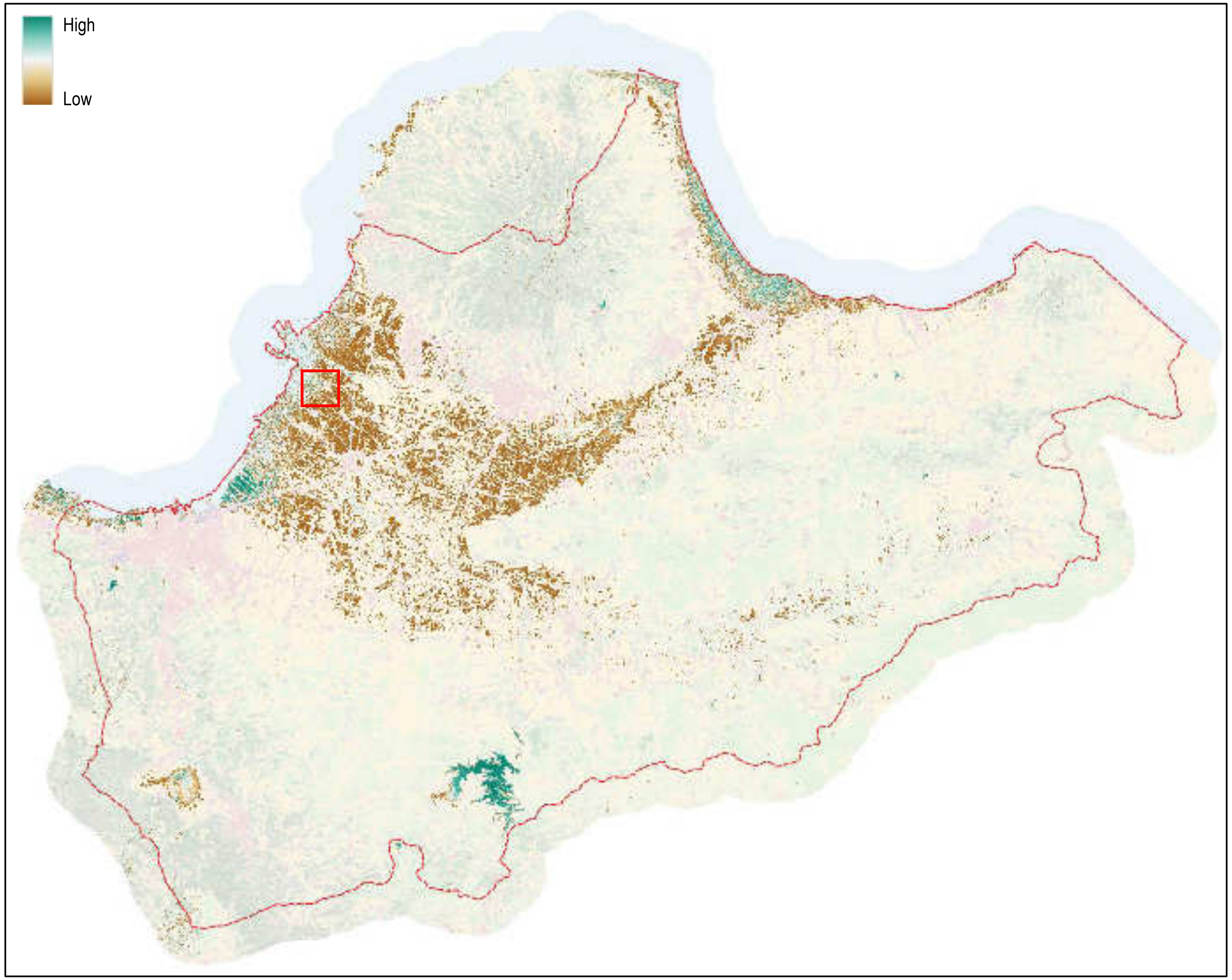
Proposed application scenarios of Geo4IRBM services

Land Cover Maps applied for the needs of investments strategic planning

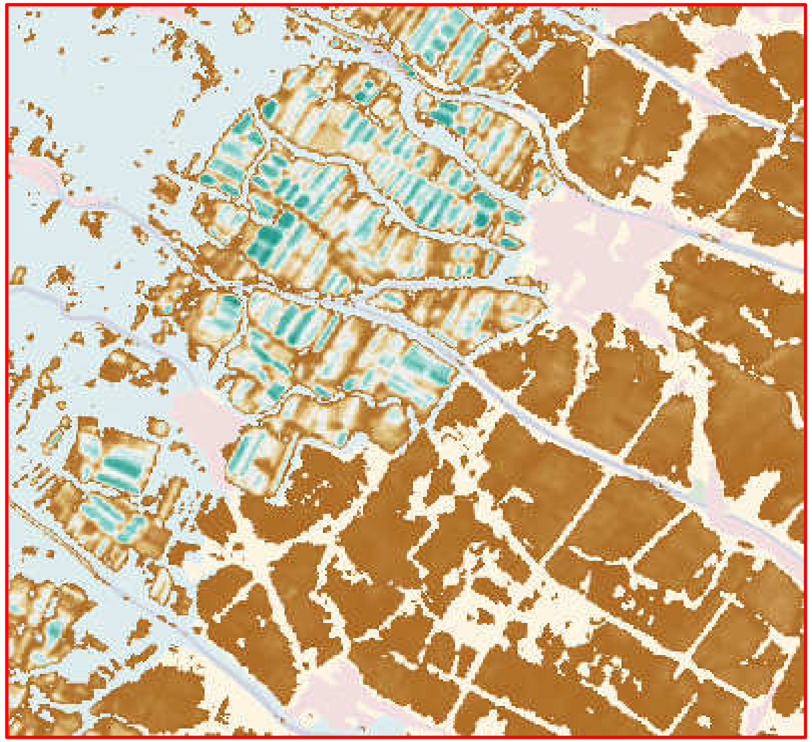
Surface Water Monitoring service inputs for the reservoirs effectiveness and responsiveness evaluation.

Ground conditions analysis could be supported with interferometric analysis of ground subsidence.

Long-term Surface Water Coverage Mapping – Objectives

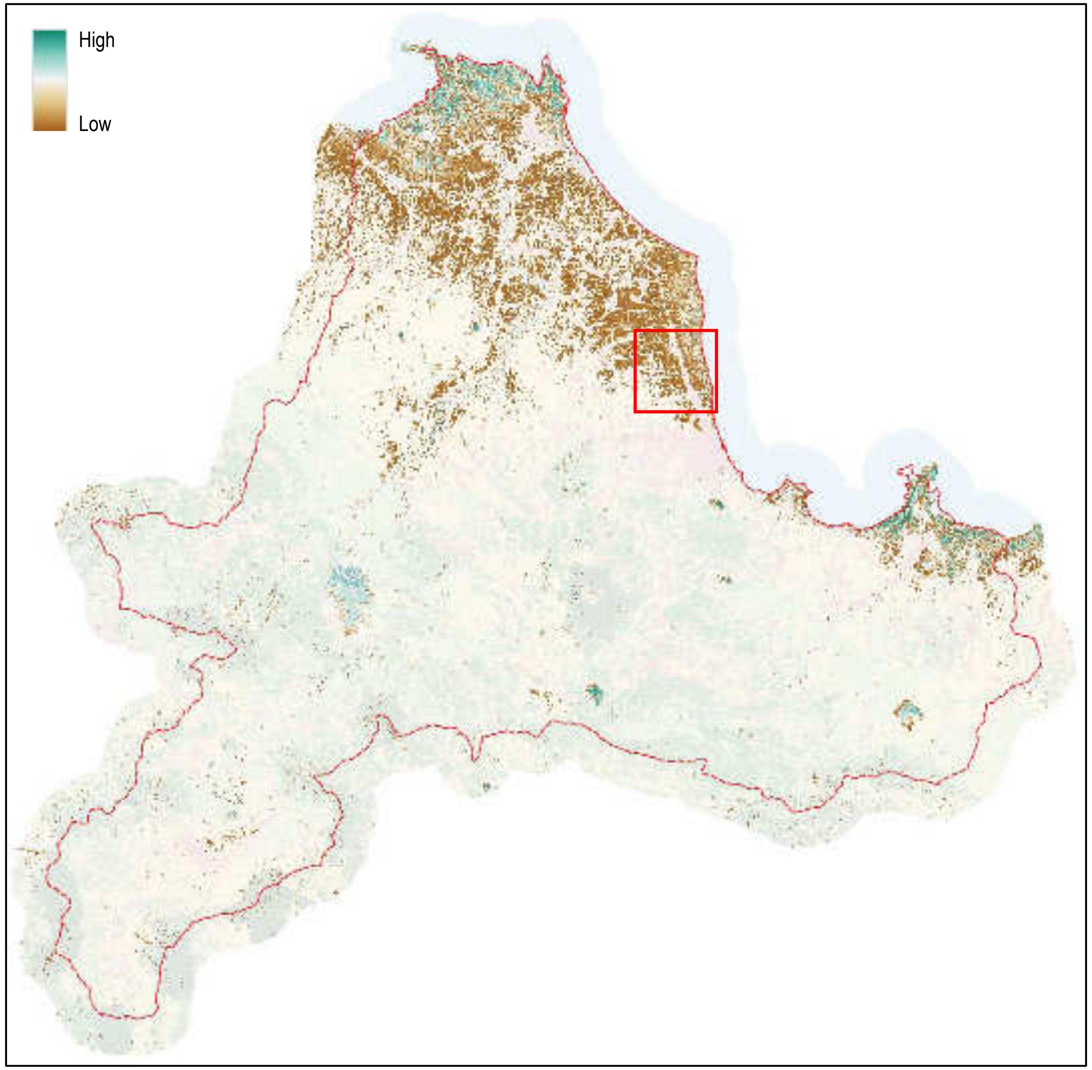


Jratunseluna river watershed

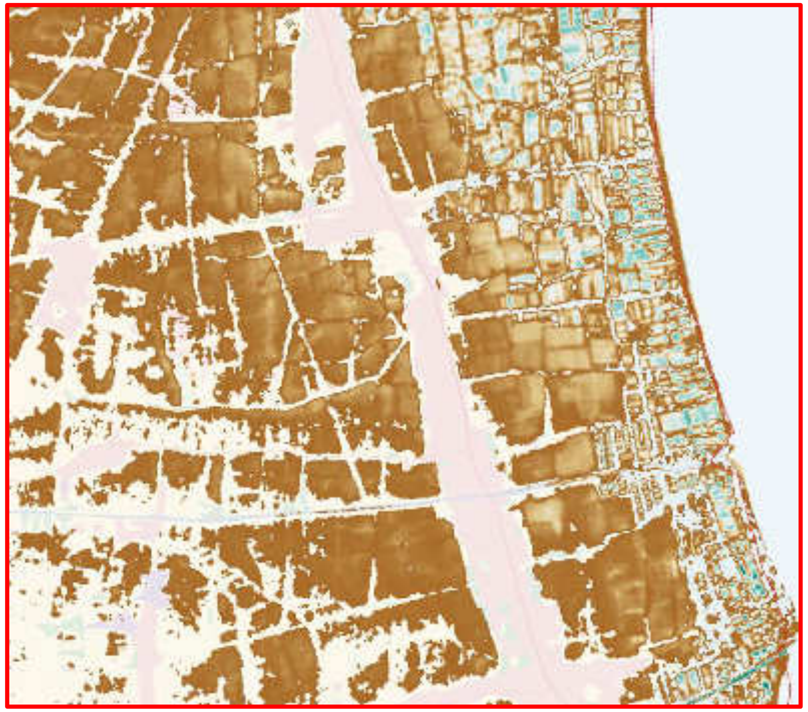


Example analysis: surface water delimitation results integrated for the period of October 2014 and October 2018 representing frequency of water detection over the Jratunseluna river watershed, Central Java, Indonesia (analysis based on the Sentinel-1 data acquired form orbit 076).

Long-term Surface Water Coverage Mapping – Objectives

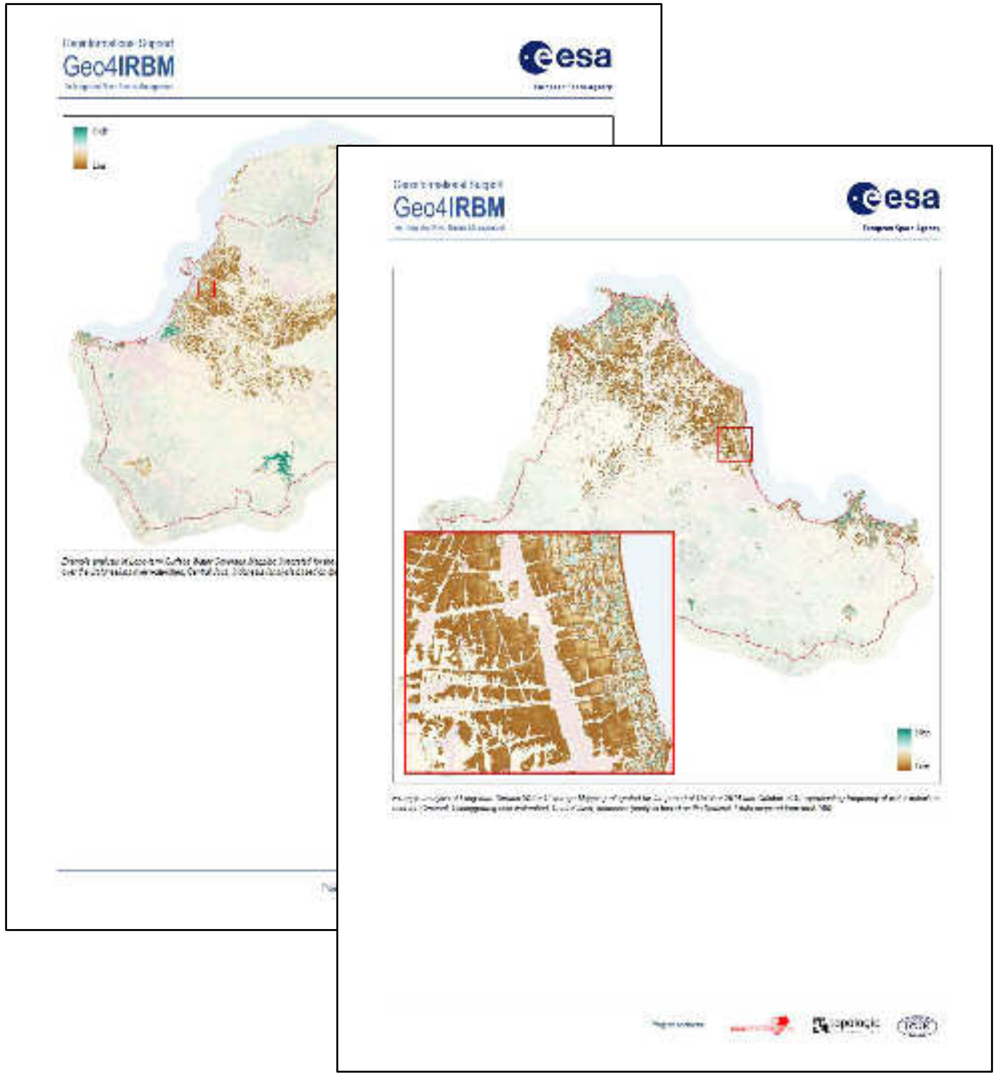


Cimanuk-Cisanggarung rivers watershed



Example analysis: surface water delimitation results integrated for the period of October 2014 and October 2018 representing frequency of water detection over the Cimanuk-Cisanggarung river watershed, Central Java, Indonesia (analysis based on the Sentinel-1 data acquired form orbit 149).

Long-term Surface Water Coverage Mapping – Objectives



Long-term Surface Water Coverage Mapping – Design approach

Product specification and production process design is driven by three factors:

- Planned application fields,
- Availability of data and information sources,
- Resources available during the project.

Service utilized historical data – satellite images of appropriate resolution available in the archive catalogues, and on the operational stage - newly acquired data which will have been collected during the project timespan. Information on surface water extent will be derived by automatic analysis of the imagery.

Service execution is based on Sentinel-1 microwave satellites monitoring capabilities utilization. Such solution provides flexibility given by regular acquisition of SAR data and ensures weather-independent service capacity.

The product is an example analysis utilising monitoring products of the Surface Water Monitoring Service – water masks generated on the base of selected orbits data. Approach allows for strait forward analysis of frequency of detection of surface water in given period of monitoring. Frequency is represented by number of water detections over time.

Long-term Surface Water Coverage Mapping – Product Use

Specific, identified application fields are:

- Agriculture oriented water management thanks to seasonal analysis,
- Analysis of fields inundation extent and time schema,
- Identification of flood risk and hazard for given period / flood event (current or historical),
- Observation of evolution of flood hazard by assessment of multiple historic flood events,
- Input into calibration of flood modelling, which represents different type of hazard estimation,
- Support risk assessment - in combination with structural or socio-economic vulnerability hazard map represents crucial input into flood risk assessment aiming at identification of areas with the highest risks,
- Damage assessment,
- Correlation of floods events with land cover changes,
- Preparation of rescue and evacuation training scenarios.

Long-term Surface Water Coverage Mapping – Limitations

Features limiting product's reliability, applicability and level of details:

- Main source of input data are Sentinel-1 IW and Sentinel-2 MSI imagery with default orthorectification applied
- Effective ground resolution of the Sentinel-1 and Sentinel 2 MSI data is 10 m which affects level of detail provided by the output product.
- Acquisition frequency of Sentinel-1 constellation and Sentinel-2 is at best 6 days. Data cannot be acquired between set acquisition dates.
- The Sentinel-1 data archive spans back to October 2014. For covering of events before acquisition period alternative data sources with (usually) much lower and irregular acquisition frequency must be considered.
- SAR imaging is sensitive to waves on water surface, which could limit ability of water detection.
- SAR data of Sentinel-1 resolution could not be sufficient for detection of inundation in densely built-up areas.
- SAR data such as Sentinel-1 are not affected by cloud coverage, but they have limited interpretability of flood inundation in certain areas or under certain conditions:
    - omission errors – connected with problematic detection of water surface under dense trees crowns cover, in radar shadow, wavy water),
    - errors of commission – caused by annexation of shadowed or due to other reasons similar to water surface to the actual flooded area, or merging the flooded area with normally existing rivers or reservoirs (especially in urban or complex backscattering areas).
- To avoid misinterpretation datasets from one orbit per watershed was selected, which have influence on the monitoring interval.

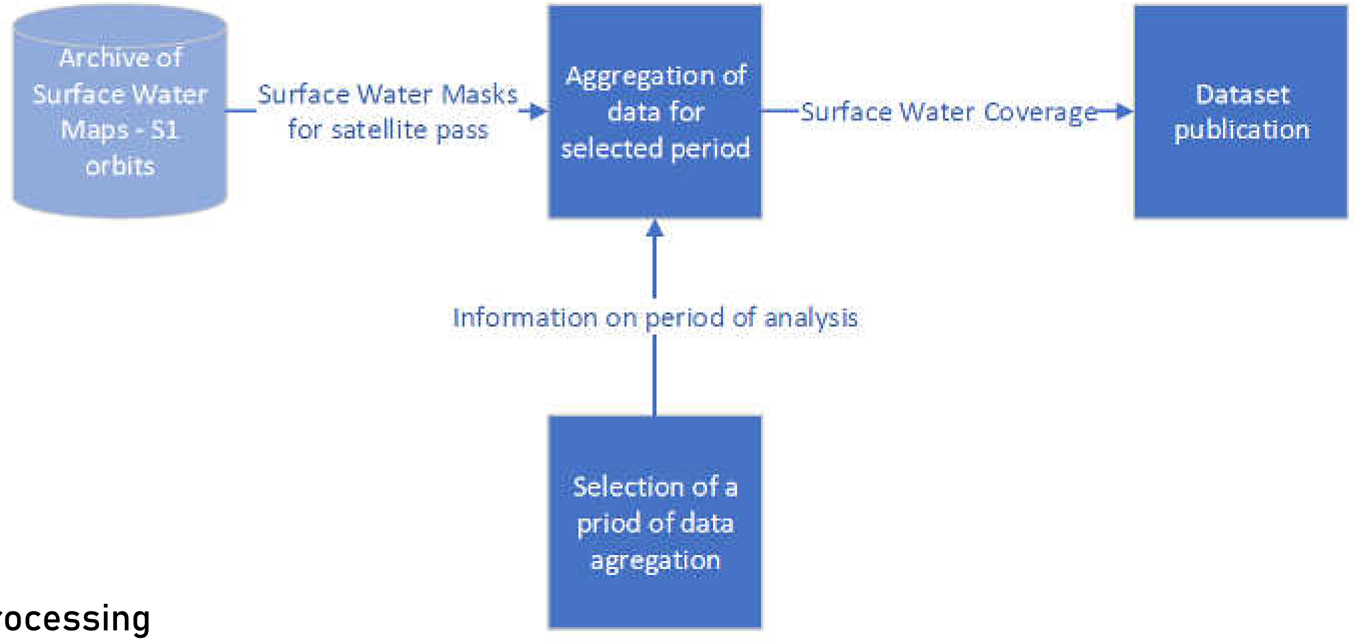
Long-term Surface Water Coverage Mapping – Requirements

ID	Requirement	Fulfilment
SWC01	Maps should cover areas defined by the end-user.	Yes
SWC02	The major source of the EO data should be Sentinel-1SAR imageries on GRD processing level, orthorectified and normalized.	Yes
SWC03	As direct input to the analysis monitoring products of the Surface Water Monitoring Service should be utilised – water masks generated on the base of selected orbits data.	Yes
SWC04	As direct input to the analysis monitoring products of the Surface Water Monitoring Service from particular orbits should be utilised – 076 for Seluna WS and 149 for Cimanuk WS.	Yes
SWC05	The map should be derived automatically originally as raster output.	Yes
SWC06	The original classification result should be an object of refinement – removing normally appearing errors, due to radar shadows and high, dense vegetation.	Yes
SWC07	Analysis should provide information on frequency of detection of surface water in given period of monitoring, which should be represented by number of water detections over time.	Yes
SWC08	Map should be stored in UTM coordination system.	Yes
SWC09	Thematic accuracy of the map should be higher than 80%.	Yes

Long-term Surface Water Coverage Mapping – Specification

Feature	Value / description
Content	Spatial representation of frequency of detection of surface water. *DN* Value – number of surface water detection in a cell during monitoring period
Geographic Coverage	AOI 1.: Jratunseluna river watershed, Central Java, Indonesia (area of the watershed: 9 367 sqkm, area with 5 km buffer: 12 706 sqkm). AOI 2.: Cimanuk-Cisanggarung, Central Java, Indonesia (area of the watershed: 7 795 sqkm, area with 5 km buffer: 10 575 sqkm).
Input data sources	*Input data:* Sentinel-1 SAR satellite data SRTM (Shuttle Radar Topography Mission) DSM
Methodology	SAR amplitude data thresholding, multitemporal data integration.
Spatial Resolution and Coverage	Not applicable.
Coordinate Reference System	UTM zone 49S / EPSG: 32749
Accuracy, Constraints	Thematic accuracy: > 80% Geometric accuracy: < 20m (dependent on Sentinel-1 scenes automatic orthorectification, noticed very rare incidences of misregistration in the initial phase of Sentinel-1 satellites operation)
Accuracy Assessment Approach	The accuracy assessment is based on comparative analysis of selected surface water maps based on Sentinel-1 data with reference data elaborated with use of the Sentinel-2 imageries. These analysis are possible only for selected dates and for limited extent due to extensive cloud coverage in the region and highly variable .
Frequency	1 month in 2014 to 3 to 8 days in October 2018 (dependently on location).
Availability	2014-now
Delivery / Output Format	GeoTIFF

Long-term Surface Water Coverage Mapping – Specification: Methodology



Schema of applied analysis and processing procedures in course of SWC elaboration

THANK YOU

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Przemysław Turos
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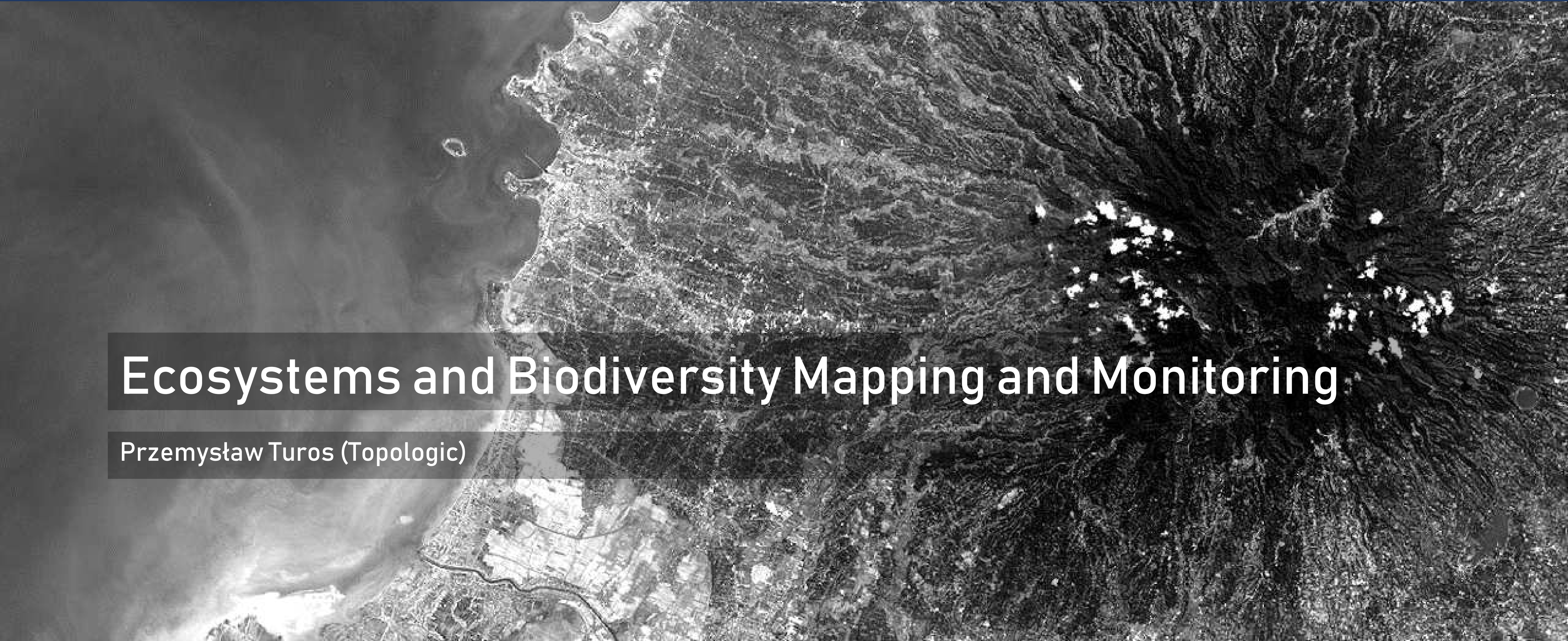
Geoinformational Support

Geo4IRBM

for Integrated River Basins Management

European Space Agency



Ecosystems and Biodiversity Mapping and Monitoring

Przemysław Turos (Topologic)

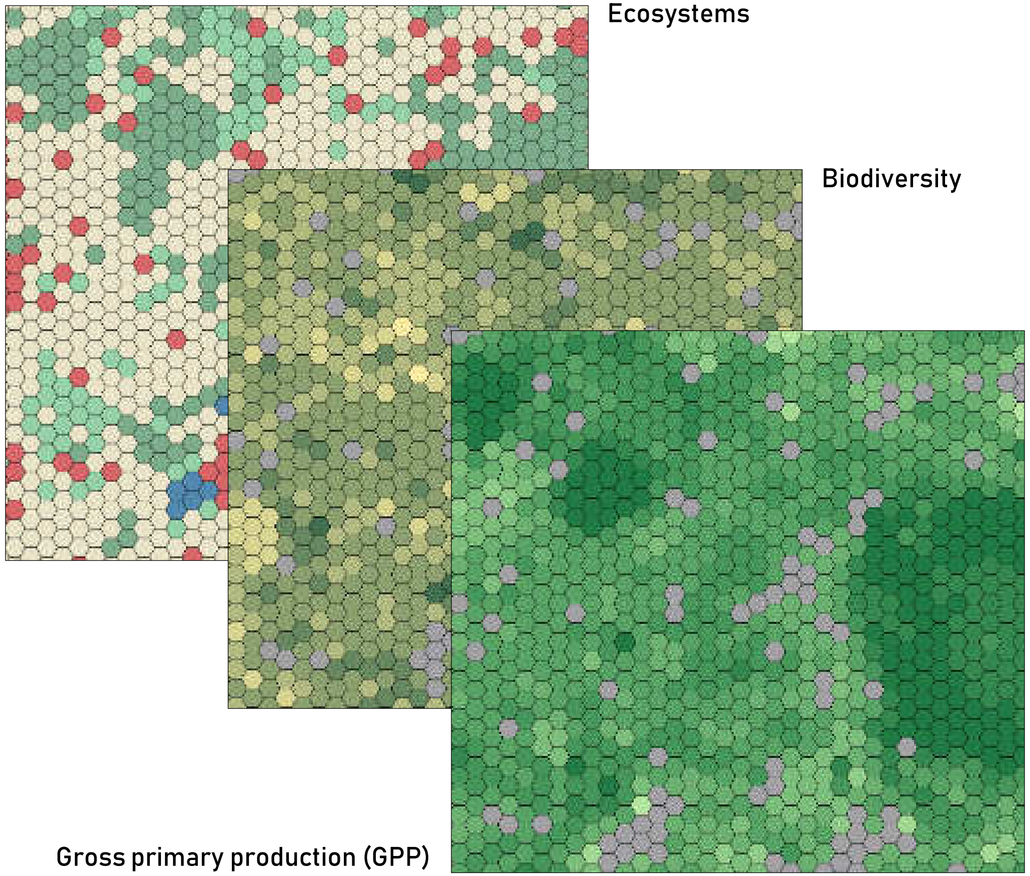
Ecosystems and Biodiversity Mapping and Monitoring – Definitions

Ecosystems and Biodiversity Map 2018 provides information on ecosystems type, biodiversity, ecosystem primary production during the year of monitoring. All information scopes are integrated in cells of a hexagonal reference network.

Ecosystem is the set of species in a given area that interact among themselves, through processes such as predation, parasitism, competition and symbiosis, and with their abiotic environment to disintegrate and become part of cycles of energy and nutrients.

Biodiversity is the variety and variability of life on Earth. Biodiversity is typically a measure of variation at the genetic, species, and ecosystem level

Gross primary production (GPP) is the amount of chemical energy as biomass that primary producers create in a given length of time. Some fraction of this fixed energy is used by primary producers for cellular respiration and maintenance of existing tissues. The remaining fixed energy is referred to as net primary production (NPP).



Ecosystems and Biodiversity Mapping and Monitoring – Background

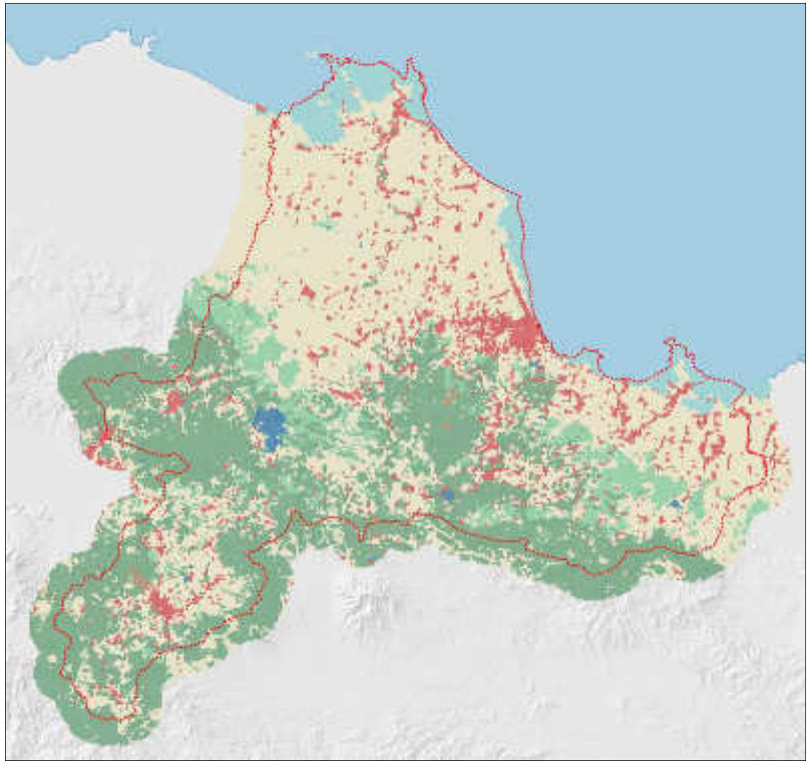
Mapping and monitoring of natural resources is important activity of implementation of The Convention on Biological Diversity coordinated by United Nations Environment Programme (UNEP).

Proposed products could be an directly applicable in the following fields of Convention, especially in the following aspects (as structured in The 5th National Report of Indonesia to The Convention on Biological Diversity):

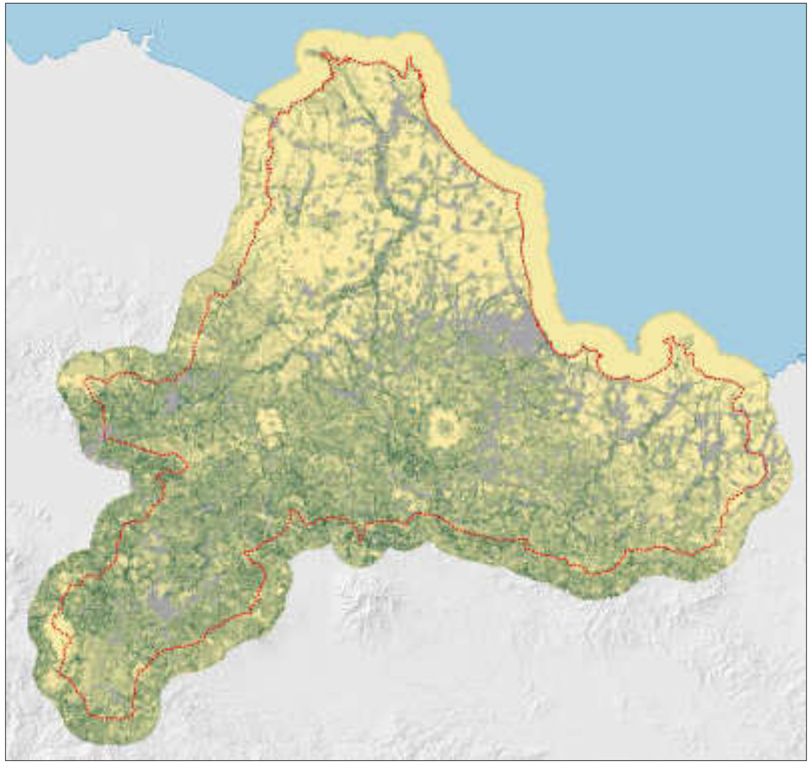
- Forests and Land Rehabilitation
- Community Based Biodiversity Management
- Biodiversity Information System
- Biodiversity Management Policy
- Biodiversity Management Strategy

Ecosystems and Biodiversity Mapping and Monitoring – Objectives

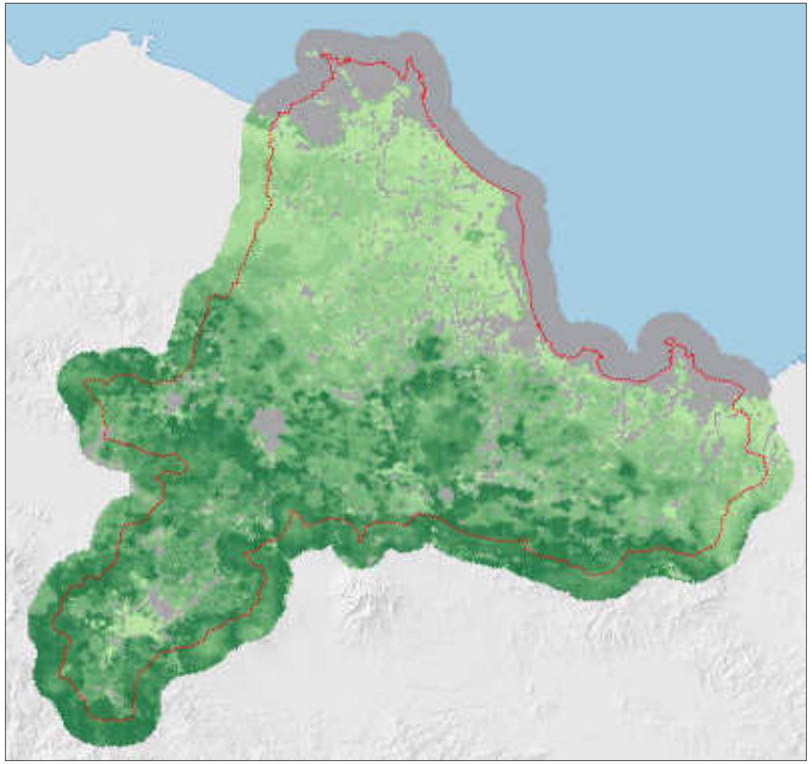
Ecosystems and Biodiversity Map 2018 provides information on ecosystems type, biodiversity, ecosystem primary production during the year of monitoring. All information scopes are integrated in cells of a hexagonal reference network.



Ecosystems types determined with use of the Land Cover Map 2018



Biodiversity indicator – variability of natural LC classes and classes with domination of vegetation (only for cells representing non-urban ecosystems.)



Gross Primary Production for the year of observation (kgC/m2/y) only for cells representing non-urban and non-water ecosystems (MODIS GPP).

Ecosystems and Biodiversity Mapping and Monitoring – Objectives

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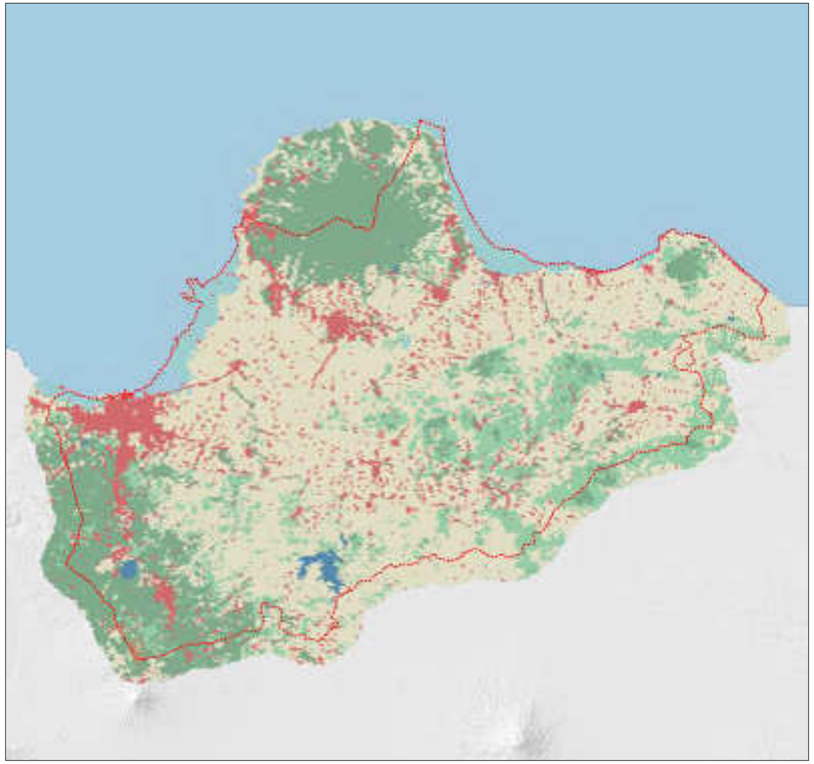

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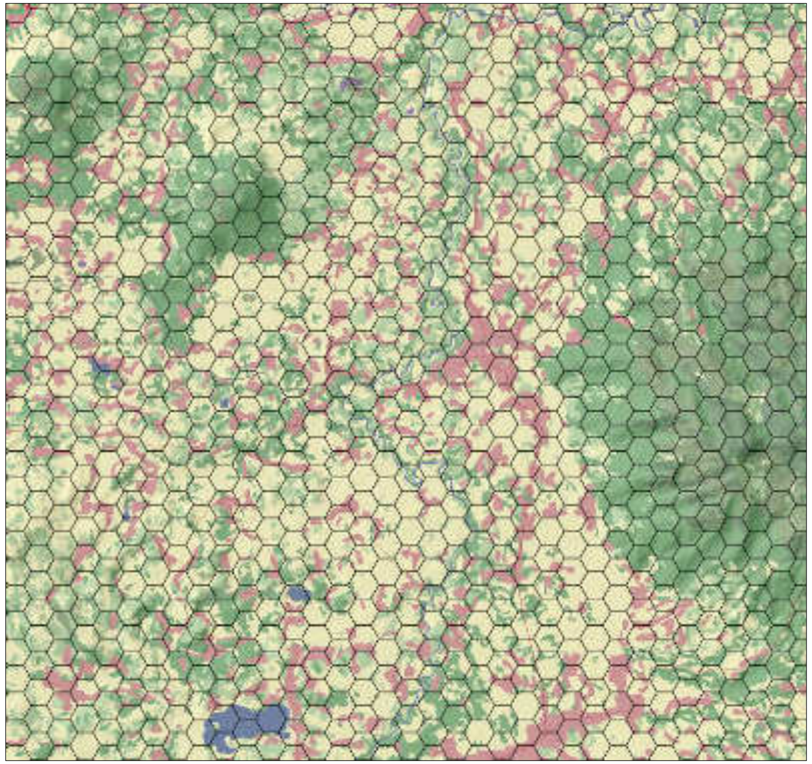

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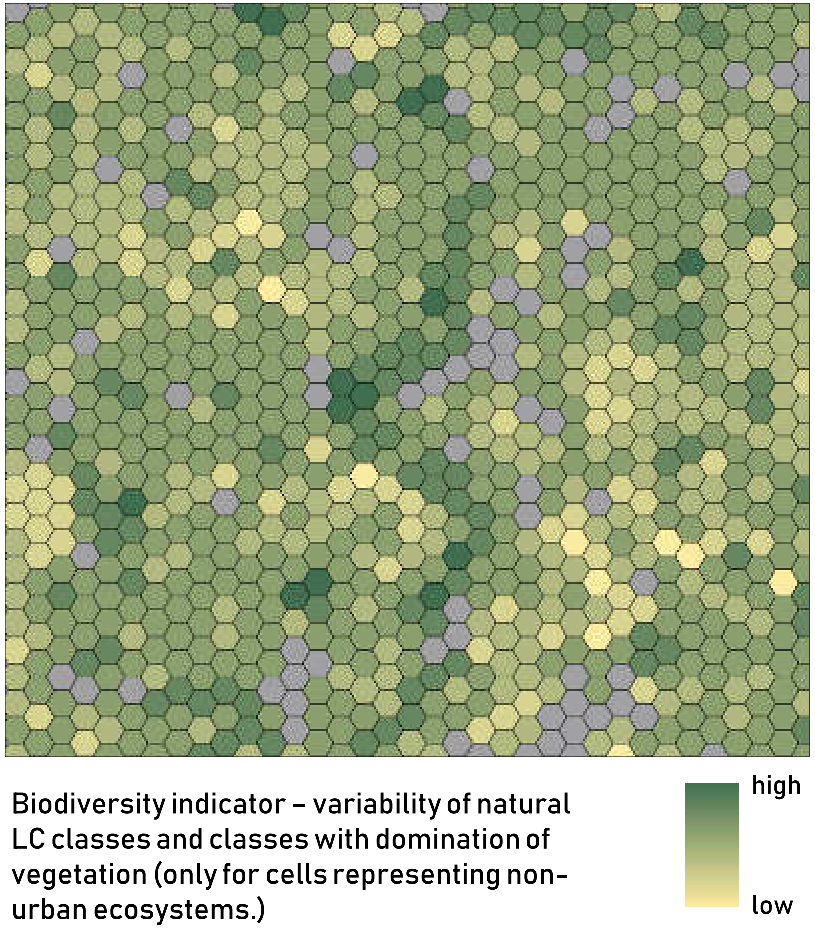

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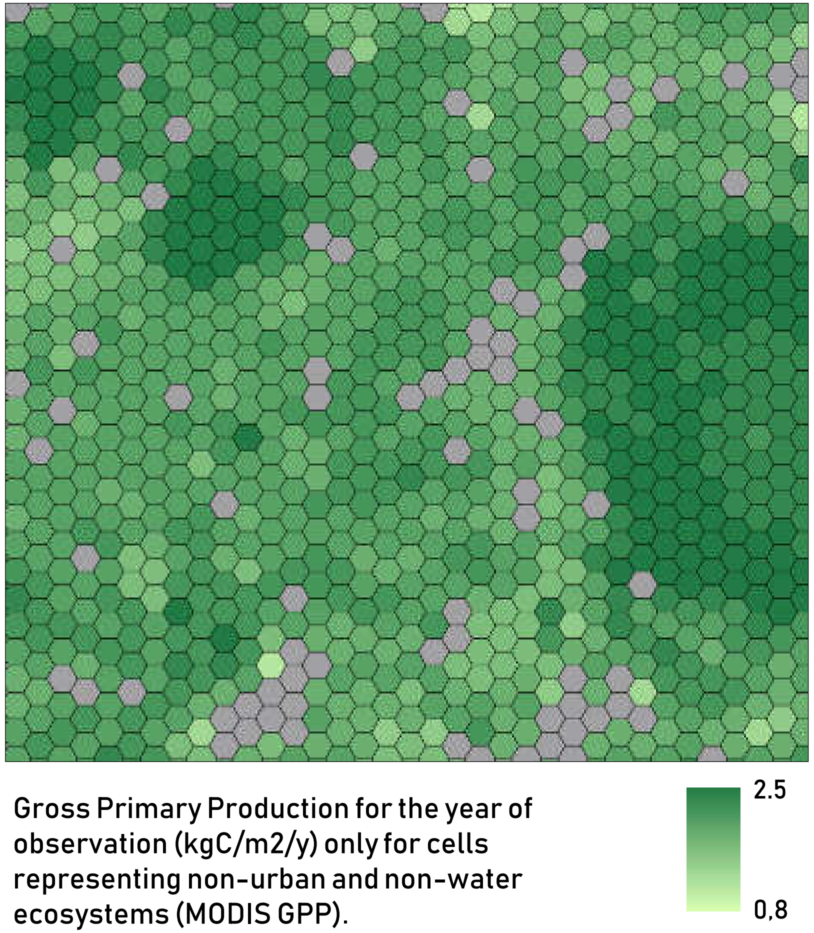

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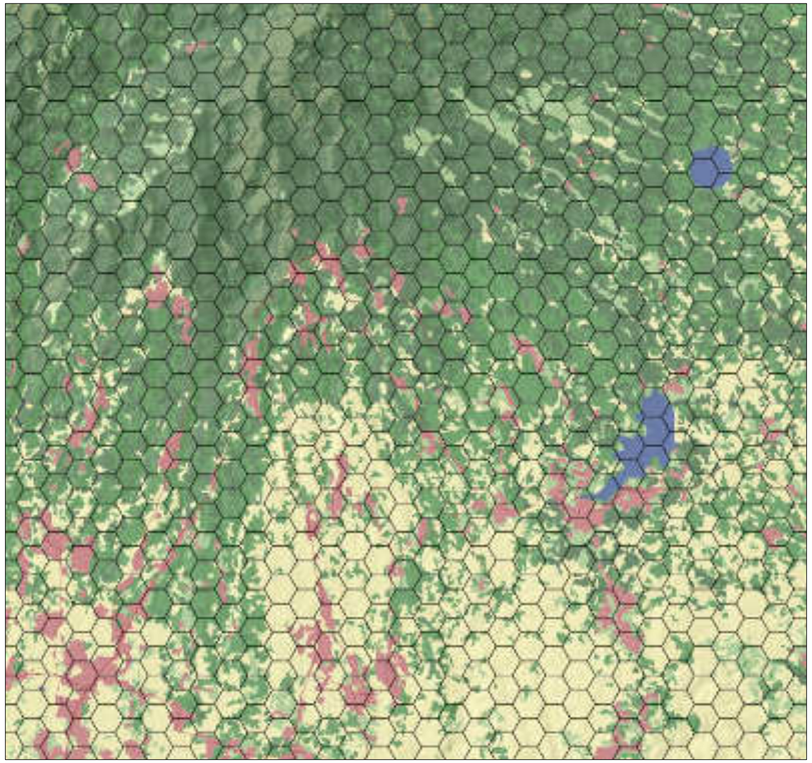
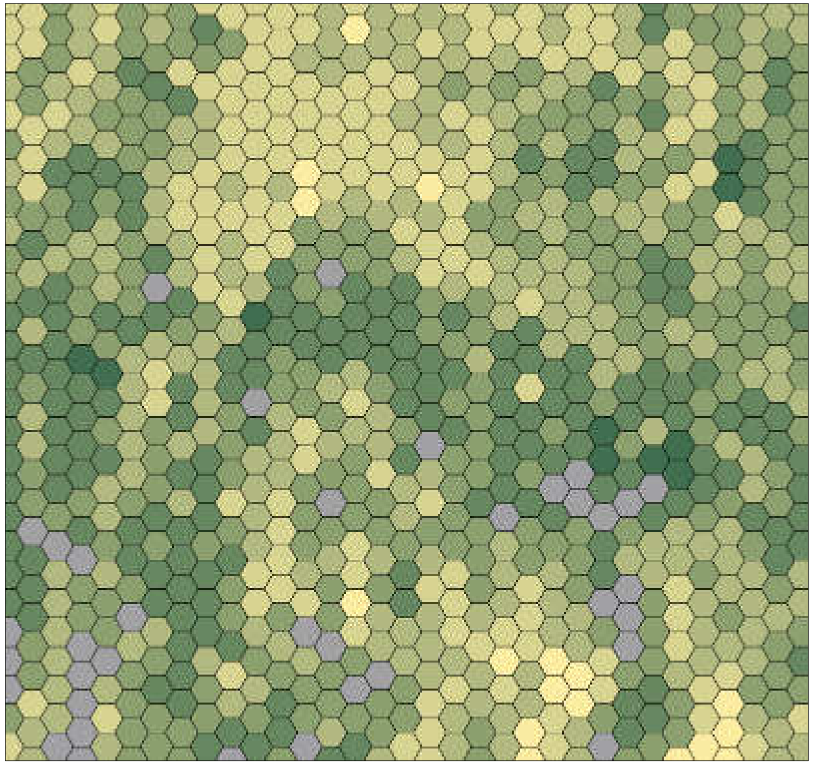


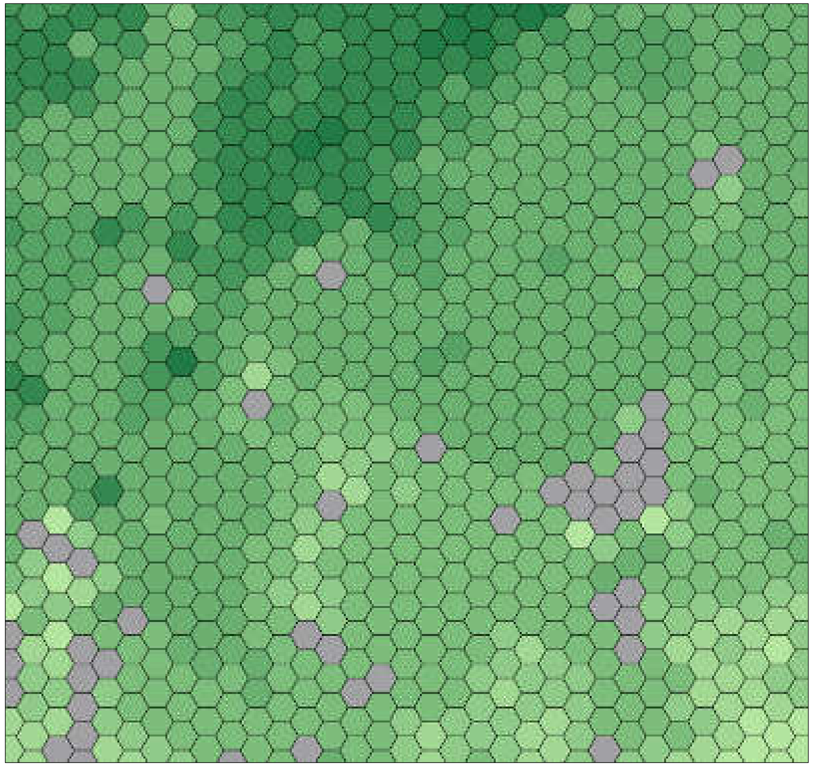
Ecosystems types determined with use of the Land Cover Map 2018



Biodiversity indicator – variability of natural LC classes and classes with domination of vegetation (only for cells representing non-urban ecosystems.)

high

low

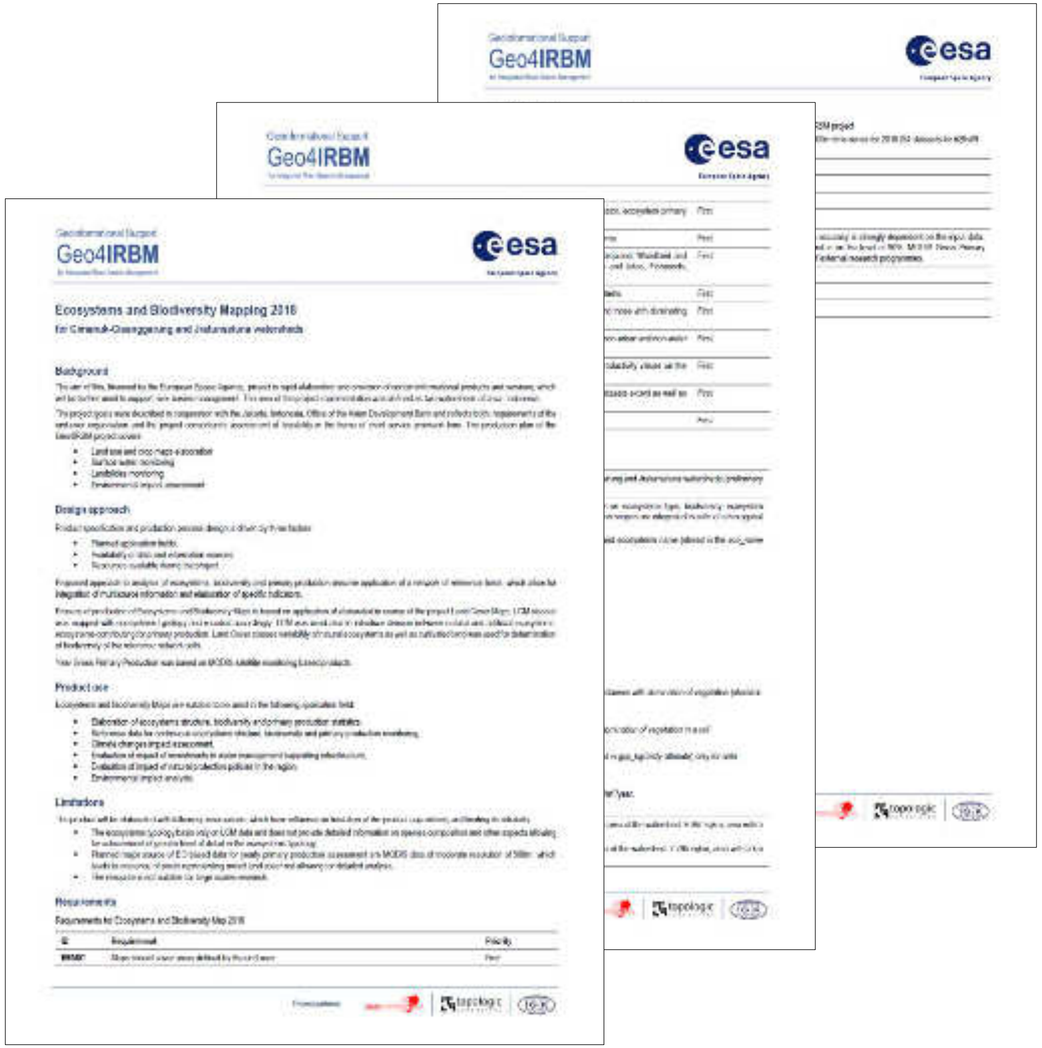


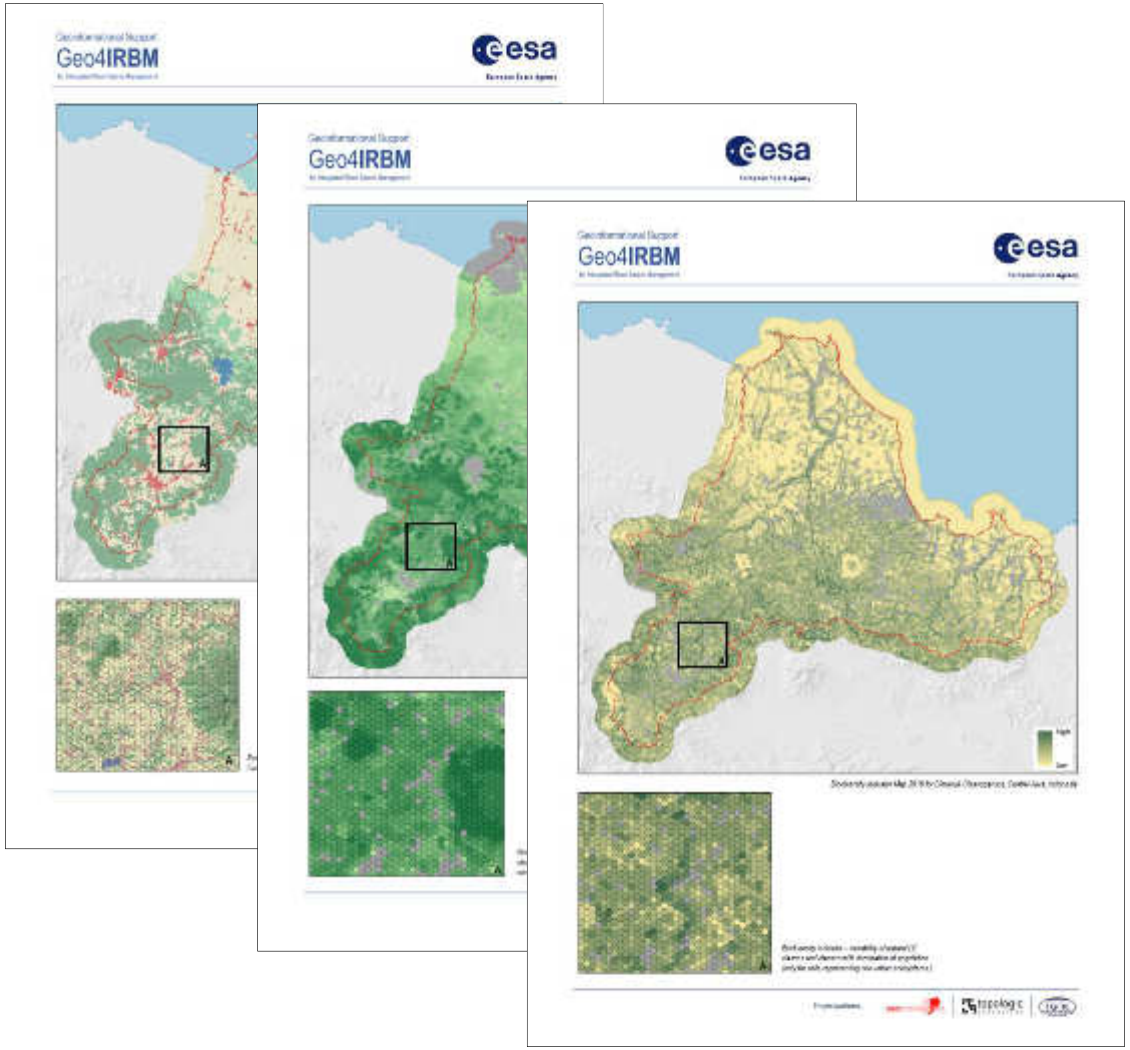
Gross Primary Production for the year of observation (kgC/m2/y) only for cells representing non-urban and non-water ecosystems (MODIS GPP).

2.5

0,8

Ecosystems and Biodiversity Mapping and Monitoring – Objectives



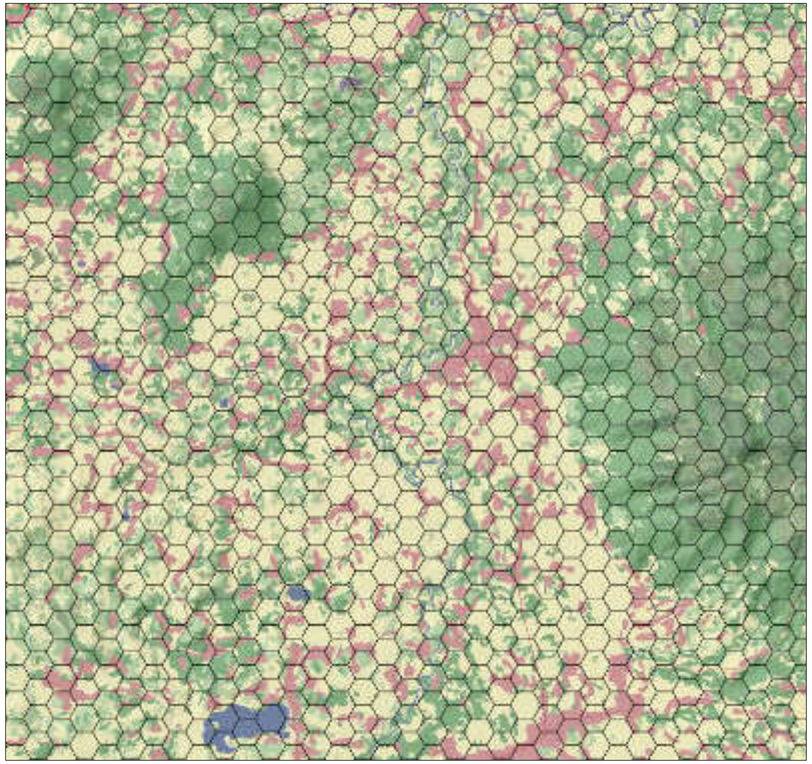


Ecosystems and Biodiversity Mapping and Monitoring – Design approach

Product specification and production process design is driven by three factors:

- Planned application fields,
- Availability of data and information sources,
- Resources available during the project.

Proposed approach to analysis of ecosystems, biodiversity and primary production assume application of a network of reference fields, which allow for integration of multisource information and elaboration of specific indicators.



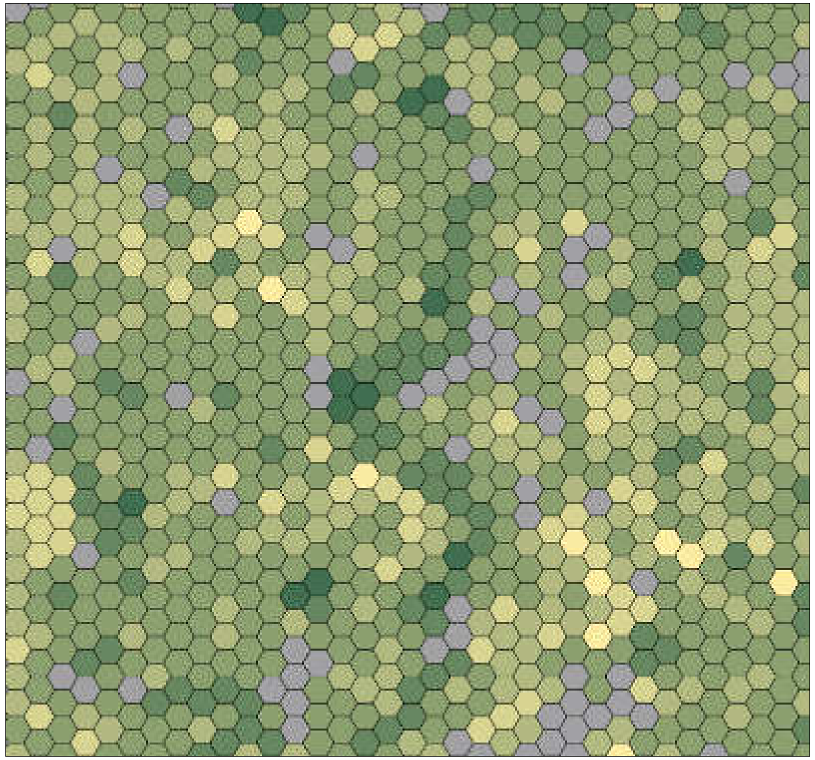
Process of production of Ecosystems and Biodiversity Maps is based on application of elaborated in course of the project Land Cover Maps. LCM classes was mapped with ecosystems typology and recoded accordingly. LCM was used also to introduce division between natural and artificial ecosystems, ecosystems contributing for primary production. Land Cover classes variability of natural ecosystems as well as cultivated land was used for determination of biodiversity of the reference network cells.

Year Gross Primary Production was based on MODIS satellite monitoring products.

Ecosystems and Biodiversity Mapping and Monitoring – Product Use

Ecosystems and Biodiversity Maps are suitable to be used in the following application field:

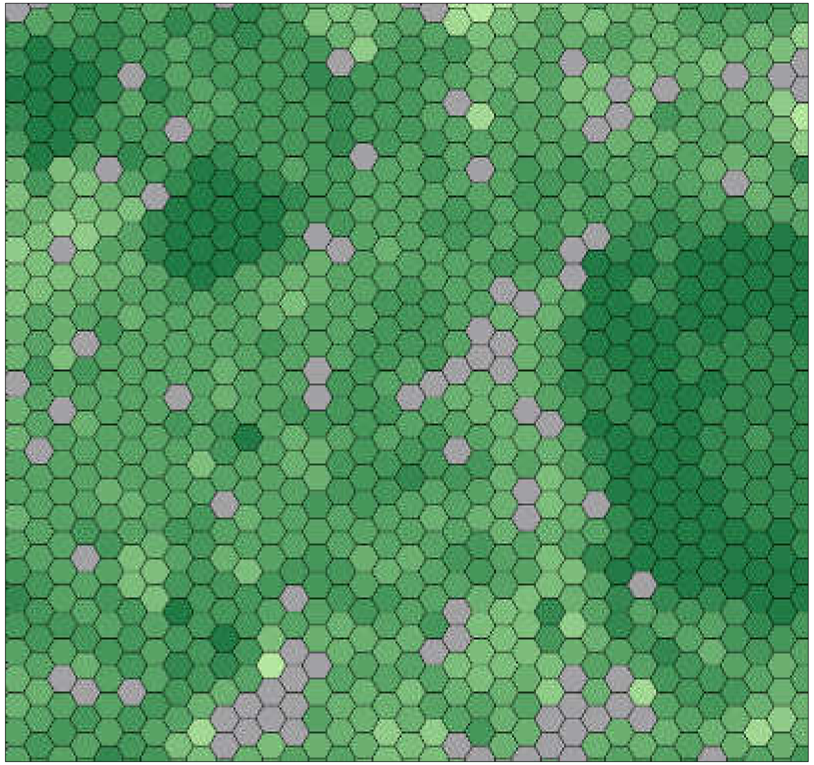
- Elaboration of ecosystems structure, biodiversity and primary production statistics,
- Reference data for continuous ecosystems stricture, biodiversity and primary production monitoring,
- Climate changes impact assessment,
- Evaluation of impact of investments in water management supporting infrastructure,
- Evaluation of impact of natural protection policies in the region,
- Environmental impact analysis.



Ecosystems and Biodiversity Mapping and Monitoring – Limitations

Below there is presented a list of conditions limiting product's reliability, applicability and level of details:

- The ecosystems typology basis only on LCM data and does not provide detailed information on species composition and other aspects allowing for achievement of greater level of detail in the ecosystems typology,
- Planned major source of EO based data for yearly primary production assessment are MODIS data of moderate resolution of 500m, which leads to existence of pixels representing mixed land cover not allowing for detailed analysis,
- The resource is not suitable for large scales research.



Ecosystems and Biodiversity Mapping and Monitoring – Requirements

ID	Requirement	Fulfilment
EBM01	Maps should cover areas defined by the end-user.	Yes
EBM02	Maps should cover the following subjects: ecosystems delimitation, biodiversity indicator, ecosystem primary production in one reference grid with resolution of 500m.	Yes
EBM03	Main sources for the ecosystem determination the Land Cover Map 2018 should become.	Yes
EBM04	Ecosystems map typology should cover at least the following ecosystems types: Cropland, Woodland and forest, Heathland and shrub, Grassland, Sparsely vegetated land, Urban, Rivers and lakes, Fishponds, Wetlands, Rivers and lakes, Coastal.	Yes
EBM05	Biodiversity indicator should be provided only for cells representing non-urban ecosystems.	Yes
EBM06	Biodiversity indicator should be based on diversity of LC types of natural character and those with dominating vegetation; the source of LC information the LCM should become.	Yes
EBM07	Primary productivity related information should be provided only for cells representing non-urban and non-water ecosystems.	Yes
EBM08	Primary productivity related information should be represented by Gross Primary Productivity values on the base of MODIS GPP products and be stored in kgC/m^2/year.	Yes
EBM09	The datasets should allow for deriving information for an AOI covering entirely the datasets extent as well as the datasets subset.	Yes
EBM10	All input data applied should be accessible for future updates.	Yes

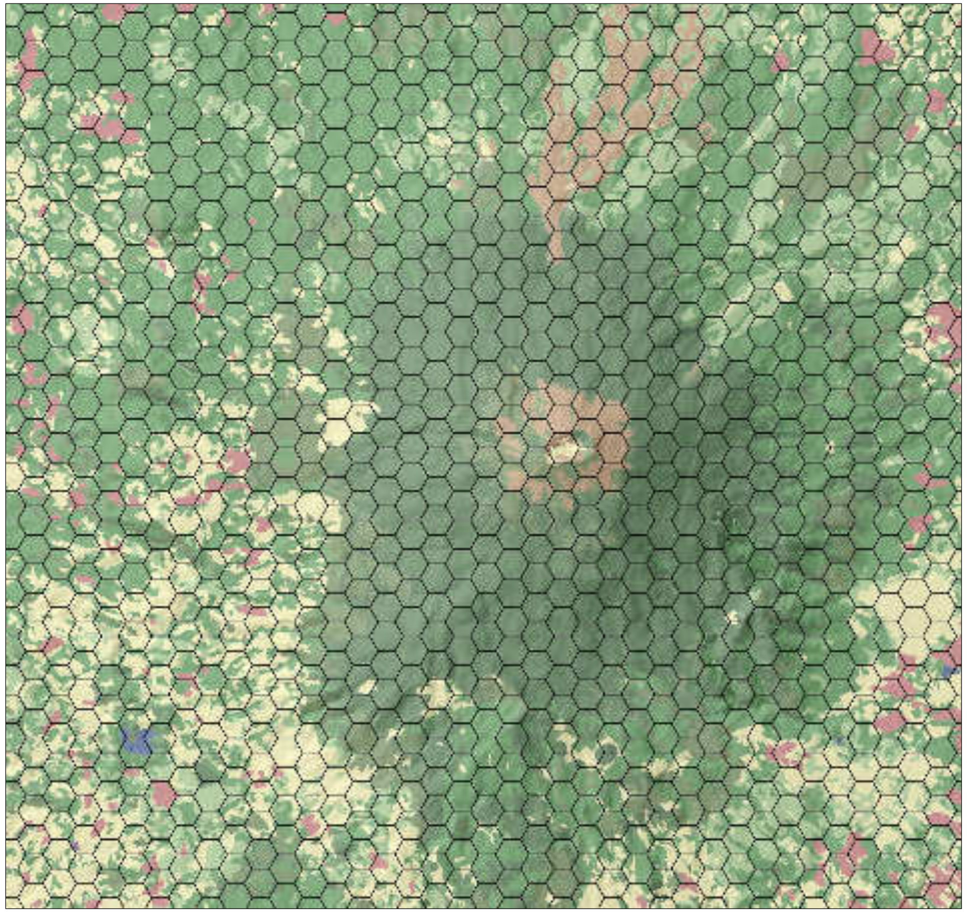
Ecosystems and Biodiversity Mapping and Monitoring – Specification

Feature	Value / description
Content	Ecosystems and Biodiversity Map 2018 provides information on ecosystems type, biodiversity, ecosystem primary production during the year of monitoring. All information scopes are integrated in cells of a hexagonal reference network. Ecosystems types code (stored in the *eco_code* attribute) and ecosystems name (stored in the *eco_name* attribute) *eco_code* *eco_name* *1* *Cropland* *2* *Woodland and forest* *3* *Heathland and shrub* *4* *Grassland* *5* *Sparsely vegetated land* *6* *Urban* *7* *Rivers and lakes* *8* *Fishponds* *9* *Wetlands* *10* *Coastal* Biodiversity indicator – variability of natural LC classes and classes with domination of vegetation (stored in *biodiv* attribute) *biodiv* *Value – number of natural LC classes and classes with domination of vegetation in a cell* Gross Primary Production for the year of observation (stored in *gpp_kgCm2y* attribute) only for cells representing non-urban and non-water ecosystems. *gpp* *Value – level of gross primary production* provided in kgC/m^2/year.

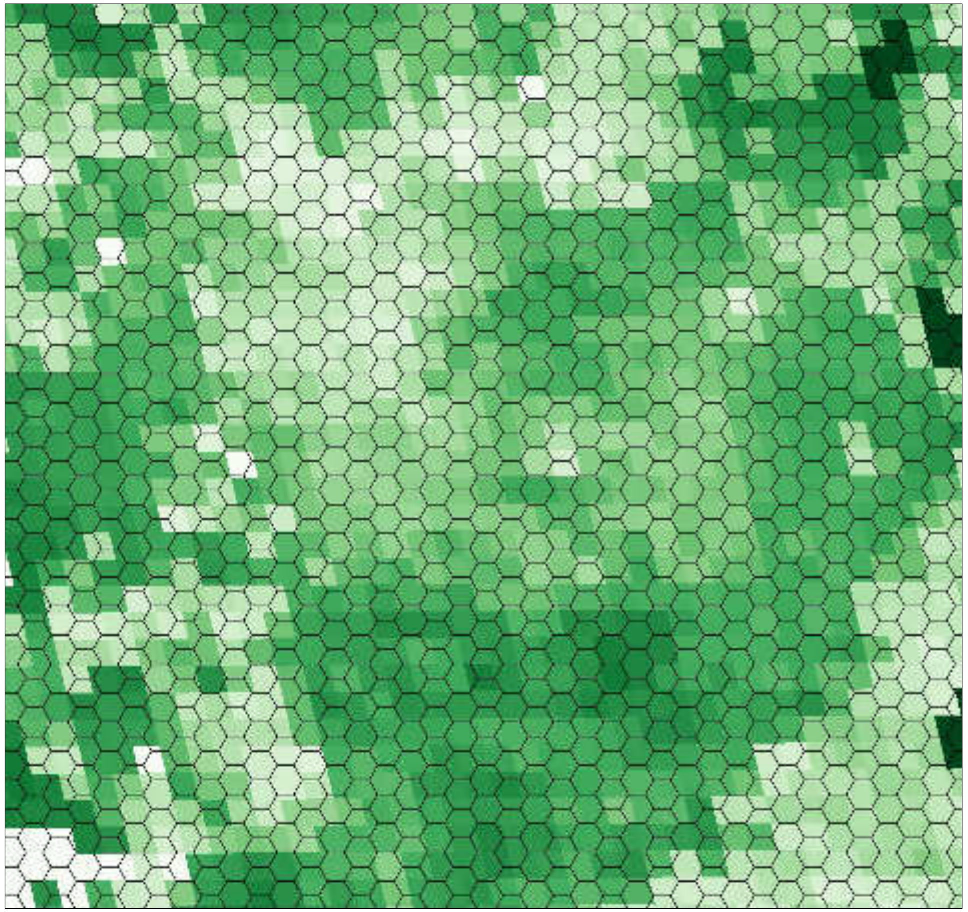
Ecosystems and Biodiversity Mapping and Monitoring – Specification

Feature	Value / description
Geographic Coverage	AOI 1.: Jratunseluna river watershed, Central Java, Indonesia (area of the watershed: 9 367 sqkm, area with 5 km buffer: 12 706 sqkm). AOI 2.: Cimanuk-Cisanggarung, Central Java, Indonesia (area of the watershed: 7 795 sqkm, area with 5 km buffer: 10 575 sqkm).
Input data sources	*Input data:* Land Cover Map 2018 elaborated in course of Geo4IRBM project MODIS Gross Primary Productivity 8-Day L4 Global 500m time series for 2018 (94 datasets for h28v09 tile and 23 datasets for h28v09 tile)MODIS
Methodology of Classification	Multisource data fusion
Spatial Resolution and Coverage	500m
Coordinate Reference System	UTM zone 49S / EPSG: 32749
Accuracy, Constraints	Thematic accuracy: > 75% (assumed, not fully verified)
Accuracy Assessment Approach	Accuracy assessment of the product was not verified. The accuracy is strongly dependent on the input data. Land Cover Map 2018 overall accuracy was assessed and is on the level of 90%. MODIS Gross Primary Productivity 8-Day L4 Global 500m accuracy is an object of external research programmes.
Frequency	It is suggested to update – annually
Availability	2018
Delivery / Output Format	Shapefile

Ecosystems and Biodiversity Mapping and Monitoring – Specification: Input data sources

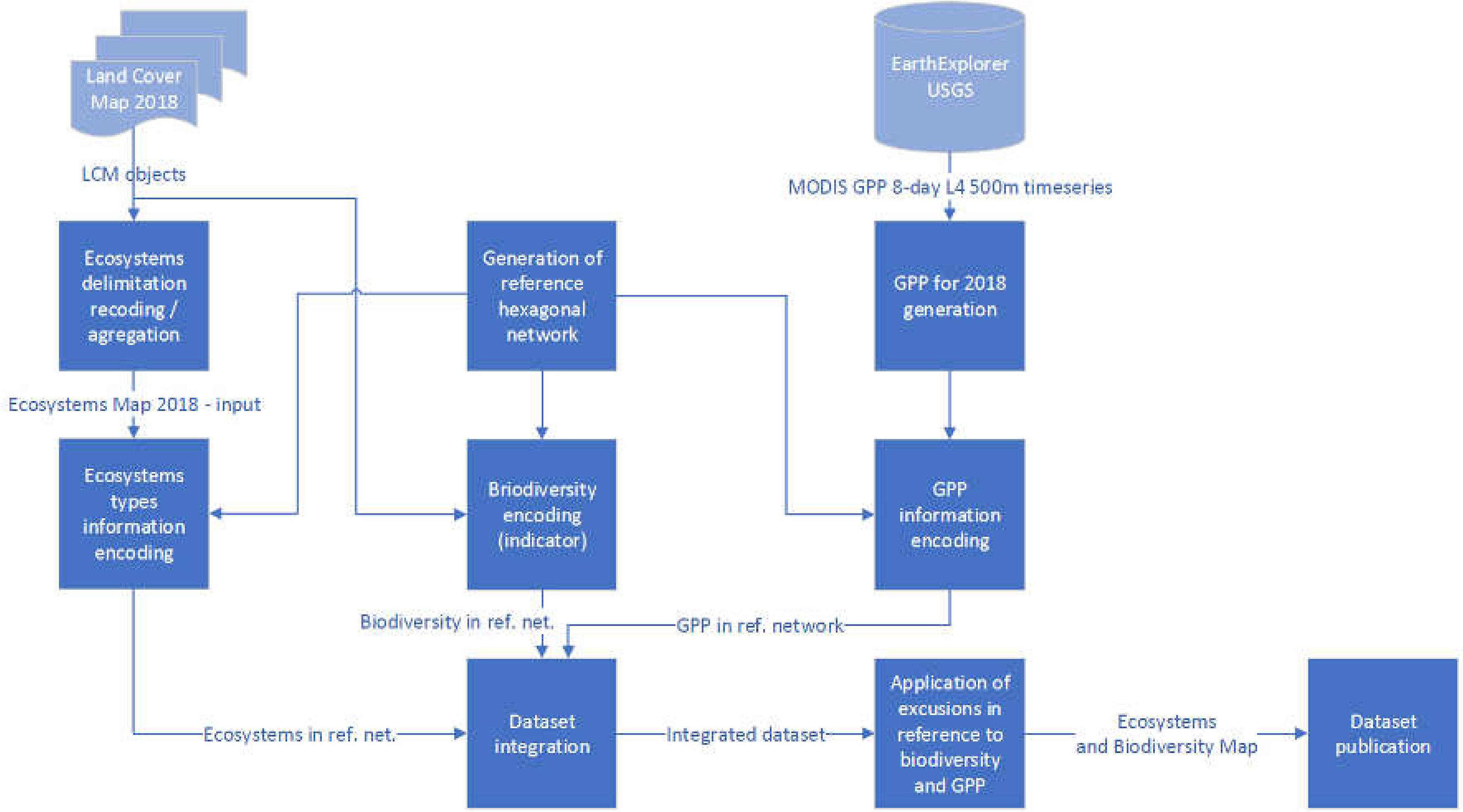


Ecosystems types and Biodiversity indicator – variability of natural LC classes and classes with domination of vegetation (only for cells representing non-urban ecosystems) were determined with use of the Land Cover Map 2018



Gross Primary Production for the year of observation (kg C/m2/y) only for cells representing non-urban and non-water ecosystems was determined with use of MODIS Gross Primary Productivity 8-Day L4 Global 500m .

Ecosystems and Biodiversity Mapping and Monitoring – Specification: Methodology



Schema of applied analysis and processing procedures in course of EBM elaboration

THANK YOU

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CONSULTING

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