Digital Landscape Architecture Conference 2019

An Iterative Landscape Planning Process for Sustaining Flood Regulation in the Ci Kapundung Upper water Catchment Area, Bandung Basin, Indonesia

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Content

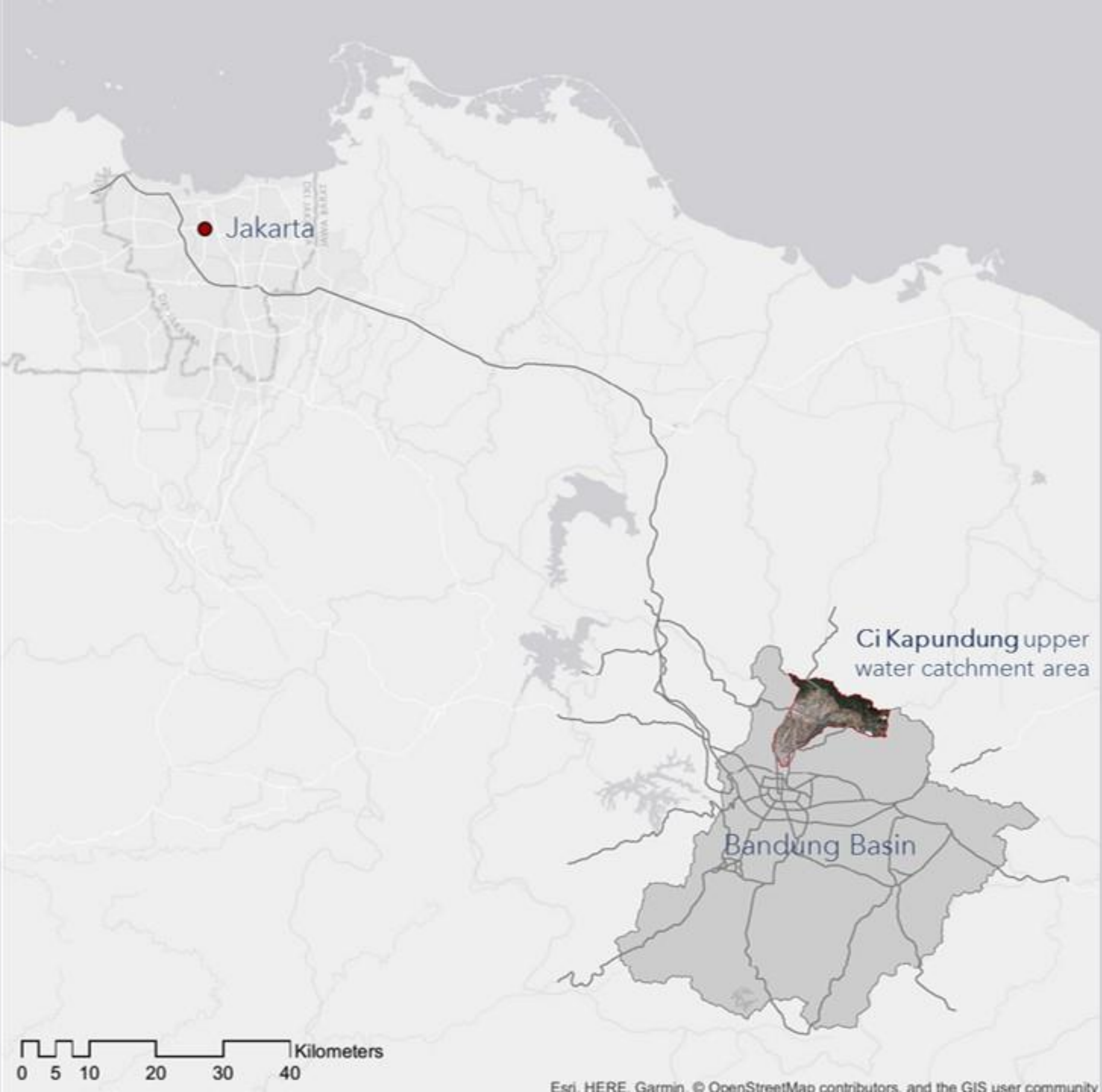
Introduction	The assessment of potential landscape planning strategies for the Ci Kapundung upper catchment area to regulate flooding in Bandung Basin, Indonesia
Methods	An iterative and interactive process to propose large-scale landscape interventions
Results and Discussion	Preliminary results from the hydrologic simulation
Conclusion	

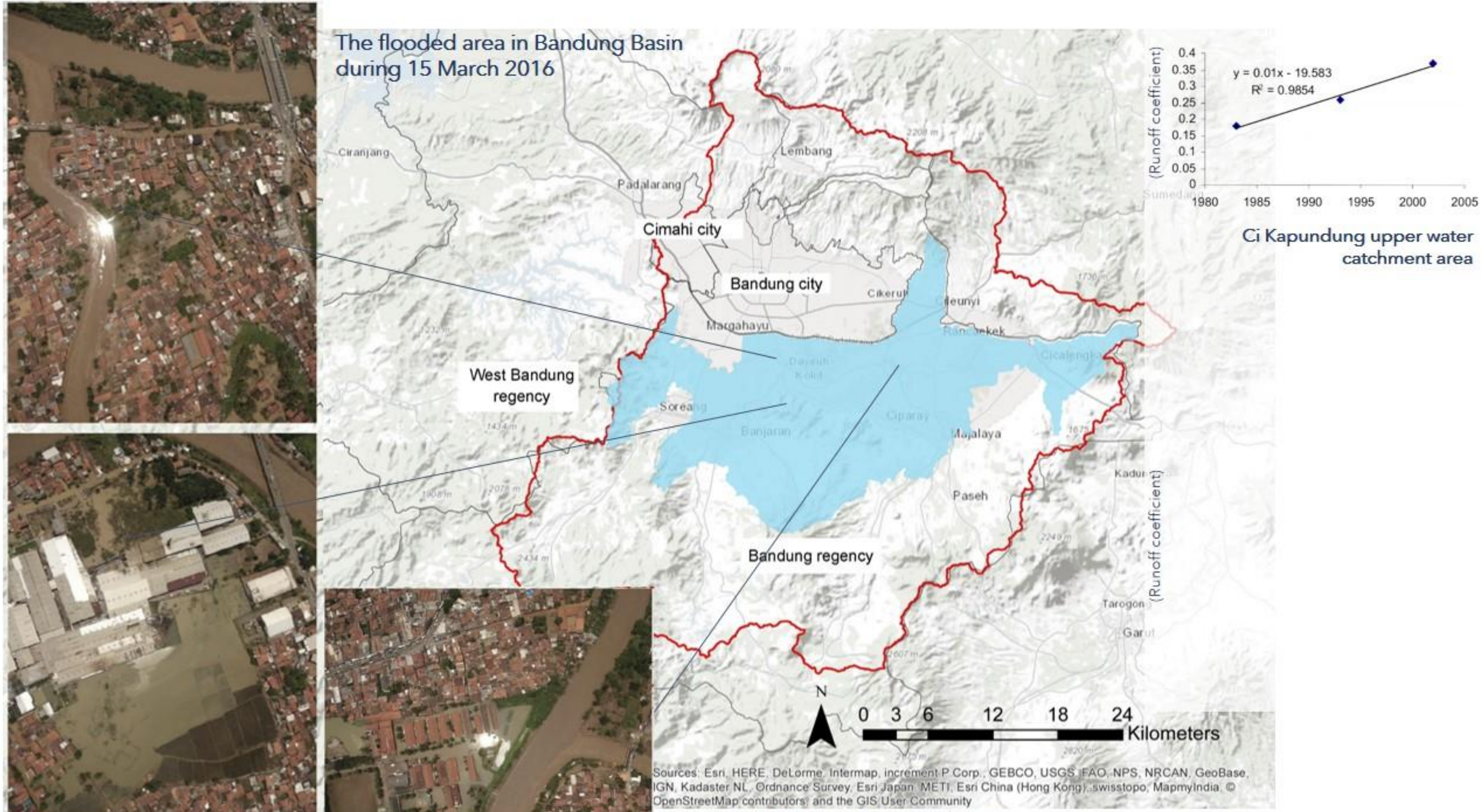
Introduction

Indonesia

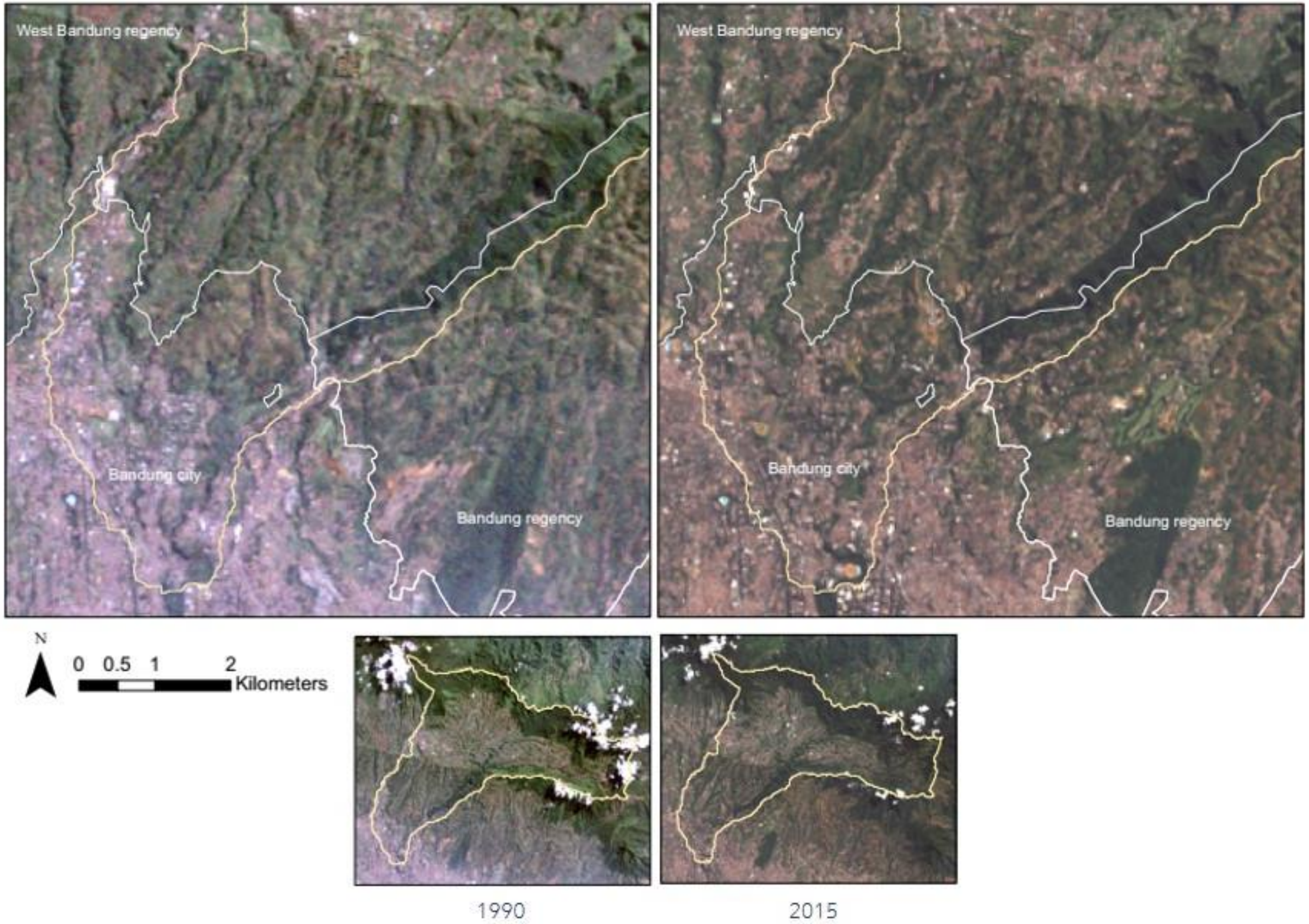
The Ci Kapundung upper water catchment area

102.86 sq km
760 – 2,206 masl

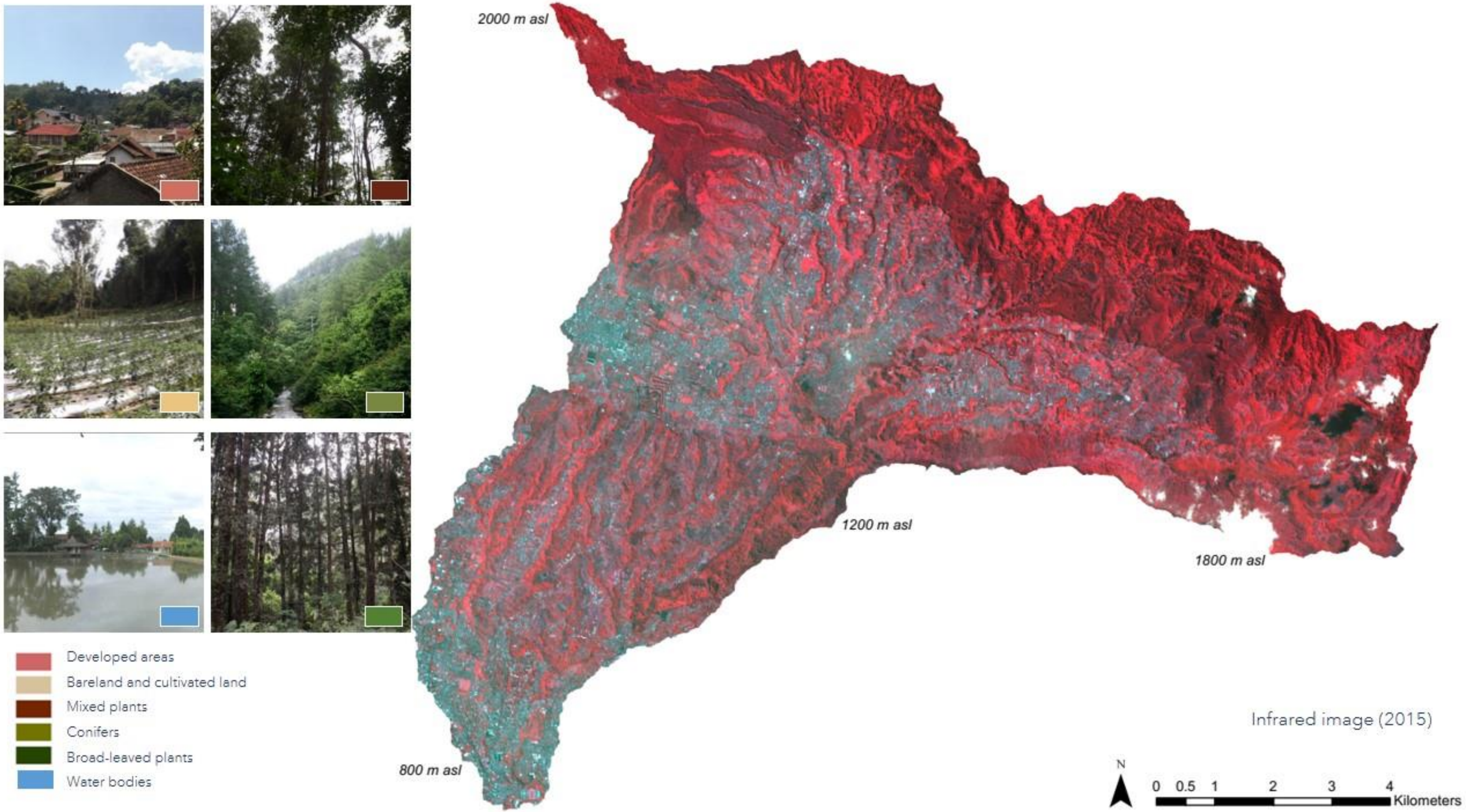




Pusdantinmas BNPB (2016); Haryanto et al. (2010)

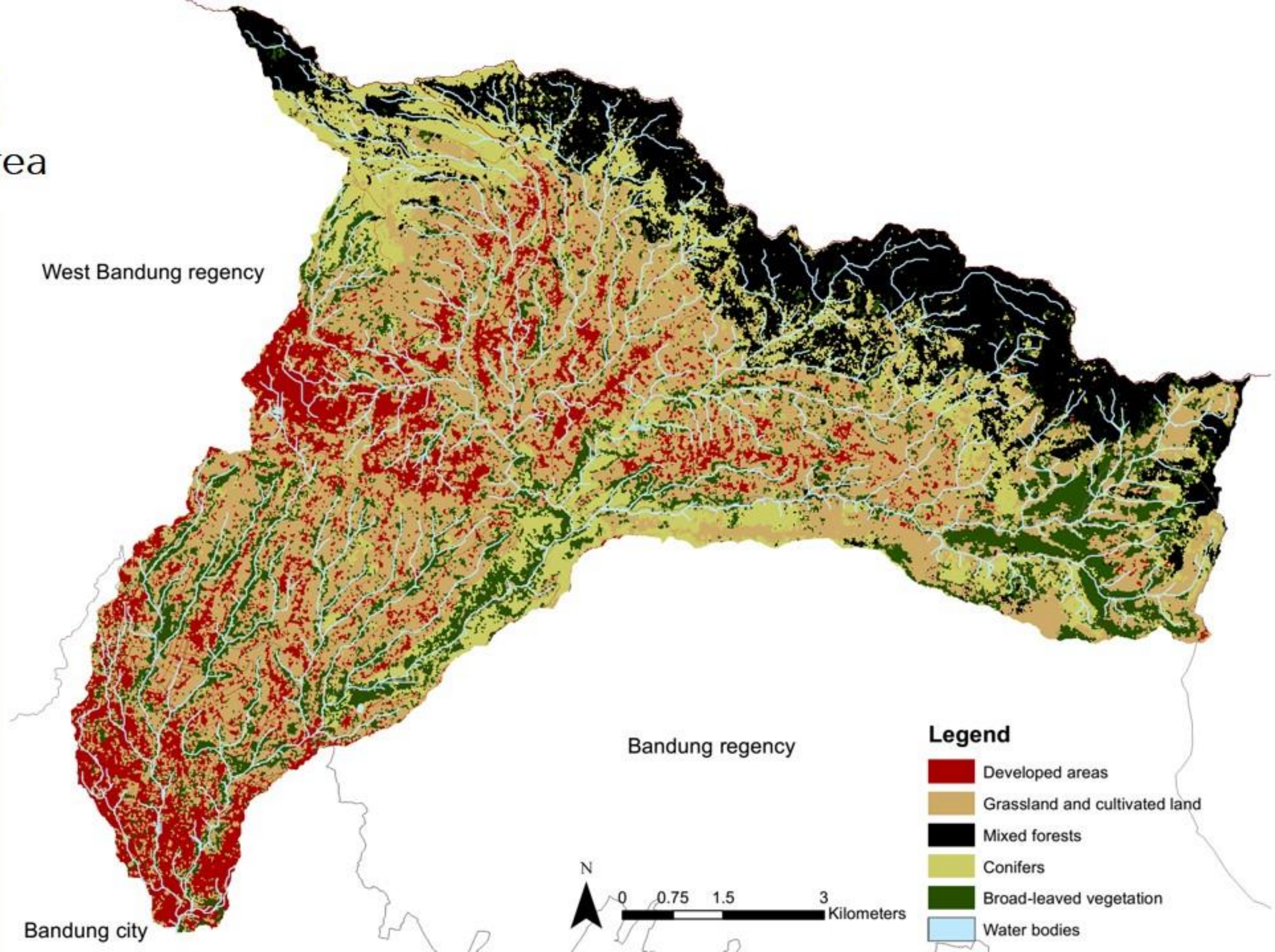


Landsat imagery of the case study area (Source: USGS)



Developed areas
Bareland and cultivated land
Mixed plants
Conifers
Broad-leaved plants
Water bodies
2000 m asl
1200 m asl
1800 m asl
800 m asl
Infrared image (2015)
N
0 0.5 1 2 3 4 Kilometers

Case study area



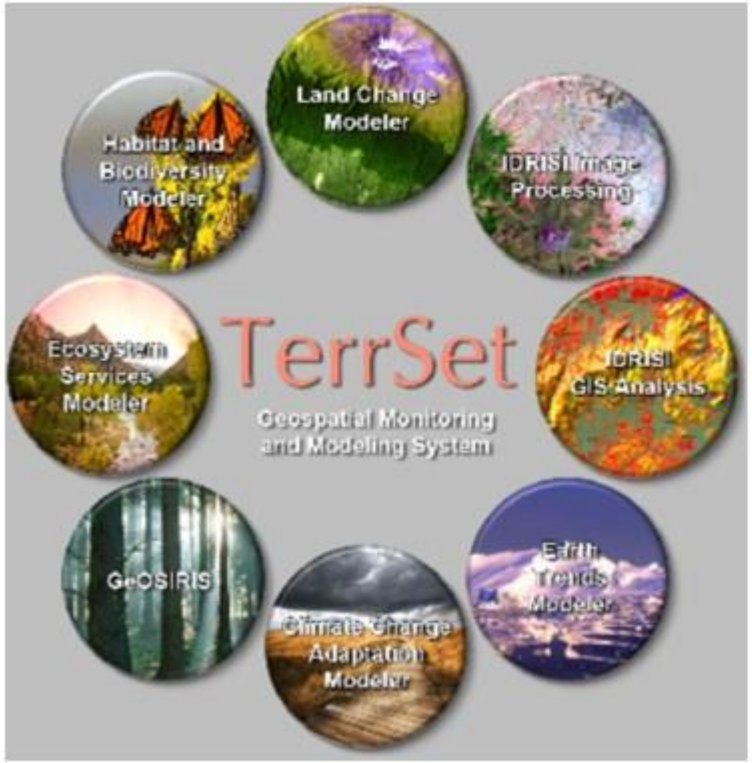
Land cover map (2015)
developed from SPOT6 satellite imagery using an object-based image classification

Methods

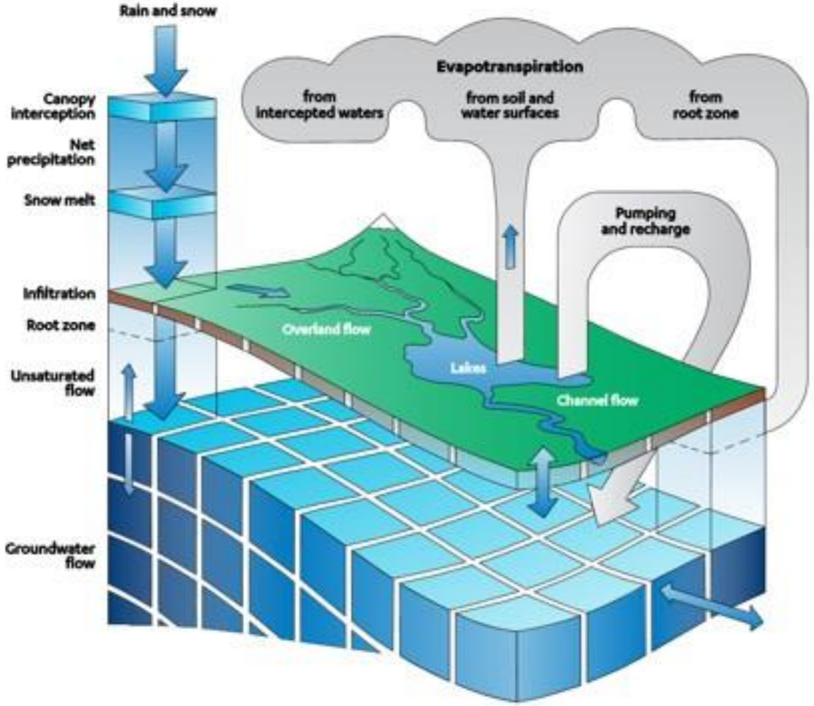
A coupled land change and hydrologic model

Land change modeler (LCM) module of Terrset
Cellular Automata (CA) and Markov model (CA-Markov) using multilayer perceptron (MLP) neural networks

MIKE SHE hydrologic model
from Danish Hydraulic Institute (DHI)



Terrset



MIKE SHE model structure

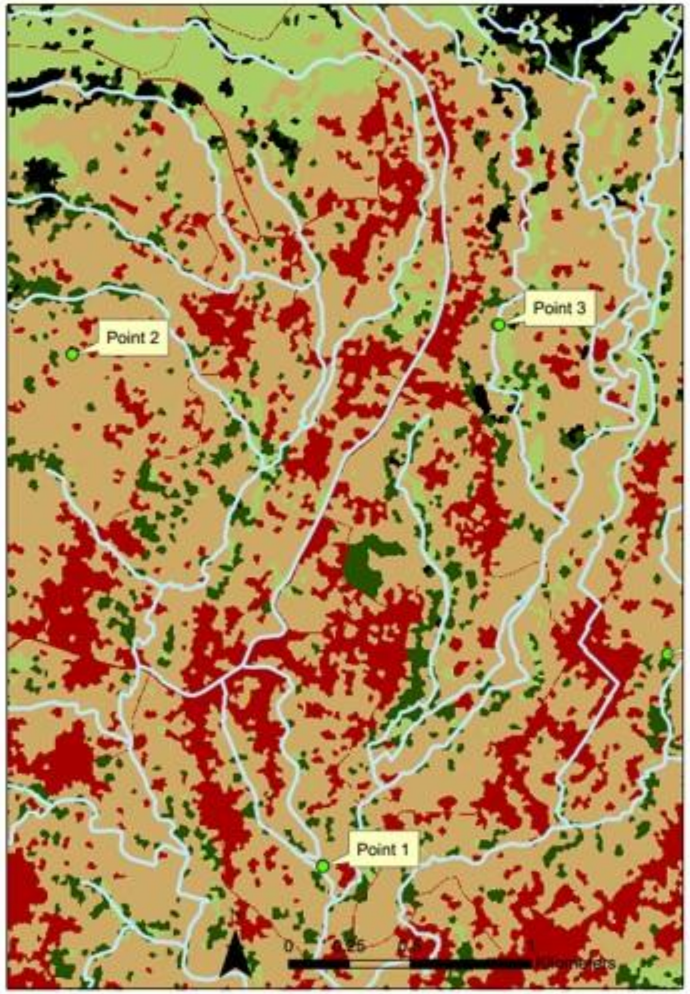
Methods

A series of flood risk simulations
to assess different landscape elements to reduce runoff

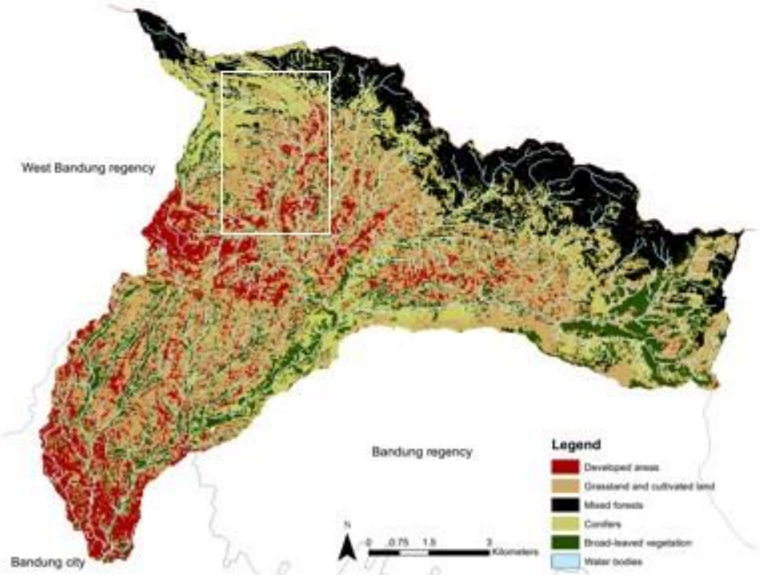
to retrieve information regarding **the suitable types of vegetation** in the river buffer that can effectively reduce runoff

to simulate how the river buffer can potentially improve the flood regulation

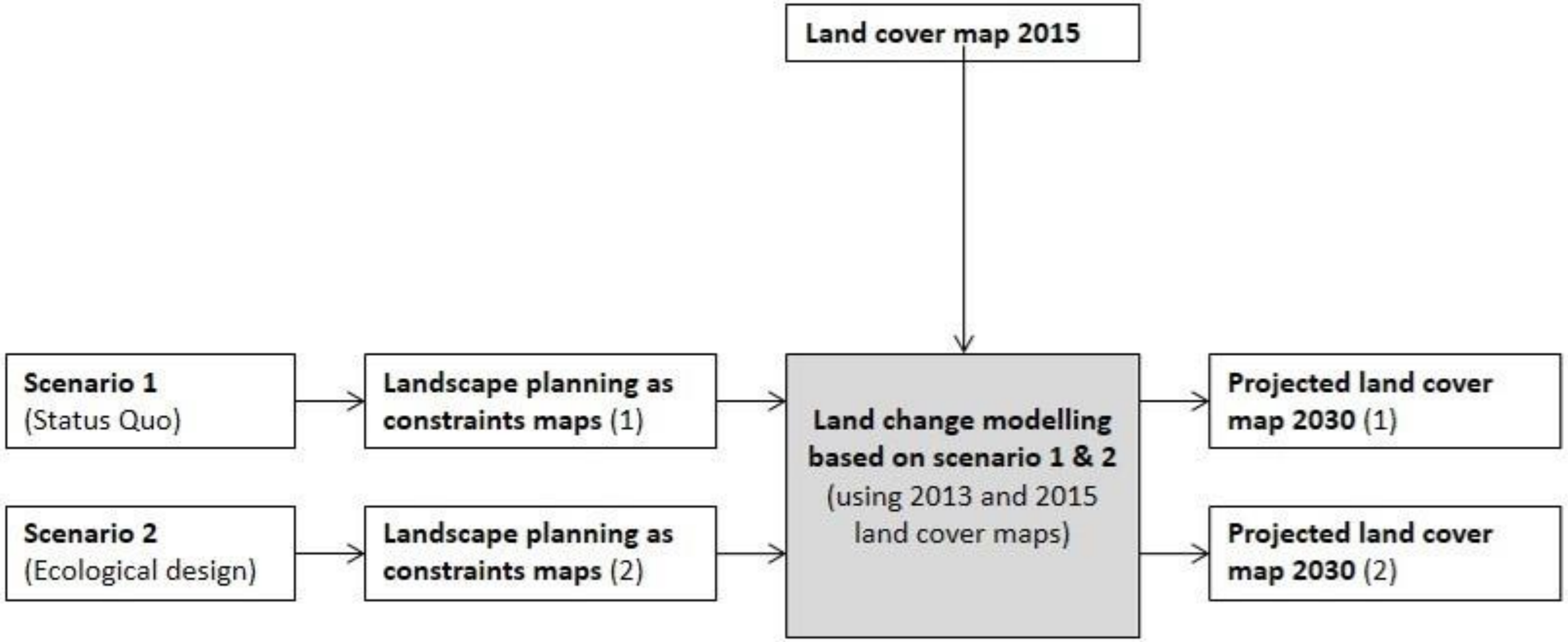
Three observation points
assigned in the model to record **the depth of overland flow**



The location of three observation points on site



Land cover map (2015)

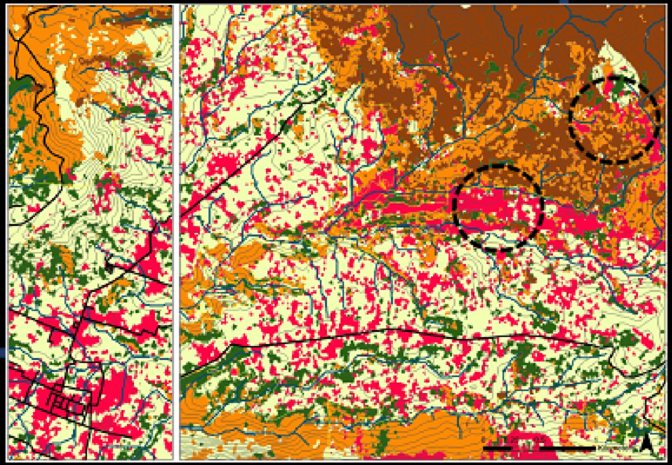

Land cover map 2015
Scenario 1
(Status Quo)
Landscape planning as constraints maps (1)
Scenario 2
(Ecological design)
Landscape planning as constraints maps (2)
Land change modelling based on scenario 1 & 2
(using 2013 and 2015 land cover maps)
Projected land cover map 2030 (1)
Projected land cover map 2030 (2)

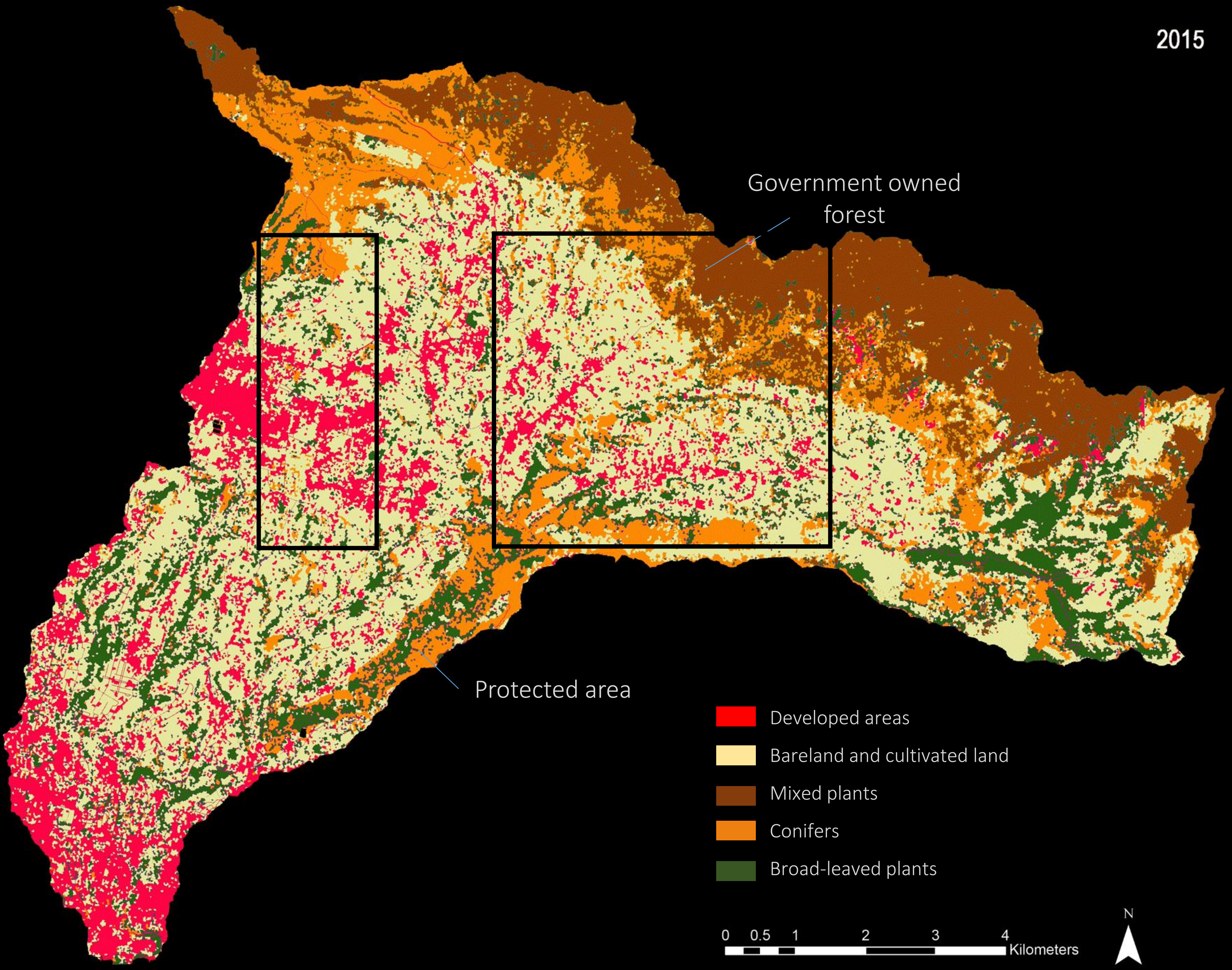
Scenario 1

(2030)

(Status Quo Scenario)
has no specific area allocated for the future development of new settlements and agriculture

dispersed settlement pattern in the watershed including in the areas with steep slopes



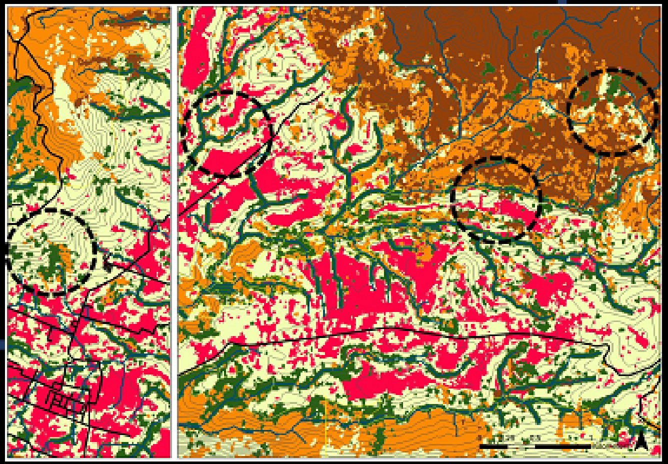


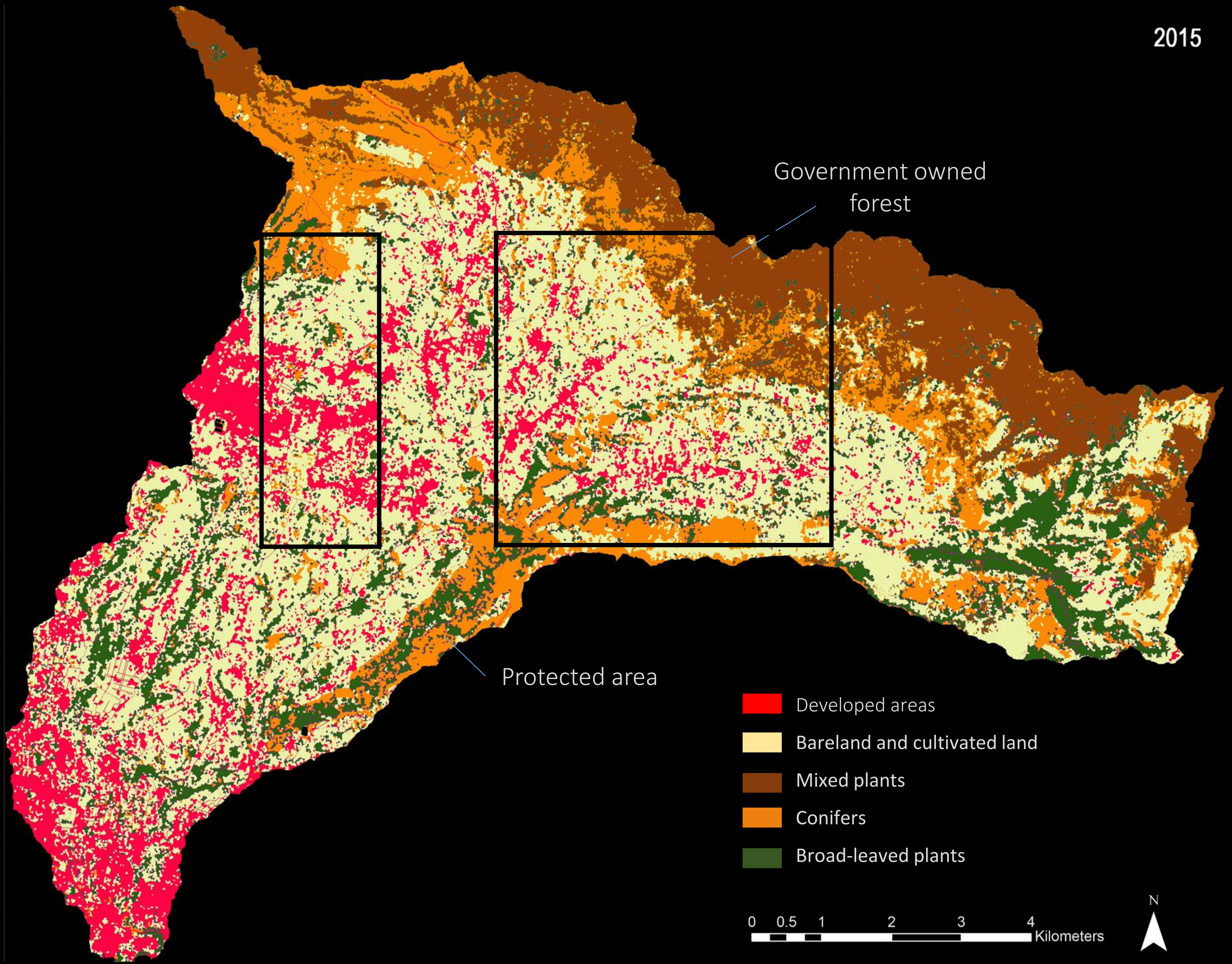
Scenario 2

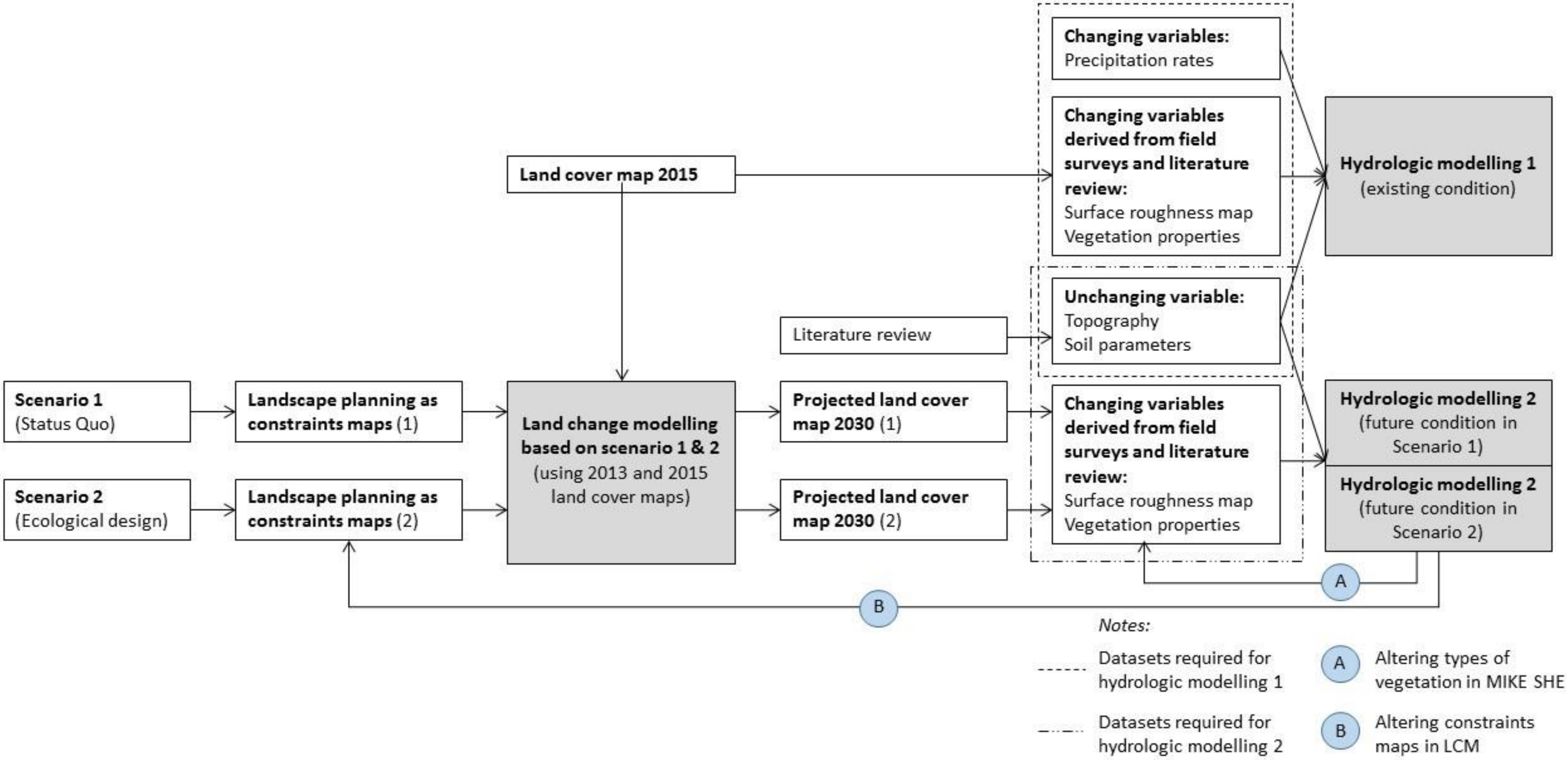
(2030)

(Ecological design scenario)
no development is allowed inside the forest, protected area, and the river buffer

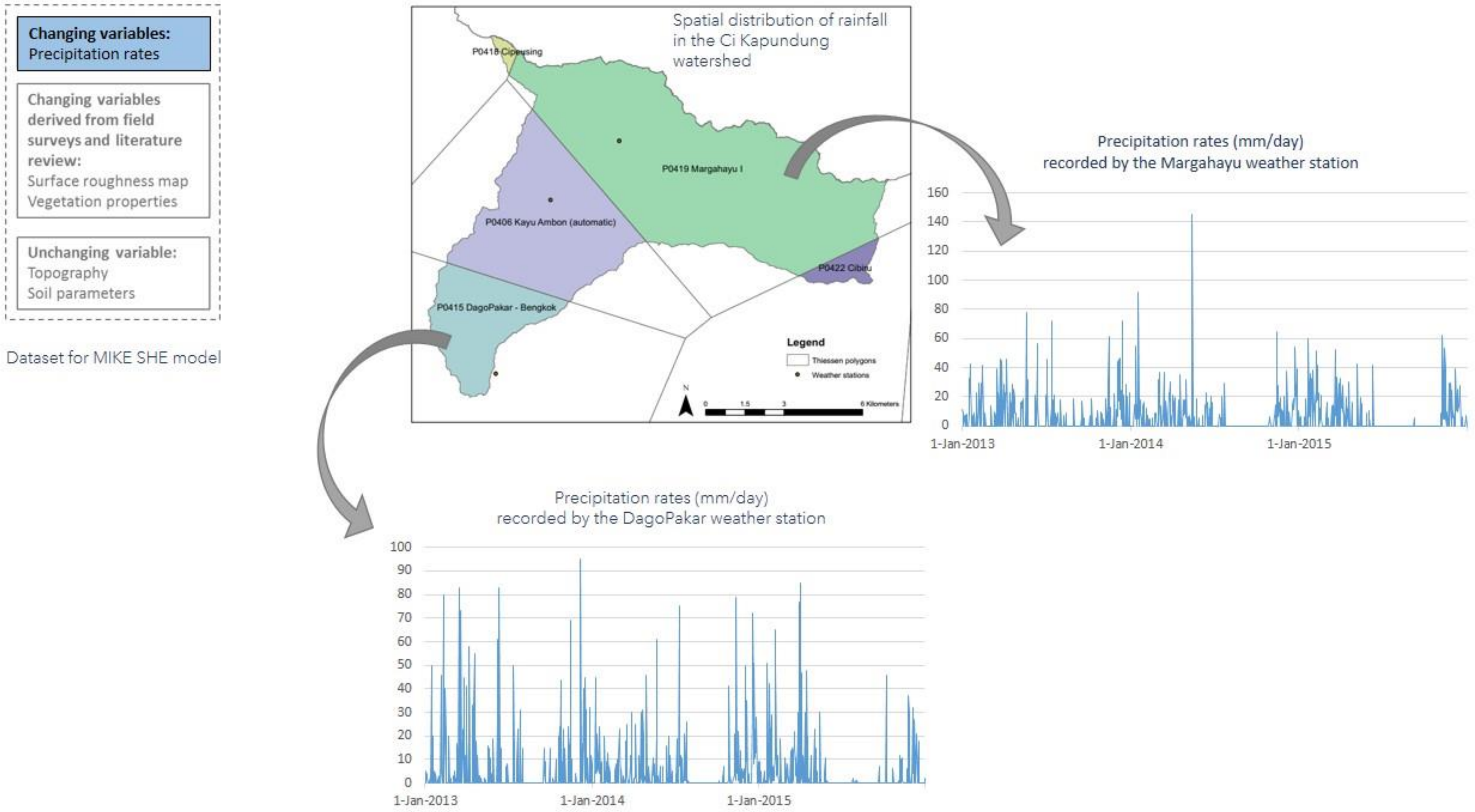
Broad-leaved vegetation will be planted in the buffer to reduce run off flowing into the river







Changing variables:
Precipitation rates
Changing variables derived from field surveys and literature review:
Surface roughness map
Vegetation properties
Hydrologic modelling 1
(existing condition)
Land cover map 2015
Unchanging variable:
Topography
Soil parameters
Literature review
Scenario 1
(Status Quo)
Landscape planning as constraints maps (1)
Land change modelling based on scenario 1 & 2
(using 2013 and 2015 land cover maps)
Projected land cover map 2030 (1)
Changing variables derived from field surveys and literature review:
Surface roughness map
Vegetation properties
Hydrologic modelling 2
(future condition in Scenario 1)
Hydrologic modelling 2
(future condition in Scenario 2)
Scenario 2
(Ecological design)
Landscape planning as constraints maps (2)
Projected land cover map 2030 (2)
A
B
Notes:
Datasets required for hydrologic modelling 1
Datasets required for hydrologic modelling 2
A
Altering types of vegetation in MIKE SHE
B
Altering constraints maps in LCM



Changing variables:
Precipitation rates
Changing variables derived from field surveys and literature review:
Surface roughness map
Vegetation properties
Unchanging variable:
Topography
Soil parameters
Dataset for MIKE SHE model
Spatial distribution of rainfall in the Ci Kapundung watershed
P0418 Cipeusing
P0419 Margahayu I
P0406 Kayu Ambon (automatic)
P0422 Cibiru
P0415 DagoPakar - Bengkok
Legend
Thiessen polygons
Weather stations
N
0
1.5
3
6 Kilometers
Precipitation rates (mm/day)
recorded by the Margahayu weather station
160
140
120
100
80
60
40
20
0
1-Jan-2013
1-Jan-2014
1-Jan-2015
Precipitation rates (mm/day)
recorded by the DagoPakar weather station
100
90
80
70
60
50
40
30
20
10
0
1-Jan-2013
1-Jan-2014
1-Jan-2015

Changing variables:
Precipitation rates

Changing variables derived from field surveys and literature review:
Surface roughness
Vegetation properties

Unchanging variable:
Topography
Soil parameters

Dataset for MIKE SHE model

Manning's M coefficients

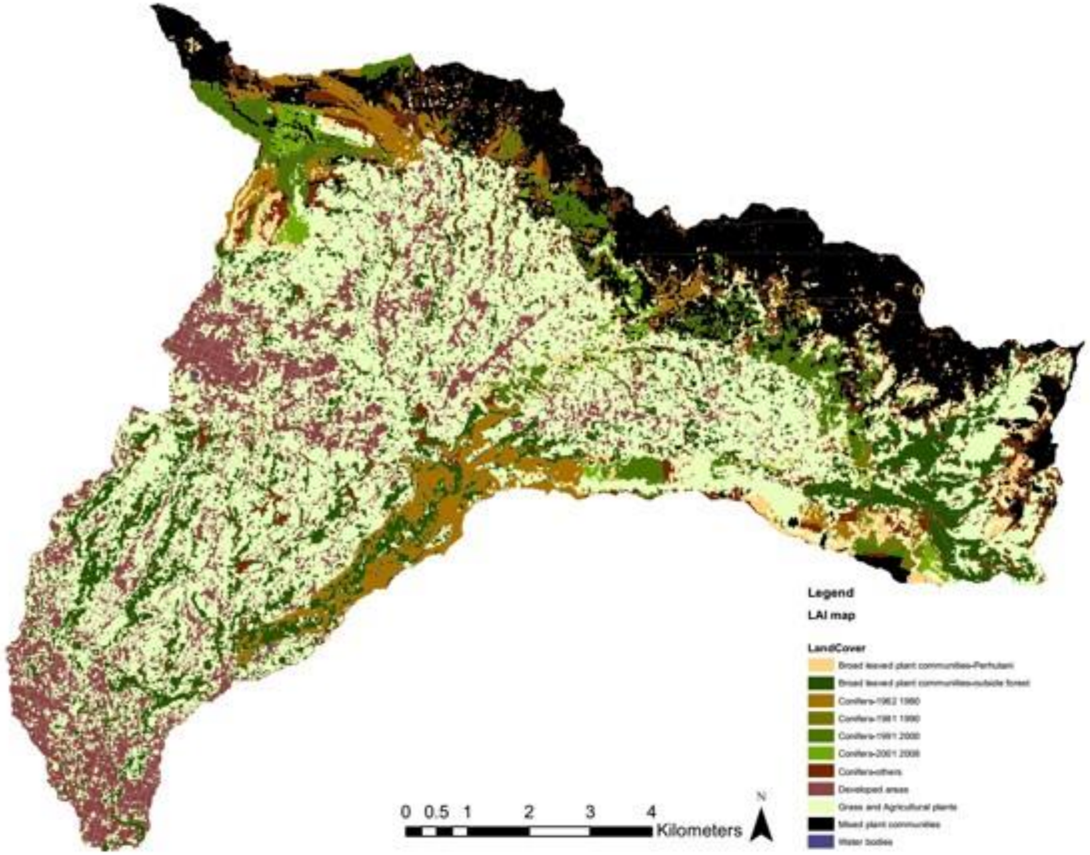
Land cover	M	References
Urban	90	(Engman 1986 cited Rossman & Huber 2016)
Bareland and cultivated land	18	(Yen 2001 cited inRossman & Huber 2016)
Mixed vegetation	2.5	(Kalyanapu et al. 2009)
Conifers	10	(Kouwen & Fathi-Moghadam 2000)
Broad-leaved vegetation	3	(Yen, 2001 cited inRossman & Huber 2016)
Water Bodies	99	Farfian, 2009

Vegetation properties (1):
Crop coefficient (Kc) and root depth

Land cover	Kc	Root depth (cm)
Developed areas	0	0
Bareland and cultivated land	0.90	75
Conifers in all age groups	1.00	100
Broad-leaved vegetation	0.90	150
Mixed vegetation	0.95	150
Water bodies	0	0

Estimated Leaf Area Index (LAI)

Vegetation	Group	Age	Mean value of LAI
Conifer (*Pinus merkusii*)	1	≤16 years	5.83
	2	17-26 years	8.09
	3	27-36 years	10.88
	4	≥37 years	14.98
Conifer (*Pinus merkusii*)	5	n/a	6.23
Broad leaved vegetation	6	n/a	7.63
Broad leaved vegetation	7	n/a	3.7
Mixed vegetation	12	n/a	6.2
Bareland and cultivated land	13	n/a	2.09
Developed areas	14	n/a	0
Water bodies	15	n/a	0



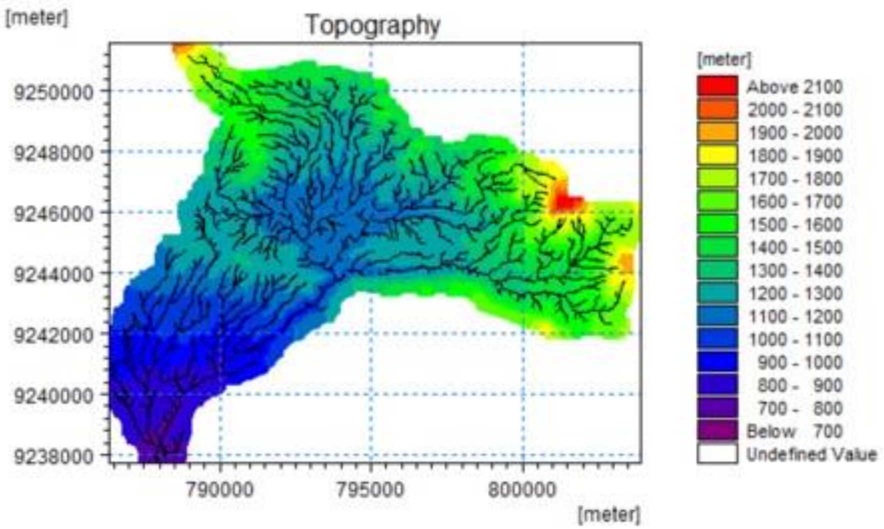
The classes with similar range of LAI

Changing variables:
Precipitation rates

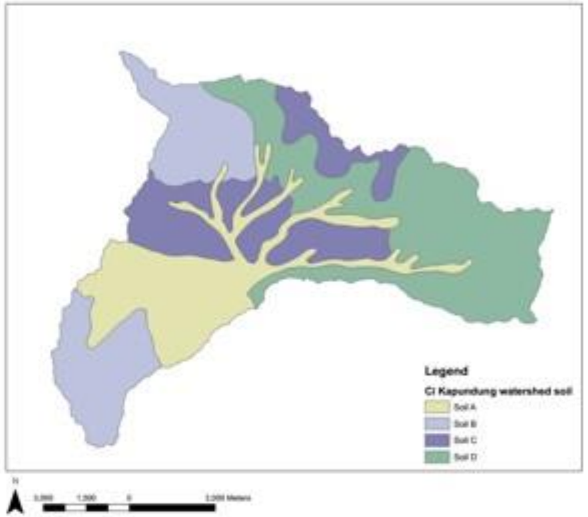
Changing variables derived from field surveys and literature review:
Surface roughness map
Vegetation properties

Unchanging variable:
Topography
Soil parameters

Dataset for MIKE SHE model

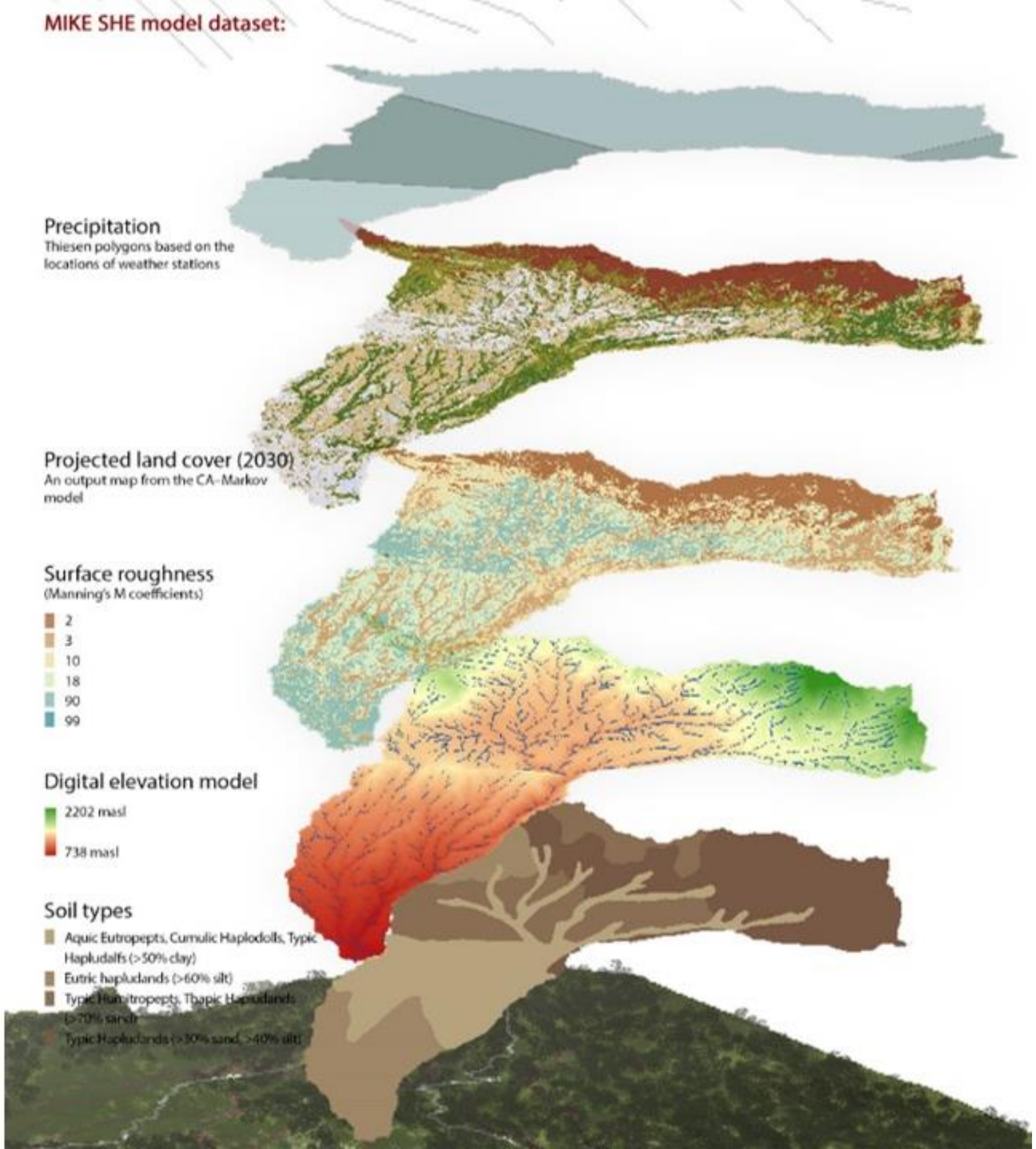


Topography of the Ci Kapundung watershed



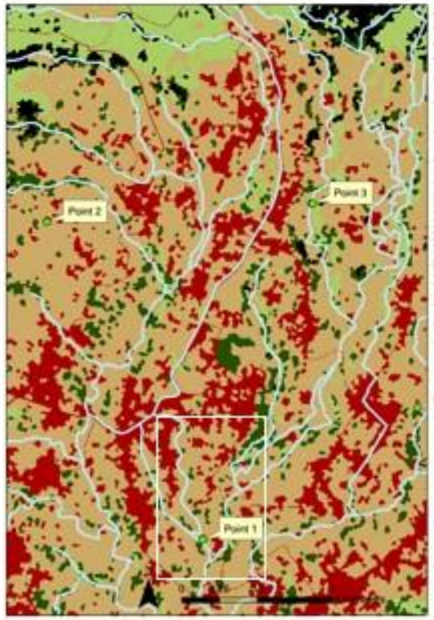
Soil map of the Ci Kapundung watershed

No	Dominant soil sub-group	New soil category	Sand	Silt	Clay
1	Aquic Eutropepts	Soil A	18.53%	29.47%	52.07%
2	Cumulic Haplodolls				
3	Typic Hapludalfs				
4	Eutric Hapludands	Soil B	18.25%	67.75%	14.00%
5	Soil from Cikidang f.				
6	Typic Humitropepts	Soil C	72.05%	14.53%	13.41%
7	Thapic Hapludands				
8	Typic Hapludands	Soil D	32.00%	48.14%	19.86%


MIKE SHE model dataset:
Precipitation
Thiesen polygons based on the locations of weather stations
Projected land cover (2030)
An output map from the CA-Markov model
Surface roughness
(Manning's M coefficients)
2
3
10
18
90
99
Digital elevation model
2202 masl
738 masl
Soil types
Aquic Eutropepts, Cumulic Haplodolls, Typic Hapludalfs (>50% clay)
Eutric hapludands (>60% silt)
Typic Humitropepts, Thapic Hapludands (>70% sand)
Typic Hapludands (>30% sand, >40% silt)

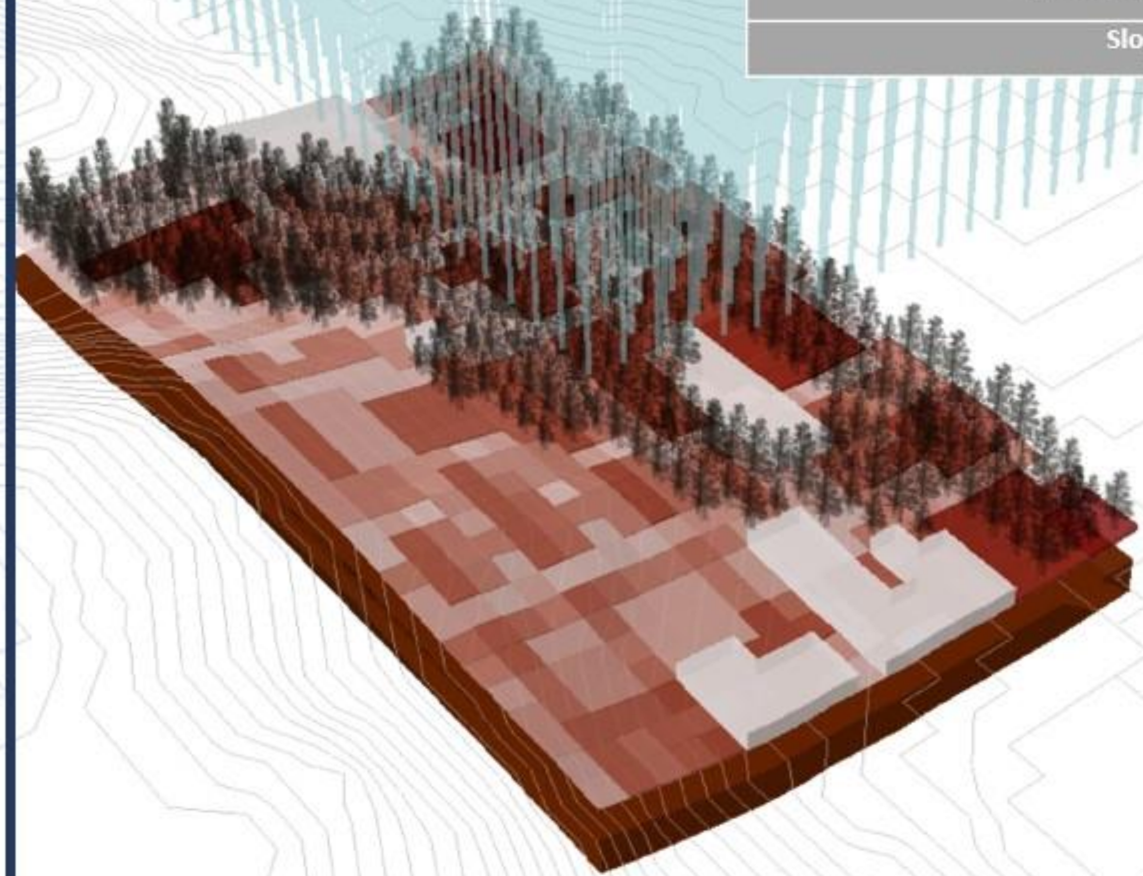
Results

The simulated depth of overland flow
during the day with the highest precipitation rate in the simulation period



The simulated depth of overland flow

Land cover maps	Depth of overland flow (mm)		
	Point 1	Point 2	Point 3
Existing condition (2015)	14.584	11.764	17.863
Status Quo scenario (2030)	14.567	11.511	16.463
Ecological Design scenario (2030)	11.697	12.244	17.146
Dominant soil types:	clay	silt	clay
Slope degree:	4.76^{0}	10.68^{0}	12.65^{0}



The simulated depth of overland flow
(Ecological Design scenario 2030)
each pixel (6m) representing the value of depth of overland flow (mm)

Results

The simulations to test the capacity of three vegetation types to reduce runoff

Each type of vegetation has different properties (e.g. Leaf Area Index/LAI, root depth, crop coefficients, surface roughness)

Conifers could potentially be planted in the proposed river buffers in the case study area

Plants with higher LAI have higher interception loss
(Merriam 1960)

The simulated depth of overland flow

Vegetation	Depth of overland flow (mm)		
	Point 1	Point 2	Point 3
Conifers	14.162	11.765	17.148
Broad-leaved vegetation	14.473	11.769	17.339
Mixed vegetation	5.074	11.768	17.265
Dominant soil types:	clay	silt	clay
Slope degree:	4.76^0	10.68^0	12.65^0

Vegetation with high LAI in river buffer as landscape element

Conclusion

Assessing potential landscape elements
to reduce runoff in the Ci Kapundung upper water catchment area

A typical geodesign framework:
the non-linear and iterative process to provide information for the landscape interventions

Conifers can effectively reduce the runoff

The future precipitation trend in the catchment area can be included in the hydrologic simulations

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Thank you