



CTCN City Climate Vulnerability Assessment and Identification of Ecosystem-based Adaptation Interventions, Lao PDR, September 13th to 15th 2017

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1 Introduction

This report contains the main activities carried out in Lao PDR during the Midterm-workshop held on September 13th to 15th 2017.

2 Overall travel and visiting Agenda

The team from DHI visited Laos PDR between 11-15 September and it was led by Mr. Henrik Garsdal, and with participation from Mr. Jesper Goodley Dannisøe, Dr. Niels D. Riegels, and Ms. Maija Bertule. The schedule for the trip is presented in Annex 1.

2.1 Meetings with the NDE and travel to Pakse

September 11th

Meetings with Ministry of Natural Resources and Environment, Department of Disaster management and Climate Change (DDMCC), responsible department for the NDE. Met with the NDE in the afternoon. Mr. Amphayvanh Oudomdeth, deputy director for the DDMCC and Mr. Vilakone Maniphousay from DDMCC. Focus was to ensure alignment of working programme and schedule for the mid-term workshop.

September 12th

This day was devoted travel day for the team to move from Vientiane to Pakse. After arriving in Pakse, the team used most of the day to prepare for the mid-term workshop.

3 Mid-term workshop

The mid-term workshop was held in Pakse Hotel from September 13th to 15th with delegates from DDMCC and the authorities of Luang Prabang, Vientiane, Paksan, Thakhek, Savannakhet and Pakse. Each city provided attendance from 5 staff, primarily staff from public works, drainage etc.

Prior to the workshop the city authorities had been instructed to present an outline of the proposed project sites and provide additional information as delivered during the workshop in January 2017. The overall invitation for as well as the timetable for the workshop is shown in Annex 1.

The overall purpose of the workshop was to present and discuss the outcome of the work on the climate change assessment, hazard mapping, vulnerability analysis and ecosystem services at city level. In addition to this, the workshop aimed at a detailed discussion and work on developing sites using ecosystem based adaptation interventions.

The list of participants for the workshop is located in Annex 2.

3.1 Agenda for the workshop

<p>September 13th</p> <p><u>Morning (8.30-11.30):</u></p> <ul style="list-style-type: none"> • Introduction to workshop by NDE 10 minutes • Introduction (consultant) Henrik 20 min. • Presentation of work on climate change (consultant) Niels 30 min. • Hazard mapping, Land use assessment and vulnerability mapping (consultant) Jesper 45 min. <p>Coffee break (15 minutes)</p> <ul style="list-style-type: none"> • Discussion 30 minutes <p>Lunch (11.30-13)</p> <p><u>Afternoon (13-16.30):</u></p> <ul style="list-style-type: none"> • Introduction to site selection (consultant) Henrik 15 minutes • Presentation of additional sites with flood problems and on sensitivity by 6 PONRE's (20 minutes each) • Break out session (6 groups) 45 minutes <ul style="list-style-type: none"> ○ Discussion on site selection in relation to vulnerability <p>Coffee break (15 minutes)</p> <ul style="list-style-type: none"> • Summary of preliminary site selection (consultant), Henrik 15 minutes
<p>September 14th</p> <p><u>Morning (8.30-12):</u></p> <ul style="list-style-type: none"> • Ecosystem services (consultant) Jesper 30 minutes • Introduction to break out sessions (consultant) Maija 10 minutes • Break out session (6 city groups) <ul style="list-style-type: none"> ○ Pairing ecosystem damages with ecosystem services (60 minutes) <p>Coffee break (10.10-10.20)</p> <ul style="list-style-type: none"> • Break out session (6 city groups) <ul style="list-style-type: none"> ○ Pairing flood damages with ecosystem services (85 minutes) <p>Group photo (11.45-12.00)</p> <p>Lunch (12-13)</p> <p><u>Afternoon (13-17.00):</u></p> <ul style="list-style-type: none"> • Ecosystem based adaptation interventions (consultant) Maija 30 minutes • Discussion 15 minutes • Introduction to break out session (consultant) Maija 10 minutes • Break out session (6 city groups) <ul style="list-style-type: none"> ○ Pairing ecosystem services with ecosystem based adaptation (65 minutes) <p>Coffee break (15-15.15)</p> <ul style="list-style-type: none"> • Introduction to break out session (consultant) Henrik 5 minutes • Presentation of proposed Ecosystem based Adaptations (EbA) by 6 PONRE's (15 minutes each)

<ul style="list-style-type: none"> • Summary of EbA's (consultant), Henrik 10 minutes
<p>September 15th</p> <p><u>Morning (8.30-12):</u></p> <ul style="list-style-type: none"> • Introduction to work (consultant) Henrik • Break out session (6 city groups) 120 minutes <ul style="list-style-type: none"> ○ Ecosystem based adaptation interventions – continued work <p>Coffee break (10.30-10.45)</p> <ul style="list-style-type: none"> • GCF proposal support (consultant) Maija, 20 minutes, Discussions for 20 minutes • Wrap up of workshop and Project plan Henrik (20 minutes) • Wrap up of workshop by NDE (15 minutes) <p>Lunch (12-13)</p> <p><u>Afternoon (13-14.30):</u></p> <ul style="list-style-type: none"> • Final discussion with NDE, Team

3.2 Presentations

The presentations provided by the consultant are attached to this report.

Annex 1 List of participants

DDMCC

No.	Name and Surname	Position/ Organizations	Email	Phone Number
1	Mr Amphayvanh OUDOMDETH	DDMCC	Am.oudomdeth@yahoo.com	020 5550 3322
2	Mr Vilakone Maniphousay	DDMCC	vilakonemp@gmail.com	020 2220 1514
3	Ms phonesouk PHOMMATHONG	DDMCC	89phonesouk@gmail.com	020 9599 9717
4	Mr Thitsavanh Inthilath	DDMCC	lah2102@gmail.com	020 5509 0505
5	Ms Aliyavan Lavongthueng	DDMCC	Aliyavan1989@gmail.com	020 2323 9911
6	Ms Ny Khamoulida	DDMCC		020 999 97054

Champasak

No.	Name and Surname	Position/Organizations	Email	Phone Number
1	Mr Vongphachanh PHOUNCHIT	Division of environment and natural resources	vongchanpasack@gmail.com	020 5527 5233
2	Mr Soupany SOULIPANYO	Director of environment and natural resources Division	-	020 5553 0334
3	Mr Bounchiem NILAKONE	Division of environment and natural resources	-	020 5906 8140
4	Mr Souksavanh	Division of environment and natural resources	Souk458@gmail.com	-
5	Mr Phetsavath	Division of environment and natural resources Division	-	020 5680 8036
6	Ms Sysouphan SENGSOULICHANH	Division of Agriculture and forestry	sisoupansslc@yahoo.com	020 5543 4185
7	Mr Khamphone Lasasimma	Division of Public Works and Transportation	-	020 9992 6929

Savannakhet

No.	Name and Surname	Position/ Organizations	Email	Phone Number
1	Mr Souvanh VORLASOUKHA	Division of environment and natural resources	-	020 5595 7406
2	Mr Khamphathith VONGSOR	Division of environment and natural resources	-	020 5544 6342
3	Mr Keoudone SOULIYA	Division of environment and natural resources	Keosulya99@yahoo.com	020 5400 1647
4	Mr Phouvong INTCHAK	Division of Agriculture and forestry	-	020 5564 1111
5	Mr Mouvone PHOMMAVANH	Division of Agriculture and forestry	-	020 5543 0246
6	Mr Bouaphim	Division of Public Works and Transportation	-	030 9936732
7	Mr Phonesack VIENGSY	Division of Public Works and Transportation	-	020 2233 9170

Thathek

No.	Name and Surname	Position/Organizations	Email	Phone Number
1	Ms Dalounny XAYYABOUD	Division of Agriculture and forestry	–	020 9951 9290
2	Ms Soukdavy	Division of Agriculture and forestry	–	020 5226 4333
3	Mr Boualamthong ONDAVONG	Division of Environment and natural resources	–	020 5656 6798
4	Mr Soudchai SINGSALATH	Division of Environment and natural resources	–	020 2232 6594
5	Mr Xaysomvang SINTHASONE	Division of Public Works and Transportation	xaisomvang@gmail.com	020 5575 1218
6	Mr Phonevisith KHOUNBOULOM	Division of Environment and natural resources	Ph.khounborlom@gmail.com	020 5560 7575
7	Mr Ouaxay PHOMHAPHA	Division of Public Works and Transportation	–	020 9944 2213

Paksan

No.	Name and Surname	Position/Organizations	Email	Phone Number
1	Mr Phonesavanh HOMLABOUNLATH	Head of Agriculture Division	Ph.lath@yahoo.com	020 2233 6441
2	Mr Phonepasueth	Driver for head of Agriculture Division	–	020 9789 1999
3	Mr Viengkeo SAYPHAKDY	Division of environment and natural resources	Viengkeo.pd@gmail.com	020 5498 7771
4	Mr Keophouvang KOSY	Division of environment and natural resources	–	020 5424 0269
5	Ms Youpha PHOKASOMBATH	Division of Public Works and Transportation	–	020 2233 5117
6	Ms Phetsomphou	Division of environment and natural resources	–	020 2233 7742
7	Mr Bounmy KHAMSAK	Division of Public Works and Transportation	–	020 9559 2213

Vientiane Capital

No.	Name and Surname	Position/Organizations	Email	Phone Number
1	Mr Thinnakone PHIMMAVONG	Division of Public Works and Transportation	Mythonna@gmail.com	020 2282 9099
2	Mr Dai SIHALAD	Division of Agriculture and Forestry	Daisihalad@gmail.com	020 5522 0076
3	Mr oulaiphone	Division of Natural Resources and Environment		020 2998 0434
4	MS Chnsouk BOUHAUGE	Division of Natural Resources and Environment	Chnsouk17@hotmail.com	020 5561 1684
5	Mr Atit SYPASEUTH	Division of Natural Resources and Environment	Atit-111@hotmail.com	020 2244 9588
6	Mr Kamsamai	Division of Public Works and Transportation		020 9887 0017
7	Mr Boumame	Division of Agriculture and Forestry		020 9443 5531

Luang Prabang

No.	Name and Surname	Position/Organizations	Email	Phone Number
1	Mr phiengkham THAMMAVONG	Division of environment and natural resources		020 2235 5222
2	Mr Somphone KEONAKHAM	Division of environment and natural resources		020 2235 0051
3	Mr Soulideth NORASING	Division of Agriculture and Forestry		030 4911325
4	Ms Chanpheng NITHSAVANH	Division of environment and natural resources	Phetlala72@gmail.com	020 5431 2555
5	Ms Daovilai BANCHONGPHANID	Division of Public Works and Transport		020 5561 2231

Consultants

No.	Name and Surname	Position/Organizations	Email	Phone Number
1	Mr Henrik GARSDAL	Team Leader, DHI	heg@dhigroup.com	+4530637331
2	Mr Jesper DANNISØE	Ecosystem expert, DHI	jda@dhigroup.com	
3	Dr Niels RIEGELS	Climate change & Ecosystems, DHI	ndr@dhigroup.com	
4	Ms Maija BERTULE	Ecosystem based Adaptations	mabe@dhigroup.com	
5	Mr Anthony Mills	CEO, C4	Anthony.mills@c4es.co.za	+27 21 715 1560

The expert in **WATER ENVIRONMENTS**



Annex 2 Presentations by consultants

City Climate Vulnerability Assessment and Identification of Ecosystem-based Adaptation Intervention

Mid-term workshop, Lao PDR, September 13th – 15th 2017

1.

Welcome and introduction to workshop



Mid-term workshop on City Climate Vulnerability assessment and Identification of Ecosystem-based Adaptation Intervention, Lao PDR September 13th – 15th 2017



Welcome to the Mid-term workshop under the full implementation of the project:

‘City Climate Vulnerability Assessment and Identification of Ecosystem based Adaptation Interventions’

funded by Climate Technology Centre & Network (CTCN).

Agenda (September 13th)

Morning (8.30-11.30):

- Introduction to workshop by **NDE 10 minutes**
- Introduction (consultant) **Henrik 20 min.**
- Presentation of work on climate change (consultant) **Niels 30 min.**
- Hazard mapping, Land use assessment and vulnerability mapping (consultant) **Jesper 45 min.**

Coffee break (15 minutes)

- Discussion **30 minutes**

Lunch (11.30-13)

Afternoon (13-16.30):

- Introduction to site selection (consultant) **Henrik 15 minutes**
- Presentation of additional sites with flood problems and on sensitivity **by 6 PONRE's (20 minutes each)**
- Break out session (6 groups) **45 minutes**
 - Discussion on site selection in relation to vulnerability

Coffee break (15 minutes)

- Summary of preliminary site selection (consultant), **Henrik 15 minutes**

Agenda (September 14th)

Morning (8.30-12):

- Ecosystem services (consultant) **Jesper 30 minutes**
- Introduction to break out sessions (consultant) **Maija 10 minutes**
- Break out session (6 city groups)
 - Pairing ecosystem damages with ecosystem services (**60 minutes**)

Coffee break (10.10-10.20)

- Break out session (6 city groups)
 - Pairing flood damages with ecosystem services (**85 minutes**)

Group photo (11.45-12.00)

Lunch (12-13)

Afternoon (13-17.00):

- Ecosystem based adaptation interventions (consultant) **Maija 30 minutes**
- Discussion **15 minutes**
- Introduction to break out session (consultant) **Maija 10 minutes**
- Break out session (6 city groups)
 - Pairing ecosystem services with ecosystem based adaptation (**65 minutes**)

Coffee break (15-15.15)

- Introduction to break out session (consultant) **Henrik 5 minutes**
- Presentation of proposed Ecosystem based Adaptations (EbA) by 6 PONRE's (**15 minutes each**)
- Summary of EbA's (consultant), **Henrik 10 minutes**

Agenda (September 15th)

Morning (8.30-12):

- Introduction to work (consultant) Henrik
- Break out session (6 city groups) **120 minutes**
 - Ecosystem based adaptation interventions – continued work

Coffee break (10.30-10.45)

- GCF proposal support (consultant) **Maija, 20 minutes, Discussions for 20 minutes**
- Wrap up of workshop and Project plan **Henrik (20 minutes)**
- Wrap up of workshop by NDE **(15 minutes)**

Lunch (12-13)

Afternoon (13-14.30):

- Final discussion with NDE, Team

Agenda (September 15th)

8.30-10.30:

Intro to work

Break out session (6 city groups)

10.30-10.45: coffee break

10.45-11.30: GCF proposal preparation by C4

11.30-11.45: Wrap up by consultant

11.45-12.00: Wrap up by NED

Lunch

13-14.30: Meeting with NDE

Participants

PLEASE STATE NAME AND WHERE YOU COME FROM and fill in the attendance sheet:

- Central government / authority
- Regional government / authority
- Institution

From Denmark:

Henrik Garsdal, Environmental Engineer, +20 years of experience in Asia



Jesper G. Dannisoe, Biologist, +20 years of experience in Asia



Mid-term workshop on City Climate Vulnerability assessment and Identification of Ecosystem-based Adaptation Intervention, Lao PDR September 13th – 15th 2017

From Denmark:

Niels Riegels, Hydrologist, +10 years of experience



Maija Bertule, Programme Advisor, UNEP-DHI, +10 years of experience



DHI is from Denmark



2.

The overall purpose of the project

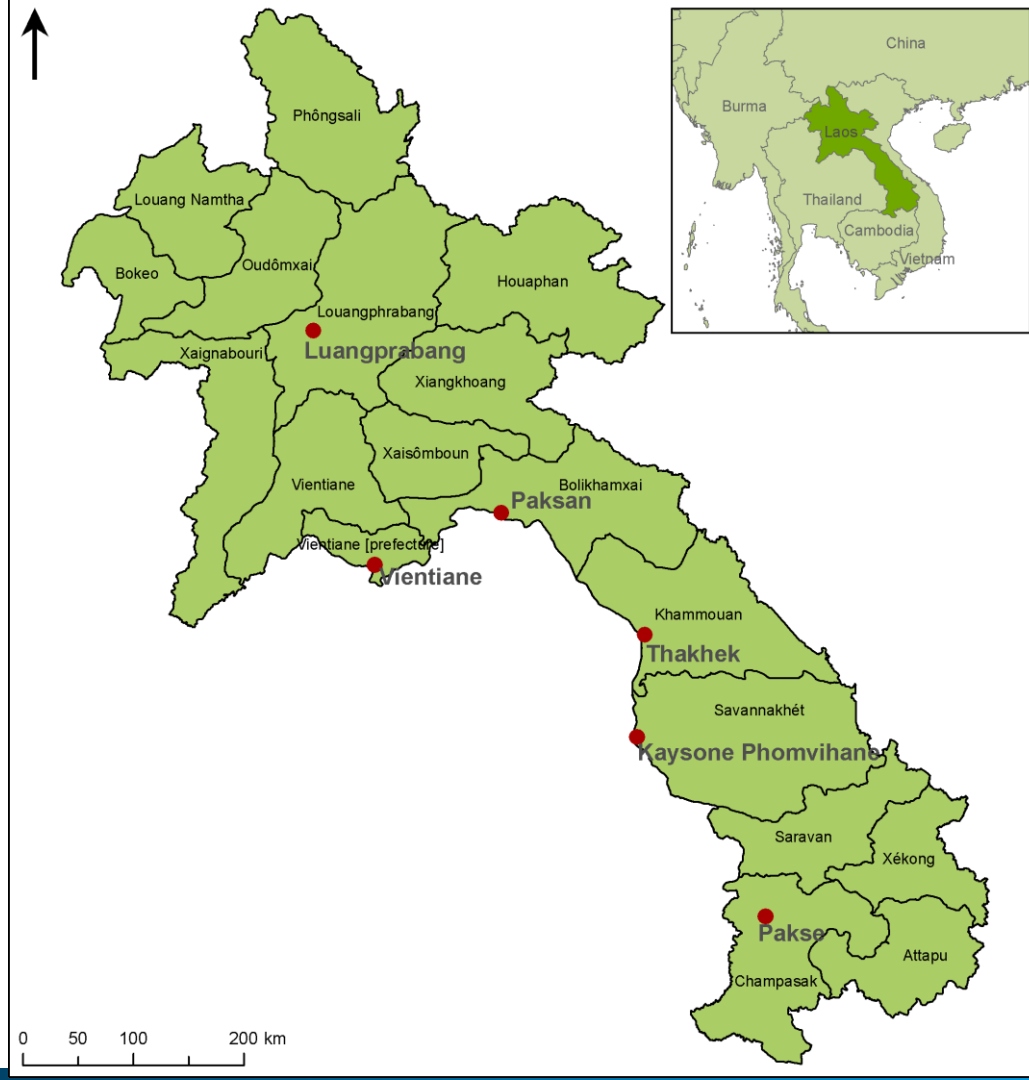


The Government of Lao PDR is pursuing a Green Climate Fund (GCF) project proposal on Urban Ecosystem-based Adaptation.

Technical assistance is requested from the CTCN to improve the foundations of and to accelerate the start up of the GCF project.

The overall goal of the CTCN project is to identify city specific ecosystem based adaptation (EBA) responses which can be implemented as part of the proposed Green Climate Fund project.

The CTCN project undertakes city level climate vulnerability assessment of people and ecosystems at Laos' six most socio-economically important cities.



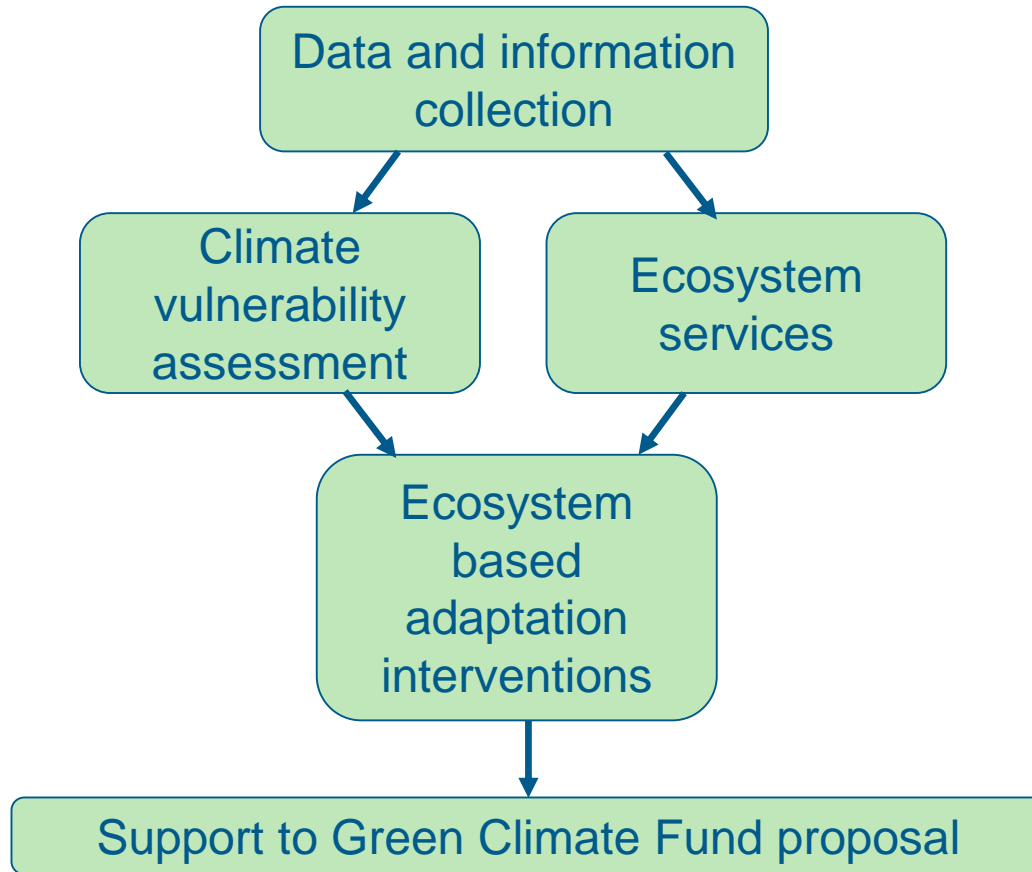
The requested city level vulnerability assessments should provide information and analysis on:

- How people living in the six cities are currently impacted by climate change and how they will be impacted under future climate scenarios
- What ecosystem goods and services are being provided to the city populations; and what is the capacity of these ecosystems to provide services under future climate scenarios

The requested city level vulnerability assessments should provide information and analysis on:

- Identify ecosystem-based adaptation interventions that would be able to respond sufficiently to reducing climate risks faced by cities. Assess the associated costs.
- Validate the findings of the vulnerability and ecosystem assessments at each of the six cities as well as with national stakeholders

Overall project activities



January 2017
May – August 2017

September –
November 2017

Final workshop in
December 2017

4.

Key findings from missions in August 2016 and January 2017



Achievements (August 2016):

- Established liaison with the NDE
- Visits to 3 cities, input from all 6 cities
- Initial overview of data situation
- Workshops conducted with assessment of flooding and ecosystem damages

Findings (August 2016):

- Confirmed that most cities have flooding problems
- Similar types of problems identified in the 6 cities
- Need for working with peri-urban areas
- Suggestion from NDE to include a training element in the project

Peri-urban areas?

- Areas in the outskirts of the city
- Often NOT connected to water supply and drainage



Achievements (January 2017):

- Visits to all 6 cities
- Preliminary site selection in all cities (Urban and Peri-urban)
- Ecosystem service presentations / training

Findings (January 2017):

- 10 out of 14 sites have high water levels in the Mekong as the main cause of flooding. 4 sites have catchment runoff as a cause of flooding.
- Ecosystem services are already in use although the concept is not well understood
- Combined grey and green infrastructure may be useful

The Mid-term workshop

- Climate change
- Hazard mapping, landuse classification and vulnerability
-> We need your feedback to proceed
- Ecosystem services
- Ecosystem based Adaptations (EbA's)
-> We need your feedback to proceed

We have so far worked in more detail with Luang Prabang, Vientiane and Pakse.

Thank you!

Henrik Garsdal
Team Leader, Consultant's team, DHI

heg@dhigroup.com



1. Write-up on (60 minutes)

- Background information
- Problem description
- Description of solution (EbA)
- Costing

2. For additional sites (60minutes)

- Short description of problem
- Intended solution EbA
- Location, drawing, costing

Wrap up of work shop

- Presentations and discussions on Climate Change work
 - > Results available in Excel file. User guide will be provided in about one weeks time
- Presentations and discussions on hazard mapping, land use classification, vulnerability
 - > GIS files are available for Luang Prabang, Vientiane, Pakse. Results from the remaining three cities will be provided within 3-4 weeks time.

Wrap up of work shop

- Ecosystem services
- Work on sites
 - Mapping the ESS versus damages on ecosystems
 - Developing EbA for the sites and identification of the ESS they provide
 - Detailed information on key site
 - Basic information on the additional sites

Wrap up of work shop

- Consultant will work in September to November on
 - Finalize the ESS and EbA mapping for the sites collected
 - Send the results to the PONRE's for confirmation/comments
 - Finalize the list of EbA's for each city
 - Finalize the draft final reporting of the CTCN assistance
 - Provide input and review of the GCF proposal
- Final workshop (December 2017)
 - Presentation of the CTCN assistance results and the draft final report

Climate change analysis

Mid-term workshop, Lao PDR, September 13th – 15th 2017

Agenda

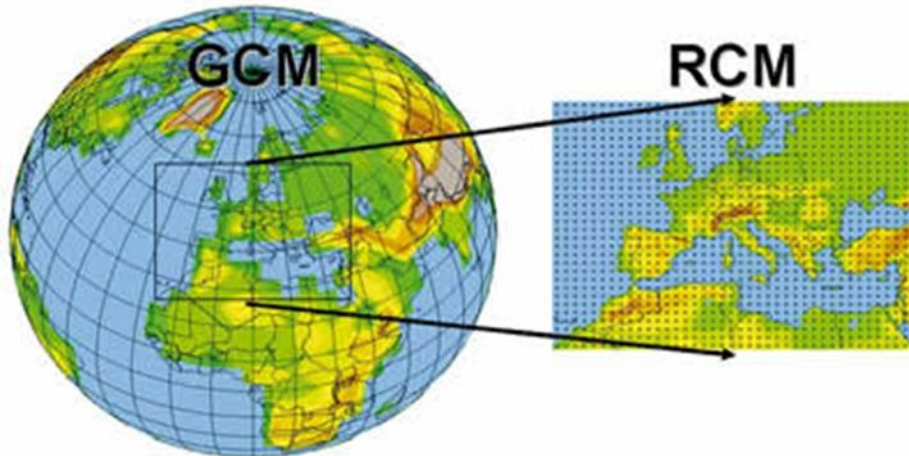
1. Overview of methodology
2. Projected changes to rainfall
3. Projected changes to temperature and evaporation

01.

Overview of methodology

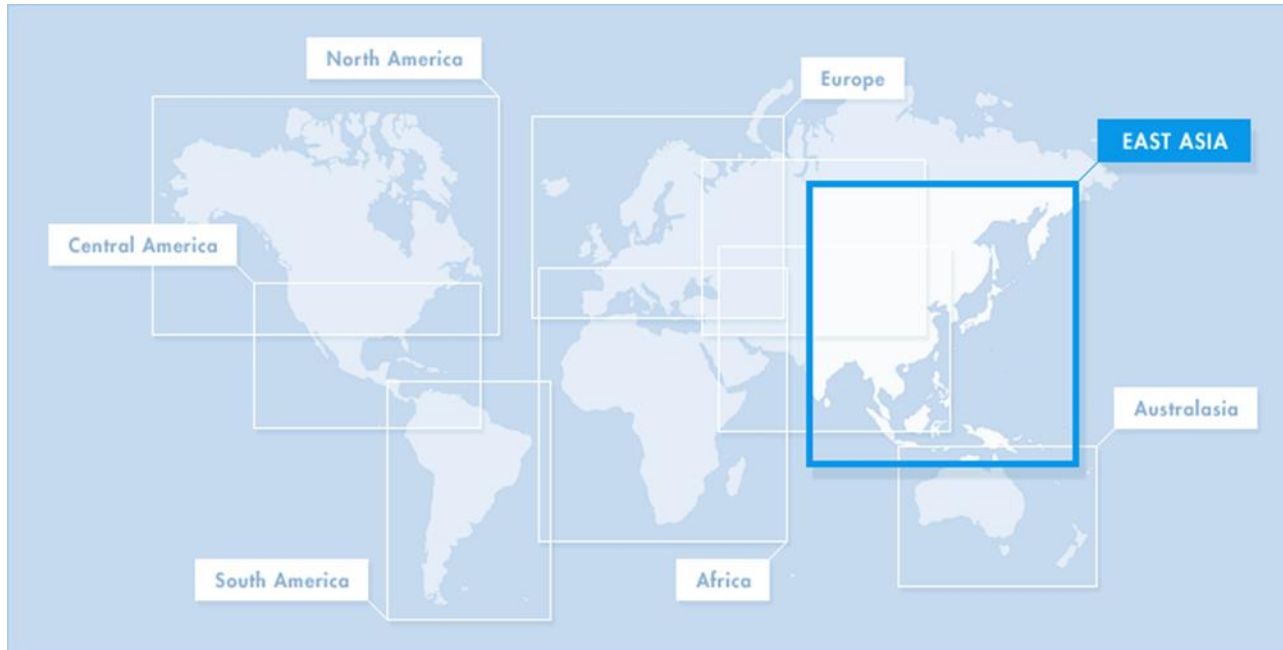


From Global to Regional Climate Model

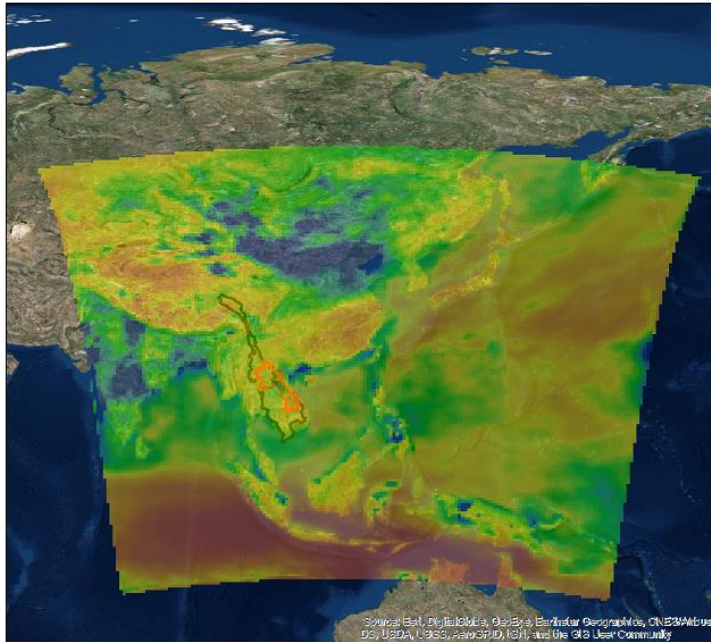


- GCM models cannot resolve all physical processes important for rainfall because of computational constraints
- RCM models simulate a smaller portion of the Earth, using GCM outputs as boundary conditions

CORDEX East Asia model domain



CORDEX East Asia model domain



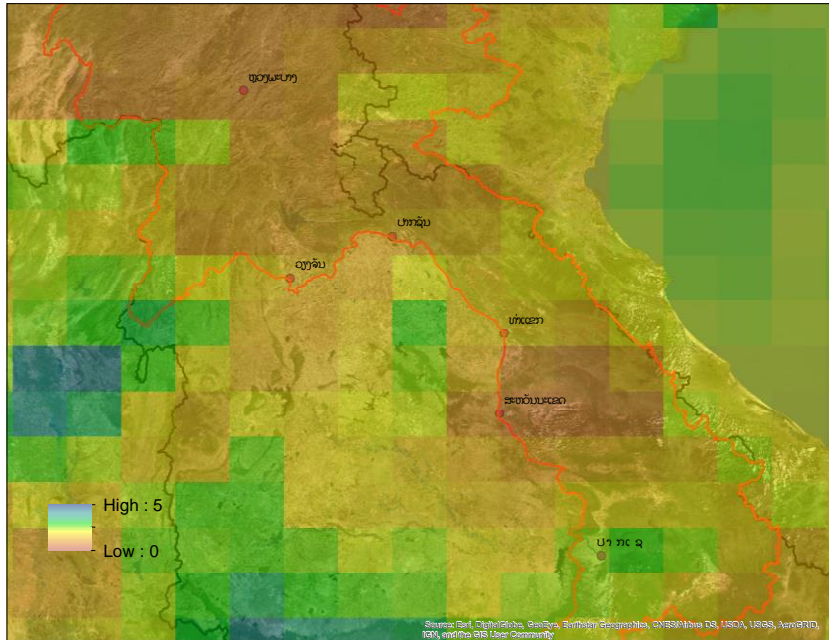
- Grid size ~50 km
- ~200 grid cells in each dimension
- 6 different models run by various universities and research institutes

Overview of models and scenarios

- 2 GCM/RCM combinations
 - ECEARTH-HIRHAM5
 - HadGEM3-RA
- 2 projection periods
 - 2046-2065
 - 2081-2100
- 2 greenhouse gas concentration trajectories
 - RCP 4.5
 - RCP 8.5

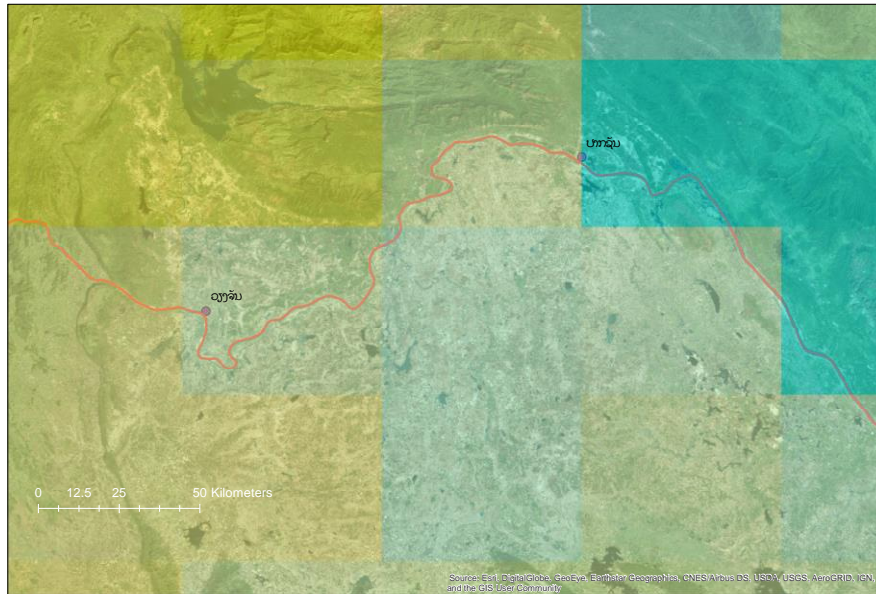
$2*2*2 = 8$ model/scenario combinations

Example of simulation grid



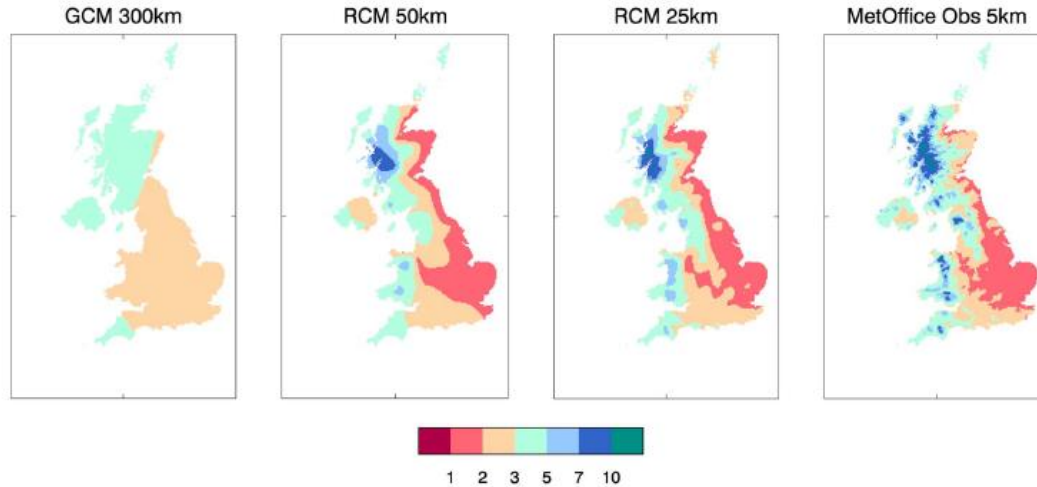
- Model: ECEARTH-HIRHAM5
- Grid cell size: ~50 km

Local downscaling and bias correction



- RCM results must be downscaled to the local scale
- ~50 km grid cell size means that some local factors that contribute to rainfall are not simulated, resulting in biases that should be corrected

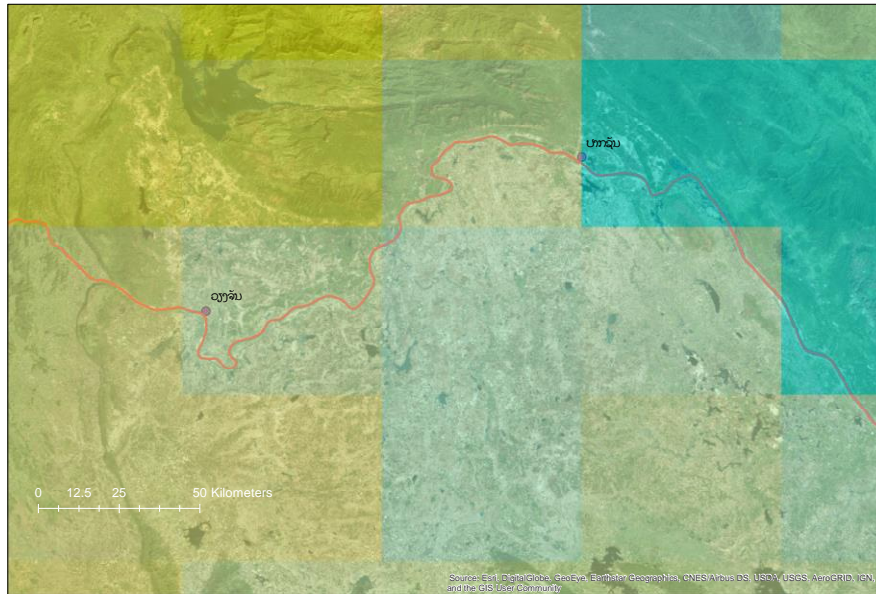
Differences between GCM, RCM, and observed



Maps show average daily winter rainfall for 1961-1990

Source: Maraun et al., *Reviews of Geophysics*, 2010

Downscaling and bias correction of rainfall

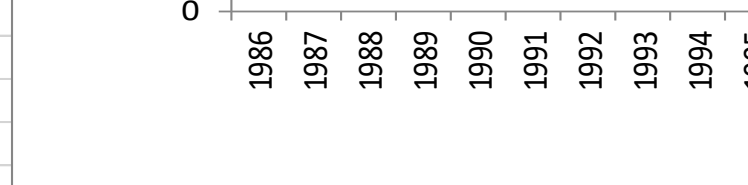
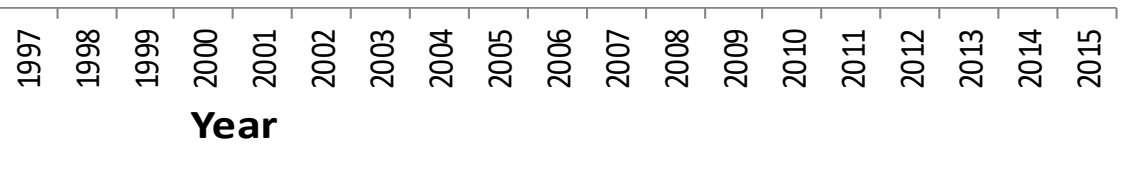


- RCM results must be downscaled to the local scale
- ~50 km grid cell size means that some local factors that contribute to rainfall are not simulated, resulting in biases that should be corrected

02.

Projected changes to rainfall



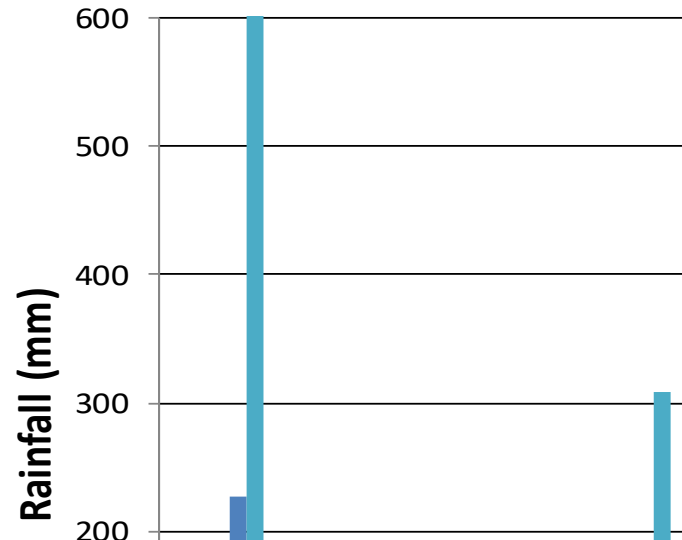


daily rainfall, Pakse, 2046-2065

Baseline ■ Avg_2046_2065



Annual maximum



Thank you!



DHI Vulnerability Mapping – The steps taken

Jesper Goodley Dannisøe

Vulnerability mapping takes a number of steps

Exemplified by working with 3 different cities:

- Luang Prabang (Hilly/mountainous)
- Vientiane (Densely populated large city)
- Pakse (Medium size city, comparable to Kaysone Phomvihane, Thakhet and Paksan)

The steps to go through:

1. Find the area to be assessed
2. Process a digital elevation model
3. Process a flood hazard map
4. Carry out a land cover classification
5. Classify land-use types according to vulnerability
6. Combine flood map with land-use to get a vulnerability map

Flooding

**Flood prone areas using HAND index and
SRTM 30 meter DEM**

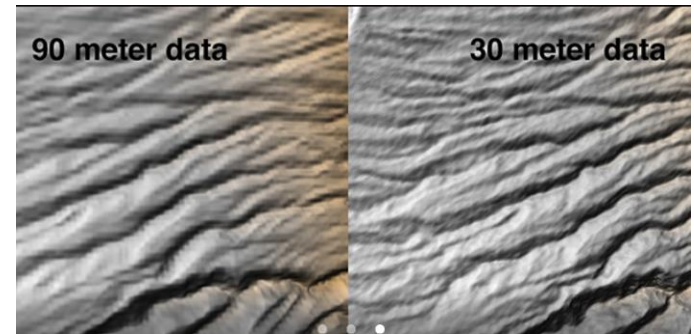
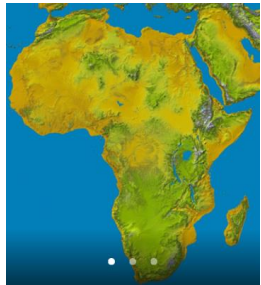
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Height Above Nearest Drainage point (HAND)

- The Height Above Nearest Drainage point (HAND) data*
 - Used to make a very first assessment of flood prone areas.
 - The HAND values are the flood levels (in meters) required for a specific area to be flooded.
 - Flood prone areas must be based on the knowledge of the historic flood depths in the different parts of a basin.
-
- * methodology described in Nobre et al (2011)

Data used for the HAND index

- 30 m SRTM data (**S**huttle **R**adar **T**opography **M**ission)
 - Digital elevation model (surface model)
 - Rough scale when urban areas are evaluated
 - Different results and accuracy of the method in hilly / flat terrains are expected
 - Hand index results overlaid with different vector data of urban areas, rivers etc. from Laos (NGDdata)



Luang Prabang – HAND index

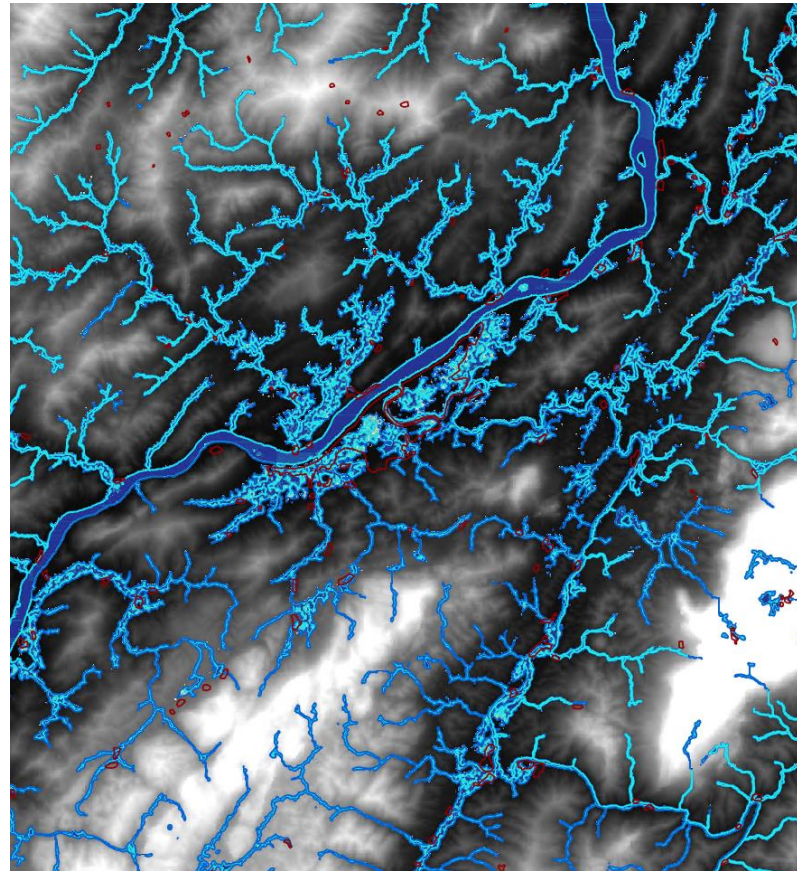
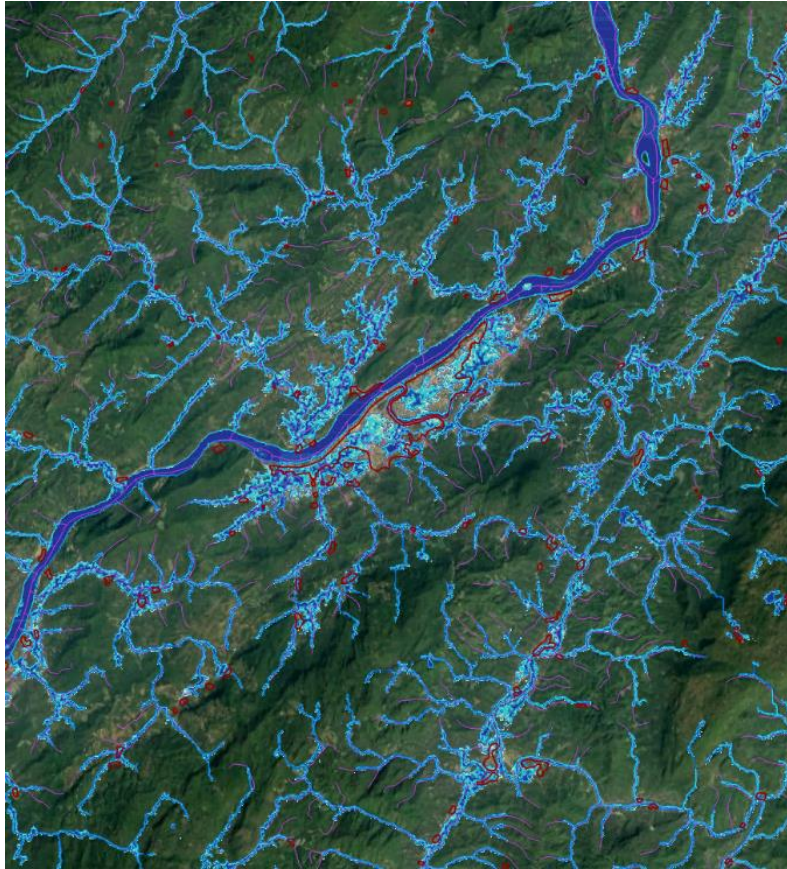
Flood mapping

- An area around the cities is designated.
- The HAND-model is applied and provides an estimate of areas (90x90m), which will be flooded if the water level above nearest discharge point is 1m, 2m, 3m etc up to 10 m
- Areas with a local altitude above 10 meter are seen as if no flooding will take place

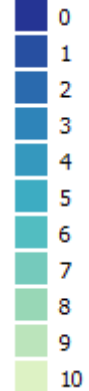
Flood prone areas for Luang Prabang 0-10 m

Left: Google maps

Right: SRTM 30m



Hand index
[m]

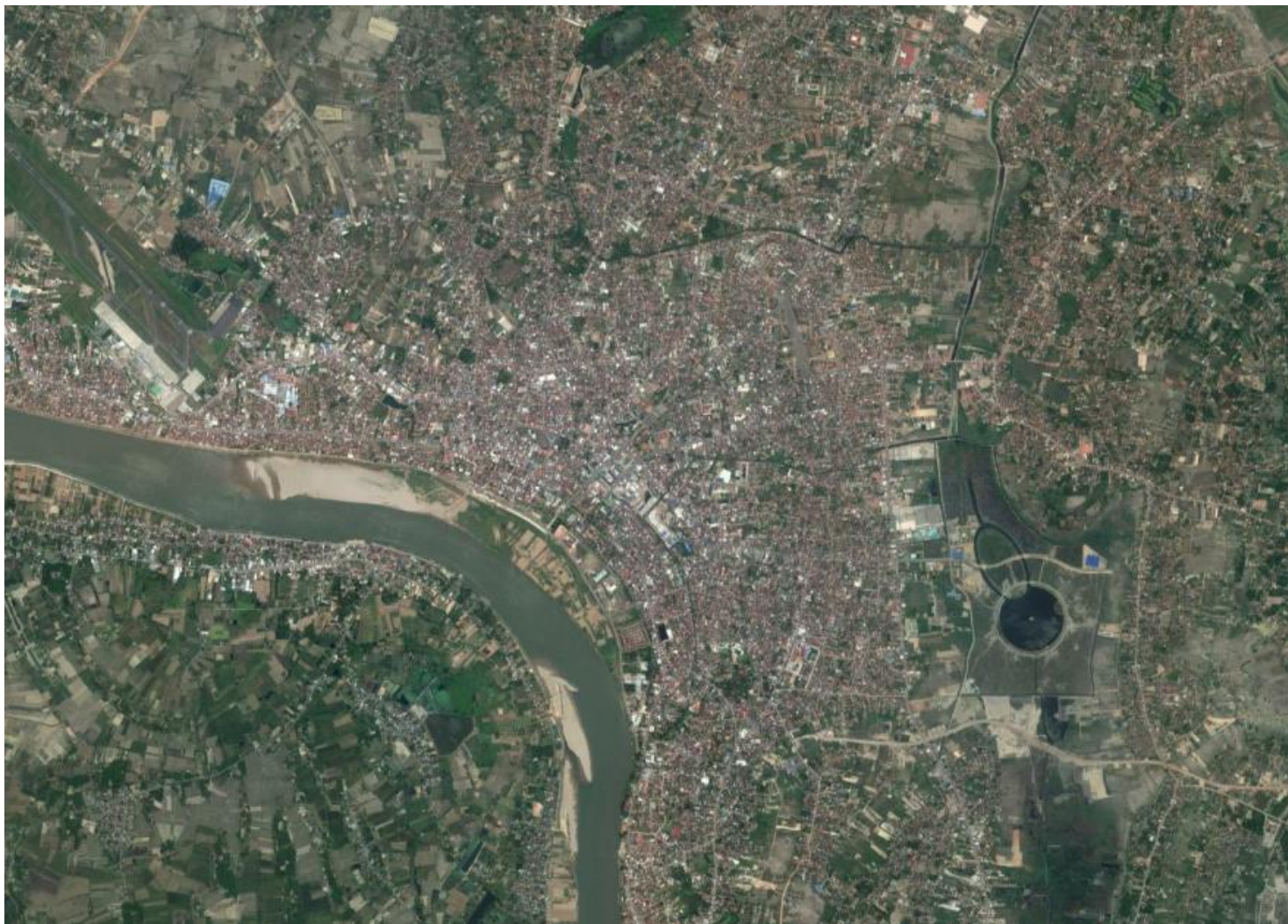


Examples of Flood prone areas Luang Prabang: 5m and 10m



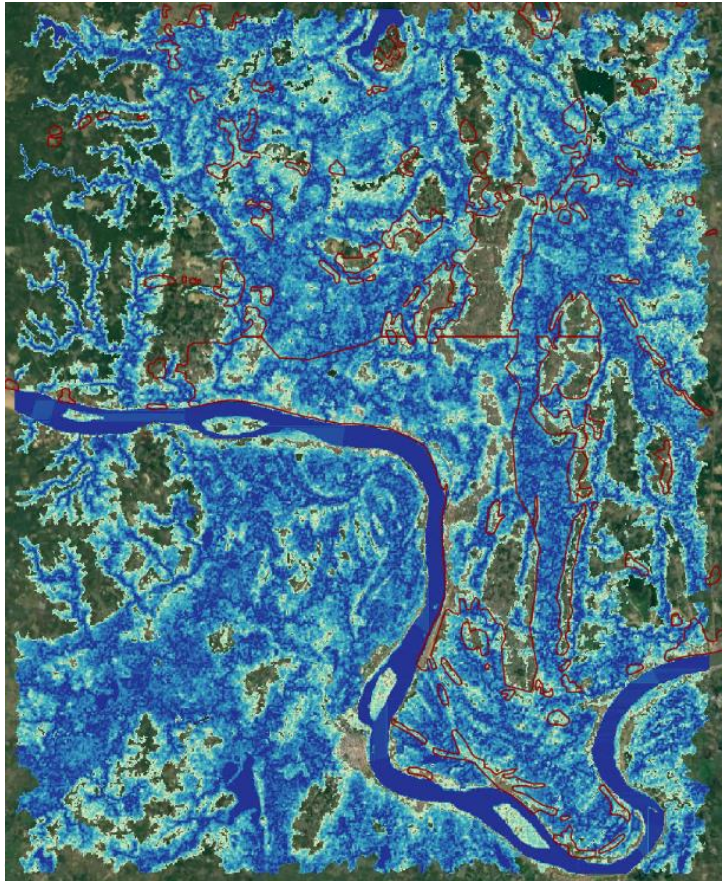
— 5m
— 10m

Vientiane – HAND index

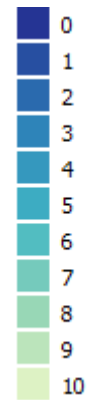


Step 1:
Find the
area to
be
assessed

Flood prone areas for Vientiane 0-10 m



Hand index
[m]



Examples of Flood prone areas in Vientiane: 5m and 10m (HAND values)

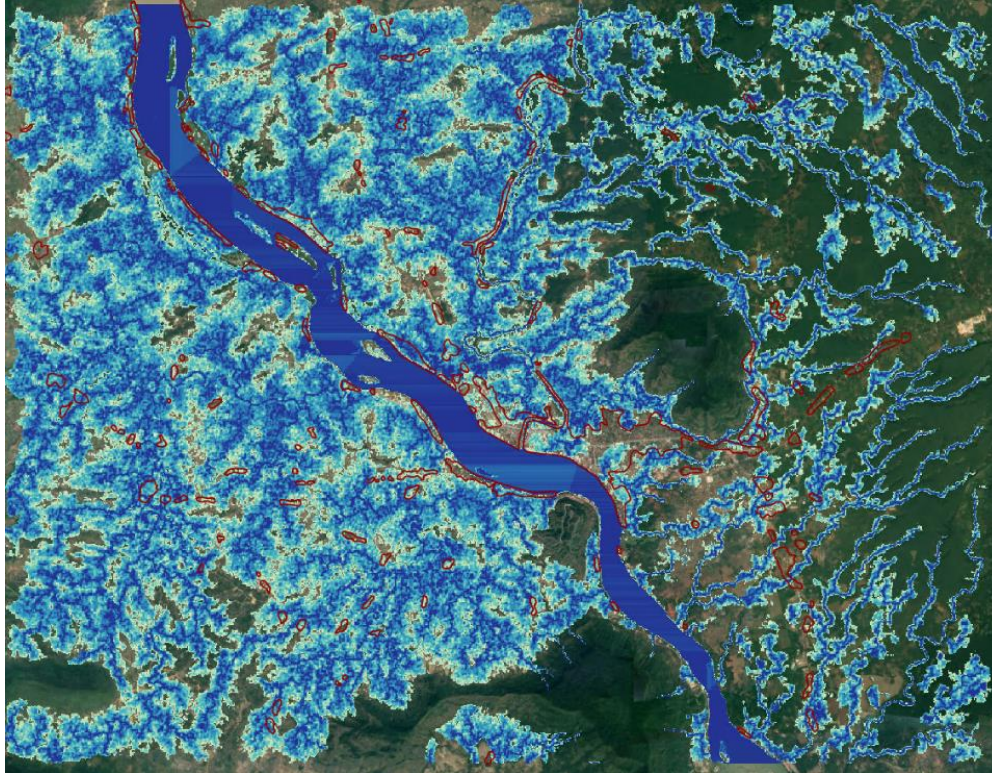


— 5m
— 10m

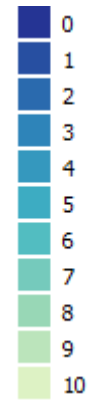


Pakse – HAND index

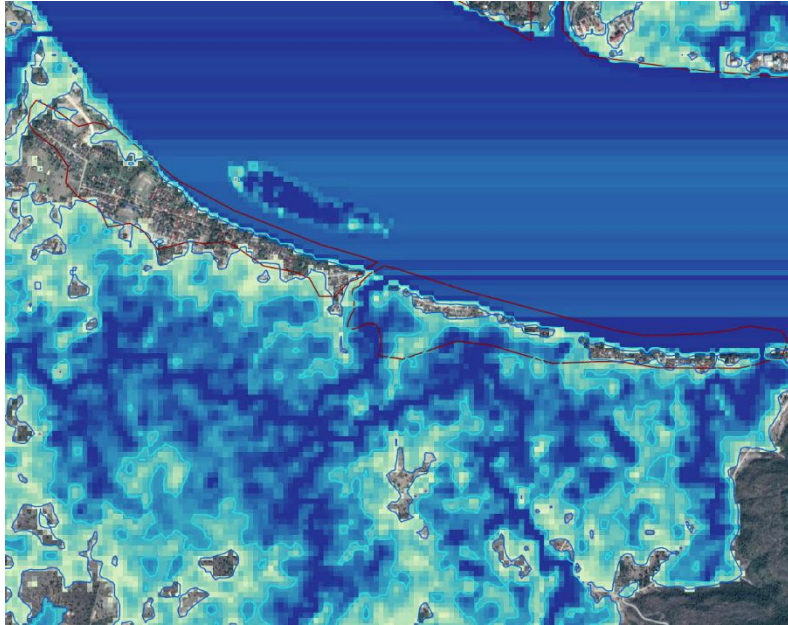
Flood prone areas for Pakse 0-10 m



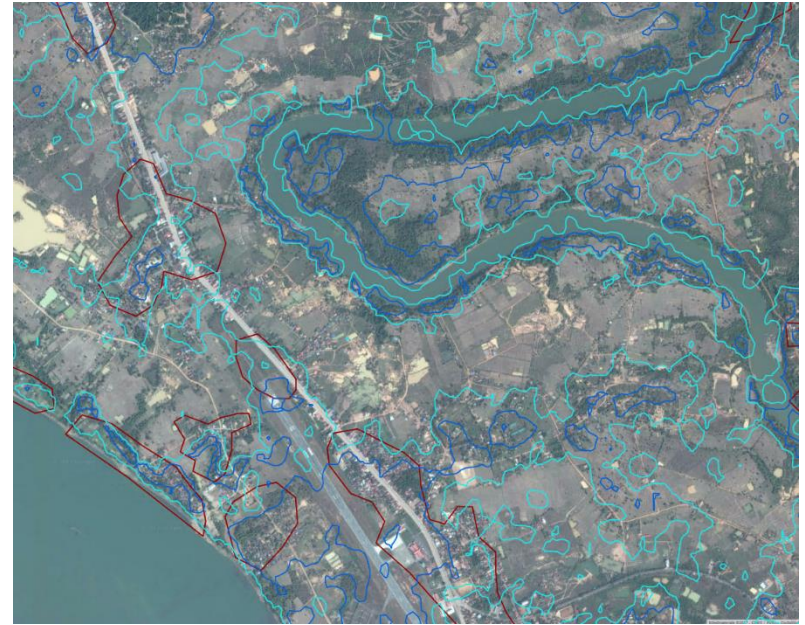
Hand index
[m]



Examples of Flood prone areas Pakse: 5m and 10m



— 5m
— 10m



Land cover classification

Land Cover Classification

	Forest (deciduous)
	Agriculture
	Bare soil
	Forest (coniferous)
	Rubber
	Rice Paddies
	Road
	Urban
	Water
	Irrigated Rice
	Grassland

Our approach:

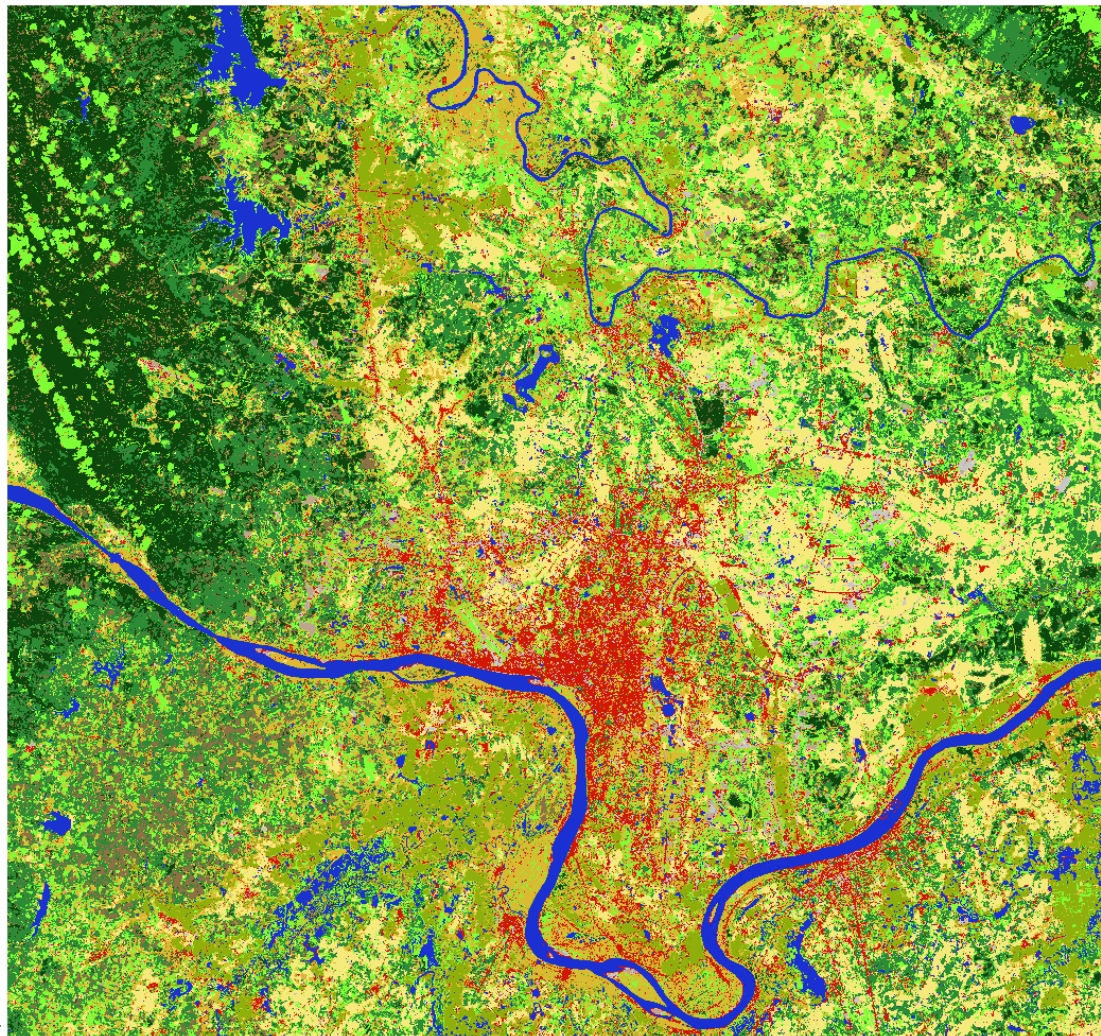
- Limited number of classes
- Two types of rice fields were found with the type “Irrigated Rice” in both summer and winter, and Rice paddies only for summers.
- “Irrigated Rice” with seasonal water supply by pumping

Vientiane data used for Land Cover Classification

- Sentinel 2 satellite images: 2017-feb-16 & 2016-nov-28
- Spatial resolution 10 m
- Classification method: Random Forest
- **Cloud on Sentinel 2 data masked out and have values: Cloud: 100, Cloud Shadow: 101**



Vientiane Land Cover Classification



- Forest (deciduous)
- Agriculture
- Bare soil
- Forest (coniferous)
- Rubber
- Rice Paddies
- Road
- Urban
- Water
- Irrigated Rice
- Grassland

Vientiane Land Cover Classification – zoom in

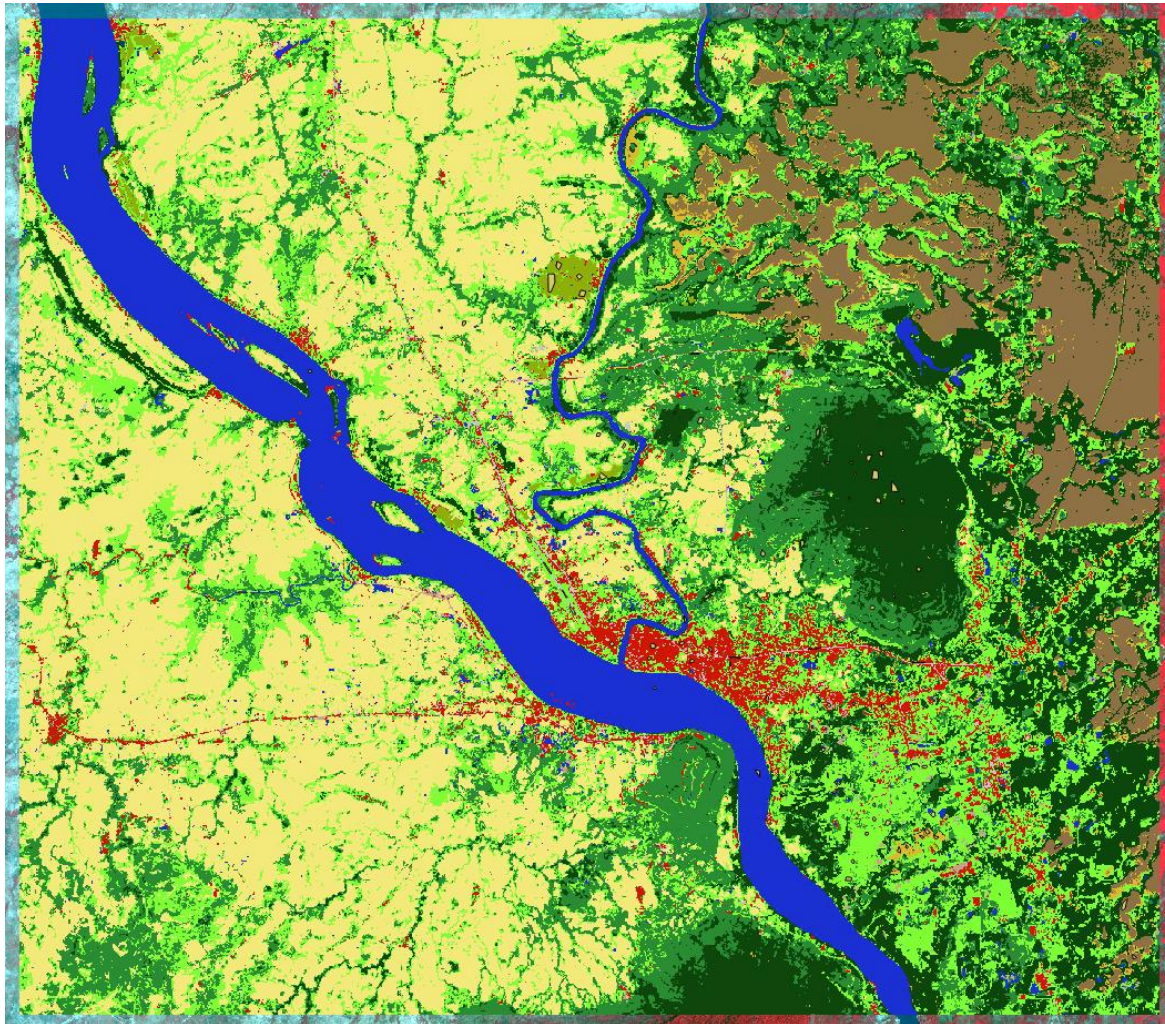


- Forest (deciduous)
- Agriculture
- Bare soil
- Forest (coniferous)
- Rubber
- Rice Paddies
- Road
- Urban
- Water
- Irrigated Rice
- Grassland

Data used for Land Cover Classification for Pakse and Luang Prabang

- Sentinel 2 satellite images: 2017-mar-02 & 2016-nov-12
- Spatial resolution 10 m
- Classification method: Random Forest
- Classes for the Pakse area are listed in figures

Pakse Land Cover Classification



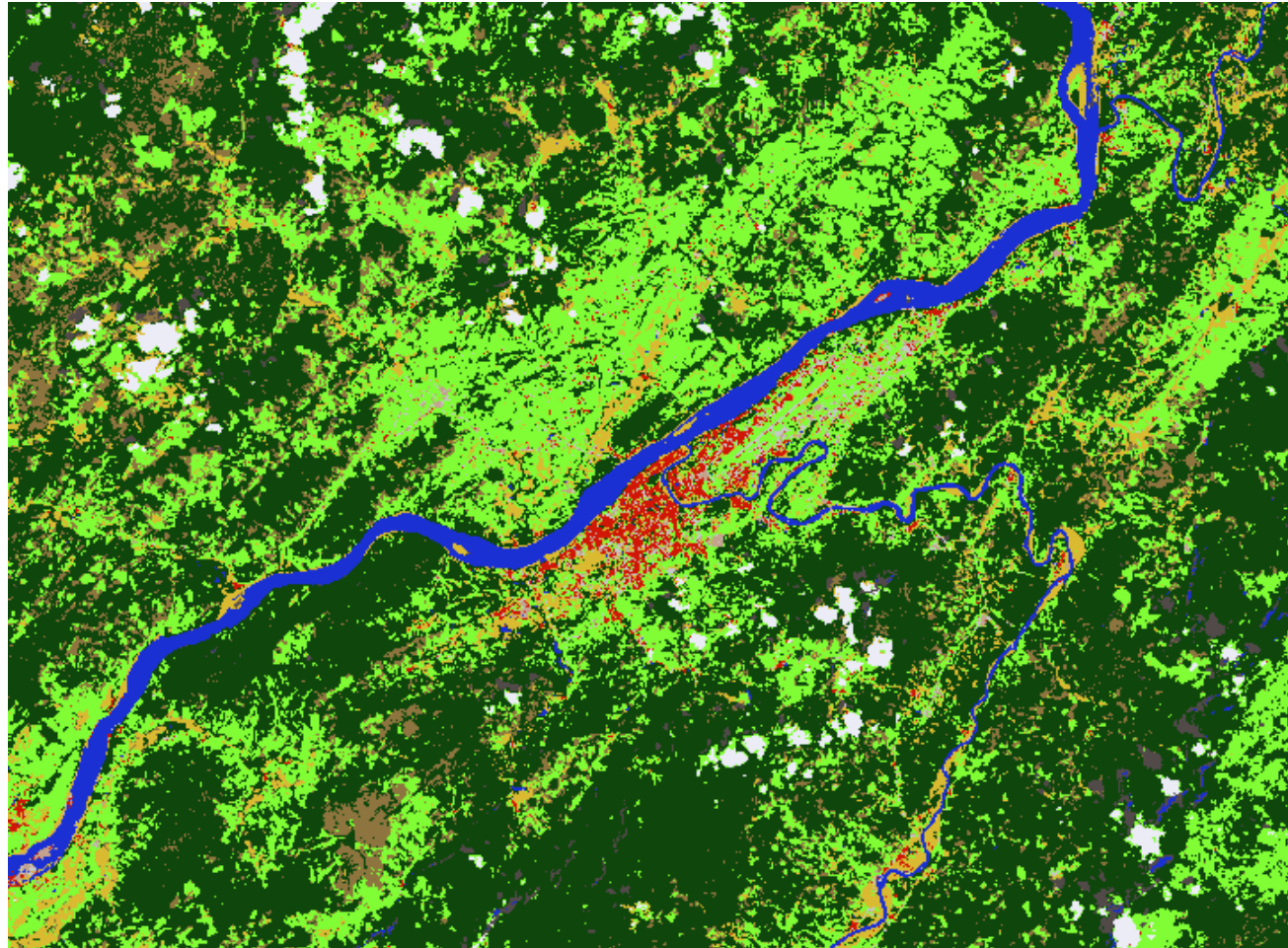
- Forest (deciduous)
- Agriculture
- Bare soil
- Forest (coniferous)
- Rubber
- Rice Paddies
- Road
- Urban
- Water
- Irrigated Rice
- Grassland

Pakse Land Cover Classification – zoom in



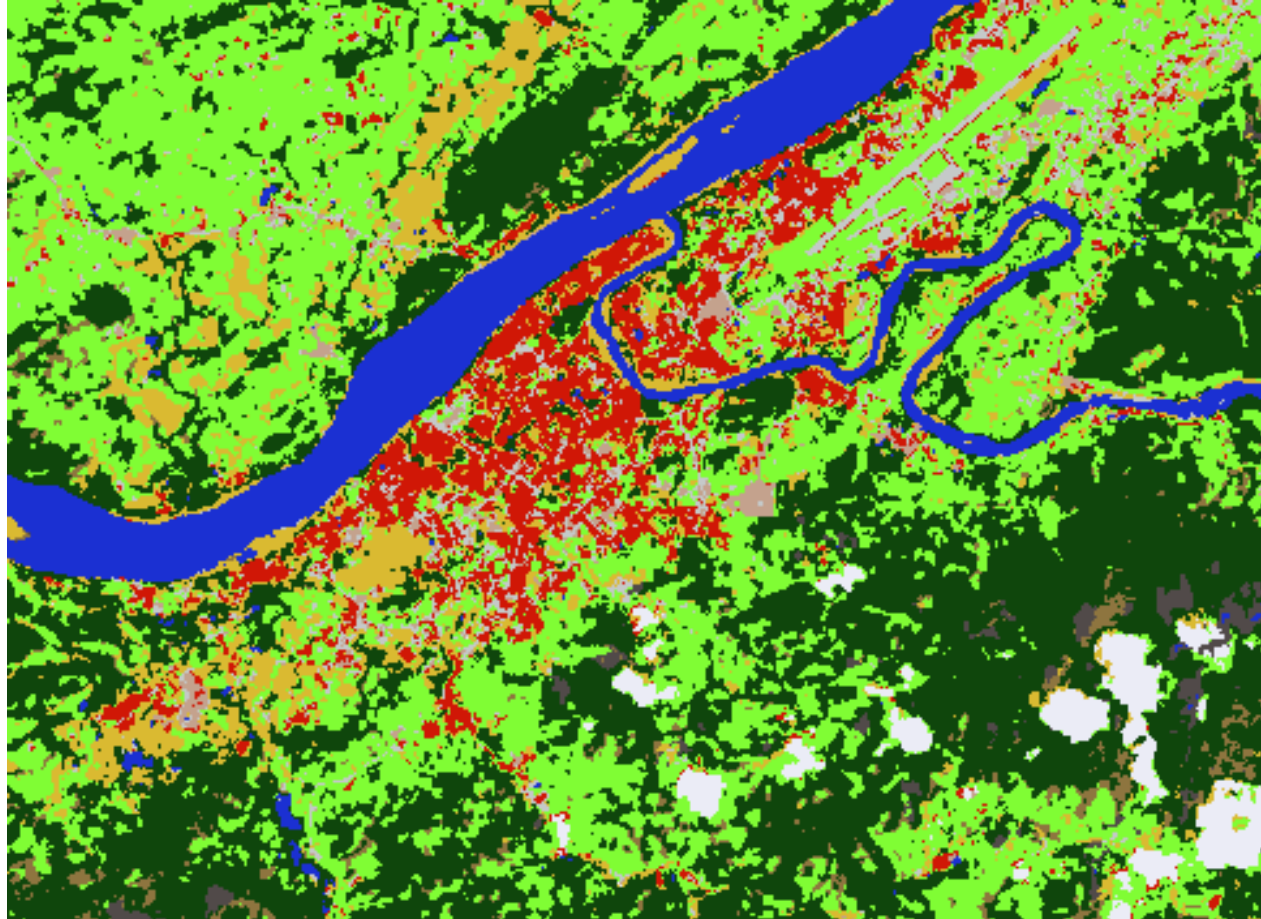
- Forest (deciduous)
- Agriculture
- Bare soil
- Forest (coniferous)
- Rubber
- Rice Paddies
- Road
- Urban
- Water
- Irrigated Rice
- Grassland

Luang Prabang Land Cover Classification



- Forest (deciduous)
- Agriculture
- Bare soil
- Forest (coniferous)
- Rubber
- Rice Paddies
- Road
- Urban
- Water
- Irrigated Rice
- Grassland

Luang Prabang Land Cover Classification – zoom in



- Forest (deciduous)
- Agriculture
- Bare soil
- Forest (coniferous)
- Rubber
- Rice Paddies
- Road
- Urban
- Water
- Irrigated Rice
- Grassland

Vulnerability analysis

Vulnerability analysis

Hazard-map (Flooding)+
Landcover +
Vulnerable index

(based on how certain
landcover classes have low,
medium, or high vulnerability)

Cl		Vulnerability
	Forest (deciduous)	Low
	Agriculture	High
	Bare soil	Low
	Forest (coniferous)	Low
	Rubber (Plantation)	High
	Rice paddies	Medium
	Roads	High
	Urban	High
	Water	Low
	Irrigated rice	Medium
	Grassland	Medium

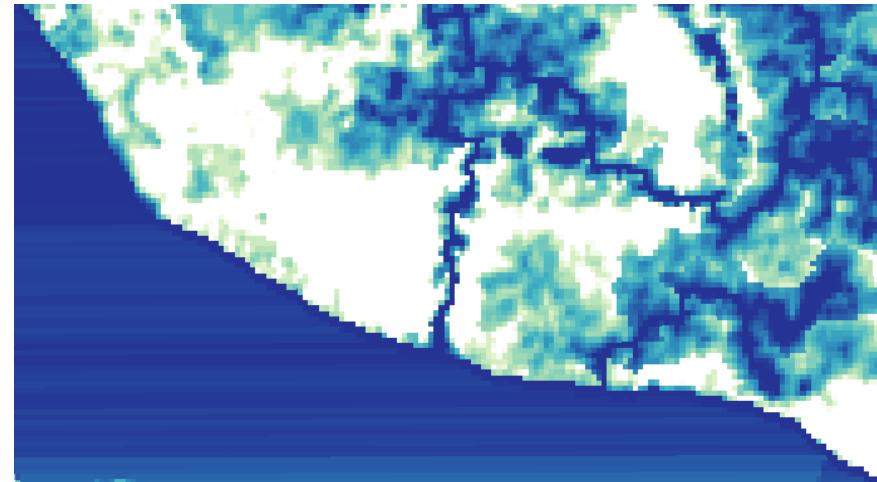
Ranking of the land cover classes

Raster value	Vulnerability rank	Classes
1	High	Agriculture, Urban, Roads, Rubber
2	Medium	Grassland, Rice paddies*
3	Low	Water, Bare soil, Forests (Con. + Dec

* We put rice paddies and irrigated rice as medium and not high since they are relatively tolerant to flooding

Ranking of the flooding results (From HAND-map)

HAND index	Risk value	Risk text
0 – 2,99	3	High risk
3,0 – 5,99	2	Medium risk
6,0 – 9,99	1	Low risk
Above 10	NULL	Very low, not taken further

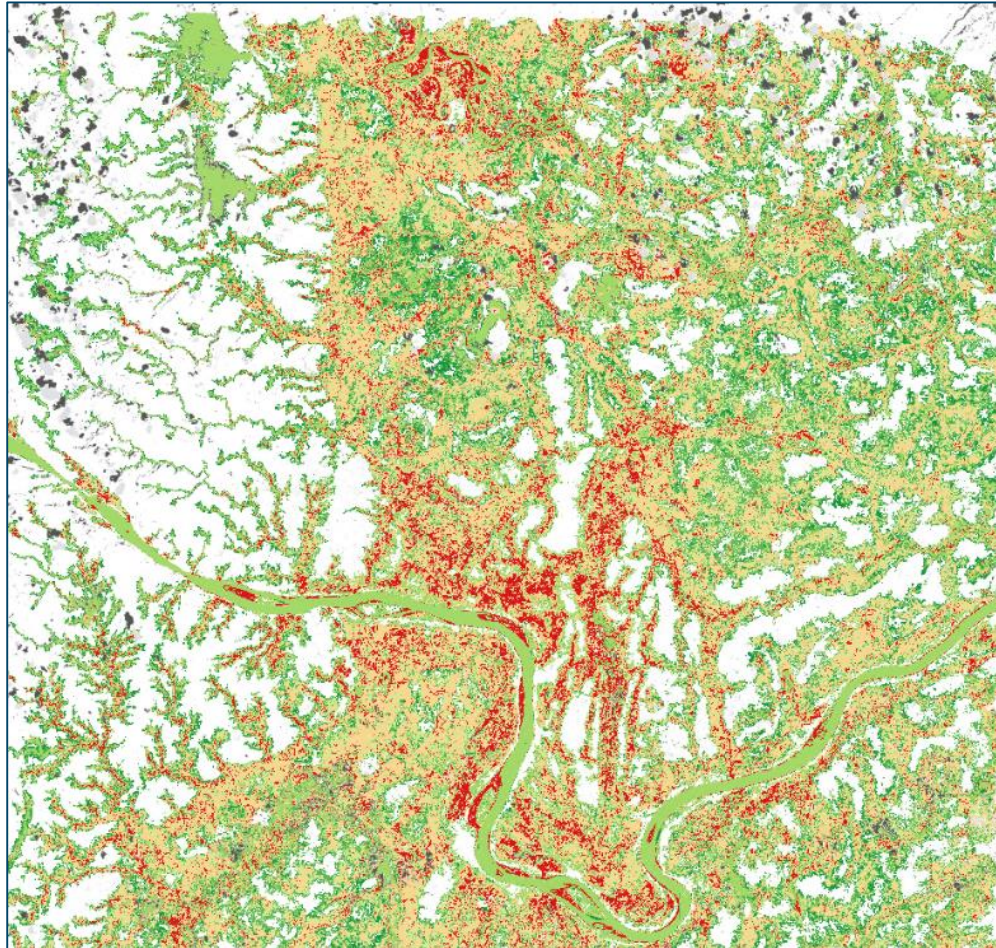


The assessment of the vulnerability

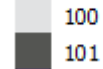
		Land cover rank 1= low severity, 3 = high severity			
		Code	1	2	3
HAND index - rank 1= low risk, 3= high risk	1	1	2	3	
	2	2	4	6	
	3	3	6	9	

Vulnerability	
1	Low
2	Low
3	Low
4	Medium
6	Medium
9	High

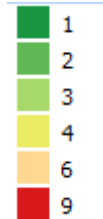
Vulnerability, Vientiane



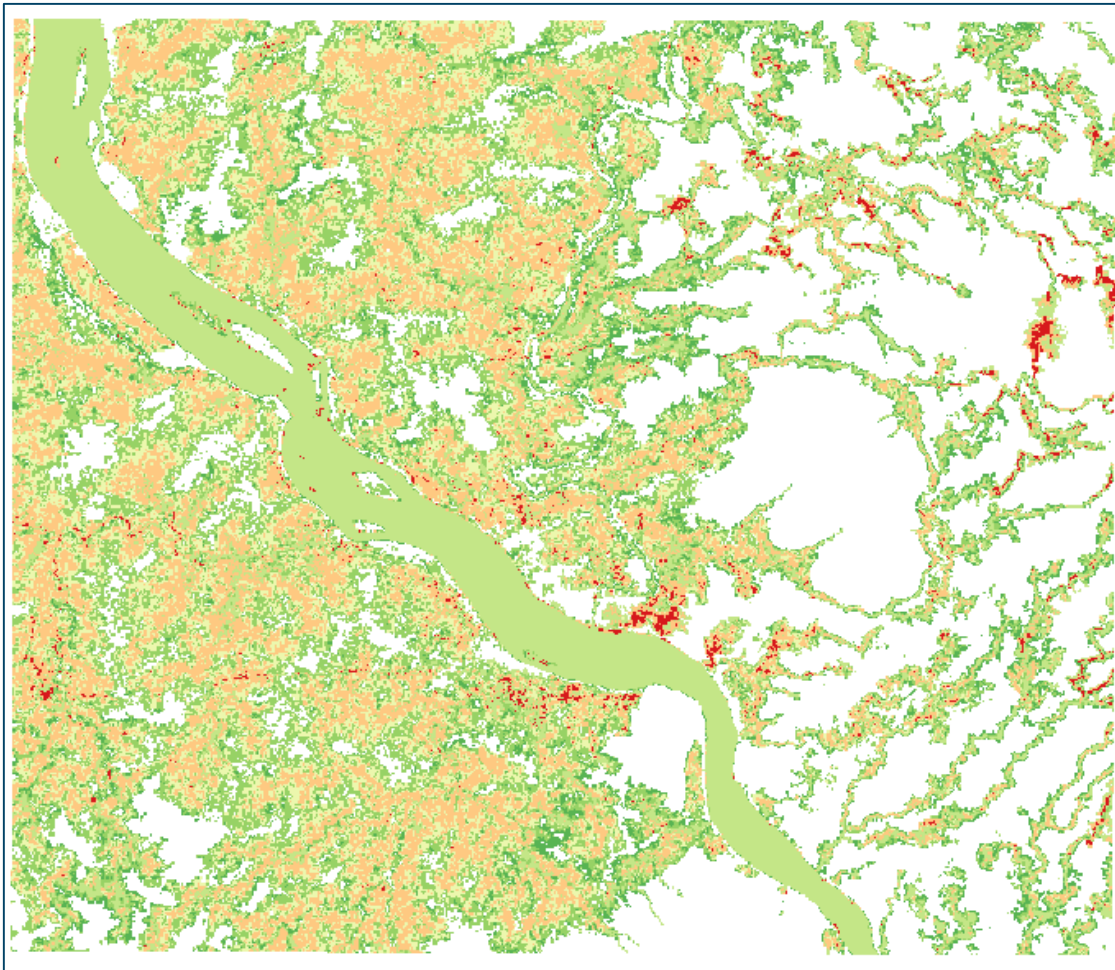
Cloud_class



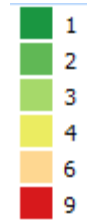
Vulnerability



White areas are having
HAND index values above 10m

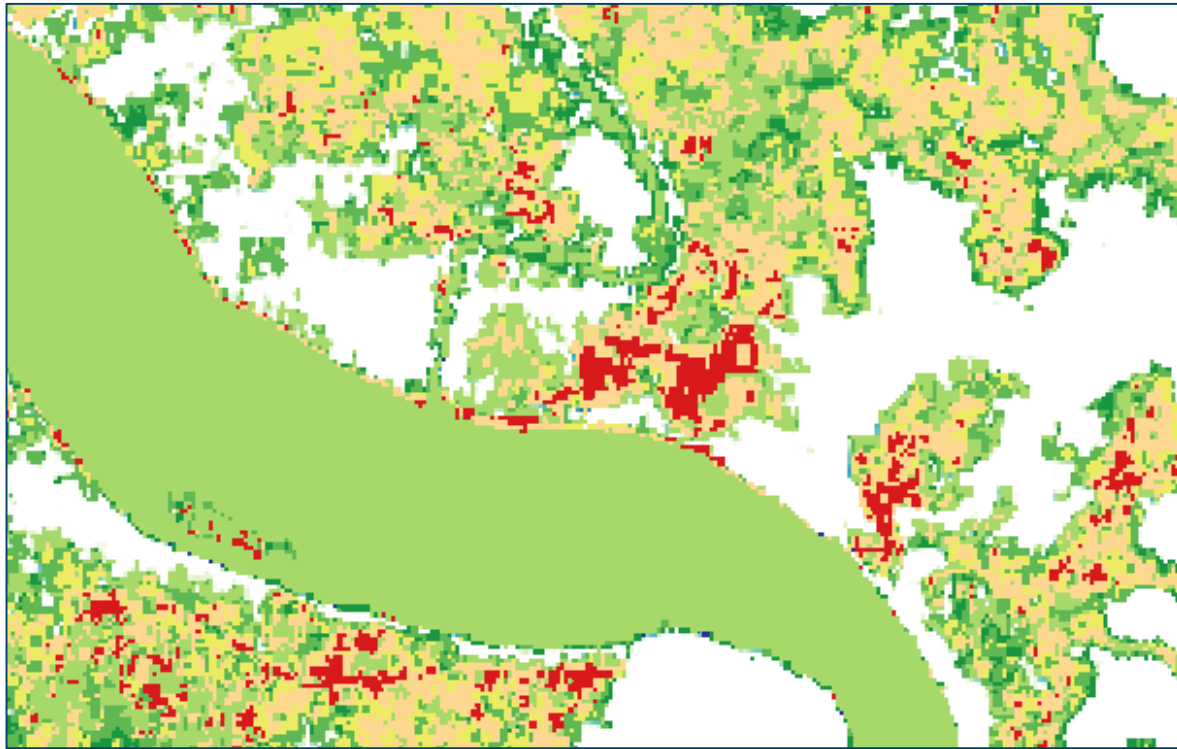


Vulnerability Pakse

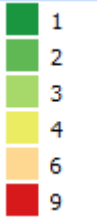
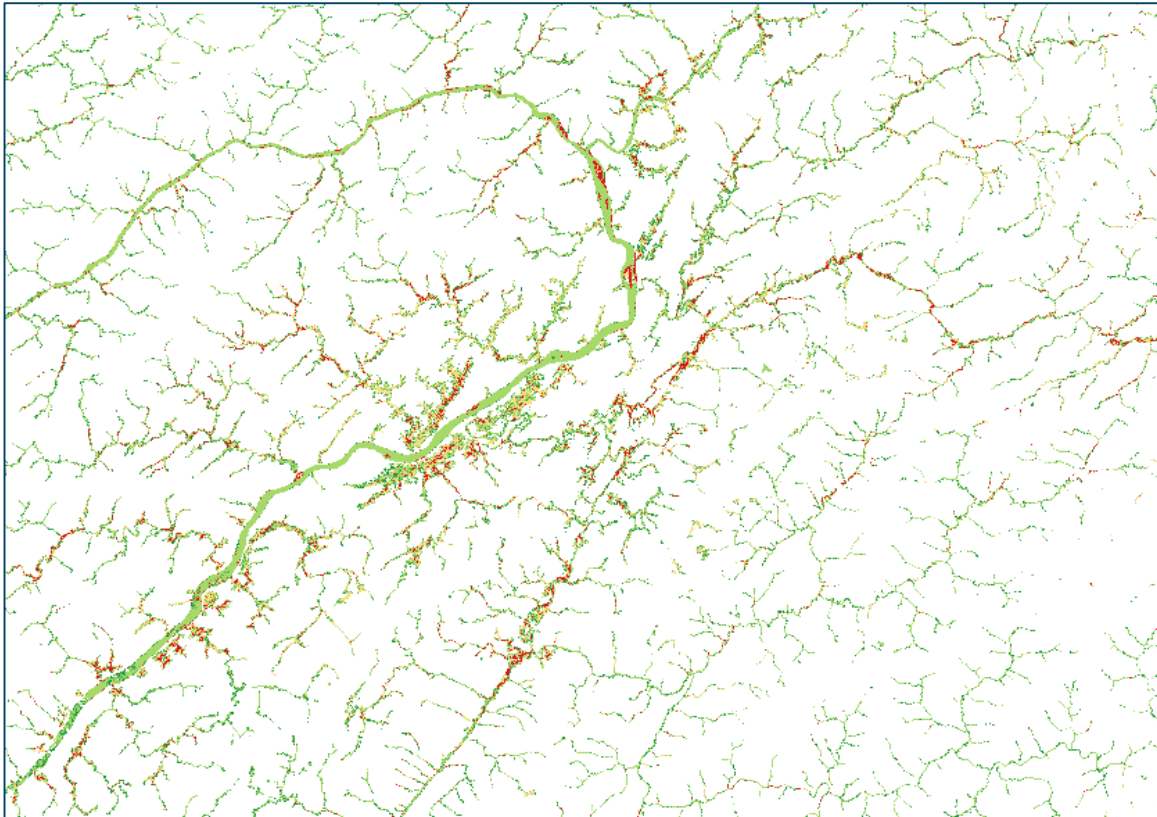


White areas are having
HAND index values above 10m

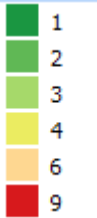
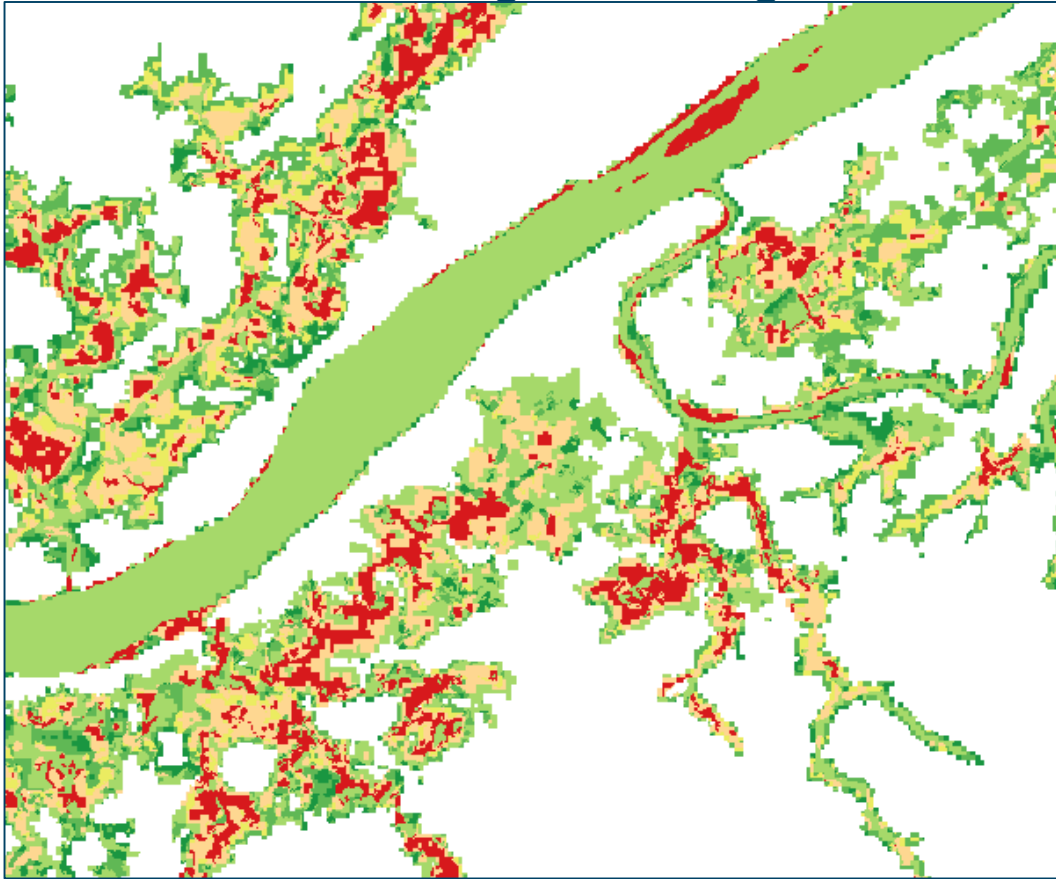
Zoom-in on Pakse



Luang Prabang vulnerability map



Zoom-in on Luang Prabang



So how to move on from here?

Individual work for the cities

- In the afternoon time for individual work for the selected sites
- Access to maps for Vientiane, Pakse and partly from Luang Prabang.

1. Go through the selected site
2. Assess with use of the flooding map (HAND) where flooding hits
3. Assess the land cover classification
4. Assess the vulnerability of the site
5. Assess any new sites.

Ecosystem-based adaptation interventions: group discussions

National Workshop, Lao PDR, September 13th – 15th 2017

What we need to find out?

1

- **Which ecosystem services are damaged by floods?**

2

- **Which ecosystem services can protect people and infrastructure?**

3

- **Which ecosystem services are provided by various ecosystem based interventions?**

1+2+3= Informing selection of most beneficial ecosystem based interventions

1

- Which ecosystem services are damaged by floods?

2

- Which ecosystem services can protect people and infrastructure?

3

- Which ecosystem services are provided by various ecosystem based interventions?

1+2+3= Informing selection of most beneficial ecosystem based interventions

Which ecosystem services are damaged by floods?



1. Select 1 site in your city for analysis

City/ຕົວເມືອງ:
Site name/ຊື່ສະຖານທີ່:

2. Mark the most important damages to ecosystems experienced in this site

Ecosystem damages
ລະບົບນິເວດທີ່ໄດ້ຮັບຄວາມເສຍຫາຍ

3. Identify the main cause of the damages

Key cause of damages?
ສາເຫດຫຼັກຂອງການເກີດຄວາມເສຍຫາຍ?

Other local (urbanization, land use change, etc) ທີ່ອື່ນ (ການນິເວດປ່ຽນແປງໃນເມັດ, ການນຳໃຊ້ທີ່ດິນ, ອື່ນໆ)

Other basin level (land use change upstream, deforestation in the basin, etc.) ລະດັບອ່າງນ້ຳຂຶ້ນ (ການນຳໃຊ້ທີ່ດິນ, ການກັ່ນຕົ້ມທີ່ກວມເປົ້າ ຢູ່ໃນແຫຼ່ງນ້ຳ, ອື່ນໆ)

Other climate change (increasing temperatures and other climate change impacts) ການປ່ຽນແປງອຸນຫະພູມອາກາດອື່ນໆ (ຄວາມຮຸນແຮງຂຶ້ນຂອງອຸນຫະພູມອາກາດອື່ນໆ)

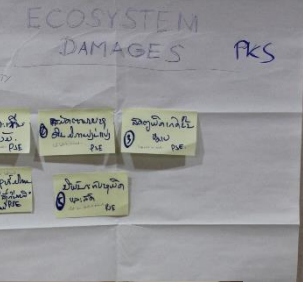
Ecosystem services affected as a result of these damages
ການບໍລິການທາງດ້ານລະບົບນິເວດ ທີ່ໄດ້ຮັບຜົນກະທົບ ນັ້ນອາດມາຈາກການເກີດຄວາມເສຍຫາຍດັ່ງນີ້

Provisioning ການຈັດຫາກະກຽມ	Regulation and Maintenance ລະບຽບ ແລະ ການບໍາລຸງຮັກສາ
Water provision ການຈັດຫານ້ຳ	Local climate and air quality ສະພາບອາກາດທີ່ອ່າງນ້ຳແລະ ຄຸນນະພາບທາງອາກາດ
Raw materials ວັດຖຸດິບ	Carbon sequestration and storage ການກັກໄວ້ ແລະ ການເກັບຮັກສາທາດຄາບອນໄດອອກໄຊ
Medicinal resources ແຕ້ວຢາ	Moderation of extreme events ການດູແລງການເກີດຜົນກະທົບແຮງ
	Wastewater treatment ການບໍາລຸງແຕ້ວ
	Erosion prevention ການປ້ອງກັນການກໍ່ຄຸກຸກ
	Maintenance of soil quality ການຮັກສາຄຸນນະພາບຂອງດິນ
	Pollination services ການບໍາລຸງການປະສົມພັນພືດ
	Biological control ການຄວບຄຸມພູມຫຼາດຮີບຂາດ

4. Identify which ecosystem services are damaged as a result of this

RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?
Biology and habitats ຊີວະວິທະຍາ ແລະ ແຫຼ່ງທີ່ຢູ່ອາໄສ																				
Terrestrial habitats for animals ທີ່ຢູ່ອາໄສຂອງສັດຢູ່ທາງບົກ																				
Aquatic animals and plants ສັດນ້ຳ ແລະ ພືດ																				
Forests and trees (excluding forest fires) ປ່າ ແລະ ສາຍໄມ້ (ບໍ່ລວມໄພໄໝ້ປ່າ)																				
Wild and cultivated crops ພືດປ່າ ແລະ ພືດຜັງປູກ																				
Non-timber forest products (Wild plants, mushrooms and wildlife) ຜົນຜະລິດຈາກປ່າໄມ້ (ພືດປ່າ, ຕື້ດ ແລະ ສັດປ່າ)																				
Timber and access to firewood ຜະລິດຕະພັນໄມ້ ແລະ ການເຂົ້າເຖິງແຕ້ວໄມ້																				

City/ຕົວເມືອງ:
 ຕື່ມາຍ/ຊື່ສະຖານທີ່:



		Ecosystem services affected as a result of these damages			
ການເສີມການທາງດ້ານນະບົບນິເວດທີ່ໄດ້ຮັບຜົນກະທົບ ຕໍ່ຮ່ອງມາຈາກການເກີດຄວາມເສຍຫາຍຕ່າງໆ		Key cause of damages? ເຫດຜົນທີ່ກຳລັງສ້າງການເກີດຄວາມເສຍຫາຍ?		Provisioning ການຈັດຫາກະສານຸມ	Regulation and Maintenance ວາລະບຸນ ແລະ ການບໍາລຸງຮັກສາ
RELEVANT? ສຳຄັນຂອງ?	Flooding ຖ້ວມນ້ຳ	Other local (urbanization land use change, etc) ສ່ວນຕົວທີ່ບໍ່ເປັນພື້ນທີ່ກະສິກຳ (ການປ່ຽນແປງໃຊ້ທີ່ດິນ ອື່ນໆ)	Other basin level (land use change upstream, deforestation in the basin, etc.) ສ່ວນຕົວຂອງພື້ນທີ່ເກີດຂຶ້ນ ທີ່ເປັນພື້ນທີ່ກະສິກຳ ທີ່ເຮັດໃຫ້ມີຜົນກະທົບຕໍ່ພື້ນທີ່ເກີດຂຶ້ນ ອື່ນໆ	Food provision ການສົ່ງອອກອາຫານ	Carbon sequestration and storage ການບັນທຶກໄດ້ແລະການເກັບຮັກສາອາກາດອາຍາໄອໂອກອາກາດ
Biology and habitats ຊີວະວິທະຍາ ແລະ ເສື້ອທີ່ຢູ່ອາໄສ Terrestrial habitats for animals ທີ່ຢູ່ອາໄສຂອງສັດຢູ່ທາງບົກ Aquatic animals and plants ສັດນ້ຳ ແລະ ພືດ Forests and trees (excluding forest fires) ບ່າ ແລະ ຕົ້ນໄມ້ (ບໍ່ວອມໄພໄໝ້ບ່າ)					
Wild and cultivated crops ພືດບ່າ ແລະ ພືດສົມບູນ Non-timber forest products (Wild plants, mushrooms and wildlife) ຜົນຜະວິດຈາກບ່າໄມ້ (ພືດບ່າ, ເຫັດ ແລະ ສັດບ່າ) Timber and access to firewood ຜະວິດຕະພັນໄມ້ ແລະ ການເຂົ້າຕັ້ງເສື້ອທີ່ໄມ້					
				Water provision ການສົ່ງອອກນ້ຳ	Waste water treatment ການບໍາລຸງນ້ຳເສຍ
				Raw materials ວັດຖຸດິບ	Erosion prevention ການປ້ອງກັນການກົ່ວຊາະ
				Medicinal resources ເສື້ອທີ່ຢາ	Maintenance of soil quality ການຮັກສາຄຸນນະພາບຂອງທີ່ດິນ
				Local climate and air quality ສະພາບອາກາດທີ່ຮ່ອງຖິ່ນແລະ ອຸນຫະພາບອາກາດ	Pollination services ການບໍາລຸງການປະສົມພັນສິດ
					Biological control ການຄວບຄຸມຜູ້ເສຍຫາຍ



City/ຕົວເມືອງ:

Site name/ຊື່ສະຖານທີ່:

		Services affected as a result of these damages																
		2 Key cause of damages? ສາເຫດຫຼັກຂອງການເກີດອາການເສຍຫາຍ?				3 Provisioning ການຈັດຫາກະສຽມ			Regulation and Maintenance ລະບຽບ ແລະ ການບໍາລຸງຮັກສາ									
1 Ecosystem damages ລະບົບນິເວດທີ່ໄດ້ຮັບອາການເສຍຫາຍ		RELEVANT? ສຳຄັນເປັນຈັດ?	Flooding ນ້ຳຖ້ວມ	Other local (urbanization, land use change, etc.) ອື່ນໆໃນບ້ານ (ການສ້າງເມັດ, ການປ່ຽນໃຊ້ສິນ, ອື່ນໆ)	Other basin level (land use change upstream, deforestation in the basin, etc.) ອື່ນໆໃນລະດັບເຂດບ້ານ (ການປ່ຽນໃຊ້ສິນເທິງເຂດບ້ານ, ການຕັດໄມ້ເທິງເຂດບ້ານ, ອື່ນໆ)	Other climate change (increasing temperature and other climate change impacts) ອື່ນໆເພາະການປ່ຽນແປງອາກາດ (ອຸນຫະພູມສູງຂຶ້ນ, ອື່ນໆເພາະການປ່ຽນແປງອາກາດ)	Food provision ການສົ່ງອາຫານ	Water provision ນ້ຳດື່ມ	Raw materials ວັດຖຸດິບ	Medicinal resources ເພັດຊາ	Local climate and air quality ອາກາດ ແລະ ຄຸນນະພາບອາກາດ ທ້ອງຖິ່ນ	Carbon sequestration and storage ການກັ່ນໄອ້ ແລະ ການເກັບຮັກສາອາກາດອະນຸຮອນ	Moderation of extreme events ການຫຼຸດລະດັບການເຮັດອາດຮາງ	Waste water treatment ການປັບປຸງນ້ຳເສຍ	Erosion prevention ການປ້ອງການການກັ່ນຕຸ້ງ	Maintenance of soil quality ການຮັກສາຄຸນນະພາບຂອງດິນ	Pollution services ການບໍລິການປະມົນສົມ	Biological control ການຄວບຄຸມໜັງຊີວະສາດ
Biology and habitats ຊີວະນິເວດ ແລະ ເສັງທີ່ຢູ່ອາໄສ																		
Terrestrial habitats for animals ທີ່ຢູ່ອາໄສຂອງສັດຢູ່ທາງບົກ																		
Aquatic animals and plants ສັດນ້ຳ ແລະ ຝັດ																		
Forests and trees (excluding forest fires) ປ່າ ແລະ ຕົ້ນໄມ້ (ບໍ່ວອນໄພໄໝ້ປ່າ)																		
Wild and cultivated crops ພືດປ່າ ແລະ ພືດຝັງປູກ																		
Non-timber forest products (Wild plants, mushrooms and wildlife) ຜົນຜະວັດຈາກປ່າໄມ້ (ພືດປ່າ, ຄູ່ນ້ຳ ແລະ ສັດປ່າ)																		
Timber and access to firewood ຜະວັດຕະພັນໄມ້ ແລະ ການເຂົ້າເຖິງເສັງໄມ້																		

Example:

Damage to ecosystem services from flooding: Rice production



Provisioning

- Food

Regulating

- Maintenance of soil quality

1

- Which ecosystem services are damaged by floods?

2

- Which ecosystem services can protect people and infrastructure?

3

- Which ecosystem services are provided by various ecosystem based interventions?

1+2+3= Informing selection of most beneficial ecosystem based interventions

Which ecosystem services can protect people and infrastructure?

1. Select which activities and habitats are impacted by floods in this site

2. Identify the main cause of the FLOODING

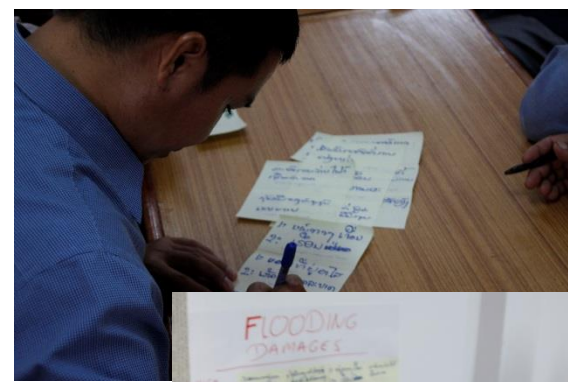
3. Select which ecosystem services are needed to mitigate these damages and SUPPORT these activities and habitats

City/ຕົວເມືອງ: _____
 Site name/ຊື່ສະຖານທີ່: _____

Ecosystem services necessary to protect and strengthen these activities and habitats
 ການບໍລິການທາງດ້ານລະບົບມິດທີ່ອໍາເປັນໃນການປົກປ້ອງ ແລະ ສ້າງຄວາມເຂັ້ມແຂງໃຫ້ແກ່ບໍລິການທາງດ້ານລະບົບມິດ














































































































































































Activities and habitats threatened and impacted by floods ກິດຈະກຳ ແລະ ທີ່ຢູ່ອາໄສ ທີ່ໄດ້ຖືກຄາດຄາມ ແລະ ໄດ້ຮັບຜົນກະທົບຈາກໄພນໍ້າຖ້ວມ	RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	Key cause of flooding? ສາເຫດຫຼັກຂອງນໍ້າຖ້ວມ?			Provisioning ການອັດຫາກະກຽມ			Regulation and Maintenance ລະບຽບ ແລະ ການບໍາລຸງຮັກສາ						
		Local (urbanization, land use change, etc.) ທີ່ອ້າງອີງ (ການເຜີຍແຜ່ນະນາຖ້ວມຂອງ, ການນໍາໃຊ້ດິນ, ອື່ນໆ)	Basin level (land use change upstream, deforestation in the basin, etc.) ລະດັບອ້າງອີງ (ການປ່ຽນແປງການນໍາໃຊ້ດິນ, ການກັດໄມ້ທ່າວາຍເປັນ ຢູ່ໃນແຫຼ່ງນໍ້າ, ອື່ນໆ)	Global (increasing temperatures and other climate change impacts) ກະບຸລຸກບໍລິໂພກ (ຂັບປະເມພາທີ່ເພີ່ມຂຶ້ນ ແລະ ຜົນກະທົບທາງອາກາດອື່ນໆ)	Food provision ການອັດຫາອາຫານ	Water provision ການອັດຫນໍ້າ	Fuels and fibers ເຊື້ອເບັງ ແລະ ຕໍ່ເນື່ອງ	Medicinal and other biochemical resources ແຕ່ງຢາ ແລະ ຊີວະຄຳມັນ	Local climate and air quality ສະພາບອາກາດທີ່ອ້າງອີງ ແລະ ຄຸນນະພາບອາກາດ	Carbon sequestration and storage ການກັບໄວ້ ແລະ ການກັບຮັກສາທາດຄາບອນບໍລິຫອນໄຊ	Moderation of extreme events ການລຽບແລະ ຫາກການທີ່ຮ້າຍແຮງ	Wastewater treatment ການປັບປຸງແກ້ໄຂ	Erosion prevention ການປ້ອງກັນການກັ່ວຄາຍ	Maintenance of soil quality ການຮັກສາຄຸນນະພາບດິນ
Agriculture, forest and aquaculture ຂະແໜງກະສິກໍາ ປ່າໄມ້ ແລະ ການລ້ຽງສັດນໍ້າ														
Crops, including rice ຜົນຜະລິດພືດ ລວມທັງເຂົ້າ														
Livestock activities ການລ້ຽງສັດ														
Forests ປ່າໄມ້														
Habitats ທີ່ຢູ່ອາໄສ														
Aquaculture ການລ້ຽງສັດນໍ້າ														
Economy and tourism ຂະແໜງເສດຖະກິດ ແລະ ການທ່ອງທ່ຽວ														
State budgets (used for repairing damages) ງົບປະມານຂອງລັດ (ສໍາລັບໃຊ້ໃນການສອບແວງຄວາມເສຍຫາຍ)														





City/ຕົວເມືອງ:

Site name/ຊື່ສະຖານທີ່:

		Ecosystem services necessary to protect and strengthen these activities and													
		ການບໍລິການທາງດ້ານລະບົບລະບົບສະໜອງບໍລິການລະບົບສະໜອງ													
Activities and habitats threatened and impacted by floods ກິດຈະກຳ ແລະ ທີ່ຢູ່ອາໄສ ທີ່ໄດ້ຖືກຄຸກຄຸນ ຄາມ ແລະ ໄດ້ຮັບຜົນກະທົບຈາກໄພນໍ້າຖ້ວມ	RELEVANT? ສໍາຄັນເທັດອັນໃດ?	Key cause of flooding? ອາຫດຕົ້ນສະບັບຂອງນໍ້າຖ້ວມ?			Provisioning ການຈັດຫາສາຍາມ			Regulation and Maintenance ວາຍຽບ ແລະ ການບໍ່ລາງຮັກສາ							
		Local (urbanization, land use change, etc.) ສັງຄົມ ແລະ ການປ່ຽນແປງໃນສະຖານທີ່ (ເງິນ, ອຸປະກອນ, ອື່ນໆ)	Basin level (land use change upstream, deforestation in the basin, etc.) ຈຸດປະສານ (ການປ່ຽນແປງໃນເຂດເທິງຂອງບ່ອນ, ການຕັດໄມ້, ການປ່ຽນແປງໃນເຂດເທິງຂອງບ່ອນ, ອື່ນໆ)	Global (increasing temperatures and other climate change impacts) ການປ່ຽນແປງອາກາດ (ອຸນຫະພູມທີ່ເພີ່ມຂຶ້ນ ແລະ ອື່ນໆ)	Food provision ການສະໜອງອາຫານ	Water provision ການສະໜອງນໍ້າ	Sand filters ຕູ້ຜັງ ແລະ ຕູ້ຜັງ	Microbial and other biochemical resources ການສະໜອງແມັງກີ ແລະ ຊີວະອົງແມັງກີ	Climate and air quality ການສະໜອງອາກາດທີ່ສູງ ແລະ ອຸນຫະພູມທີ່ດີ	Carbon sequestration and storage ການສະໜອງຄາບອນທີ່ຊຸກລຸກ ແລະ ການເກັບຮັກສາຄາບອນ	Moderation of extreme events ການຫຼຸດລຽມການເຮັດອຸນຫະພູມທີ່ຮ້າກຮຽງ	Wastewater treatment ການປັບປຸງນໍ້າເສຍ	Erosion prevention ການປ້ອງກັນການກວາດຖະ	Maintenance of soil quality ການຮັກສາຄຸນນະພາບດິນ	
Agriculture, forest and aquaculture ຂະແໜງກະສິກໍາ ປ່າໄມ້ ແລະ ການວັງຮັດນໍ້າ															
Crops, including rice ຜົນຜະລິດພືດ ວອມທົ່ງເຂົ້າ															
Livestock activities ການວັງຮັດ															
Forests ປ່າໄມ້															
Habitats ທີ່ຢູ່ອາໄສ															
Aquaculture ການວັງຮັດນໍ້າ															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															
															

City/ ຕຳວັດ ແມ່ນ:

Site name/ ຊື່ ສະຖານທີ່:

		Ecosystem services necessary to protect and strengthen these activities and habitats															
		2 ການບໍລິການທາງດ້ານລະບົບ ສາເຫດຫຼັກຂອງນ້ຳຖ້ວມ?				3 Provisioning ການຈັດຫາກະກຽມ				Regulation and Maintenance ລະບຽບ ແລະ ການບຳລຸງຮັກສາ							
1 Activities and habitats threatened and impacted by floods ກິດຈະກຳ ແລະ ທີ່ຢູ່ອາໄສ ທີ່ໄດ້ຖືກຄຸກຄາມ ແລະ ໄດ້ຮັບຜົນກະທົບຈາກໄພນ້ຳຖ້ວມ		RELEVANT? ທີ່ກ່ຽວຂ້ອງ?	Local (urbanization, land use change, etc.) ທ້ອງຖິ່ນ (ການເພີ່ມທະວີຕົວເມັດຂອງ, ການປ່ຽນໃຊ້ທີ່ດິນ, ອື່ນໆ)	Basin level (land use change upstream deforestation in the basin, etc.) ລະບົບອ້ອມຂ້າງ (ການປ່ຽນແປງການປ່ຽນໃຊ້ທີ່ດິນ, ການຕັດໄມ້ທີ່ເພີ່ມຂຶ້ນ ຢູ່ໃນເຂດອ້ອມຂ້າງ)	Global (increasing temperatures and other climate change impacts) ກົນຈັກບໍລິໂພກ (ຊັບພະຍາກຳທີ່ເພີ່ມຂຶ້ນ ແລະ ຜົນກະທົບທາງອ້ອມຂ້າງ)	Food provision ການຈັດຫາອາຫານ	Water provision ການຈັດຫານ້ຳ	Fuels and fibers ເຊືອເທັງ ແລະ ຮົ່ມໄມ້	Medicinal and other biochemical resources ແຮງຊີວະທຳ ແລະ ຊີວະຄາມຢືນຢັນ	Local climate and air quality ສະພາບອາກາດທ້ອງຖິ່ນແລະ ຄຸນນະພາບອາກາດ	Carbon sequestration and storage ການກຳໄລ້ ແລະ ການບັນທຶກສາທາຍາບອນໄດອອກໄຊ	Moderation of extreme events ການດູແລຫາການທີ່ຮ້າຍແຮງ	Wastewater treatment ການປັບປຸງນ້ຳເສຍ	Erosion prevention ການປ້ອງການກັ່ນຕະສຸກ	Maintenance of soil quality ການຮັກສາຄຸນນະພາບຂອງດິນ	Pollination services ການບໍລິການປະສົມພືດພືດ	Biological control ການຄວບຄຸມທາງຊີວະພາບ
Agriculture, forest and aquaculture ຂະແໜງກະສິກຳ, ປ່າໄມ້ ແລະ ການລ້ຽງສັດນ້ຳ																	
Crops, including rice ຜົນຜະລິດພືດ ລວມທັງເຂົ້າ	X		X	X		●	●					●		●	●	●	●
Livestock activities ການລ້ຽງສັດ																	
Forests ປ່າໄມ້	X		X				●								●	●	●
Habitats ທີ່ຢູ່ອາໄສ																	
Aquaculture ການລ້ຽງສັດນ້ຳ																	
Economy and tourism ຂະແໜງເສດຖະກິດ ແລະ ການທ່ອງທ່ຽວ																	
State budgets (used for repairing damages) ງົບປະມານຂອງລັດ (ສຳລັບໃຊ້ໃນການຮັບປະກັນແບ່ງຄວາມເສຍຫາຍ)																	
Tourism industry, temples ອຸດສາຫະກຳການທ່ອງທ່ຽວ, ບັດວາອາຮາມ	X	X	X			●			●			●		●			

Example:

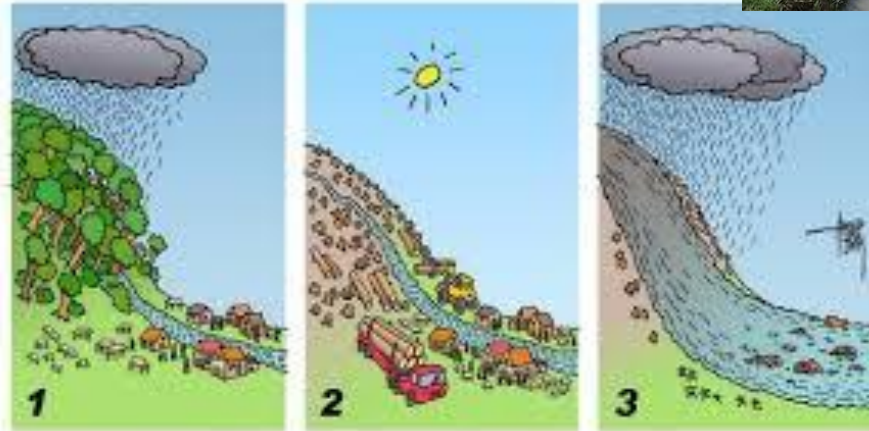
Ecosystem services that protect against damages: Damage to roads and bridges



Moderation of extreme events:
Natural flood storage

Moderation of extreme
events: Reduction of runoff

Erosion prevention:
Reduction of drainage
channel sedimentation



1

- Which ecosystem services are damaged by floods?

2

- Which ecosystem services can protect people and infrastructure?

3

- Which ecosystem services are provided by various ecosystem based interventions?

1+2+3= Informing selection of most beneficial ecosystem based interventions

Evaluating the potential ecosystem based interventions and the ecosystem services they can provide: site-based analysis

1. Select 1-3 potential ecosystem-based adaptation interventions for your site

2. Identify scale of intervention

3. Discuss what ecosystem services this intervention will provide

Providing or contributing to following ECOSYSTEM SERVICES: ການອັດຫາ ຫຼື ການໃຫ້ການສະໜັບສະໜູນບົລິການທາງດ້ານລະບົບນິເວດດັ່ງລຸ່ມນີ້										Other considerations ສິ່ງອື່ນໆທີ່ຄວນພິຈາລະນາອື່ນ										
Scale of intervention ຂະໜາດຂອງການແລກແລງ		Provisioning ການອັດຫາກະກຽມ		Regulation and Maintenance ລະບຽບ ແລະ ການປົກປ້ອງຮັກສາ						Habitat/Support ທີ່ຢູ່ອາໄສ/ແຈ້ງສະໜັບສະໜູນ	Cultural ວັດທະນະທຳ	Complexity of implementation ຄວາມສັບສົນໃນການອັດຕັ້ງປະຕິບັດ	Cost of implementation ຄ່າໃຊ້ຈ່າຍໃນການອັດຕັ້ງປະຕິບັດ	Timeframe for achieving maximum benefits from ESS ໄລຍະເວລາທີ່ຈະບັນລຸຜົນປະໂຫຍດສູງສຸດຈາກລະບົບນິເວດ						
Local ທ້ອງຖິ່ນ	Basin/watershed ແຫຼ່ງນ້ຳ/ສ່ວນນ້ຳ	Local ທ້ອງຖິ່ນ	Basin/watershed ແຫຼ່ງນ້ຳ/ສ່ວນນ້ຳ	Local ທ້ອງຖິ່ນ	Basin/watershed ແຫຼ່ງນ້ຳ/ສ່ວນນ້ຳ	Local ທ້ອງຖິ່ນ	Basin/watershed ແຫຼ່ງນ້ຳ/ສ່ວນນ້ຳ	Local ທ້ອງຖິ່ນ	Basin/watershed ແຫຼ່ງນ້ຳ/ສ່ວນນ້ຳ	Local ທ້ອງຖິ່ນ	Basin/watershed ແຫຼ່ງນ້ຳ/ສ່ວນນ້ຳ	LOW/ຕ່ຳ	MEDIUM/ປານກາງ	HIGH/ສູງ	LOW/ຕ່ຳ	MEDIUM/ປານກາງ	HIGH/ສູງ	Immediate/ທັນທີ	Short term/ໄລຍະສັ້ນ	Long term/ໄລຍະຍາວ
Re/afforestation and forest conservation ການຕັດໄມ້ທຳລາຍປ່າ/ການປູກປ່າ ແລະ ການອະນຸລັກປ່າໄມ້																				
Riparian buffers ປ່າຊາຍນ້ຳ																				
Wetland restoration or conservation ການຜືນຜູ້ ຫຼື ການອະນຸລັກພື້ນທີ່ຊຸມນ້ຳ																				
Constructing wetlands ການສ້າງພື້ນທີ່ຊຸມນ້ຳ																				
.....																				

Add your own suggested ecosystem based interventions

4. Discuss how complex, expensive and time intensive are these interventions

3

4

Providing or contributing to following ECOSYSTEM SERVICES:

ກຳນົດສະໜອງ ຫຼື ການ ໃຫ້ການສະໜັບສະໜູນບໍລິການທາງດ້ານລະບົບນິເວດດັ່ງລຸ່ມນີ້:

Other considerations

ສິ່ງອື່ນໆທີ່ຄວນພິຈາລະນາອື່ນ

1

2

Ecosystem-based adaptation options for the site ອີງໃສ່ລະບົບນິເວດ ສ້າງສັບສະຖານທີ່

Scale of intervention ຂະໜາດຂອງການແຈກແຈງ

Provisioning ການອັດຫາກະກຽມ

Regulation and Maintenance ລະບຽບ ແລະ ການບໍາລຸງຮັກສາ

Habitat/Support ທີ່ຢູ່ອາໄສ/ແຫຼ່ງສະໜັບສະໜູນ

Cultural ວັດທະນະທຳ
Complexity of implementation ຄວາມສັບຂ້ອນໃນການຈັດຕັ້ງປະຕິບັດ
Cost of implementation ຄ່າໃຊ້ຈ່າຍໃນການຈັດຕັ້ງປະຕິບັດ
Timeframe for achieving maximum benefits from ESS ໄລຍະເວລາ ທີ່ອະນຸຍາດສູງສຸດຈາກລະບົບນິເວດ

Local ທ້ອງຖິ່ນ
Basin/watershed ແຫຼ່ງນ້ຳ/ຮ່ວມນ້ຳ
Food provision ການອັດຫາອາຫານ
Water provision ການອັດຫານ້ຳ
Fuels and fibers ເຊື້ອໄຜ່ ແລະ ສິນເຊີຍ
Medicinal and other biochemical resources ແຫຼ່ງນ້ຳ ແລະ ຊີວະຄຸນອື່ນໆ
Local climate and air quality ສະພາບອາກາດທ້ອງຖິ່ນແລະ ຄຸນນະພາບທາງອາກາດ
Carbon sequestration and storage ການຮັກສາໄວ້ ແລະ ການເກັບຮັກສາທາດຄາບອນໄດອອກໄຊ
Moderation of extreme events ການຈຸດເຈດຕະນາທີ່ຮ້າງແຮງ
Wastewater treatment ການປັບປຸງນ້ຳເສຍ
Erosion prevention ການປ້ອງກັນການກໍ່ເຈຊະ
Maintenance of soil quality ການຮັກສາຄຸນນະພາບຂອງດິນ
Pollination services ການບໍລິການປ່ຽນພັນພືດ
Biological control ຄວບຄຸມທາງຊີວະພາບ
Habitat maintenance ການບໍາລຸງຮັກສາທີ່ຢູ່ອາໄສ
Maintenance of genetic diversity ການຮັກສາຄວາມຫຼາກຫຼາຍທາງພັນທຸກຳ
Spiritual, religious, aesthetic, and inspirational experiences ຄວາມເຊື່ອ, ສາສະໜາ, ຄວາມສວຍງາມ ແລະ ການສົ່ງແຮງບັນດານໃຈ
Recreation and tourism ການພັກຜ່ອນ ແລະ ການທ່ອງທ່ຽວ

X

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X

X

X

.....

Add your own suggestions for ecosystem based interventions

Thank you!

*Maija Bertule
Programme Advisor, UN Environment – DHI Centre
mabe@dhigroup.com*



Important considerations for planning



Choosing solutions that address the problem and are locally suitable:

- Do the solutions address the main problem? (e.g. do they provide the necessary efficiency of infiltration)
- Long term solution? (e.g. how will climate change affect the ecosystem services in 20-30-50 years?)
- Locally suitable (e.g. choosing plant and tree species that are native species)
- Carefully consider potential undesired impacts on surrounding ecosystems and people (e.g. creating habitats for mosquito breeding, invasive species, increased needs for maintenance, etc.)

Ecosystem-based adaptation interventions

National Workshop, Lao PDR, September 13th – 15th 2017

Maija Bertule, UN Environment-DHI



1.

Introduction to ecosystem-based adaptation interventions



Ecosystem-based adaptation

= use of ecosystems and Ecosystem Services (ESS) for climate change adaptation:

- ❖ Restoration of ecosystems
- ❖ Improved management of existing ecosystems
- ❖ Conservation of existing ecosystems
- ❖ Creating new objects and areas



Using ecosystem services for adaptation purposes

ESS

Ecosystem services for adaptation - examples

Moderation of extreme events

- Flood mitigation
- Drought mitigation

Temperature control

- Heat mitigation in increasingly hot climate (e.g. urban temperature control in cities that heat up due to urbanization and climate change)

Water supply

- Providing clean water for people and agriculture (food security)
- Maintaining sustainable water supply

All important for adaptation to climate change

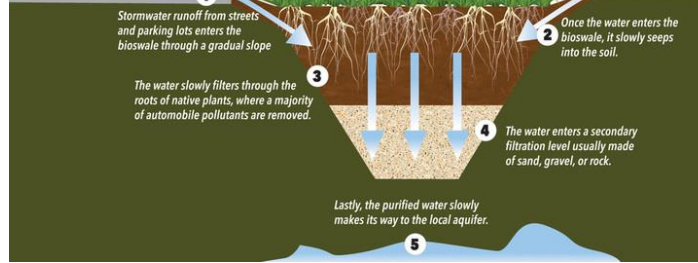
Examples of Ecosystem-based adaptation interventions (for flood management)

(often referred to as ‘green infrastructure’, because such interventions make use of ecosystem services (=nature) as flood mitigation ‘infrastructure’)

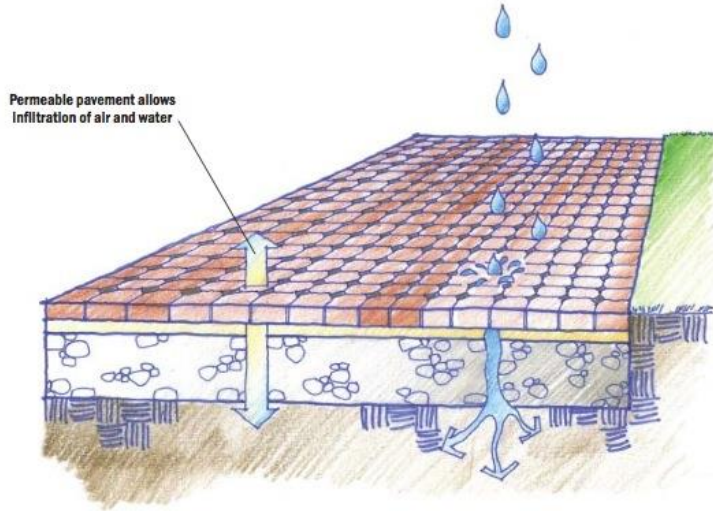
Green spaces for urban flood management



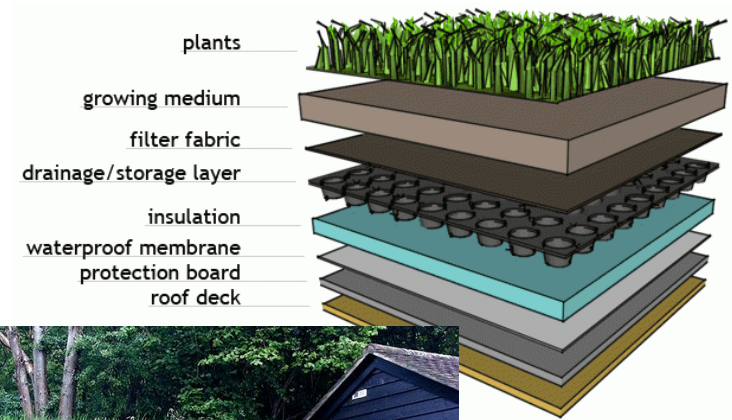
Bioswales – for urban stormwater management



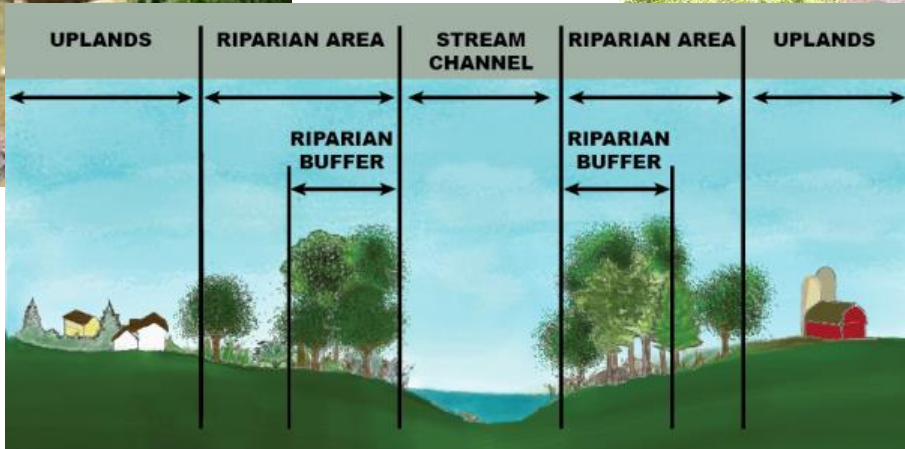
Permeable pavements



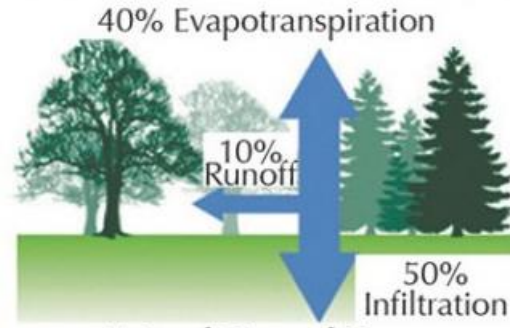
Green roofs



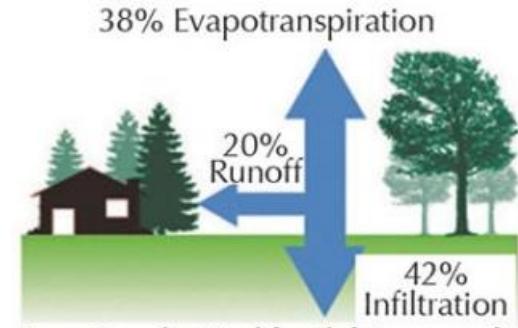
Riparian buffers



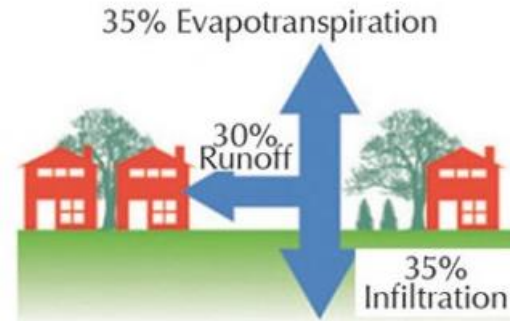
EFFECTS OF IMPERVIOUSNESS ON RUNOFF AND INFILTRATION



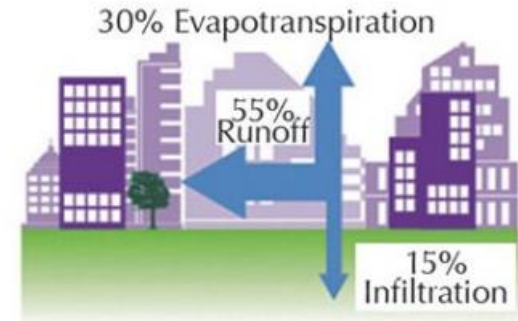
Natural Ground Cover
0% Impervious Surface



Low Density Residential (e.g. rural)
10–20% Impervious Surface



Medium Density Residential (e.g. subdivision)
30–50% Impervious Surface



High Density Residential / Industrial / Commercial
75–100% Impervious Surface

How green areas interact with water in urban spaces? (example)

2.

The benefits of ecosystem-based adaptation

(beyond flood mitigation)



‘Sponge cities’ project in China

Green roofs



Wetlands for rainwater storage



Permeable pavements



+

+

**Urban
stormwater
mitigation**

+ recharge
of
groundwater

+ water
purification

+
biodiversity
benefits

+ improved
air quality

+ temperature
control

Ecosystem based flood mitigation in Singapore

Flood mitigation

- + Recreational area in times of no flood
- + Urban heat island mitigation (urban temperature control)
- + Water filtration (groundwater recharge)
- + Habitats for species
- + Air quality
- +++




















Bishan-Ang Mo Kio Park, Singapore


















Ecosystem-based interventions have more benefits than just flood control

=

they provide a wide a range of additional ecosystem services

	Ecosystem services (TEEB classification)																
	Provisional				Regulating						Supporting		Cultural				
	Water supply	Food production	Raw materials	Medicinal resources	Temperature control	Carbon Sequestration + storage	Moderation of extreme events	Water purification	Erosion control (incl. shoreline)	Pollination	Biological control	Habitats for species	Maintenance of genetic diversity	Recreation	Tourism	Aesthet/c/ cultural value	Spiritual experience
GI solution																	
Re/afforestation and forest conservation																	
Riparian buffers																	
Wetlands restoration/conservation																	
Constructing wetlands																	
Reconnecting rivers to floodplains																	
Establishing flood bypasses																	
Water harvesting																	
Green roofs																	
Green spaces (Bioretention and infiltration)																	
Permeable pavements																	
Protecting/restoring mangroves, marshes and dunes																	
Protecting/restoring reefs (coral/oyster)																	

		Ecosystem services (TEEB classification)																
		Provisional				Regulating						Supporting		Cultural				
EBA intervention		Water supply	Food production	Raw materials	Medicinal resources	Temperature control	Carbon Sequestration + storage	Moderation of extreme events	Water purification	Erosion control (incl. shoreline)	Pollination	Biological control	Habitats for species	Maintenance of genetic diversity	Recreation	Tourism	Aesthetic/cultural value	Spiritual experience
																		
Re/afforestation and forest conservation																		

		Ecosystem services (TEEB classification)																
		Provisional				Regulating						Supporting		Cultural				
EBA intervention		Water supply	Food production	Raw materials	Medicinal resources	Temperature control	Carbon Sequestration + storage	Moderation of extreme events	Water purification	Erosion control (incl. shoreline)	Pollination	Biological control	Habitats for species	Maintenance of genetic diversity	Recreation	Tourism	Aesthetic/cultural value	Spiritual experience
	Green spaces (Bioretention and infiltration)																	

3.

Combining ecosystem-based approaches with conventional 'grey' infrastructure



Combining the ‘green’ and the ‘grey’

- Maximizing use of existing green spaces
- Creating connectivity between the green spaces where needed
- Improved management of ‘grey’ infrastructure to maximize use of ecosystem services

Examples

- Creating connectivity by repairing existing infrastructure (functional flood gates, pumps, pipes and drainage channels)
- Using combination of flood protection measures – some ecosystem based and some constructed (e.g. protecting strategic sites with built infrastructure and other areas with ecosystem-based measures)

Example of case in Greve, Denmark (urban flood mitigation)



Combining green-grey infrastructure: Example of case in Greven, Denmark (urban flood mitigation)



Combining green-grey infrastructure: The case of urban flood mitigation



Group discussion – exercise 3

Thank you!

*Maija Bertule
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Ecosystem-based adaptation

= use of ecosystems and Ecosystem Services (ESS) for climate change adaptation:

- ❖ Restoration of ecosystems
- ❖ Improved management of existing ecosystems
- ❖ Conservation
- ❖ Creating new objects and areas



Examples



Bioswales for urban stormwater management



Mangroves for coastal storm protection



Watershed conservation for source water protection



Reconnecting rivers with floodplains for reduced flood damage

Most green infrastructure solutions have more benefits than just flood control

=

Providing a range of additional ESS

	Ecosystem services (TEEB classification)																
	Provisional				Regulating					Supporting		Cultural					
	Water supply	Food production	Raw materials	Medicinal resources	Temperature control	Carbon Sequestration + storage	Moderation of extreme events	Water purification	Erosion control (incl. shoreline)	Pollination	Biological control	Habitats for species	Maintenance of genetic diversity	Recreation	Tourism	Aesthet/c/ cultural value	Spiritual experience
GI solution																	
Re/afforestation and forest conservation																	
Riparian buffers																	
Wetlands restoration/conservation																	
Constructing wetlands																	
Reconnecting rivers to floodplains																	
Establishing flood bypasses																	
Water harvesting																	
Green roofs																	
Green spaces (Bioretention and infiltration)																	
Permeable pavements																	
Protecting/restoring mangroves, marshes and dunes																	
Protecting/restoring reefs (coral/oyster)																	

Examples of GI solutions and co-benefits (Urban green infrastructure for flood mitigation in Singapore)

- Flood mitigation
- Recreational area in times of no flood
- Urban heat island mitigation (temperature control)
- Water filtration
- Habitats for species
- +++

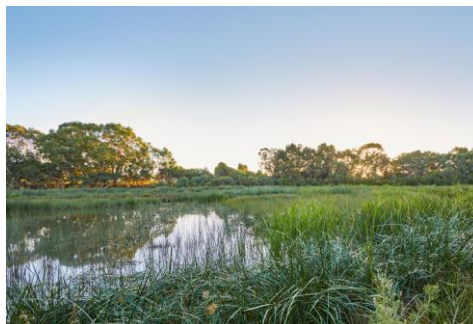


'Sponge cities' project in China (currently in planning)

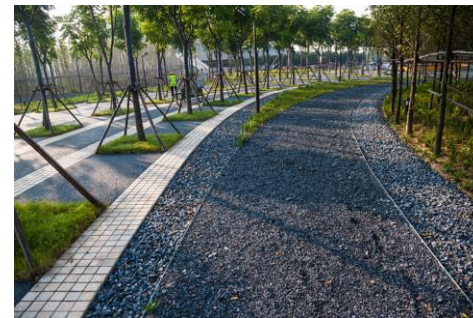
Green roofs



Wetlands for rainwater storage



Permeable pavements



- Flood mitigation
- Recharge of groundwater
- Water filtration
- Recreational value
- Temperature control

- Biodiversity benefits
- Improved air quality
- ...

Multifunctionality



Bishan-Ang Mo Kio Park, Singapore



Seoul's Cheonggyecheon River is an example of how a city can work with nature to reduce flooding and improve the urban landscape.

Jessica Gardner/Flickr

Pagmatic approaches: combining the green and grey

- Maximizing use of existing green spaces
- Creating connectivity between the green spaces where needed
- Improved management of grey infrastructure to maximize use of both green and grey infrastructure efficiency

Example of case in Greven, Denmark (urban flood mitigation)



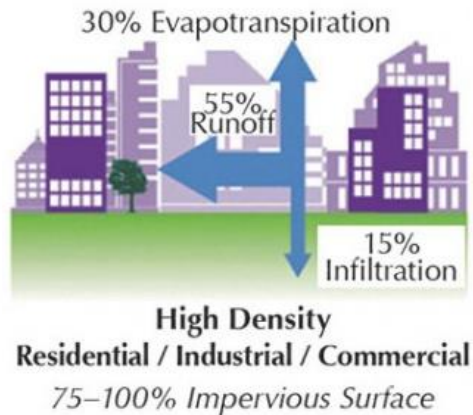
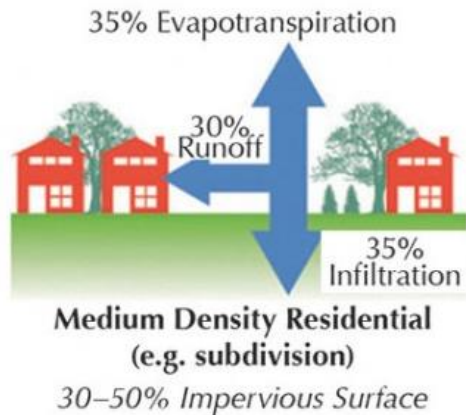
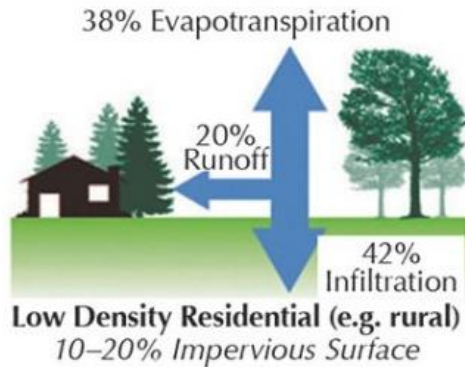
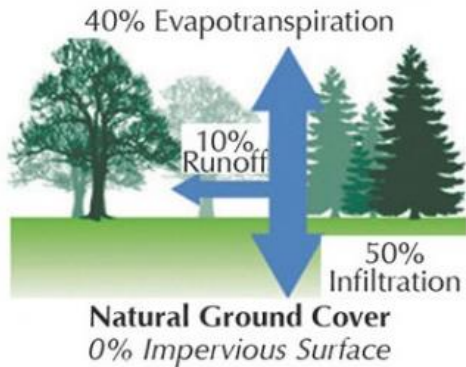
Combining green-grey infrastructure: Example of case in Greven, Denmark (urban flood mitigation)



Combining green-grey infrastructure: The case of urban flood mitigation



EFFECTS OF IMPERVIOUSNESS ON RUNOFF AND INFILTRATION



Important considerations for planning



Choosing solutions that address the problem and are locally suitable:

- Do the solutions address the main problem? (e.g. do they provide the necessary efficiency of infiltration)
- Long term solution? (e.g. how will climate change affect the ecosystem services in 20-30-50 years?)
- Locally suitable (e.g. choosing plant and tree species that are native species)
- Carefully consider potential undesired impacts on surrounding ecosystems and people (e.g. creating habitats for mosquito breeding, invasive species, increased needs for maintenance, etc.)

2.

Introduction to the exercise



Group exercise

Evaluation of ecosystem-based adaptation options in your city

1. Select 1 site in your city
2. Discuss potential ecosystem-based adaptation options for each site (select 1-3 relevant ones). PLEASE ADD ADDITIONAL, LOCALLY RELEVANT, ADAPTATION OPTIONS IN THE TABLE.
3. Evaluate what additional ecosystem services each solution provides
4. Evaluate the relative complexity, costs

Repeat for other sites when finished !

Thank you!

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City Climate Vulnerability Assessment and Identification of Ecosystem-based Adaptation Intervention

Mid-term workshop, Lao PDR, September 13th – 15th 2017

1.

Introduction to site selection



During the January 2017 workshop visits were made to all 6 cities, and preliminary sites, both urban and peri-urban, were identified.

The aim of the 'Site selection' session is

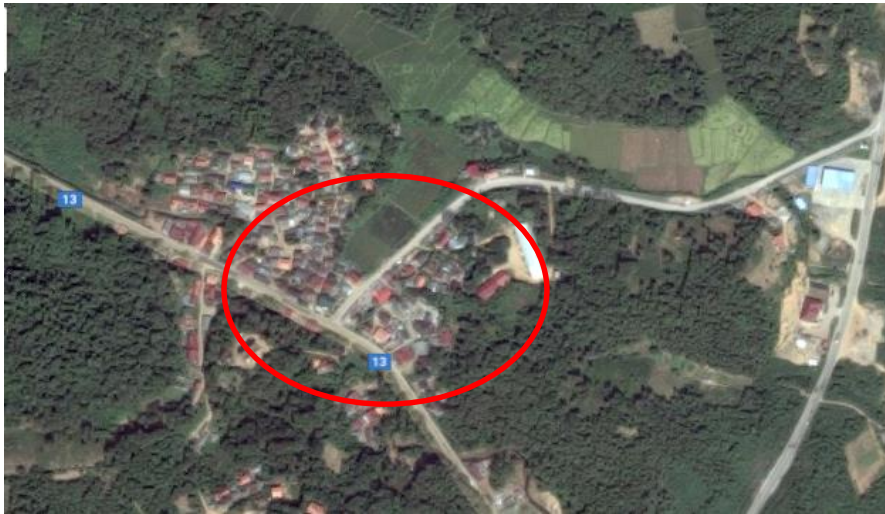
- For the PONRE's to present their work on additional flood sites and sensitivity assessment
- To discuss the usage of the vulnerability analysis to support the site selection
- To feed back to consultant the preliminary prioritised site selection

City	No	Name	Influenced by:		Suitable?	Remarks
			Mekong water level	Local rain	CTCN/GCF	
VTE	1	Beung That Luang		X	Yes	Direct work with ecosystem services on publicly owned land around new office building
	2	Ban Saythani	X	X	(No)	Flooding problems caused both by MK river and reservoir releases
LPB	1	Houay Mao Bridge	X	X	Yes	Catchment management
	2	Ban Hog New Village		X	Yes	Catchment management
	3	Flooding of the main road near the Southern Bus terminal		X	No	Drainage structure problem
	4	Bank erosion along Nam Khan			No	Dam operation and brink management
PXE	1	Ban He, Hoy Ya stream	X	X	No	Needs physical structures in place prior to GCF work
	2	Confluence of River xx with Sedone	X	X	No	Requires large water lock
	3,4	Pumping stations and drainage channels	X	X	No	Infrastructure problem
	5	Drainage channel in Ban Kae.	X	X	Yes	Minor physical changes can lead to a good project site
SVK	1	Hoang Loun Kong	X	X	Yes	Urban and Peri-urban in one site
THK	1,2	Future development area along Highway 12 towards Vietnam	X	(X)	No	Rural area, will be developed in 10-30 years
	3,4,5	Catchment in the peri-urban area of the city, near Ban Non Bo	X	X	Yes	A large site with urban and peri-urban elements
PKS	1,2	Ang Houy Peung and along Nam Zan, Ban Tabor, upstream of Ang Houy Peung	X	X	Yes	A large site with urban and peri-urban elements

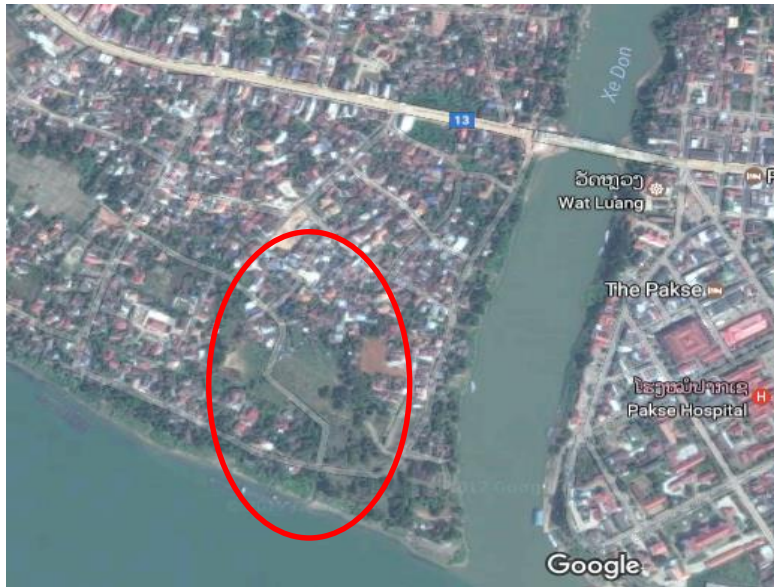
VTE, Site 1: Beung That Luang (Urban site). New ministry building will cause increased flooding due to limited capacity of nearby drainage channel. Calls for Retention, infiltration and storage solutions.



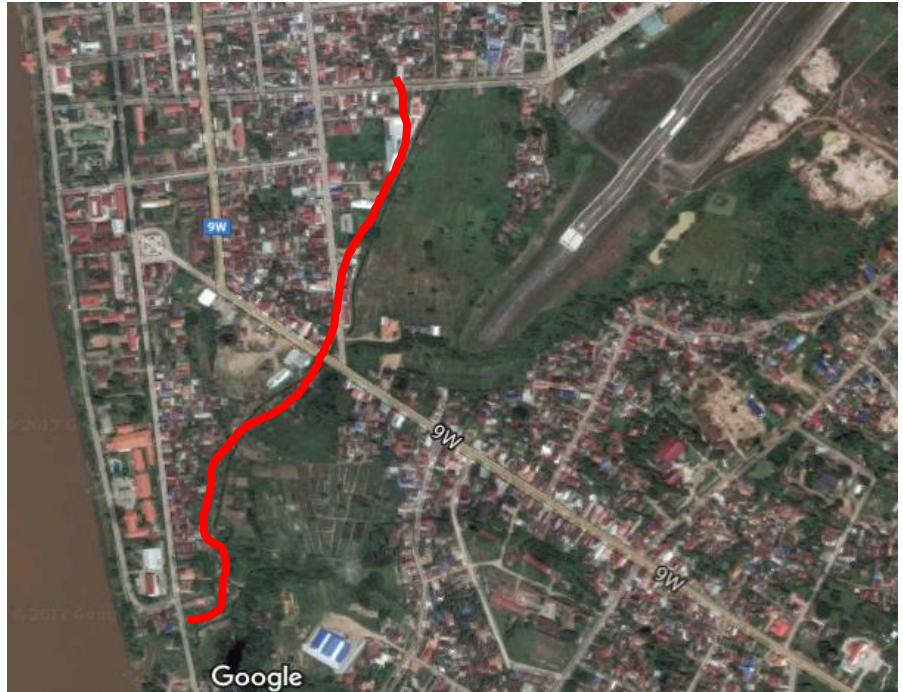
LPB Site 2: Ban Hog New Village (Peri-urban). Damages on water supply systems and Crop land in the village due to intense floods caused by changes in upstream land use. Needs land use changes that slows down flow velocity and establishments of dikes/ponds for sediment retention.



PKX: Site 5: Drainage channel in Ban Kae (Urban). Green area which can be used to store water from local rainfall, but also to convey water to the Mekong via an existing channel. Flap gats at the outlet channel is malfunctioning, hence Mekong flood water can enter and the outflow can not be controlled. Calls for a mixed grey-green solution.



SVK: Site 1: Hoang Loun Kong. (Urban). Densely populated area exposed to flooding from the Mekong. The green area can be used for flood control when combined with dykes along the fringes of the city. Considerations to build water lock towards the Mekong.



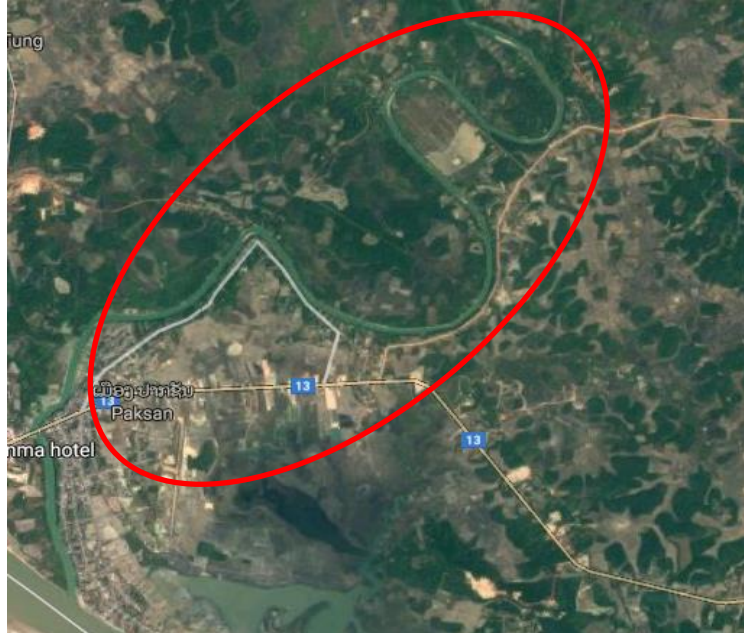
THK Site 3, 4 and 5. Catchment in the peri-urban area of the city, near Ban Non Bo. (Peri-Urban area)

Flooding in both lower and upper part of catchment. Lower part impacted by the Mekong, the upper part by local rainfall. Ecosystem services may be used in the lower urban part of the catchment for flood control.



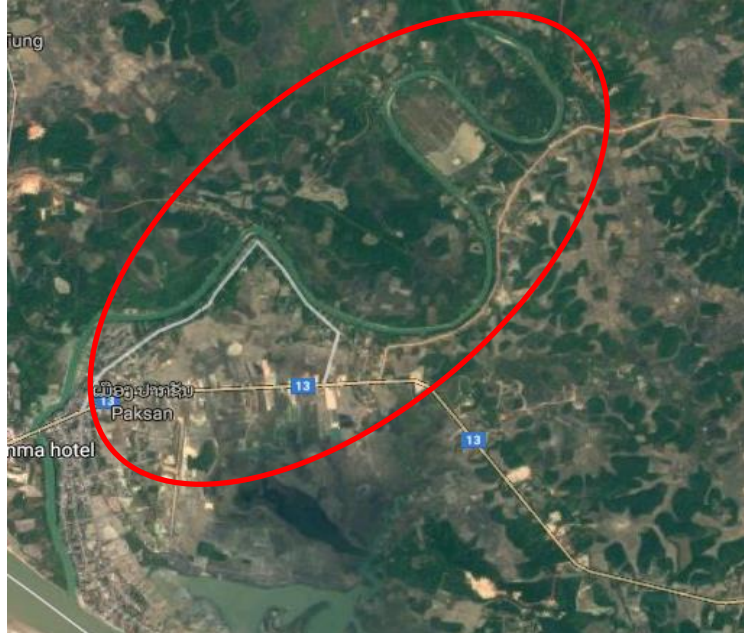
PKS, Site 1: Ang Houy Peung and along Nam Zan (Peri-urban area).

A road embankment prevents river water from entering the area. Houses on both sides are flooded, the river side annually from the river and the protected side is sometimes flooded from water upstream in the catchment.



PKS, Site 1: Ang Houy Peung and along Nam Zan (Peri-urban area).

A road embankment prevents river water from entering the area. Houses on both sides are flooded, the river side annually from the river and the protected side is sometimes flooded from water upstream in the catchment.



Questions to the PONRE's on site selection

- What are the the names of your proposed site(s)? Please provide map and coordinates of the sites
- Which responses / solutions have you thought of for the site(s) Are any of these responses based on Green Infrastructure?
- What is the cause of flooding at the site?
- What is impacted during flooding? What are the most important things being impacted?
- Do you have additional sites?