WEMDST
Wastewater and environment decision support tool

Pressures to the lake Shkodra and identified measures for water quality improvement

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PROJECT INTRODUCTION

Preparation of a WEMDST - Wastewater Management Decision Support Tool

WEMDST for Drin River Basin

WEMDST for Shkodra City

- **Tool:** designed for Drin river basin.
- **Testing:** on Shkodra city.

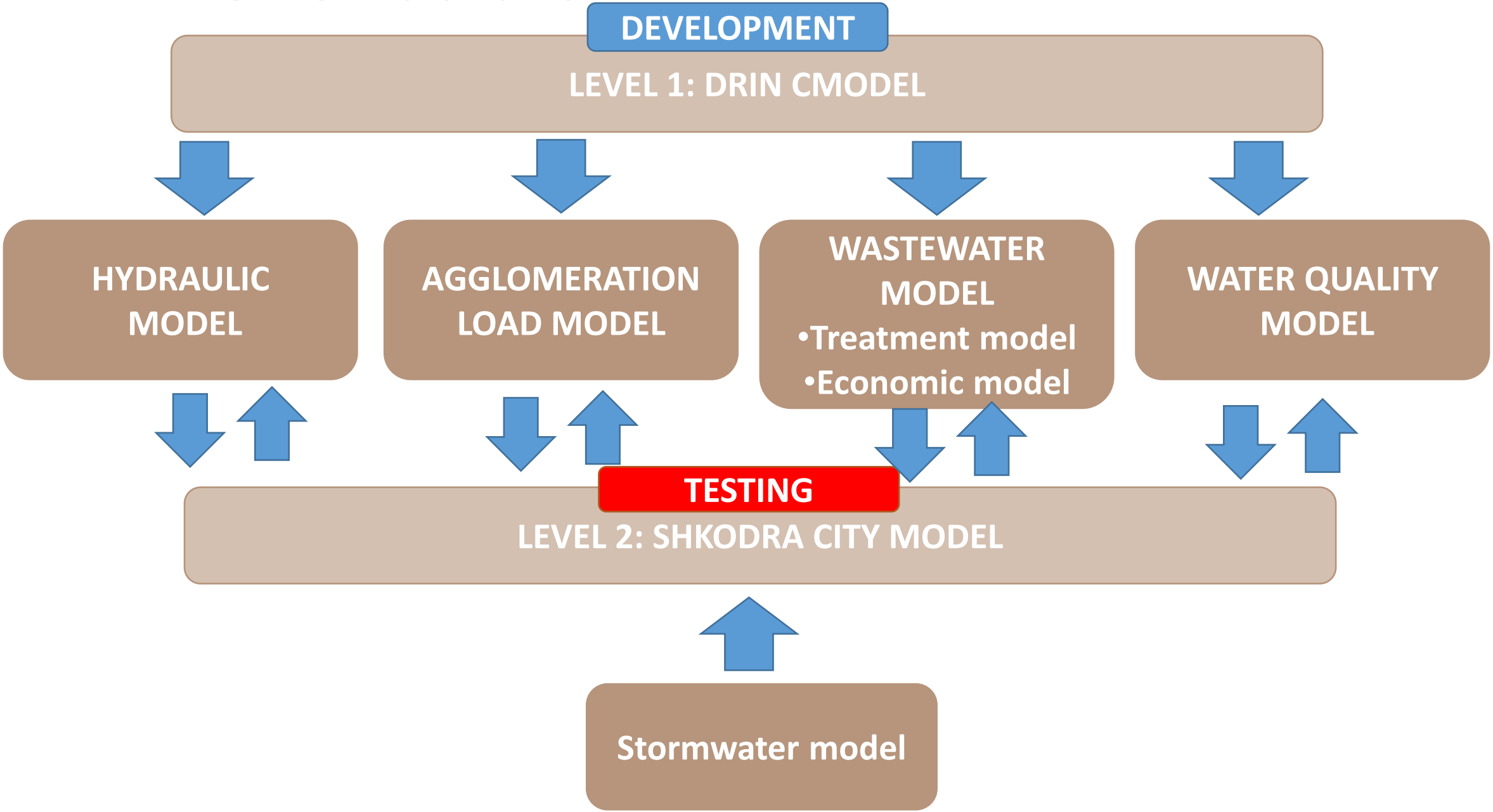
Project background

The development of WEMDST is one of the six Demonstration activities of the GEF Drin Project.

WEMDST objectives:

- To establish regional coordination mechanisms at Drin river basin level;
- To support work of national and local institutions in the area of wastewater treatment and environmental management;
- To support the implementation of the EU UWWTD;
- To enable future sustainable decision-making process and achieve effective wastewater treatment network that would improve the water quality in the Drin river;
- To be in a stronger position to make the right technical and investment choices;
- To promote the increase in resource recovery from wastewater.

WEMDST Structure



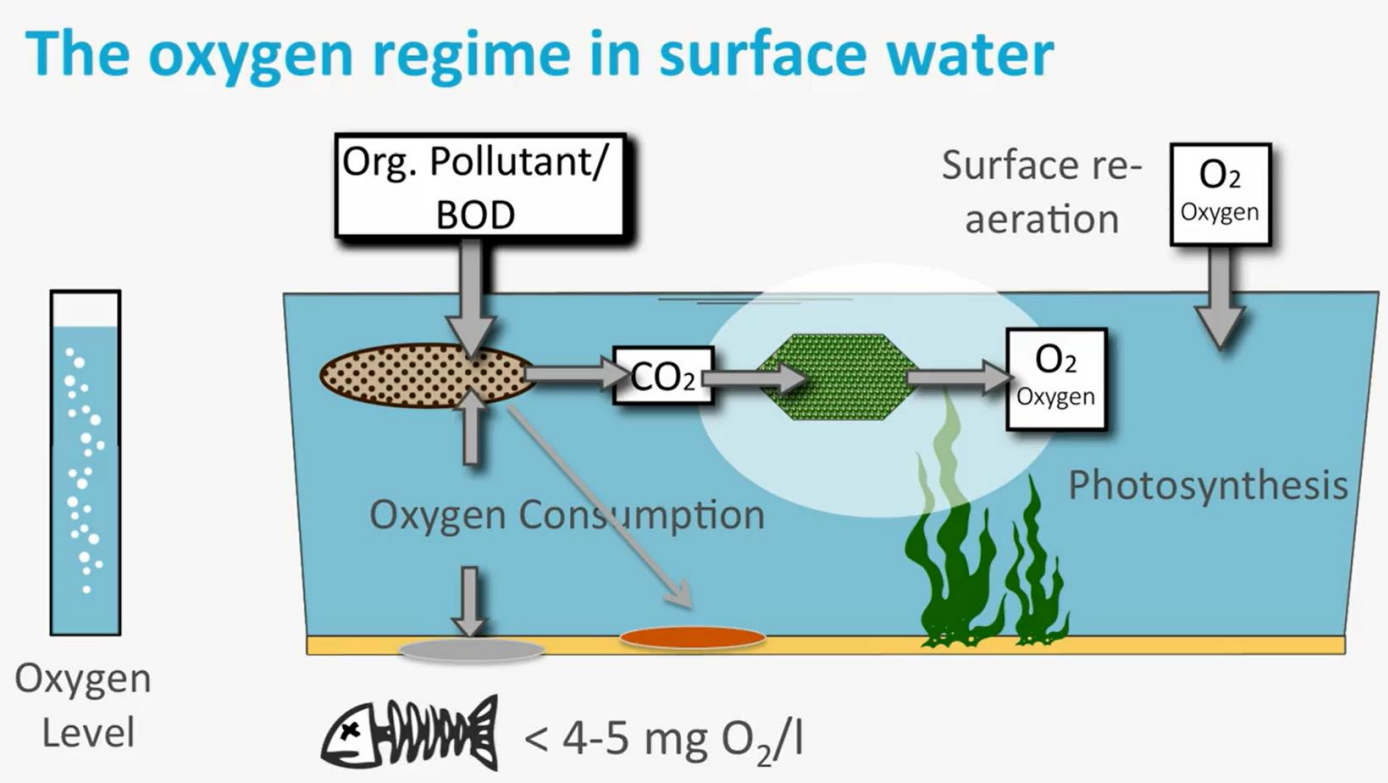
Shkodra city

- Served as the areas of reference for the development and testing of the WEMDST
- **Project recommendations on wastewater and flood management** in the city of Shkodra (presentation to the city authorities and report)
  - **Concept solutions** - Identification of the most appropriate wastewater treatment system (centralized and decentralized scenarios) in combination with management of storm waters/flood protection measures
  - **An action plan** for the improvements of the wastewater collection system and stormwater management in the city of Shkoder has also been proposed.

WASTEWATER PRESSURES

Wastewater pressures

- **Coarse particles and settleable solids** – sludge accumulation, decompostion, oxygen depletion
- **Nutrients (nitrate, phosphate)** – eutrophication, influencing oxygen content
- **Ammonia** - oxygen depletion, toxic for fish, eutrophication
- **Resistant organic particles/Inorganic particals** – poisoning, destroying biotope, accumulation in the food chain
- **Pathogens** - worsening hygienic quality



Source: Urban Sewage Treatment course, TU Delft

Discharge of raw wastewater causes disturbance of the natural functions.

Wastewater pressures

Shkodra city:

- Three main sewer lines, separated system (73% connection rate)
- Outlet from sewage system is into the Drin River (emergency outflow into Buna River)
- No WWTP for Shkodra city
- In the case of high water level, untreated wastewaters threaten Lake Shkodra.
- Discharge loadings: BOD, COD, TSS, TN, TS
- It is estimated that approximately 115.000 PE is being discharged to the surface water (25% industry).

Malesi e Madhe District

- Relevant for prevention of WW pollution of the lake Shkodra.
- Only town of Koplik has a sewage system and there are about 300 household connections.
- Other households have improvised permeable septic tanks

Source: LSIEMP transboundary project. 2012.

Regulations

Wastewater requirments:

Required secondary treatment (BOD, COD, TSS)

- Planned tertiary treatment (BOD, COD, TSS, TN, TP)
- Specific standards set by the UWWD depend on the agglomeration size and whether or not the effluent is discharged to sensitive area

Parameter	Maximum Concentration
Biochemical Oxygen Demand (BOD_5)	25 mg/l
Chemical Oxygen Demand (COD)	125 mg/l
Total Suspended Solids (TSS)	35 mg/l
Total Nitrogen (TN)*	10 mg/l
Total Phosphorus (TP)*	1 mg/l

Sludge requirments:

- Sludge reuse in agriculture is allowed (heavy metals)

Parameter	HM IN SOIL (mg/kg of dry matter)	HM IN SLUDGE (mg/kg of dry matter)	HM ANNUALLY ADDED AMOUNT (kg/ha/yr)
Cadmium	3	20-40	0,15
Copper	100	1.000	12
Nickel	75	400	3
Lead	200	800	15
Zinc	300	3.500	30
Mercury	1,5	20	0,1
Chromium	-	-	-

IMPACT OF WASTEWATERS ON WATER QUALITY IN THE RECEIVING WATERS

Wastewater Management Decision Support Tool

WEMDST - Wastewater management decision making support tool

Goal: to design a management decision support tool to address wastewater related problems in **Drin river basin**.

Objectives:

- To establish regional coordination mechanisms at Drin river basin level;
- To support work of national and local institutions in the area of wastewater treatment and environmental management;
- To support the implementation of the EU UWWTD;
- To enable future sustainable decision-making process and achieve effective wastewater treatment network that would improve the water quality in the Drin river;
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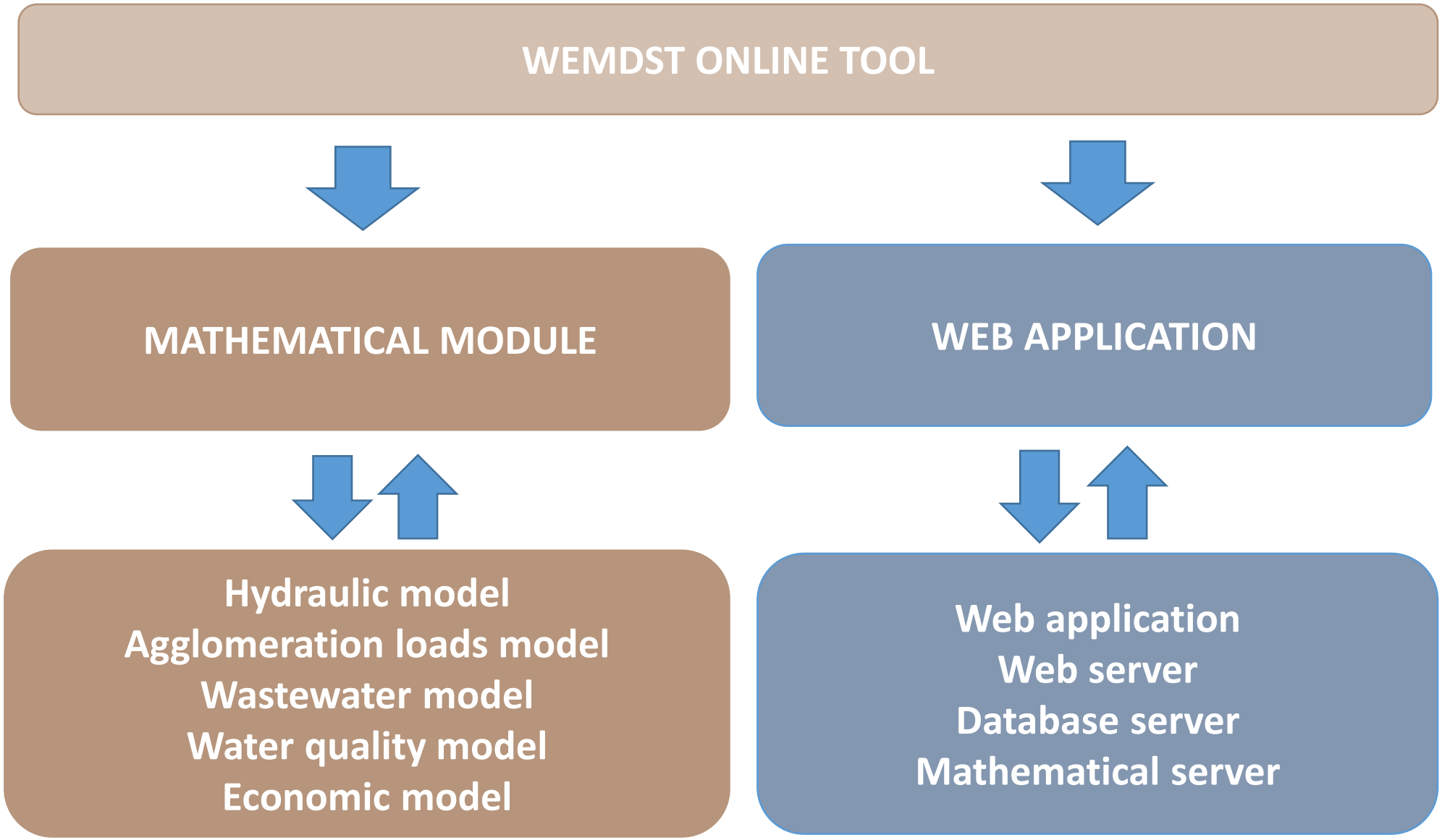
WEMDST Structure



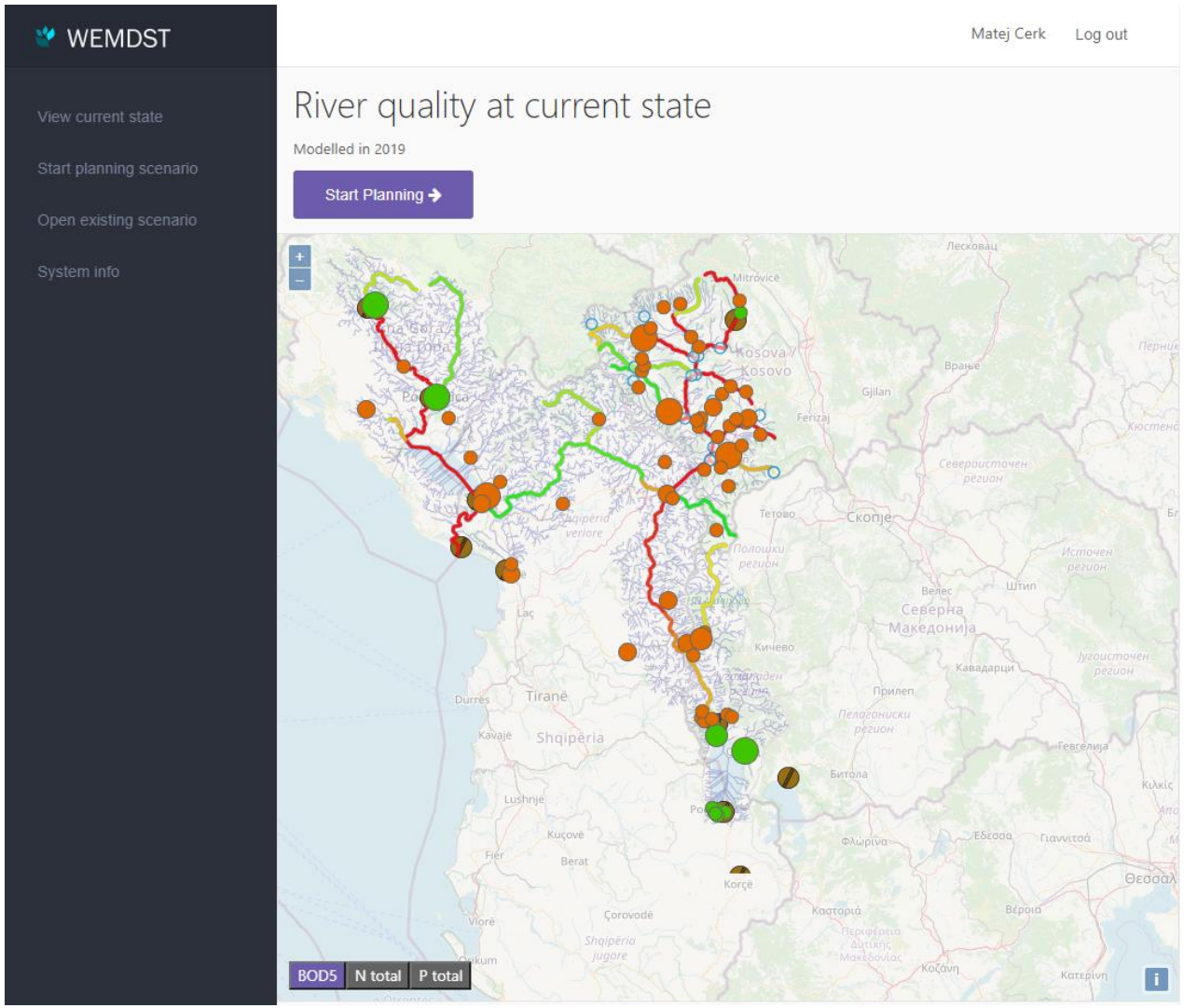
WEMDST Web application

Linux

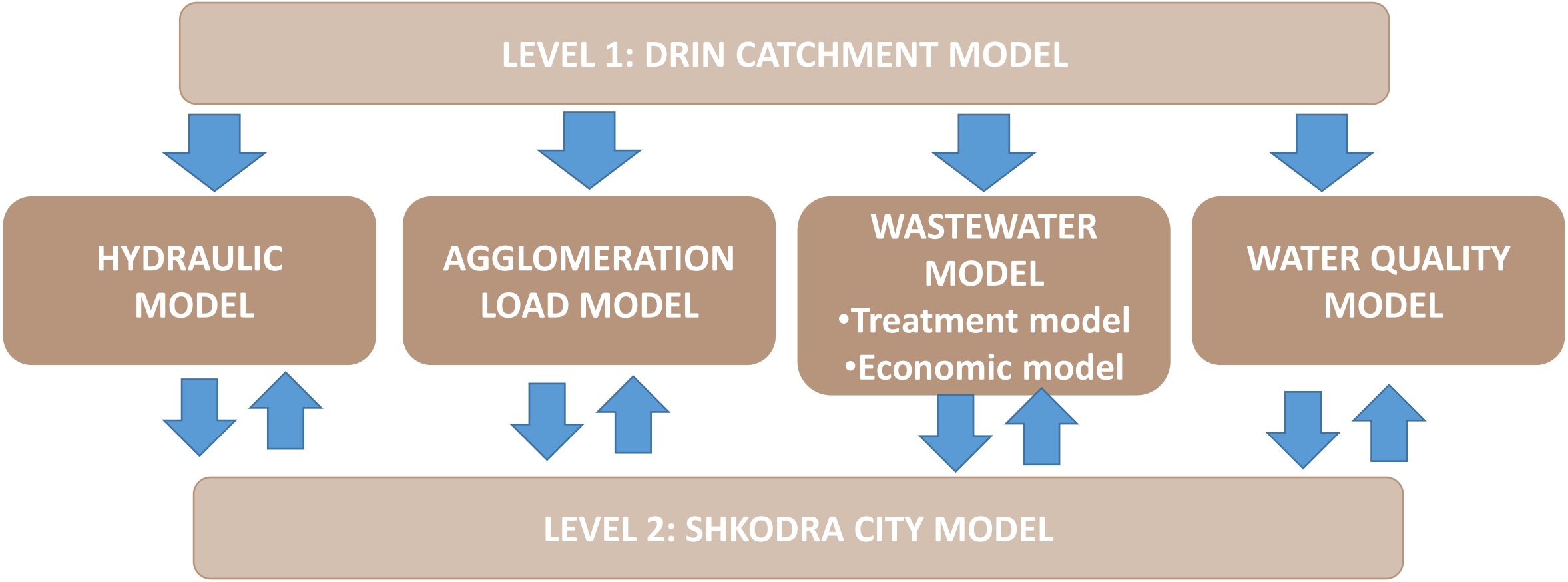
Windows

Web server
Database server

Mathematical server



WEMDST Mathematical module



HYDRAULIC MODEL

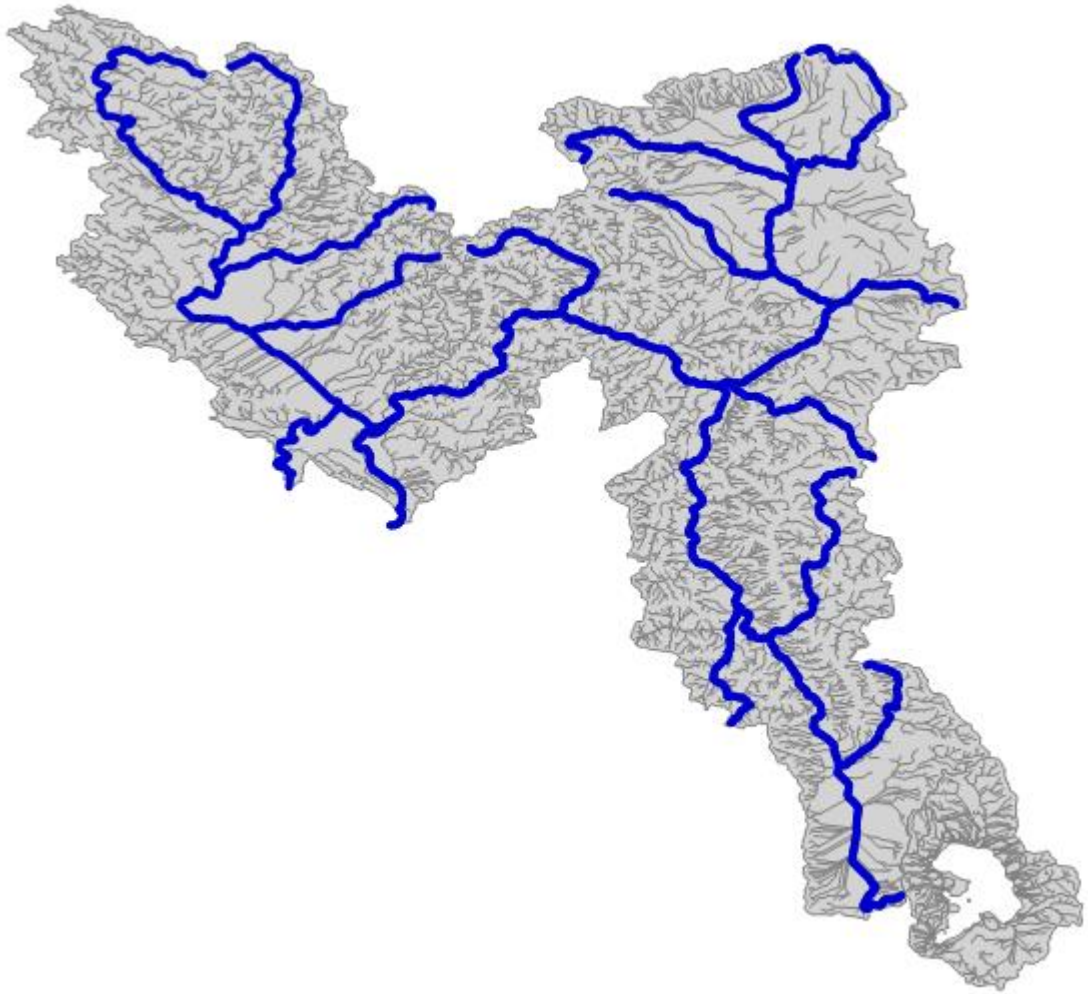
Hydraulic model

1D hydraulic model for main rivers within Drin catchment

Simulation of summer months (low discharges)

Model set based on:

- water levels from water level and discharge measurements
- river network
- 3d terrain data



AGGLOMERATION LOAD MODEL

Agglomerations

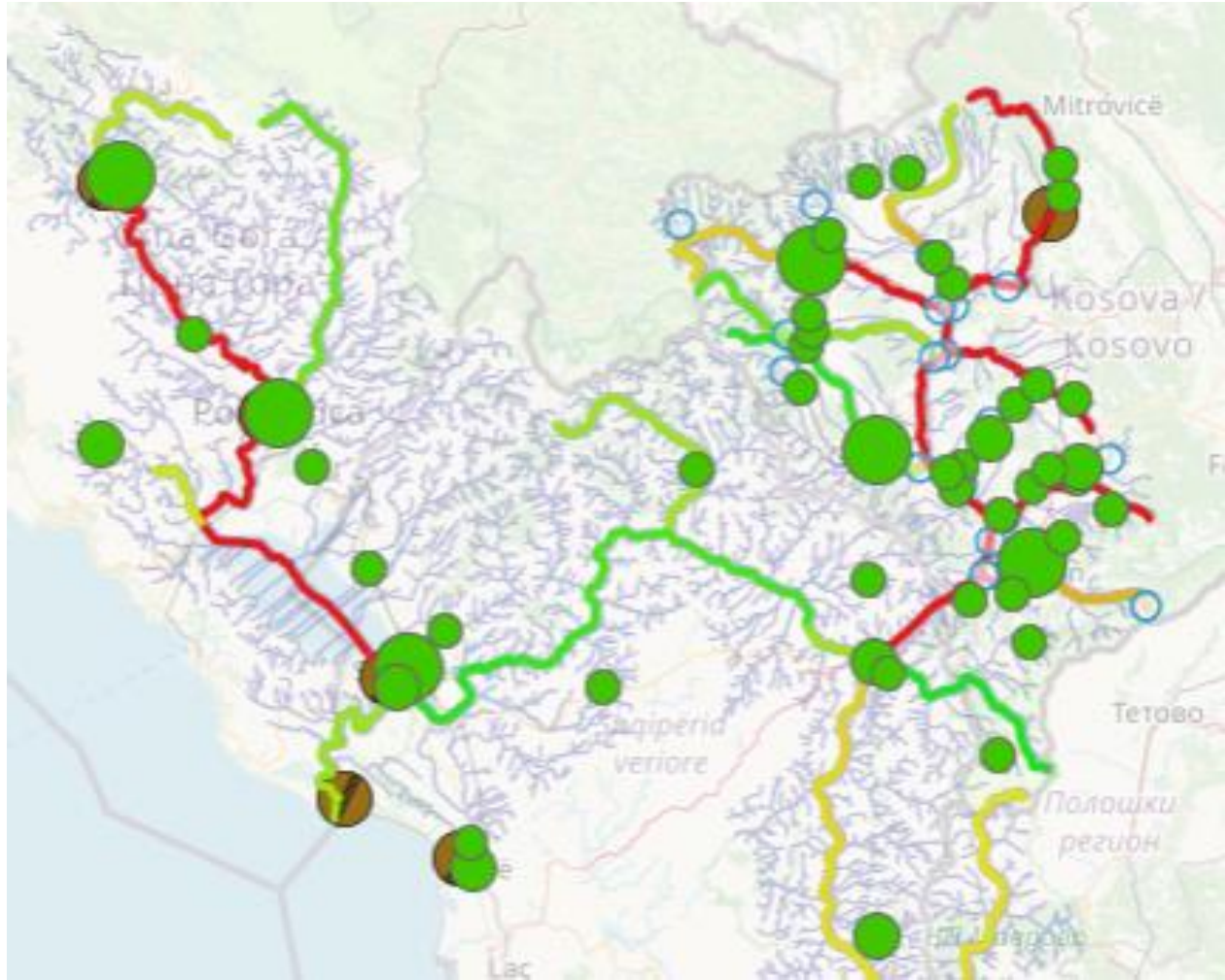
Agglomerations identified based on:

- satellite data
- individual data

930 agglomerations identified

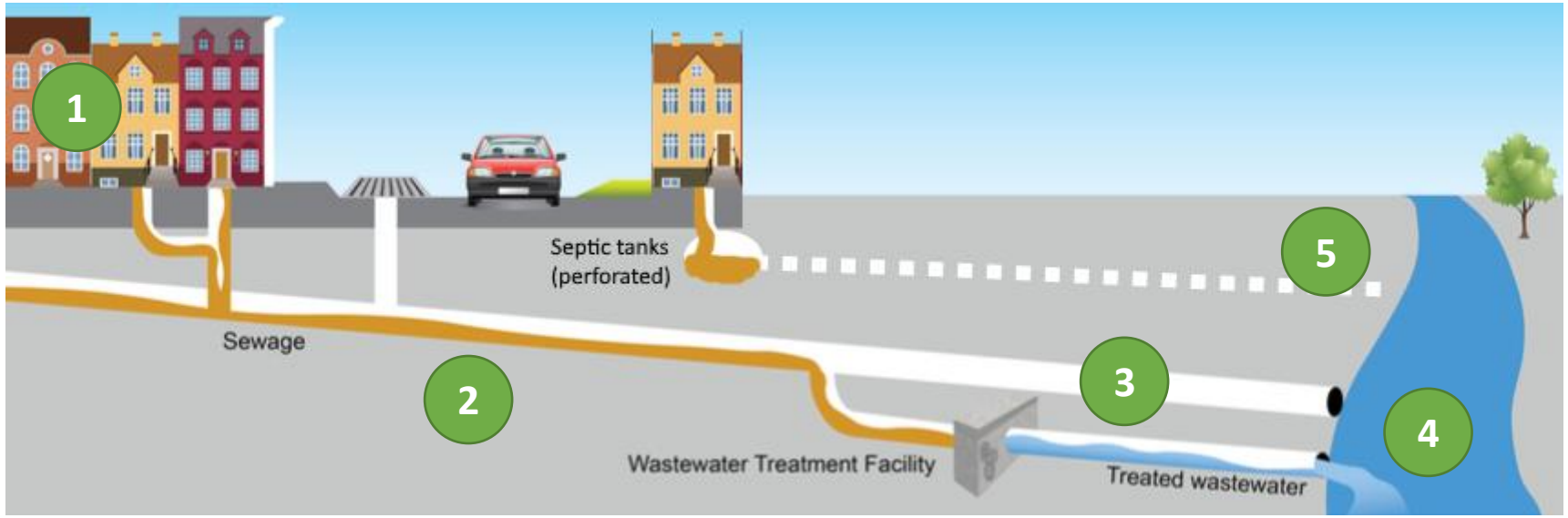
78 agglomerations modelled

(>2000 PE according to WFD – water framework directive)



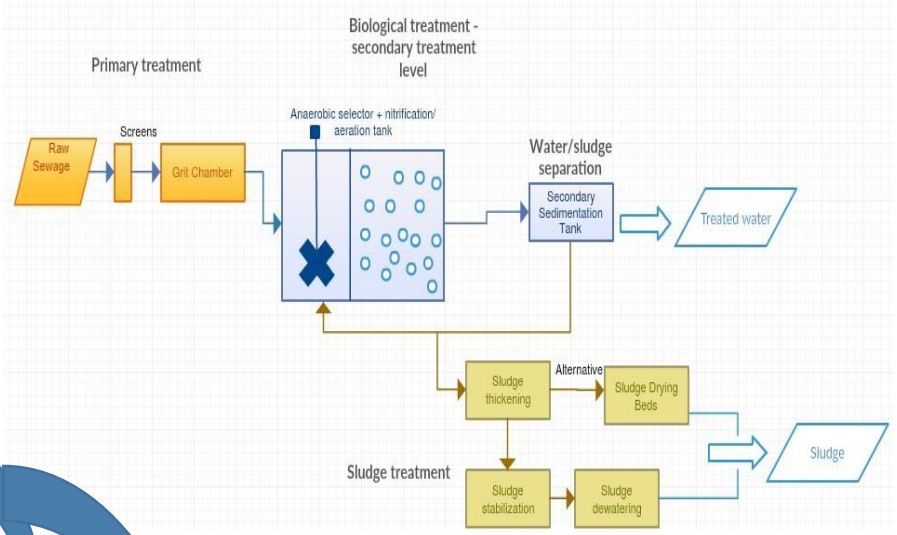
Estimated loads

1. Loads released households per PE (e.g. 60 BOD5 per PE per day
2. Collected loads (sewage)
3. Treatment (WWTP)
4. Loads released to rivers through sewage
5. Released to rivers through perforated septic tanks



WASTEWATER TREATMENT MODEL

Wastewater Treatment Model



- Treatment model
  - Based on activated sludge technology (general)
  - Enables secondary or tertiary treatment (2 models)
- Sludge model
  - Applied two technologies:
    - Mechanical dewatering – energy – intensive process
    - Sludge drying reed beds – nature based solution
  - Two options for sludge disposal:
    - Incineration
    - Reuse in agriculture
- Wastewater reuse model
  - UV desinfection
  - Irrigation

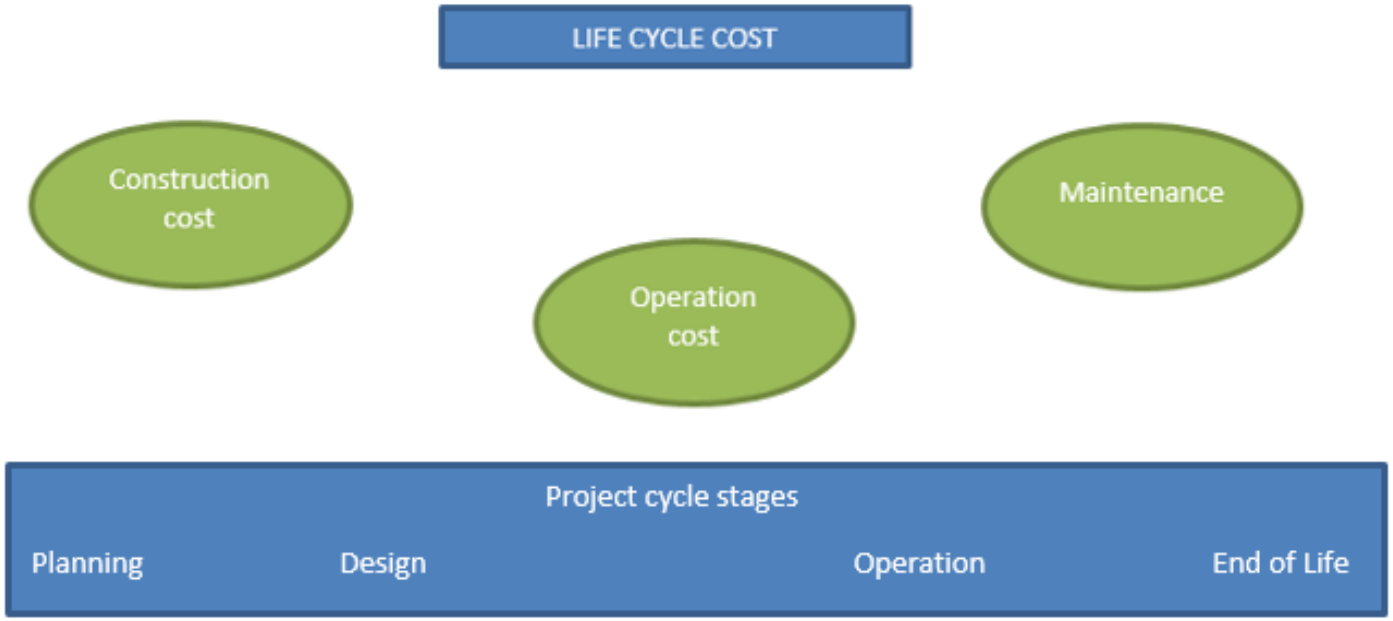
Hydraulic loadings

Pollution loadings

ECONOMIC TREATMENT MODEL

Economic Treatment Model

- Estimates costs (CAPEX, OPEX)
- The cost functions use the P.E., as the main cost driver
- The cost functions reflect regional prices



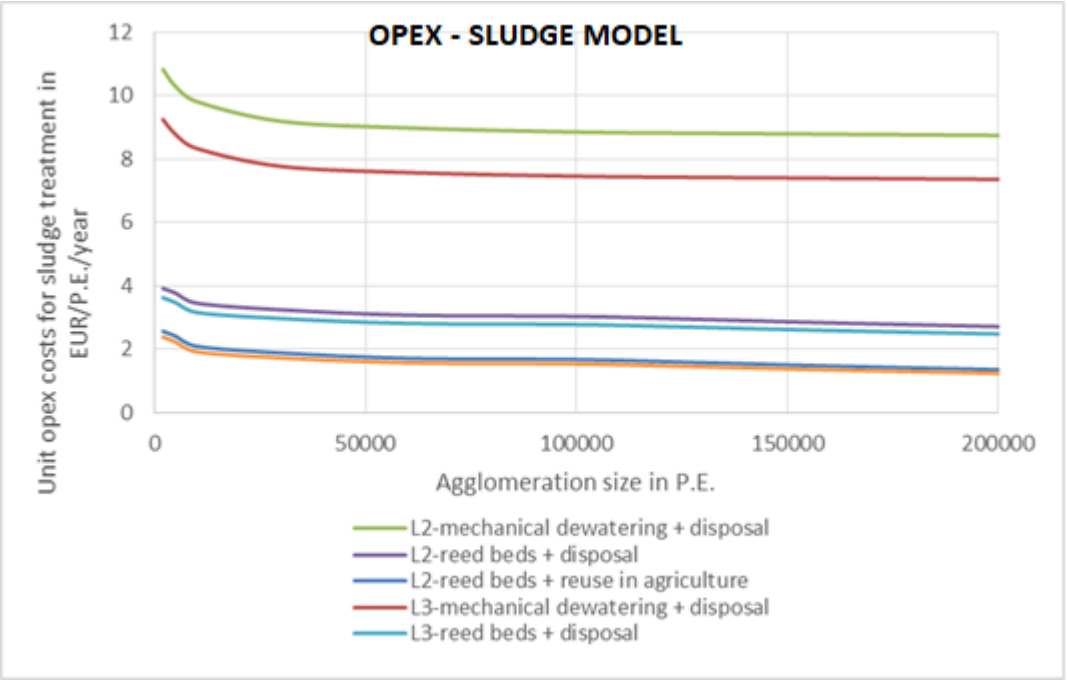
COST FUNCTIONS:

- **Sewage system**
- **Treatment level**
- **Sludge treatment**
- **Sludge disposal**
- **Sludge reuse**
- **Water reuse**

CAPEX and OPEX

CAPEX model includes:

- Designs, permits, trial operation
- Treatment facilities
- Administration buildings
- General infrastructure



OPEX model includes:

- Energy (Electricity consumption, Heating)
- Reagents (P-precipitation
- Other (filter cleaningg, process water)
- Workforce and service (no. of staff)
- Maintenance (% of capex expenditure)
- Monitoring (formal, intern)

VARIABLE UNIT COSTS are market based and can be modified by users:

- Electricity (0,1 €/kWh)
- Polymer (3,4 €/kg)
- Sludge transport and incineration (60 €/ton)
- Sludge transport and reuse in agriculture (15 €/ton)
- Monitoring

Additional

NET PRESENT VALUE (NPV)

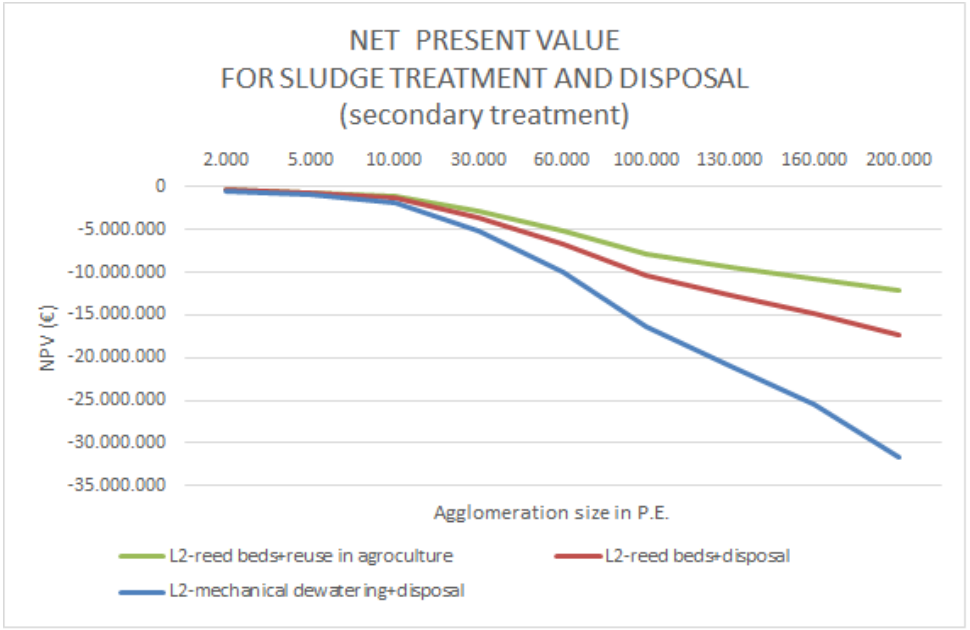
- Indicator for project overall performance
- The real discount rate applied is 4%

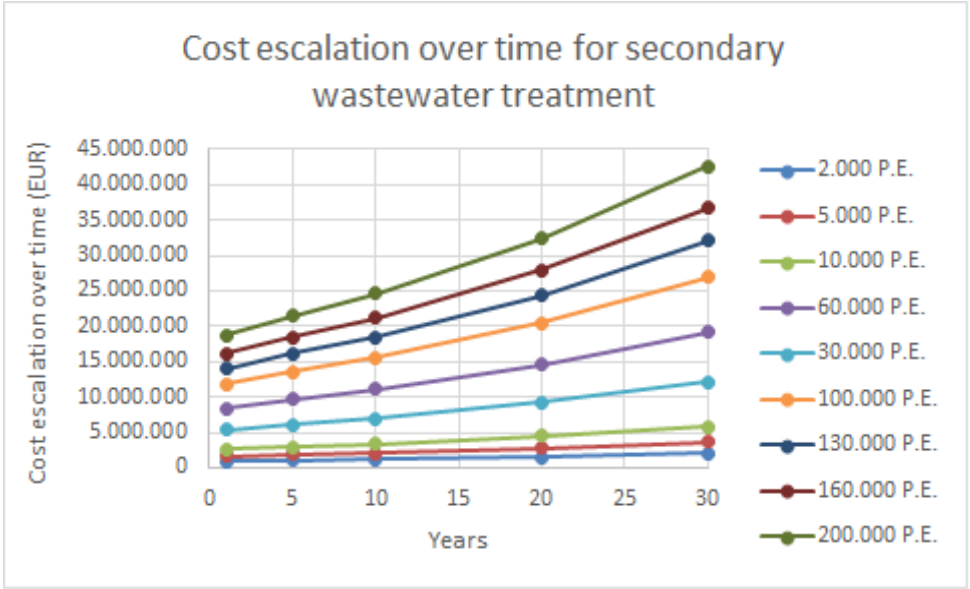
COST ESCALATION FACTOR

- Average annual rate of inflation for Drin (2,79 %)
- Time horizon of 30 years

LAND ACQUISITION COSTS

- Not included in the model
- **Included land requirements for implementation of reed beds**





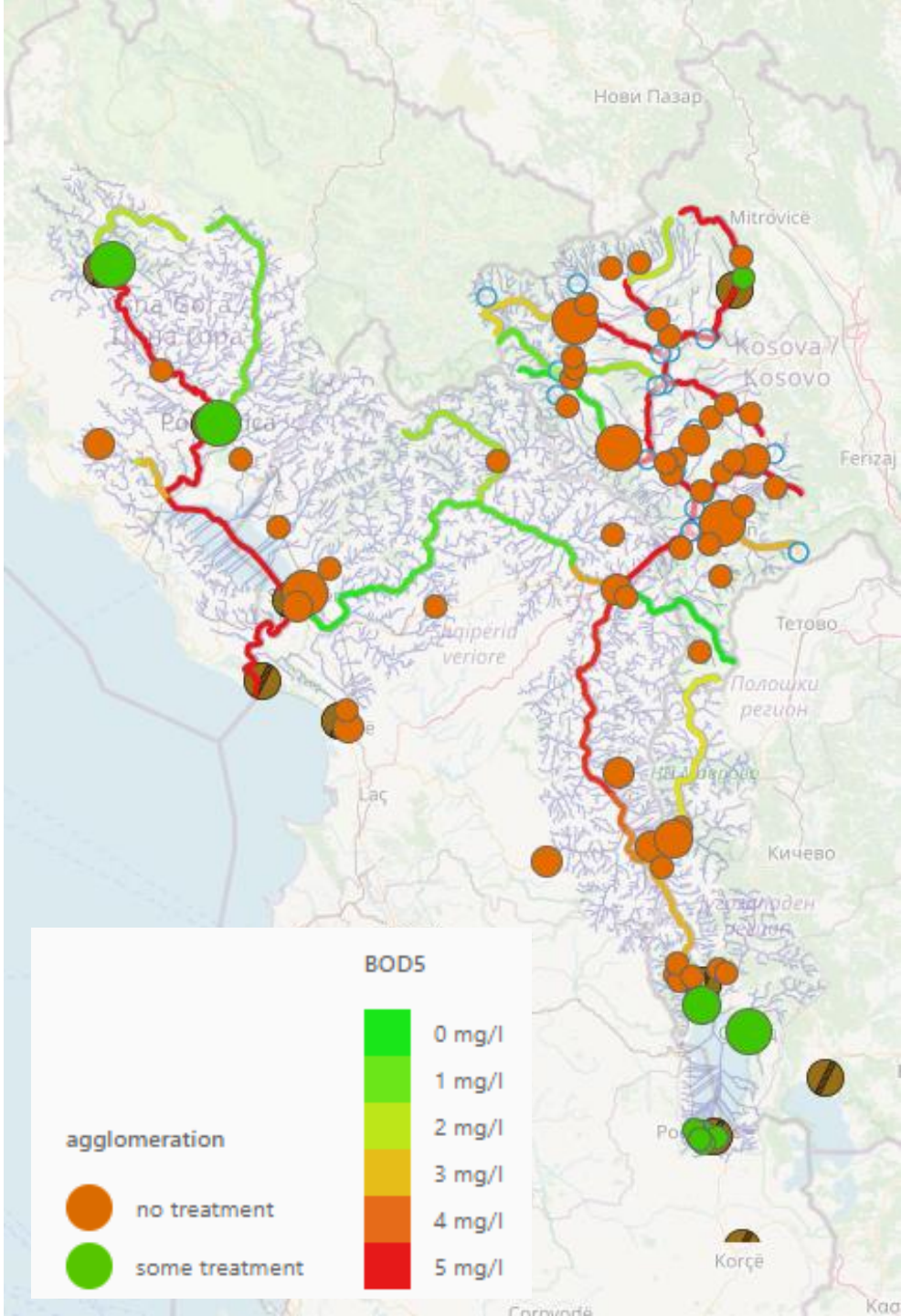
WATER QUALITY MODEL

Water quality model

Based on hydraulic model, loads, treatment efficiencies.

Water quality is assessed in dry summer months.

BOD5, N total, P total



MODEL USE

City scenario

- video

Catchment scenario

- video

KEY MESSAGES

Messages to take home

SDG 6: Ensure access to water and sanitation for all

WEMDST actions and use are targeted:

- To coordinate better local, national and regional interests – priorities! (funding)
- To ensure appopriate wastewater treatment alligned with WFD and UWWD
- To raise awarness about wastewater and biosolids reuse
- To build capacities of local authorities in the water-wastewater-environmental-related matters
- To strengthen cooperation on a Drin river level

WEMDST Development → **WEMDST Use**

WASTEWATER CONCEPT SOLUTIONS

WWTP for Shkodra City

WWTP:

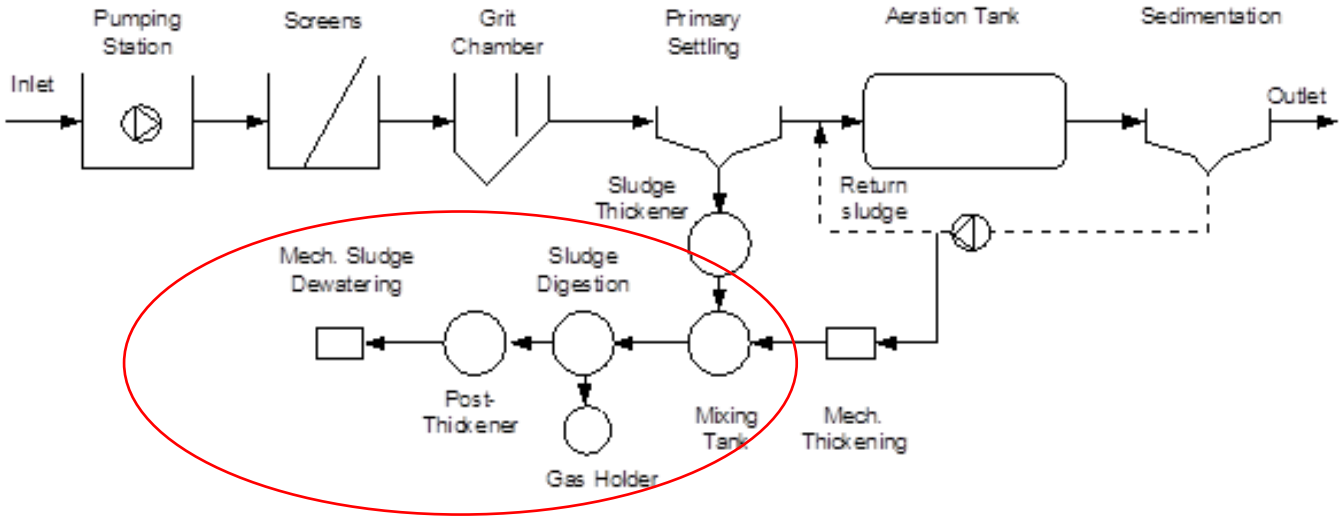
- Identification of the most appropriate technology
- Elaboration of detail concept solution for SBR

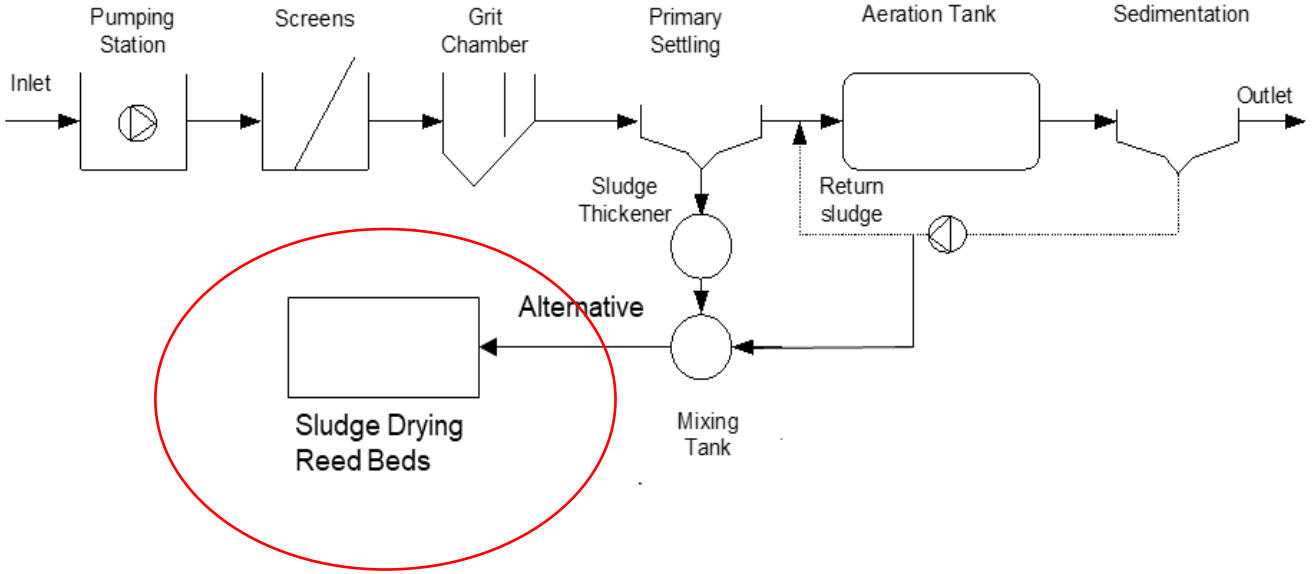
Key conslusions:

- MBR technology is commonly used in touristic coastal areas where land availability is scarce, expensive and high quality effluent is required due to bathing waters.
- Both CAS and SBR are well established technologies in Western Balkan Region.
- Question of sludge disposal arrises. According to EU guidelines every country is responsible for disposal of own sludge quantities (limited import of sludge from abroad).
- Alternative sludge management approaches are being increasingly used, also aiming to accumulate or reuse sludge until incineration plant would be implemented.

Parameter	Option 1: Conventional activated sludge (CAS)	Option 2: Sequencing batch reactor (SBR) with extended aeration	Option 3: Membrane bioreactor (MBR)
Investment costs (EUR)	1	2	3
O&M costs (EUR/year)	2	1	3
Land requirements	3	2	1
Ease of operation	1	2	3
Maintenance	1	2	3
Energy consumption	1	2	3
Environmental impact	3	2	1
Water reuse	2 (no)	2 (no)	1 (yes)
Treatment efficiency	2	2	1
TOTAL:	16	17	19
RANKING:	2	1	3
CONCLUSIONS:	- adopted for large scale applications	- commonly used technology in WB - good relation between price-performance and land requirements	- applicable for required high quality effluent

WWTP for Shkodra City





MECHANICAL PRE-TREATMENT: Aerated Grit and Grease Chamber, Pre-sedimentation

BIOLOGICAL PROCESS: SBR process in one chamber, rotary blower, aeration system, fast-revolving mixer, excess sludge pump station, sludge silo

2 OPTIONS FOR SLUDGE TREATEMNT:

- **Mechanical dewatering:** anaerobic digestion of sludge, the digester machine, biogas tank, purification of biogas, gas torch, digested sludge tank, sludge dehydration, dehydrated sludge tank

- **Sludge drying reed beds:** mineralization and stabilization, 16 reed beds planted with common reed, distribution and drainage system

SLUDGE ALTERNATIVE – REED BEDS

MECHANICAL DEWATERING

- Solid content (% TS): 20-25
- Required use of chemicals (flocculants, coagulants)

Belt press, centrifuges…

BIOLOGICAL SLUDGE TREATMENT

- Solid content (% TS): up to 40
- Due to mineralization lower organic content
- Less volume – lower costs

Sludge drying reed beds

COST ANALYSIS

WWTP

- Investment costs: 16.745.000 €
- Operational costs: 804.965 €/year

	Scenario 1: mechanical dewatering	Scenario 2: sludge dyring reed beds	
Sludge alternatives	disposal	disposal	reuse in agriculture
CAPEX [€]	905.000	5.319.685	5.319.685
OPEX [€/y]	855.900	421.262	246.212
NPV O&M [€/y]	-14.800.251	-7.284.477	-4.257.506
NPV INVESTMENT [€]	-905.000	-5.319.685	-5.319.685
NPV TOTAL [€]	-15.705.251	-12.604.162	-9.577.191
Ranking	3	2	1

SLUDGE TREATMENT (2 options)

Mechanical dewatering and digestion

- Investment costs: 905.000 €
- Operational costs: 135.900 €/year withouts sludge disposal
- Operational costs: 855.900 €/year with sludge disposal

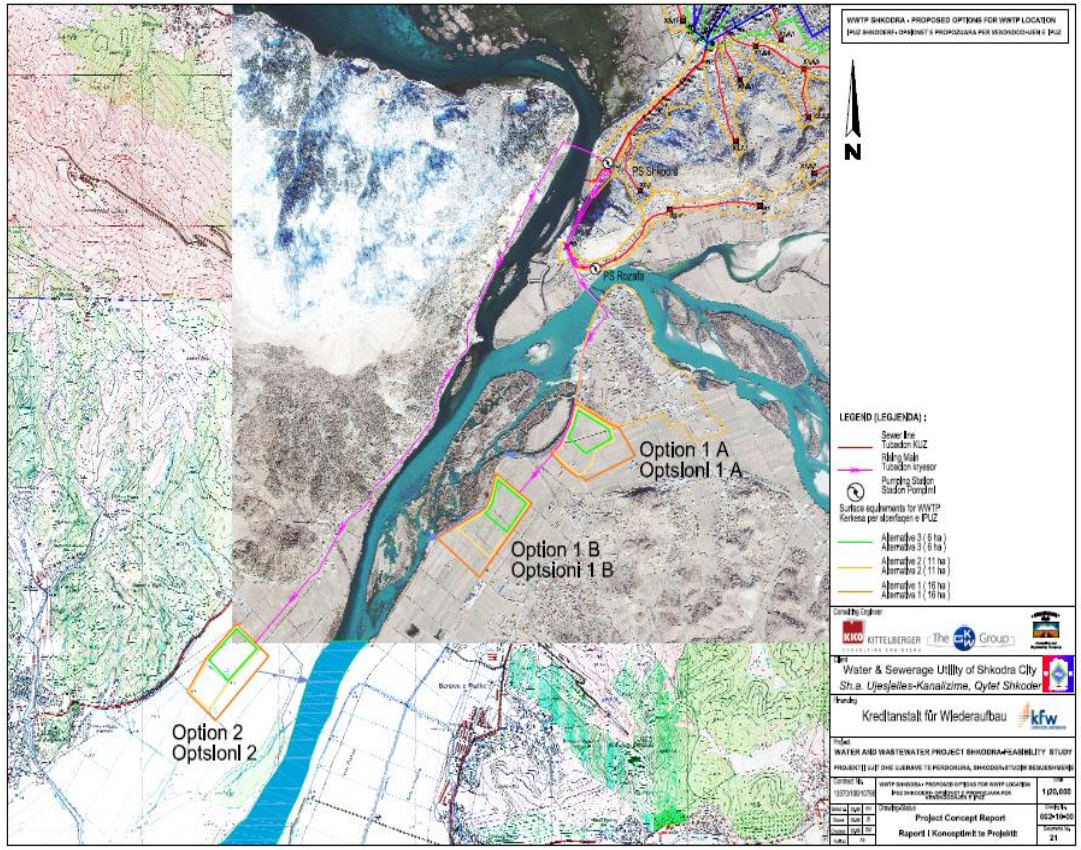
Sludge drying reed beds

- Investment costs: 5.319.685 €
- Operational costs: 187.862 €/year withouts sludge disposal
- Operational cost: 421.262 €/year with sludge disposal
- Operational costs: 246.212 €/year with sludge resue

WWTP location analysis

Assessment parameter	Option 1A	Option 1B	Option 2
Vulnerable to flooding	yes	yes	yes
Flood depth (Q100)	1,0-1,5 m	0,8-1,3 m	0,2-0,8 m
Water velocities	0,4-0,6 m/s	0,4-0,5 m/s	0,5-0,7 m/s
Distance from existing settlements	only few meters away from first houses	30 -100 meters	200 meters
Distance from existing sewage outflow (Kwf, 2006)	1.870	2.600	4.600
River crossing	Drin river crossing	Drin river crossing	Buna river crossing
Land use	agricultural land	agricultural land	agricultural land
Cadastral plots	fragmented	fragmented	fragmented
Land owners	mostly private	mostly private	mostly state
SBR land requirements (4 ha)	feasible	feasible	feasible
SDRB land requirments (7,6 ha)	feasible	feasible	feasible
*Land purchase (SBR + reed beds)	305.230 EUR	278.435 EUR	376.295 EUR
Option ranking:	2	2	1
Elevation of flood treath for Q100:			8,00 m.a.s.l.

- **Flood impact assesment**
- **Vicinity of settlements**
- **Land purchase costs**



Source: Water & sewerage project Shkodra feasibility study, Project concept report" (June 2006)

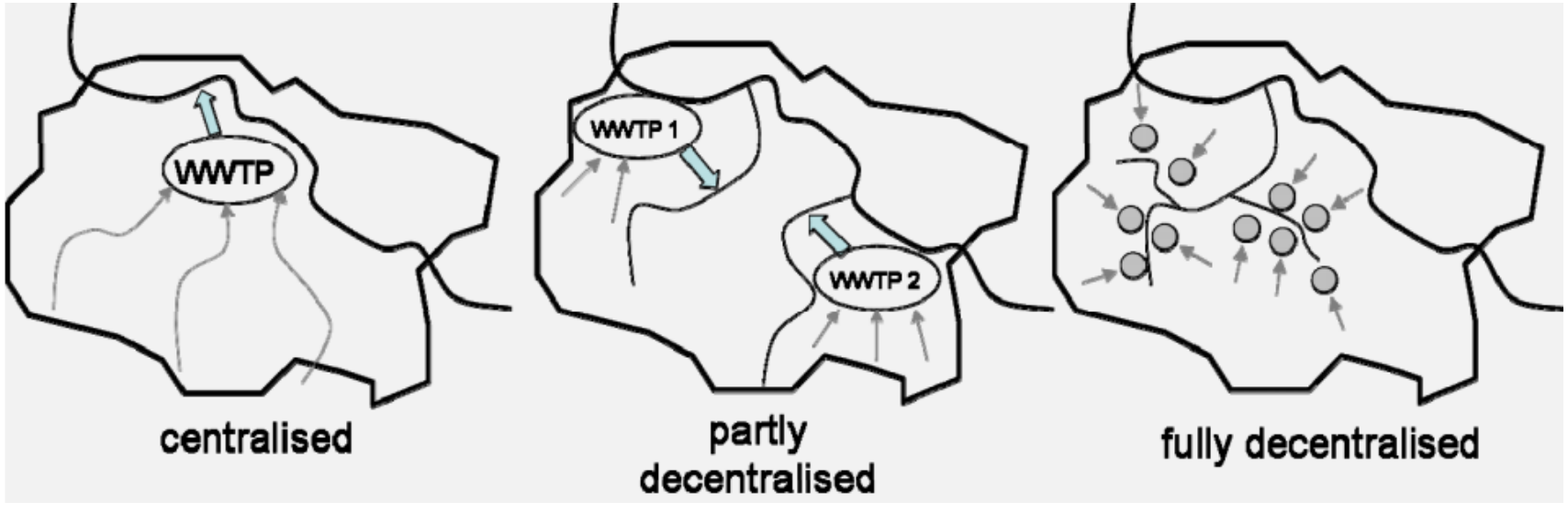
Centralised or decentralised system – Shkodra lake

- **Village Kaldrun**
- **Village Koplik i Sipërm**
- **Village Drisht**

- Basic dimensioning
- Cost analysis (capex, opex)
- Technical and Financial aspects

Analysed following options:

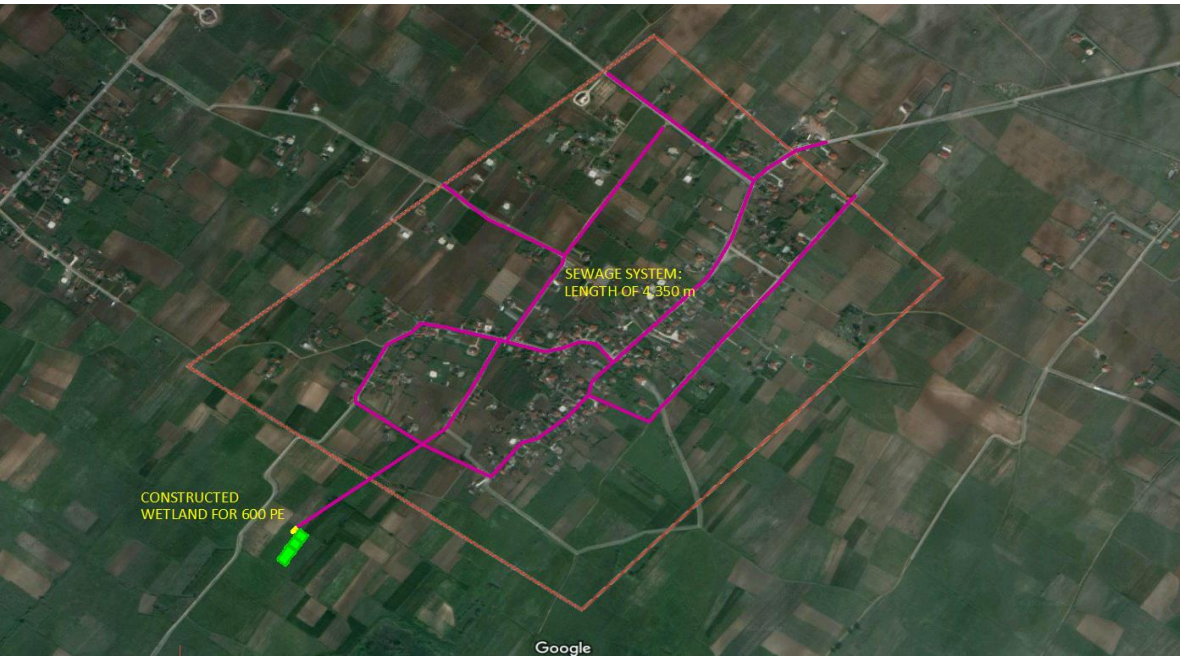
- OPTION 1 – Autonomous small WWTP in the village
- OPTION 2 – Centralized WWTP in Koplik city
- OPTION 3 – Centralized WWTP in Shkodra city



Village Kalldrun

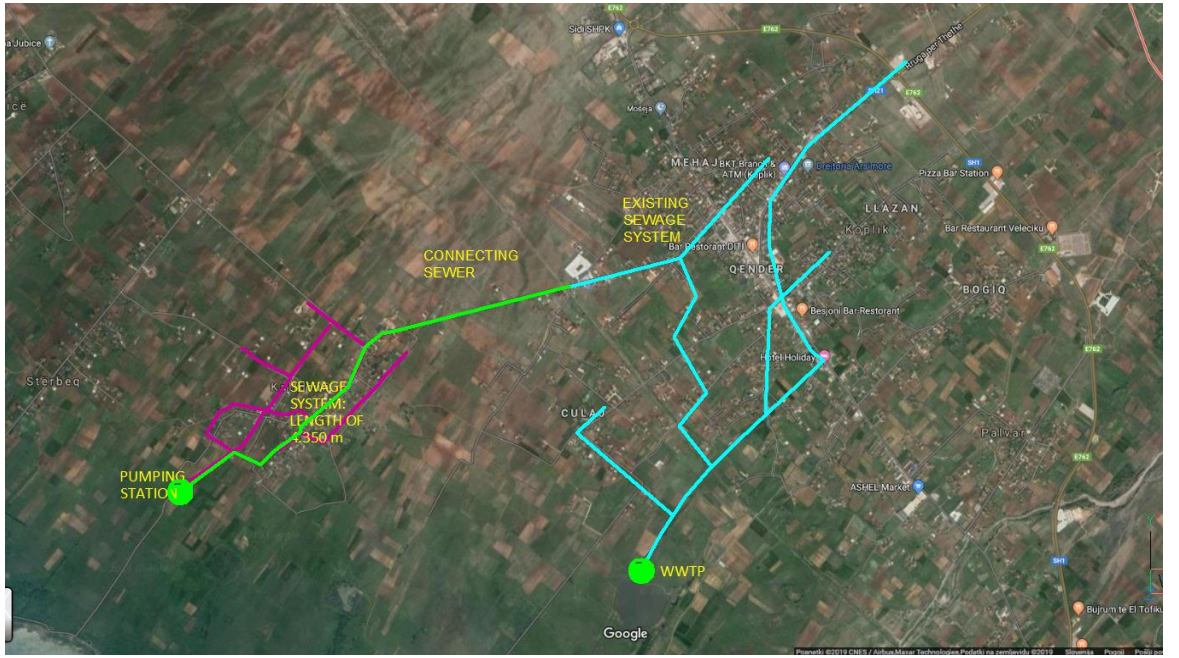
OPTION 1: Autonomous small WWTP

(4.350 m of sewer + constructed wetland for 600 PE)



OPTION 2: Centralized WWTP in Koplik city

(6.750 m of sewer + WWTP for 4.600 PE)



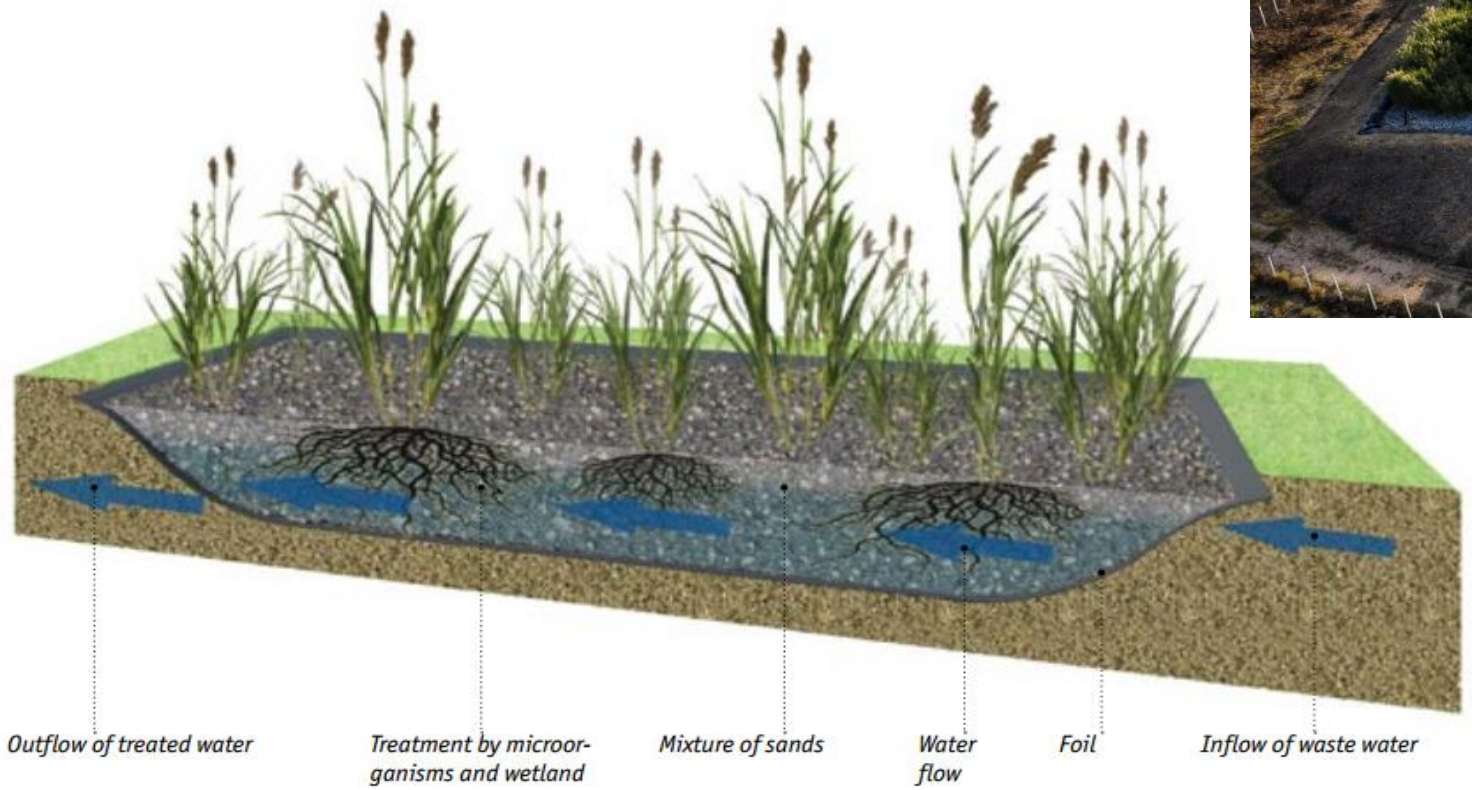
OPTION 3: Centralized WWTP in Shkodra city

(22.850 m of sewer + upgrade of central WWTP for 600 PE)

COSTS	Option 1	Option 2	Option 3
INVESTMENT COSTS (EUR)	1.237.500	1.567.500	5.782.500
COST OF OPERATION AND MAINTENANCE (EUR/year)	2.770	5.100	2.400
INVESTMENT AND O&M COSTS – RANKING THE VARIANTS	1	2	3

Constructed wetlands – appropriate solutions for dispersed settlements

Conxtructed wetland mimic the physical, chemical, and biological purification processes of a natural wetland.



- Good efficiency
- Ease of operation
- Low maintenance costs
- High buffering capacity
- Simple construction involving local construction
- Landscape attractiveness
- Land intensive technology (from 2 m2/PE).

STORMWATER CONCEPT SOLUTIONS

Hydrology/hydraulic model for storm water

The objectives of these scenarios were:

- to assess storm events and flow quantities,
- to define possible retention areas,
- to define measures to reduce frequency and intensity of urban flooding with improved urban drainage and retention

Input data

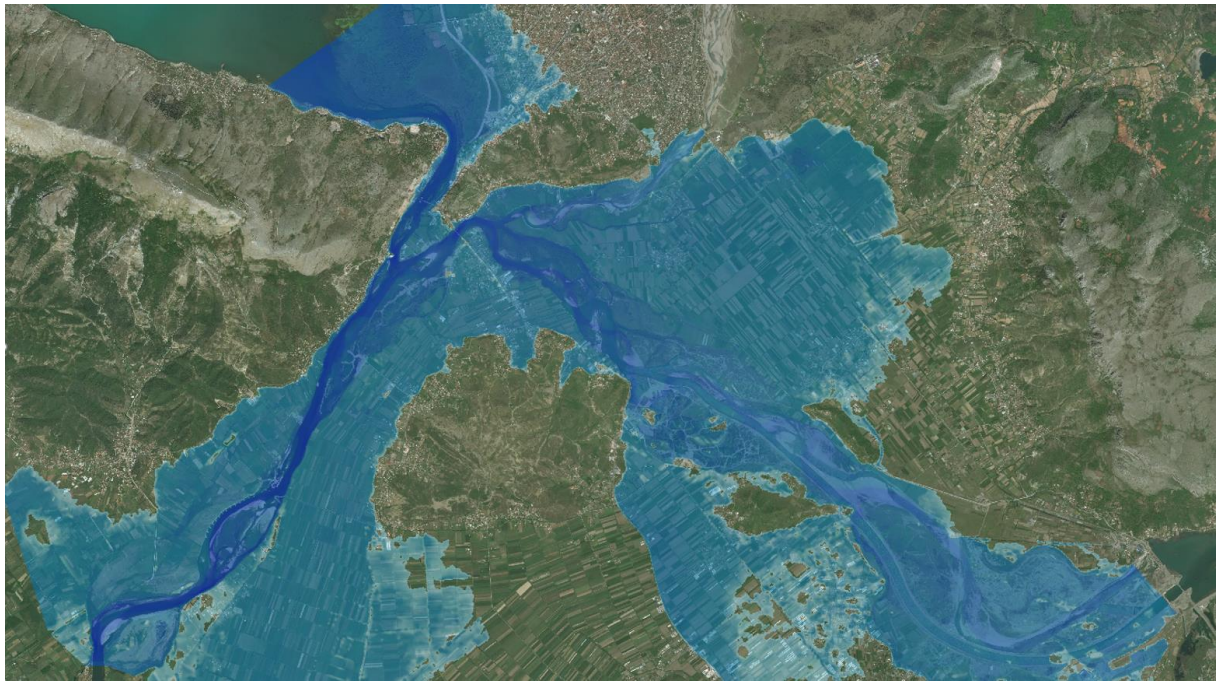
- digital terrain data
- buildings
- civil infrastructure (bridges, culverts)
- precipitation data
- land use
- terrain roughness data

Hydraulic model

- Software used: River flow 2D model (full 2d modelling)
- Multiple hydraulic combinations based on discharges of incluent rivers (Drini, Shkodra lake)

Outputs

- Flood propagation animations
- Discharge hydrographs
- Velocity fields in Shkodra city
- Flood depths



WEMDST

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Thank you for your attention!

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