Sustainable land-use along the Mertvovid River (southern Ukraine)

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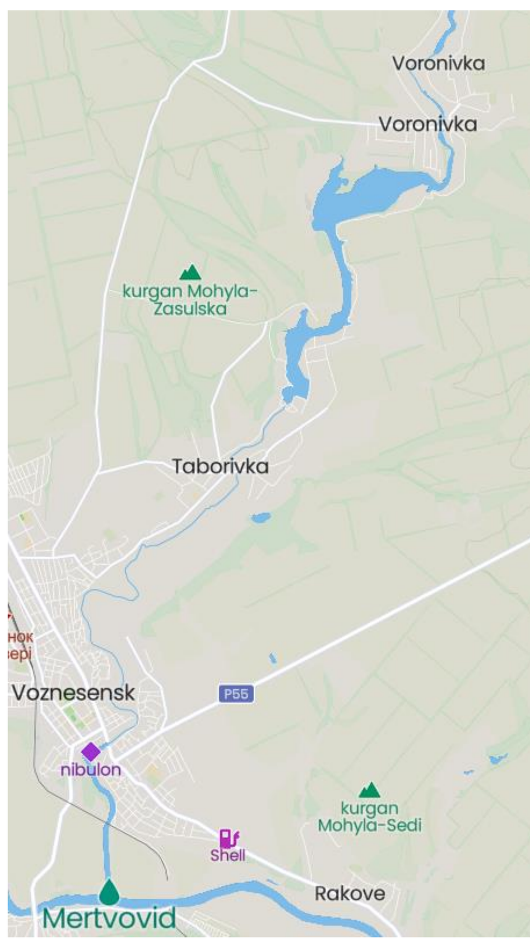
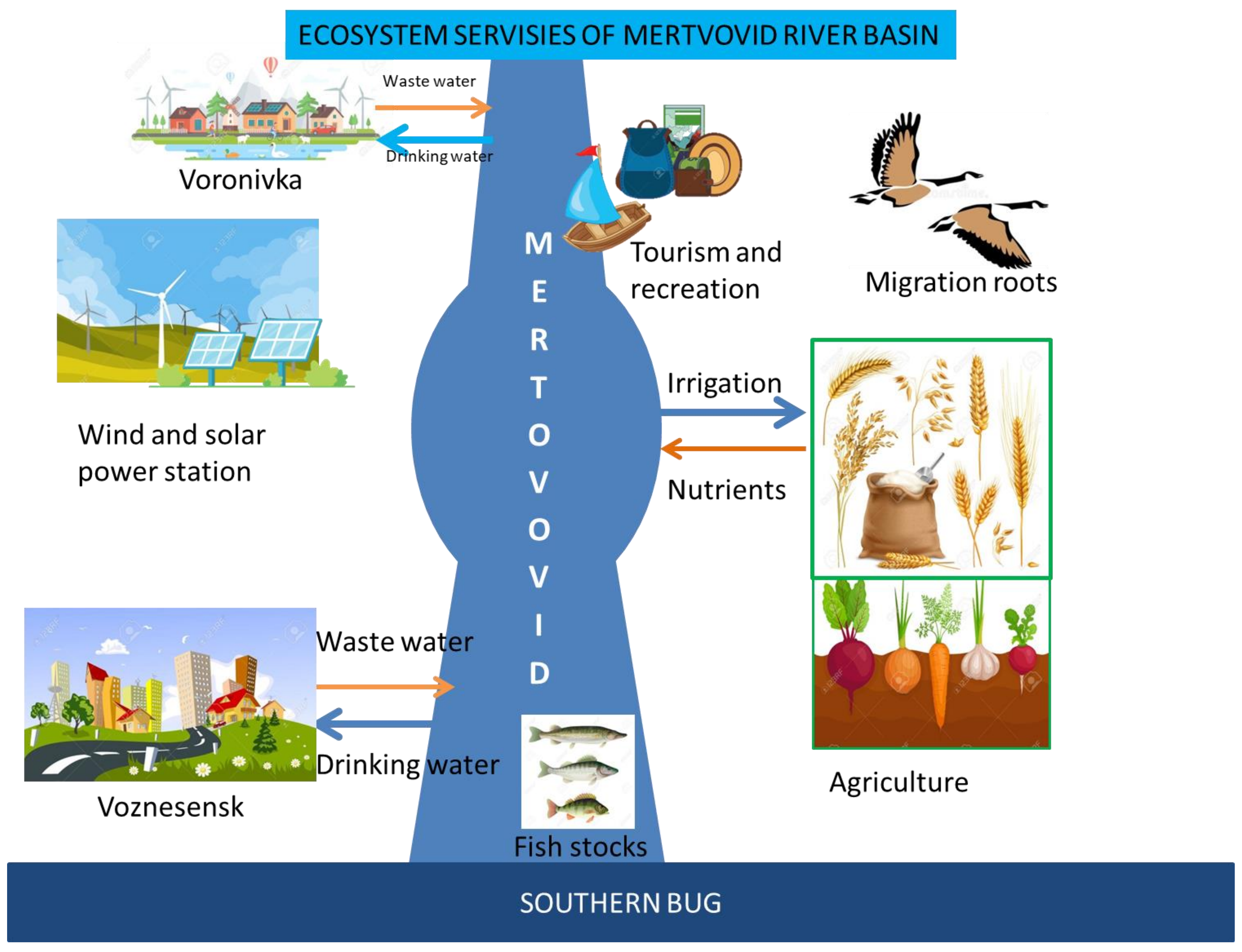
BACKGROUND

This example of decision-support modeling is from a 2022 course with participants and teaching assistance from Ukraine. This case study deals with sustainable land-use within the lower (southern) Mertvovid River basin in the Mykolaiv region. Archaeological and natural heritage of local significance are found in the study area. Annual rainfall: 517 mm. Soil types: mainly chernozems. Total forest cover of the territory is less than 4%. The river has 1820 km² area of watershed. Important European migratory routes for birds pass along this river basin. This region is one of the most popular for game fishing, recreation and tourism in Ukraine. Here, farming is successfully combined with the preservation of natural protected areas. In the last decade, the region has experienced rapid development of alternative energy production. The construction of solar and wind farms, as well as military actions, can upset the existing balance of reasonable environmental management.





SYSTEM STRUCTURAL ANALYSIS

Using variables related to the System Sketch, the system dynamics are evaluated from their impact relationships with the help of relative impact values (0-3 scale, matrix below), based on theory, expert experience and literature information. The Cause-Effect plot and relationships diagram graphically illustrate the system, which contains mainly high-active variables that influence each other. But the most highest value factor was the land-use, that has both positive and negative influence on other environmental services and highly related with the economical development of Mykolaiv region.

IMPACT MATRIX FOR SUSTAINABLE DEVELOPMENT OF REGION
(0-3 relative scale)

Parameters	Water pollution	Land-use	Alternative energy production	Biodiversity	Recreation& tourism	Economy	Flow regime	Cause
Water pollution	0	1	0	3	2	2	2	10
Land-use	3	0	3	2	2	3	2	15
Alternative energy production	0,5	3	0	2	1,5	3	0	10
Biodiversity	0	1	0,5	0	2	1	2	6,5
Recreation& tourism	1	1	0,5	2,5	0	2	1	8
Economy	2	2	2,5	1	1	0	2	10,5
Flow regime	2	1,5	0	1,5	1	1	0	7
Effect	8,5	9,5	6,5	12	9,5	12	9	67

WEIGHTING MATRIX FOR SUSTAINABLE DEVELOPMENT OF REGION

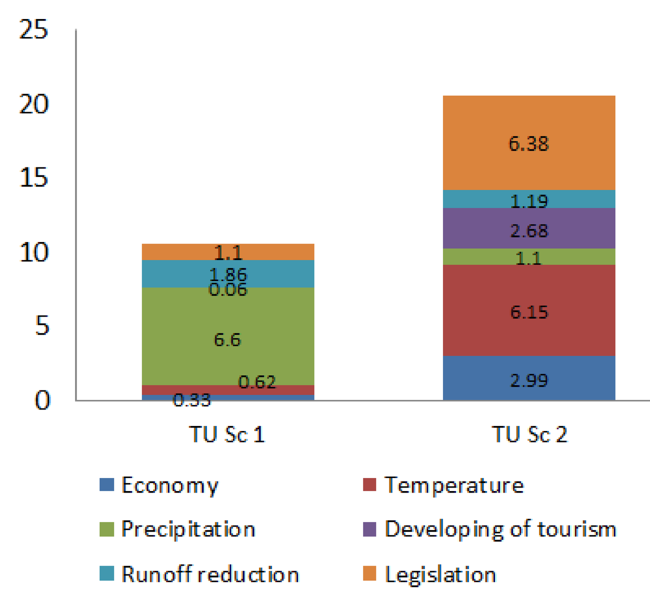
Parameters	Water pollution	Land-use	Alternative energy production	Biodiversity	Recreation& tourism	Economy	Flow regime	Weight
Water pollution	P1	1/3	1	3	1/3	1	1/3	6,0
Land-use	3	P2	7	3	7	9	1/3	29,3
Alternative energy production	1	1/7	P3	3	1	7	1	13,1
Biodiversity	1/3	1/3	1/3	P4	1/3	1	1/3	2,7
Recreation& tourism	3	1/7	1	3	P5	3	1	11,1
Economy	1	1/9	1/7	1	1/3	P6	1	3,6
Flow regime	3	3	1	3	1	1	P7	12,0

WEIGHTING MATRIX FOR SUSTAINABLE LAND-USE OF REGION

Parameters	Eco	Temp	Prec	Dtour	RunR	Leg	Weight
Economy	P1	1/3	1	3	1	3	8,3
Temperature	3	P2	1/3	3	5	1	12,3
Precipitation	1	3	P3	1	5	1	11,0
Developing of tourism	3	1/3	1	P4	1	1/3	5,7
Runoff reduction	1	1/5	1/3	1	P5	1	3,5
Legislation	5	1	1	3	1	P6	11,0

UTILITY

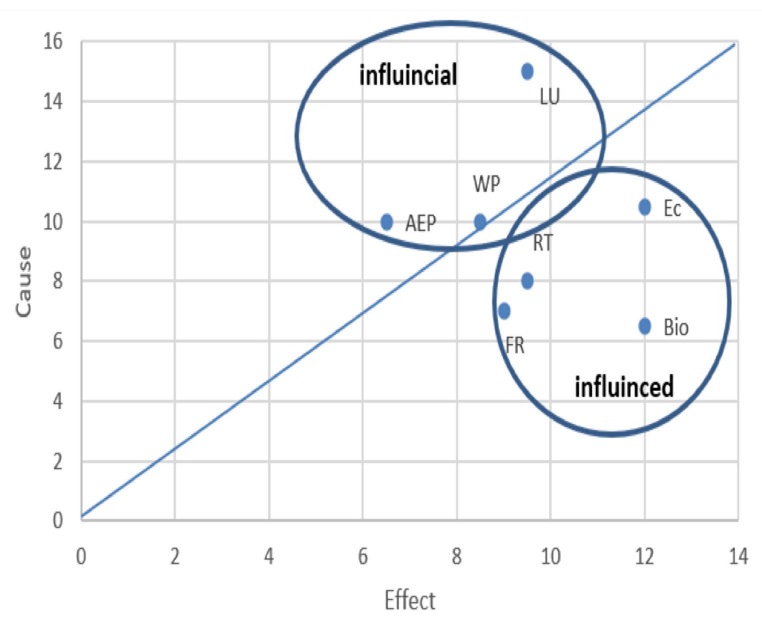
Parameters	Weight	U1 (in 2023)	U2 (in 2033)	TU Sc 1	TU Sc 2
Economy	8,3	0,04	0,36	0,33	2,99
Temperature	12,3	0,05	0,50	0,62	6,15
Precipitation	11,0	0,60	0,10	6,60	1,10
Developing of tourism	5,7	0,01	0,47	0,06	2,68
Runoff reduction	3,5	0,53	0,34	1,86	1,19
Legislation	11,0	0,10	0,58	1,10	6,38

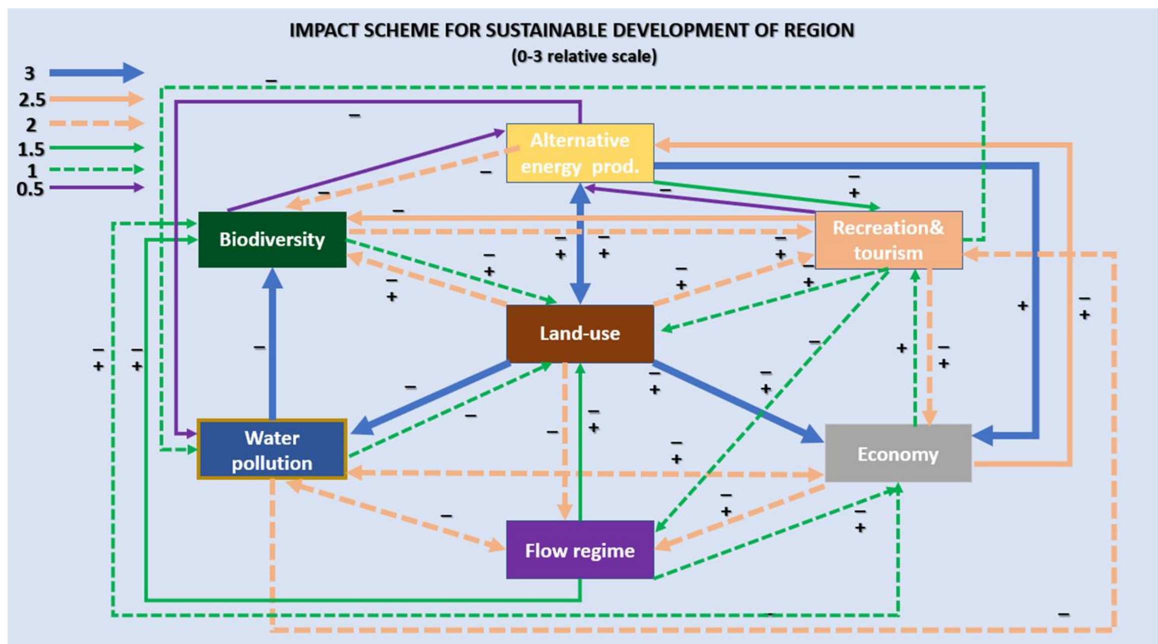


SYSTEM SKETCH

The following main water and environmental parameters have been identified for the Mertvovid basin:

- Water pollution (by nutrients, by dissolved organic matter, by metals, by toxicants, by pesticides)
- Land use (for urban/rural, for agriculture, for alternative energy)
- Alternative energy production (wind farms, solar power plants)
- Biodiversity (fish stock, migration roots, bird nesting)
- Recreation & tourism (tourist routes, camping, sanatoriums, creative inspiration from landscapes)
- Economy (economic development/decline of the region, increase in the well-being of residents)
- Flow regime (current velocity, dam, siltation, shallowing)





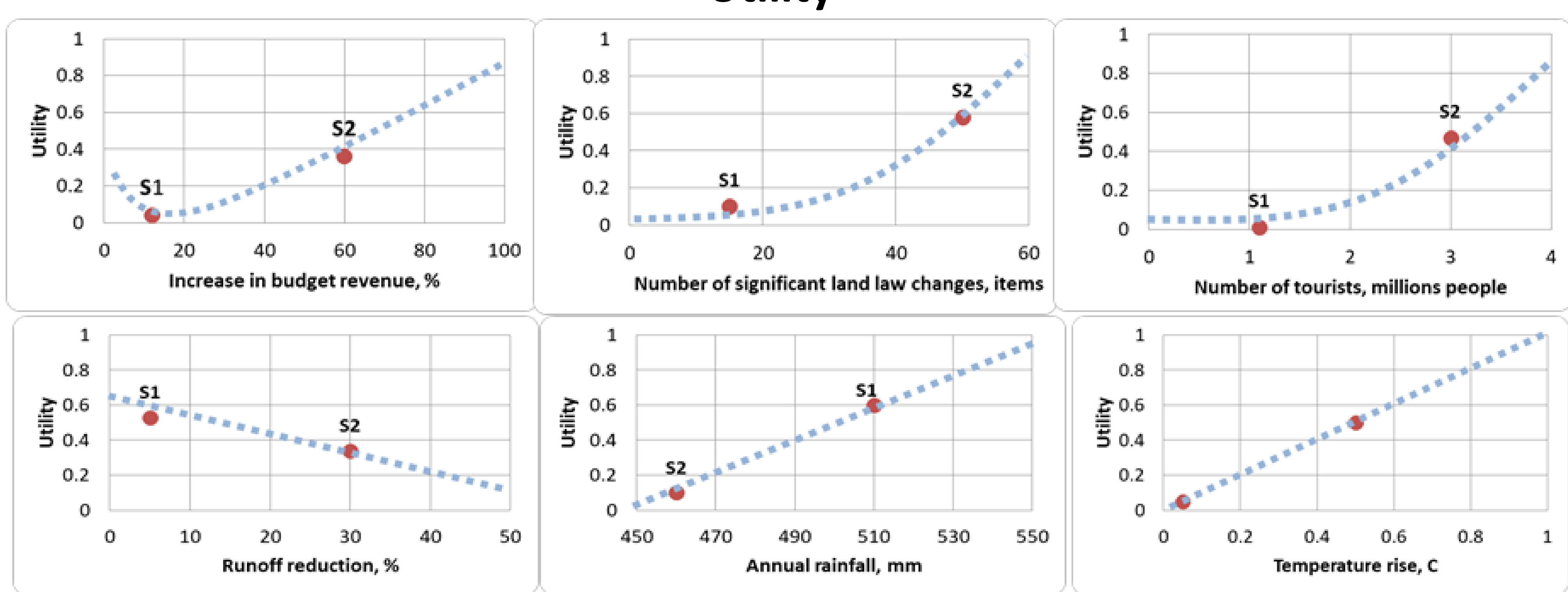
MULTI-CRITERIA EVALUATION

The conceptual analytical modeling above can also lead to predictive modeling using, for instance, MCE with the following equation:

$$\Sigma_i\, w_i \bullet u_i = \text{Total "utility"} \qquad \text{(used to rank different scenarios)}$$

We developed two weighting matrixes: for sustainable development of the region and sustainable land use. For each of the parameters considered, the weights (w) are assigned according to their relative importance for the question/issue considered (pair-wise matrix comparisons) and the utility is the impact with the site-specific conditions of each parameter. We analyzed two scenarios of regional land-use development: 1) short-term (ca. 1 year) and 2) long-term one (ca. 10 years).

Utility



CONCLUSIONS

This structured approach to system analysis is suitable as a first, desk-top step which will ideally give focus to more detailed documentation, revision and testing. The land use is the key parameter of sustainable development of Mertvovid River basin.

Nevertheless, the MCE scenario utilities (left) suggest that with the described conditions, climate and legislation changes have the most impact of the sustainable land use. According to the modeling results, the temperature rise, precipitation decrease and legislative changes will have ten times greater impact in 10 years than in 1 year.

The attention should be paid for these parameters to keep a favourable balance between the interests of farming, energy production and tourism in selected area.