Modeling Selected Ecosystem Services in Bugunski Region Watersheds

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Aral Sea Decline

- The Aral Sea is declining in area, water quality and habitat, as are large wetland complexes that receive irrigation return flows from farming villages in the Syr Darya River Basin
- Agriculture in the Syr Darya River Basin consumes large amounts of water for irrigation of cotton, corn, alfalfa, cucumber, potatoes and grapes
- Irrigation is inefficient, primarily flood irrigation is practiced
- Canals lose 30% of their water supply, while field level irrigation efficiency is only 50%
- Farmers over irrigate due to an unreliable supply of water

Study Area

- The Bugunski Reservoir region in southern Kazakhstan has been selected as an area for evaluation of better agricultural practices and their impact on selected ecosystem services
- Villages downstream of the Bugunski Reservoir, such as the Dugun and Karachik villages, rely on irrigation water supplied through canals from the Bugunski Reservoir

SWAT Modeling

- A GIS database of information about these villages includes information on elevation, land use, soil properties, agricultural management practices, reservoir inputs and outputs, water intake and supply
- These data are being used with the Soil Water Assessment Tool (SWAT) by Dr. Srinivasan to conduct detailed evaluation of water usage and other agricultural management practices and their impacts on crop yields and return flows

Ecosystem Services Modeling

- The objective of this sub-project is to identify a suite of ecosystem services that are affected by the alternative agricultural practices modeled with SWAT, and then to evaluate changes in provision of these ecosystem services using the Resource Investment Optimization System (RIOS) model.

RIOS Model

- The RIOS model allows users to identify a set of alternative land use management practices and then identify the ecosystem services that result when these practices are allocated in different ways across the landscape
- RIOS also allows users to optimize selected ecosystem services for a specified level of investment by identifying where on the landscape it is best to implement a suite of management practices

Alternative Practices Evaluated

- Better fertilizer management
- Better irrigation water management
- Substitution of existing crops with more water efficient crops
- Retirement or alternative uses for marginal crop land
- Improved or targeted policies and subsidies

Ecosystem Services Modeled

- Agricultural crop production
- Baseline water discharge from agricultural lands
- Water quality (nitrogen and phosphorus) in return flows

RIOS Modeling Steps

- Diagnostic screening with an ecosystem service score for each alternative management practice implemented one at a time
- Cost effectiveness of each alternative management practice is estimated by dividing ecosystem service score by the cost of implementing that practice
- Optimize the selection of management practices according to location in the watershed based on various levels of monetary investment to pay for implementation

Value of Water

- We can also assess the value of water by evaluating how agricultural crop production differ for the village closest to the Bugunski Reservoir relative to production in the village farthest from the Reservoir as water supply decreases
- Decreases in water supply may cause decreased household income, decreased land rental rates, increased use of fertilizer and/or increased costs to buy electricity for pumping of supplemental groundwater irrigation

Data Needs

- Impacts on agricultural production from:
  – Better fertilizer management
  – Better irrigation water management
  – Substitution of existing crops with more water efficient crops
  – Retirement or alternative uses for marginal crop land
- Impacts of these changes on economics are also important

Data Needs

- Changes in baseline water discharge from agricultural lands and
- Changes in water quality (nitrogen and phosphorus) in return flows from:
  - Better fertilizer management
  - Better irrigation water management
  - Substitution of existing crops with more water efficient crops
  - Retirement or alternative uses for marginal crop land
  - Improved or targeted policies and subsidies

RIOS Data Requirements

Table IV.2. RIOS Data Requirements by Objective

Service	Data
Erosion Control for Drinking Water Quality or Reservoir Maintenance	DEM Rainfall erosivity Soil erodibility Soil depth Location and# of beneficiaries per reservoir OR per surface drinking water source
Phosphorous Retention for Drinking Water Quality	DEM Rainfall erosivity Soil erodibility Soil depth Location and # of beneficiaries per surface drinking water source
Nitrogen Retention for Drinking Water Quality	DEM Soil depth Location and # of beneficiaries per surface drinking water source

RIOS Pixel Interactions

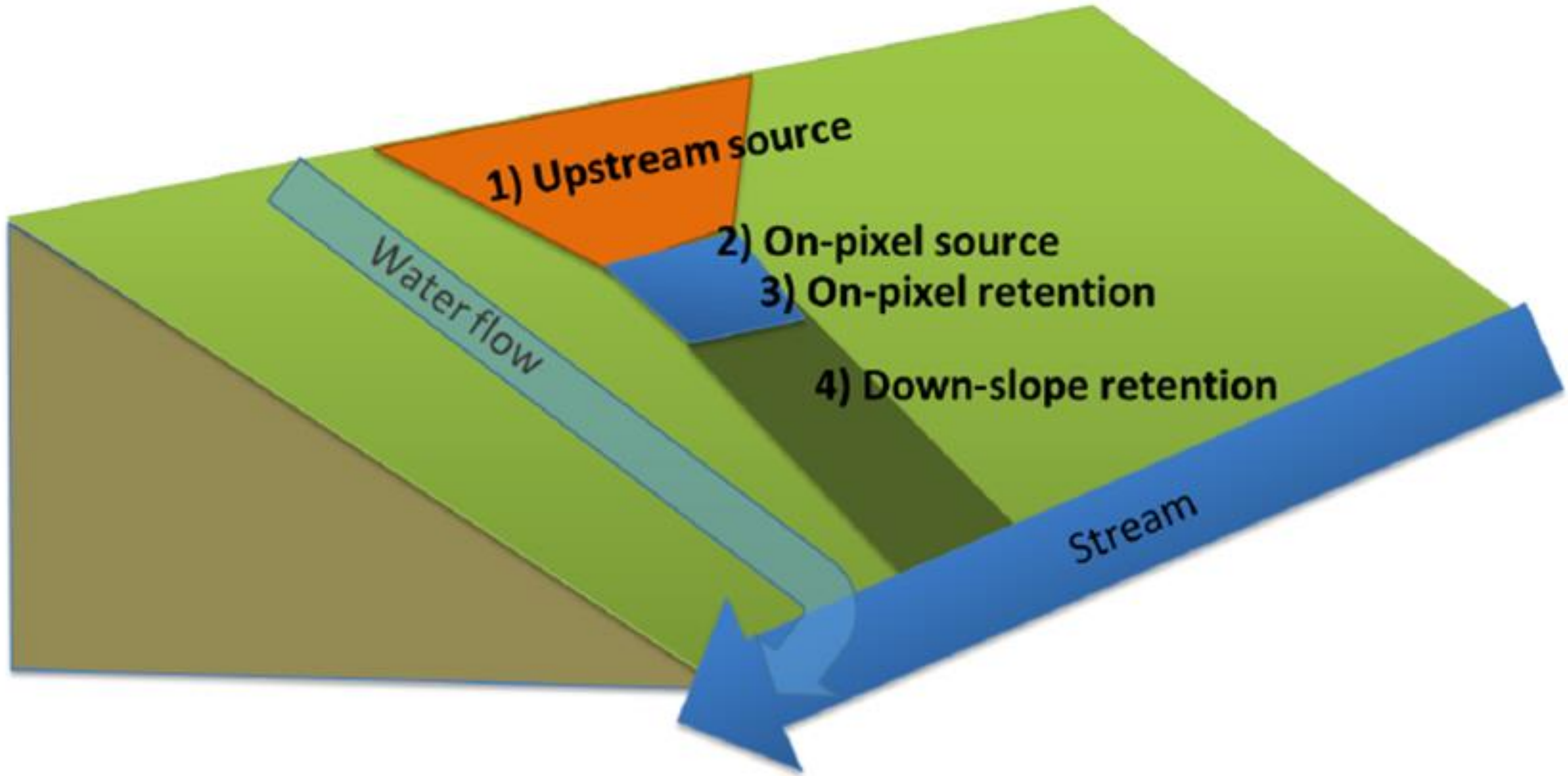


Figure 4. The four key processes that account for the impact of a transition on an objective in the RIOS framework.

RIOS Ranking Process

Table III.vi. Factors and default weights for Dry Season Baseflow. Each factor is input directly or derived from a land use-land cover map provided by the user.

Factor (Tool Inputs)	Process Captured	Notes	Keep Native Veg	Re-veg (Asst.)	Re-veg (Un-asst.)	Ag veg mgmt.	Ditching	Fertilizer mgmt.	Pasture mgmt.
Rainfall depth	Source at pixel	Average Annual Precipitation	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Actual Evapo-transpiration	Source at pixel	Average Annual AET	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Vegetative cover index	Source at pixel	Derived from LULC and Coefficients Table (cover_Rank)	0.2	~0.2	~0.2	~0.2	~0.2	~0.2	~0.2

RIOS Benefit Rankings

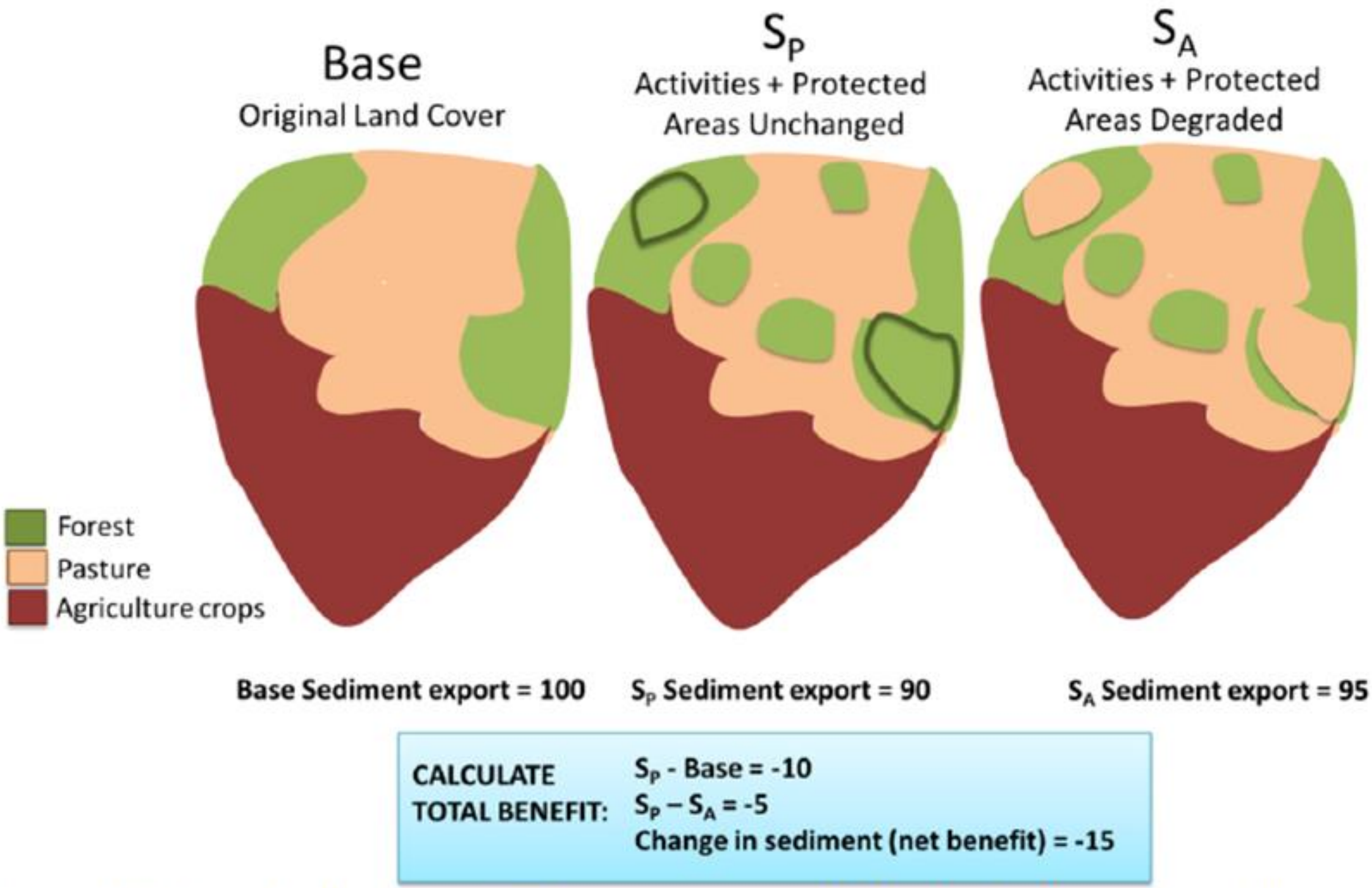
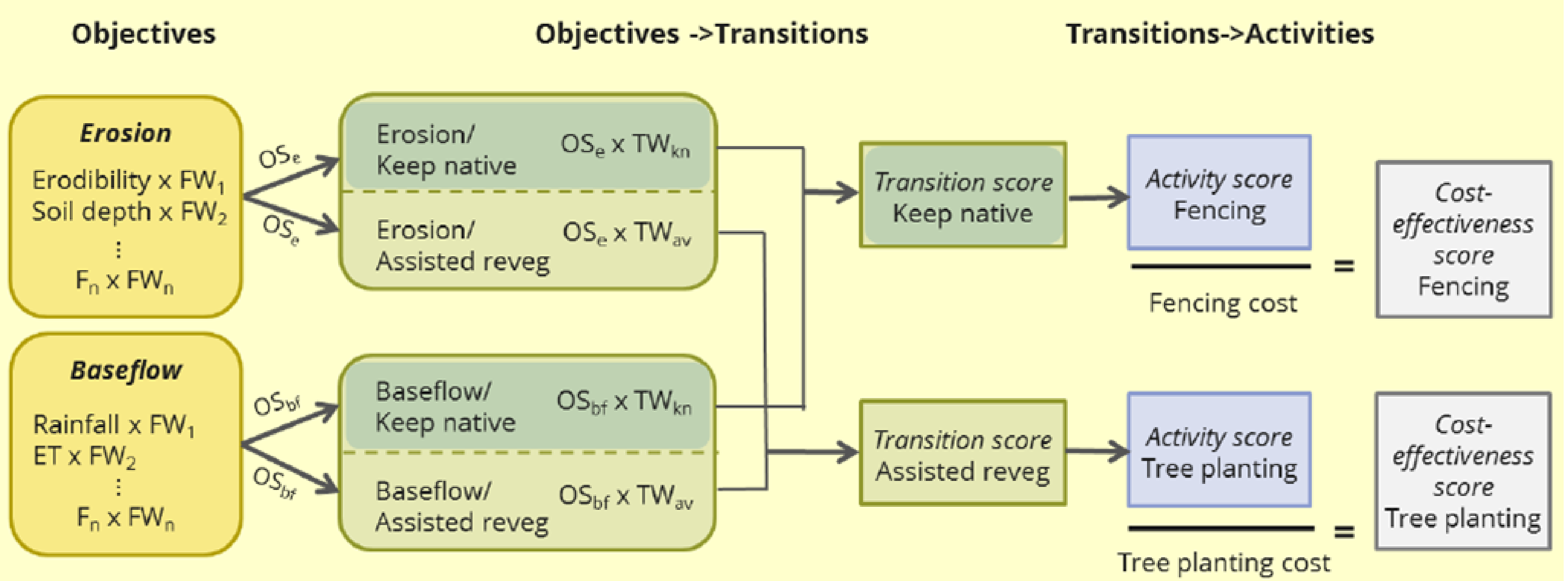


Figure 10. Example of how benefits from investments could be calculated using outputs from RIOS. The total ES returns from the portfolio are calculated as the benefits from restoration plus

RIOS Cost Effectiveness Scoring



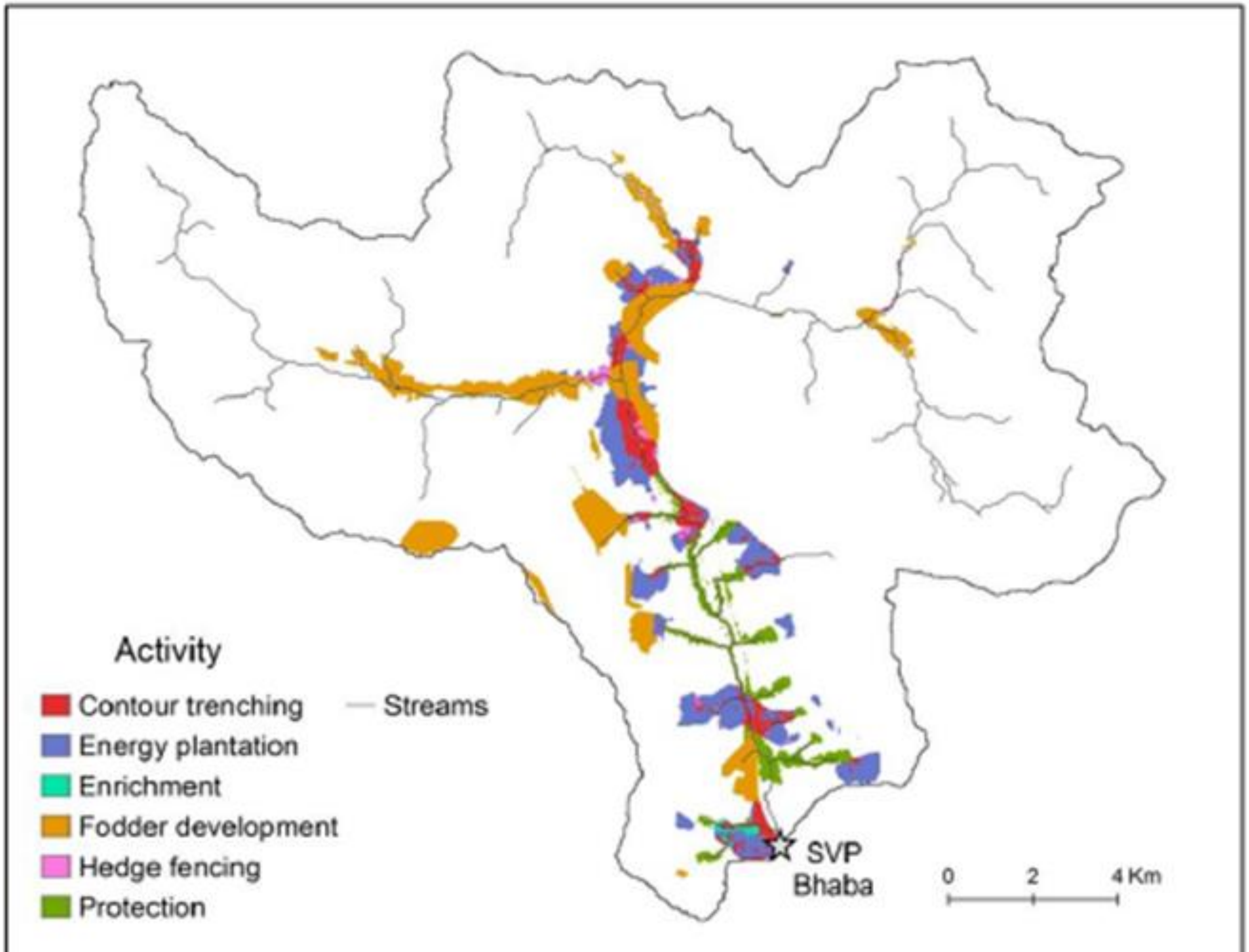
Objectives: $F_{1...n}$ are biophysical factors related to each objective, and $FW_{1...n}$ are weights assigned to each factor, indicating how much influence the factor has on the given objective. *OS* is the resulting score for each objective across all factors.

Objectives->Transitions: *TW* are weights assigned to each transition, indicating how effective the transition is at helping meet each objective. A score is calculated for each transition, across all objectives, the *transition scores* above.

Transitions->Activities: Each transition score is assigned to the activity that causes that transition, producing the biophysical *activity scores* for fencing and tree planting. To create the final *cost-effectiveness score* map, the *activity scores* are divided by the cost of the activity.

RIOS Investment Optimization

Catchment area for SVP Bhaba hydropower facility, India



Thank You. Questions?