MODELING HYDROLOGICAL ECOSYSTEM SERVICES AND TRADE-OFFS UNDER LAND USE LAND COVER CHANGE SCENARIOS IN THE SYRDARYA RIVER BASIN

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The Syrdarya river basin in Central Asia is facing a strong degradation of ecosystems and water quality deterioration mainly attributed to intensive agriculture. Predicted population growth and land use change call for more comprehensive, integrated management that considers entire coupled social-ecological systems. Within SES (Social-Ecological Systems) framework, the master's thesis is focused on upstream land use change impacts on downstream ecosystem services to reveal the trade-offs. The study performs a biophysical assessment of changes in three hydrological ecosystem services, one provisioning (water supply) and two regulating (water purification and erosion control) by developing spatially explicit models of land use change using Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) software. This assessment was achieved by designing alternative land use scenarios and then exploring the spatial patterns of ecosystem services in order to better understand linkages and consequences of land use change. This research presents an analytical framework for integrating direct human benefits and ecosystem services in policy decision-making and illustrates its application.

The key concept behind is *ecosystem services framework*, the benefits people obtain from ecosystems, which is increasingly being considered crucial for decision-makers in the search for sustainability. The development of international initiatives such as the Millennium Ecosystem Assessment or the UNEP Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) highlights the growing need to synthesize information around ecosystem services for balancing human well-being with the maintenance of critical ecological processes. Ecosystem services maps are powerful tools for decision makers and managers, enabling them to spatially identify which areas should be maintained due to their high supply of ecosystem services. These maps are also important to assess spatial trade-offs and/or synergies among multiple ecosystem services, as well as to prioritize areas that will allow governing multiple conservation goals. In this regard TnVEST is a useful tool for the creation of the future scenarios of how land use change is likely to impact the ecosystems.

In VEST model is a spatially explicit model, using maps as inputs and producing maps as outputs. It makes use of ecological production functions that determine how changes in an ecosystem's structure and function are likely to affect the provisioning of ecosystem services across a land- or a seascape. To estimate upstream land use change impacts on downstream ecosystem services in order to identify potential trade-offs:

(1) Baseline assessment of streamflow, nutrient (nitrogen and phosphorous) load and sediment load were made using In VEST tool. Before running the In VEST model, it is required to preprocess the data in ArcGIS. Input data to In VEST consists of:

- Topography data (USGS SRTM DEM 1 arc-sec);
- Watershed and sub-watershed boundaries (generated using ArcGIS Hydrology tool);
- Land Use Land Cover (Globelann30, based on Landsat TM);
- Precipitation (WorldClim);

• Evapotranspiration (calculated from WorldClim using the Modified Hargreaves method);

• Soil hydrologic groups (HiHydroSoil, 2014);

• Soil erosivity (estimated from WorldClim precipitation data using Renard and Freimund equations);

• Soil erodibility (determined from FAO Digital Soil Map of the World according to Williams etal);

• Nutrient load and retention efficiency values (literature review).

(2) Two different land use change scenarios were applied, namely: Riparian Reforestation and Agricultural Expansion. They were generated using the «Scenario Generator» sub-model in TnVEST. Scenario generator replaces land use class of choice with another land use class. For example: shrublands along the river are replaced with forests for «Riparian Reforestation» scenario.

After the baseline assessment is made, LULC maps for «Riparian Reforestation)) and «AgriculturaI Expansion) from the scenario generator are used to run the In VEST model again.

Outputs from baseline assessment and two other scenarios are compared using statistical methods to reveal the potential synergies and/or trade-offs.

The findings identified trade-offs between water yield and nutrient'sediment retention services under Riparian Reforestation scenario. Until relatively recently riparian buffers seemed like a uˈin-\vin situation. Trees are usually represented as an opportunity to simultaneously reduce erosion and nutrient pollution, provide shelter and also generate income. However reforestation decreased the water yield by 2% in the watershed, which, from the point of view of water security, is even more important in wˈater-scarce arid regions of the world such as lowlands of Central Asia.

Provisioning of all three ecosystem services declined under Agricultural Expansion scenario. This phenomenon is widely-known as «ecosystem disservices)) from agriculture. Traditionally, agro-ecosystems are considered as sources of provisioning ecosystem services. The improvement of provisioning services comes at the expense of regulating services. Water yield declined by 2%, sediment export increased by 2% and N and P export by 9 and *1%,* respectively.

Applying land use change scenarios demonstrates how science-based planning can inform conservation effort and lead to greater environmental health improvements.