Sebastian Arnhold

Land use and land cover change in mountainous watersheds: Consequences for ecosystem services of water yield and water quality
Background

Mountain landscapes & ecosystem services

- Mountains provide a wide range of services
- As “water towers” they ensure the supply of fresh water
- Headwater catchments are key elements for supply

The “Flying Dragon” waterfalls in the Seoraksan National Park, South Korea
Background

Mountain landscapes & ecosystem services

- Land use and land cover change alter the provision of services
- Urbanization, deforestation, and agricultural expansion degrade water regulation capacity
- Headwater catchments convert to water pollution “hotspots”

Highland cash crop cultivations are major sources of water quality degradation
Background

Mountain landscapes & ecosystem services
Land use & land cover change
Land use & land cover change

Economy & environ. policies → CA + LR → Land use & land cover change → SWAT → Water yield & water quality

Population density
Conservation & protected areas
Distance & neighborhood
Terrain & climate data
Historical land cover maps
Land use & land cover change

Environmental policy scenarios

- **No policy**: Current development trend without political interventions
- **Forest protection**: Restriction of forest conversion on high slope areas
- **Forest restoration**: Reforestation on high slope and elevation areas
- **Protection & restoration**

Dryland agriculture and rice paddies are primarily affected by environmental policies
## Land use & land cover change

### Soyang Lake watershed

<table>
<thead>
<tr>
<th>Land cover</th>
<th>Area 2006 (km²)</th>
<th>Area 2056 (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No policy</td>
<td>Forest protection</td>
</tr>
<tr>
<td>Forest</td>
<td>2333.0</td>
<td>2381.1</td>
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<tr>
<td>Dryland fields</td>
<td>106.2</td>
<td>71.7</td>
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<tr>
<td>Rice paddies</td>
<td>45.4</td>
<td>37.9</td>
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<tr>
<td>Residential</td>
<td>31.4</td>
<td>39.2</td>
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<tr>
<td>Others</td>
<td>41.3</td>
<td>27.4</td>
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</tbody>
</table>
Land use & land cover change

Soyang Lake watershed

- No policy
- Forest protection
- Forest restoration
- Protection & restoration
Land use & land cover change

Mandae Stream watershed

2006
- No policy

2056
- Forest protection
- Forest restoration
Water yield & water quality
Water yield & water quality

- Economy & environ. policies
- CA + LR
- Land use & land cover change

SWAT

- Biophysical data
- Climate
- Topography
- Soils
- Land use & management

Water yield & water quality
Water yield & water quality

Model setup

- 45 subbasins and ca. 3100 HRUs
- 6 climate stations and 19 rain gages
- 2 water monitoring sites

Simulation period

- 5 years with 2 years warmup
- Baseline 2005-2007
### Water yield & water quality

#### Calibration & validation

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>P-factor</td>
<td>R-factor</td>
</tr>
<tr>
<td>Streamflow</td>
<td>0.73</td>
<td>0.30</td>
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<tr>
<td>Sediment</td>
<td>0.69</td>
<td>0.38</td>
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<tr>
<td>Total nitrogen</td>
<td>1.00</td>
<td>0.96</td>
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<tr>
<td>Total phosphorus</td>
<td>0.69</td>
<td>0.90</td>
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</table>

Typhoon “Ewiniar” approaching Japan and South Korea (Source: NASA)
Water yield & water quality

Soyang Lake watershed

- **Water yield (million m³/yr)**
- **Sediment (1000 tons/yr)**
- **Nitrogen (tons/yr)**
- **Phosphorus (tons/yr)**

Legend:
- Baseline
- Forest protection
- No policy
- Forest restoration
- Protection & restoration
Water yield & water quality

Mandae Stream watershed

Graphs showing:
- Sediment (1000 tons/month) over simulation time step (months)
- Nitrogen (tons/month) over simulation time step (months)
- Phosphorus (tons/month) over simulation time step (months)

Legend:
- Baseline
- No policy
- Protection & restoration
Conclusions & outlook

Land use & land cover change

- Urbanization and forest regeneration occur at the expense of agriculture
- Environmental policies strongly accelerate forest regeneration

Water yield & water quality

- Streamflow and water supply remain stable under all policy scenarios
- Sediment, nitrogen, and phosphorus loads decrease considerably
Conclusions & outlook

Potential side effects

- Decline of agricultural production will lead to increasing imports of crop products
- Imports will translocate production and pressure on the environment to other regions

South Korean rice imports by country (Source: FAOSTAT)
Conclusions & outlook

Further questions

- How do policies displace land use and land cover change through global trade?
- How do displacements impact the provision of ecosystem services elsewhere?
Contact

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