Report on integrated model framework for ecosystem service assessment and sustainability assessment

A2. Deliverable:
Report on integrated model framework for ecosystem service assessment and sustainability assessment (30.06.2018)

A2. Milestones:
Database for integrated modelling of ecosystem services ready (30.06.2018)

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1. Introduction

Ecosystems generate a range of goods and services important for human well-being, collectively called ecosystem services (ES). Over the past decades, progress has been made in understanding how ecosystems provide services and how service provision translates into economic value. Nonetheless, the losses of ES continue more rapidly than ever due to changes in global change drivers, such as changes in land-use, pollution and climate, as well as their interactions. In the Action A2 model and indicator systems for assessing ES for freshwater ecosystems will be developed and their use and outcomes demonstrated using data from selected target area of the project. In the Karjaanjoki river basin we aim to sustainable agricultural production that does not harm water ecosystems. Indicator species are trout and river pearl mussels. For that purpose we chained mathematical models to assess the threats of human activity in the catchment area to ecosystem services. These activities can influence water quality and thus living conditions of these species.

2. Concept of ecosystem services

A large variety of ecosystem services' lists have been addressed by ecosystem services assessments. ES are grouped into four broad categories: provisioning, such as the production of food and water; regulating, such as the control of climate and disease; supporting, such as nutrient cycles and oxygen production; and cultural, such as spiritual and recreational benefits.

Maes et al. (MAES 2014) have analyzed the ES by water bodies. With a slightly different approach, Brauman al. (2007) discussed the 'hydrologic ecosystems services', defined as "the benefits to people produced by terrestrial ecosystem effects on freshwater", each hydrological service being characterized by the hydrological attributes of quantity, quality, location and timing. Both approaches consider the integration of the processes, the first by accounting for all the ecosystems in the analysis, the second by integrating the processes in the river basin. The primary focus is on the ecosystem services delivered by the aquatic ecosystems, which can be linked to the water body status and biodiversity, and secondary an interest in the hydrological ES relevant for river basin management, which may include processes related to the interaction of water and land in different ecosystems, such as forest, agriculture, riparian areas, wetlands, and water bodies.

While the ecological status of waters expresses the quality of the structure and functioning of the aquatic ecosystems, ecosystem services refer to the benefits that people obtain from them, the direct and indirect contributions of ecosystems to human well-being (TEEB, 2010). The catchment is the appropriate scale to observe and quantify processes related to the water cycle. Within the catchment, the aquatic ecosystems and their services can be further mapped at the water body scale or by sub-catchments or regions, depending on the data availability and the resolution desired for the assessment. The main pressures that affect the aquatic ecosystems are related to alterations of water quantity and quality, and to changes in the habitat and the biological components (Table 1).

Table1. Main pressures that affect aquatic ecosystems.

Water quantity Flow modifications: • Quantity and frequency (dams, water abstractions, irrigation, transfer) • (Groundwater abstraction) • Climate change • Land use change	**Water quality** Diffuse and point pollution: • Nutrients • pH, Metals • Pathogens • Litter, suspended solids Land use change (erosion) Brownification
Habitat Hydromorphological alterations	**Biota** Overfishing

We simplified conceptual framework based on the cascade model of Haines-Young & Potschin (2010) for structuring the analysis and the classification of indicators of ES. The framework presented in Figure 1. includes the Capacity of the ecosystem to deliver the service (e.g. grains, timber), the actual Flow of the service (e.g. annual yield), and the Benefits. Capacity refers to the potential of the ecosystem to provide ES, while flow is the actual use of the ES. The capacity relies on biophysical data, while flow requires the acquisition of socio-economic data. Benefits are associated to the human well-being and the value of the system.

Services are often associated with high exploitation of the ecosystem; the risk is an unsustainable use of nature. In this case study our main interest lies in living conditions of trot and river pearl mussel. For this reason we are interested in looking at the sustainable flow of services. As most of the decisions are made by individual farmers, we do sustainability analysis on farm level. This is considered in the conceptual framework by including sustainability indicators, i.e. indicator combining capacity and flow. In many cases, the information on capacity and flow is lacking, or the full capacity of the ecosystem is unknown or unaccountable. In these cases we try to collect indicators about the efficiency of processes, for comparing two different scenarios or ecosystem performances in delivering services.

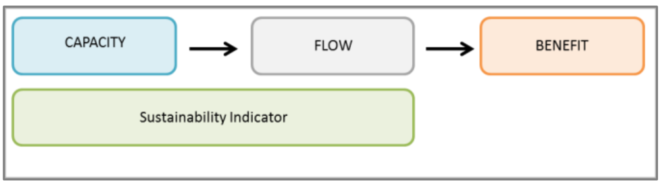

Figure 1. Conceptual framework to classify indicators of water related ecosystem services

3. Area description

The Karjaanjoki River basin (2050 km²) consists of numerous lakes, rivers and brooks, which cover 12% of the river basin area. The river basin is characterized by the large Lakes Lohjanjärvi (92 km²) and Hiidenvesi (29 km²). Geographically and geologically the Karjaanjoki catchment area varies a lot, including also acidic sulphate soils. The upstream parts of the catchment are largely covered with forest while the downstream part is dominated by agricultural areas.

Our case study area the River Mustionjoki is located downstream of the Lake Lohjanjärvi. It transports water from the river basin to the Gulf of Finland through an old cultivated landscape. The watercourse accommodates freshwater mussels and has a natural stock of trout (Figure 2). The watercourse is currently facing several problems: a power station in the downstream area and several minor man-made structures affect the flora and fauna and contribute to sedimentation; active forestry and logging as well as agriculture disturb the ecosystem; scattered housing without sewage treatment facilities also lower water quality.

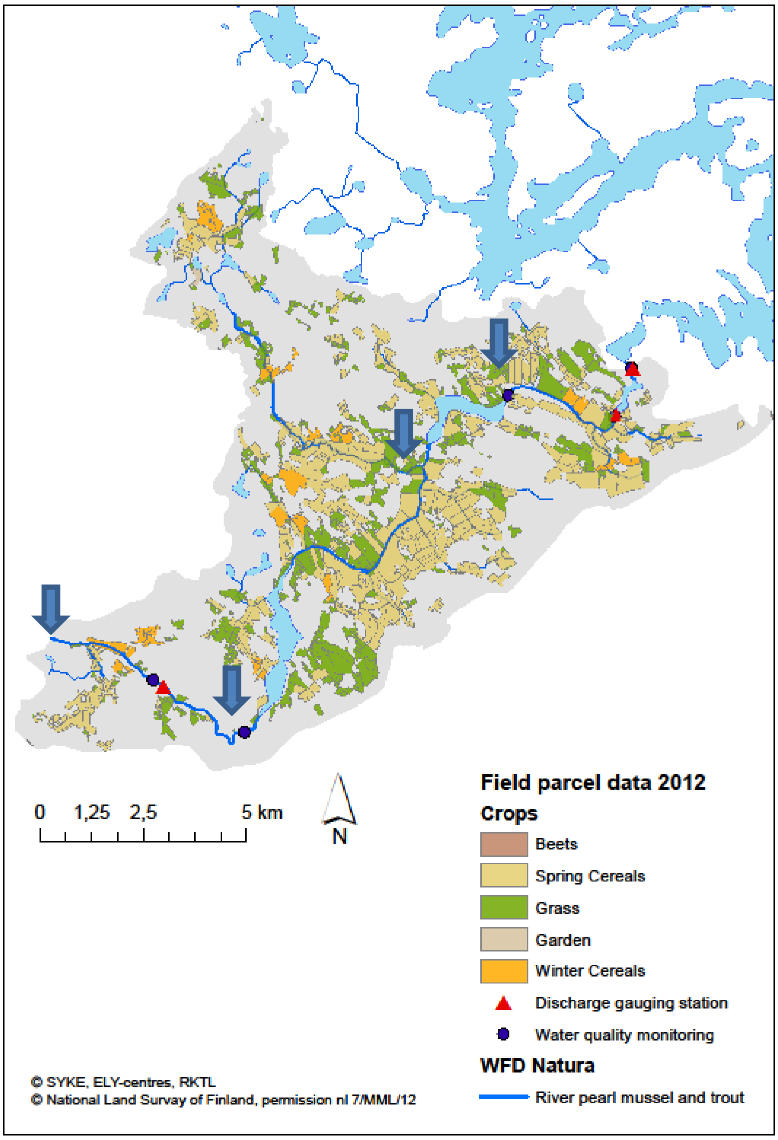

Figure 2. Location of the interest areas in the River Mustionjoki

We selected 4 points of interest along the river to study water quality based on expert opinion (Figure 2). These points are located close to water quality sampling stations in Natura conservation areas. In addition, we found volunteer pilot farms to attend the work. We needed to collect detailed data from management practices from farmers (Figure 3) as that data was not available in open statistics or can't be shared with other data in open data sources (e.g. www.biodiversity.fi).

We created a story of river pearl mussels to internet (Attachment 1). In addition, we wrote a brochure for farmers in which we explained and advertised the project (Attachment 2).

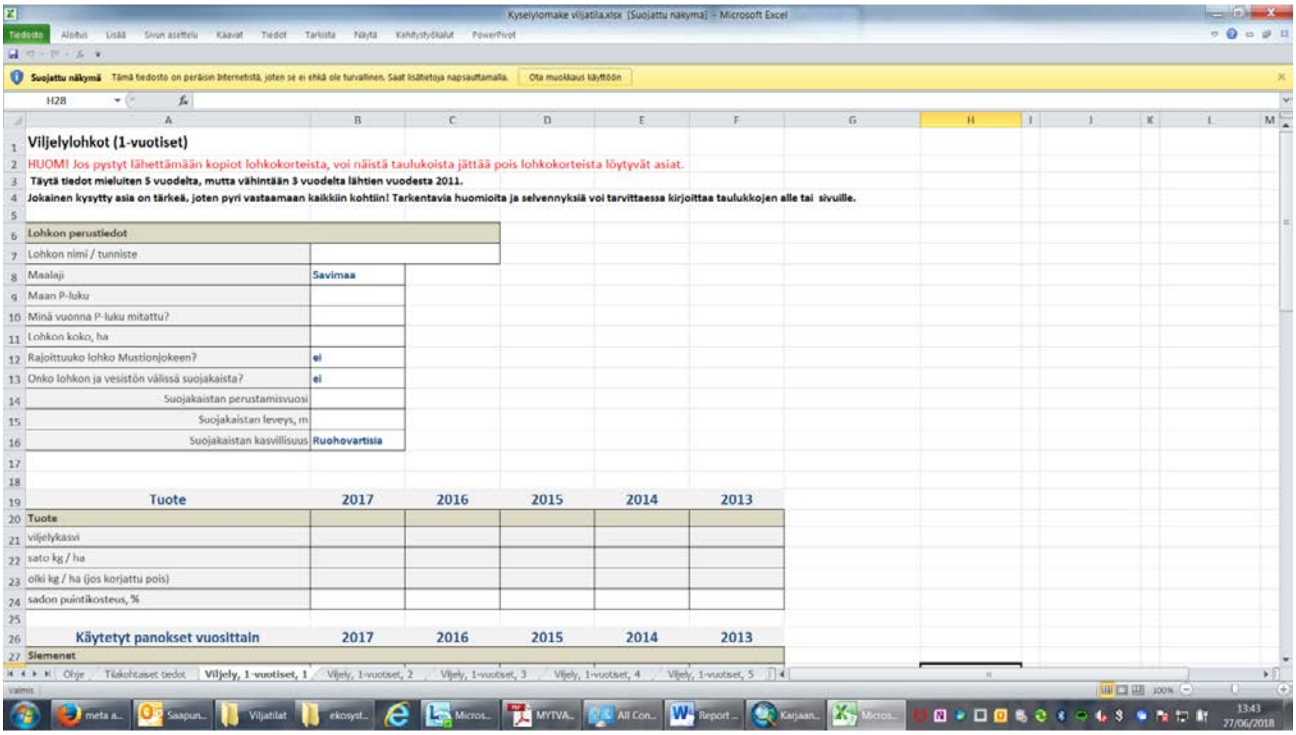

Figure 3. Questionnaire of farming practices on pilot farms

4. Model description

We created an integrated model chain to allow quantification of main ecosystem freshwater services and assessment of different loading scenarios from agricultural practices. The different models and their linkages are shown in Figure 4.

The integrated model system will allow:

- assessment of loading of nitrogen, phosphorus and suspended sediments from agricultural fields assuming different scenarios for agricultural production (load).
- identification of retention areas for nutrients (nitrogen, phosphorus) and suspended solids (capacity)
- planning of reduction measures
- assessment of impacts on habitats of sensitive/protected freshwater species (trout, river pearl mussel) (benefit)
- analysis of sustainability performance of different agricultural products (flow)

- a quantitative assessment of key ecosystem services (provisioning, regulation/maintenance and cultural services), using an integrated assessment framework (benefit)

RUSLE 2015

RUSLE2015 (Panagos et al.2015) is an European GIS modification of Universal Soil Loss Equation (USLE) (Renard et al. 1994) to calculate the relative erosion sensitivity for each of the fields at the catchments. It is based on information of land use, soil type and topography. USLE-type models calculate soil loss by multiplying *R* (rainfall erosivity), *K* (soil erodibility), *LS* (topographic factor), *C* (plant cover and farming techniques) and *P* (erosion control practices) factors:

$A = R \times K \times LS \times C \times P$ (1).

The *R* and *K* factors have units (the SI units were used in this study) and the rest of the factors are unit less. A is an estimation of soil loss in long term in ton ha^{-1} yr^{-1}.

RUSLE provides maps of erosion sensitive areas and total erosion load from different land uses or field types. This information is used e.g. in planning agricultural water protection measures, like location of buffer zones. We provide also erosion sensitivity maps for fields of our pilot farms.

SimaPro

Life-cycle assessment (LCA, also known as life-cycle analysis is a technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. SimaPro is the professional tool to collect, analyze and monitor the sustainability performance data. LCAs can help avoid a narrow outlook on environmental concerns by:

- Compiling an inventory of relevant energy and material inputs and environmental releases;
- Evaluating the potential impacts associated with identified inputs and releases;
- Interpreting the results to help make a more informed decision to help you decision-making to change your products' life cycles for the better.

We make LCA for pilot farms to guide the production to more sustainable direction. LCA will provide data for scenarios of e.g. fertilizer use.

Meta-analysis and literature study

Conceptually, a meta-analysis uses a statistical approach to combine the results from multiple studies in an effort to increase power (over individual studies), improve estimates of the size of the effect and/or to resolve uncertainty when reports disagree.

We use literature study to find critical living conditions of pearl mussels, and meta-analysis to find effectiveness of different water protection measures.

PERSiST and INCA

PERSiST is a flexible rainfall-runoff modelling toolkit for use with the INCA family of models (Futter et al. 2014). It is designed for simulating present-day hydrology; projecting possible future effects of climate or land use change on runoff and catchment water storage. PERSiST has limited data requirements and is calibrated using observed time series of precipitation, air temperature and runoff at one or more points in a river network.

INCA is a dynamic mass-balance model, and as such attempts to track the temporal variations in the hydrological flowpaths and nutrient transformations and stores, in both the land and in-stream components of a river system (Whitehead et al.1998). INCA provides as output daily and annual land-use specific organic and inorganic-nutrient fluxes for all transformation processes and stores within the land phase, concentrations in the soil and ground waters and in direct runoff.

INCA provides water quality changes, and thus living conditions of pearl mussels under different scenarios of agricultural water protection measures.

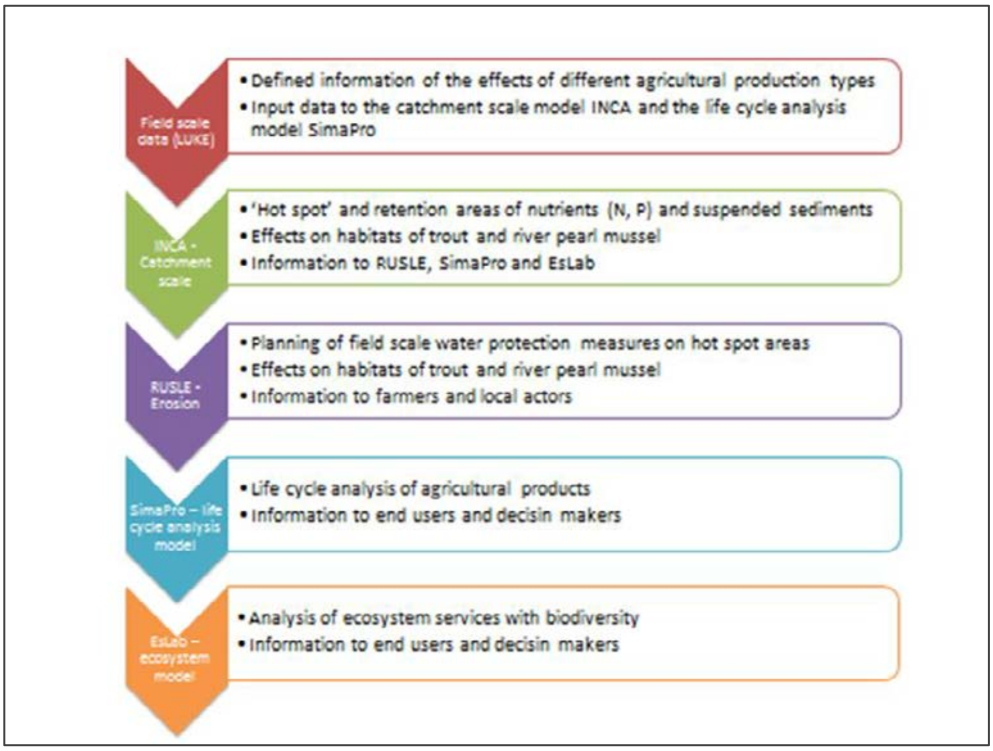

Figure 4. Integrated model framework for ecosystem service assessment including main information products to different users.

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Attachment 1.
https://metsahallitus.maps.arcgis.com/apps/Cascade/index.html?appid=ce5d2492cfb24a768fc6d964a3f364c9

Attachment 2.

Viljelijät Mustionjoen Raakkua pelastamassa

Mustionjoki on Suomen eteläisin raakkujoki. Raakut eli jokihelmisimpukat uhkaavat kuitenkin hävitä Mustionjoesta, koska olosuhteet ovat muuttuneet niin, etteivät raakut pysty enää siellä lisääntymään. FRESHABIT-hanke pyrkii turvaamaan raakun elinympäristön Mustionjoessa ja tukemaan alueen ihmisiä raakkukannan säilyttämisessä. Työ on tärkeää, koska raakut ovat käymässä harvinaisiksi koko esiintymisalueellaan.

FRESHABIT-hanke auttaa tiloja ravinnepäästöjen ja eroosion vähentämisessä

Raakun elinoloihin vaikuttaa vesistöjen rakentaminen ja valuma-alueen maankäyttö. Mustionjoella maatalouden vesistöpäästöt vaikuttavat keskeisesti raakun elinoloihin. Viljelijöillä on mahdollisuus tarkastella oman tilan vaikutusta Mustionjoen vedenlaatuun ja raakun elinoloihin osana FRESHABIT-hanketta.

Viljelijä saa käyttöönsä arvion ja tulkinnan

1. **tuotteiden rehevöittävästä vaikutuksesta ja ilmastovaikutuksesta ja**
2. **peltojensa eroosioherkkyydestä.**

Tulosten avulla voi hahmottaa peltolohkoilla tehtävien toimenpiteiden vaikutusta vesistöön ja mahdollisuuksia vähentää vaikutuksia.

Hankkeeseen osallistuminen on viljelijälle maksutonta. Arvioinnin onnistuminen edellyttää viljelijältä yhteistyötä tutkijoiden kanssa viljelytoimenpidetiedon keräämiseksi. Käytännössä tarvitaan lohkokirjanpidosta löytyvää tietoa sekä muutamia tilakohtaisia tietoja liittyen mm. viljankuivaukseen ym. Tietoja käsitellään luottamuksellisesti.

Mustionjoen raakun ja lohikalojen yhteinen tarina

Katso tarinakartta

http://www.luvy.fi/fi/etusivu/uutiset/?a=viewItem&itemid=2364

Raakku on kranttu ja siksi vaarassa

Jokihelmisimpukka eli raakku on hitaasti kasvava ja pitkäikäinen simpukkalaji. Raakku on vaativa ympäristönsä suhteen. Glokidit eli pikkutoukat tarvitsevat isäntäkalakseen lohen tai taimenen, jonka kiduksiin se voi kiinnittyä ottaakseen kehityksensä ensiaskeleet. Seuraavassa kehitysvaiheessa pikkusimpukka taas tarvitsee sopivan sorapohjan, johon se voi kaivautua kasvamaan. Pohjan liettyminen haittaa pikkusimpukoita - pikkusimpukat tukehtuvat kun happitilanne on huono. Muutaman vuoden päästä raakku nousee joen pohjasedimentin pintaan ja ryhtyy suodattamaan ravintoa vedestä.

Mustionjoki ei täytä laatuvaatimuksia

Veden laatu Mustionjoessa ei ole nykyisellään raakun lisääntymiselle otollinen. Muun muassa fosforin ja nitraattitypen pitoisuudet ja veden sameus haittaavat täysikasvuisten raakkujen hyvinvointia ja estävät lisääntymisen. Pohjan liettyminen tukahduttaa pikkuraakut sorakoissa.

Eroosio poistaa maa-ainesta pelloilta ja samentaa vesistöjä

Raakku tarvitsee kirkkaan veden ja liettymättömän pohjan. Mustionjoella eroosio on yli kolme kertaa suurempaa (1,729 t/ha/v) kuin Suomessa keskimäärin ja voi olla jossain vaiheessa vuotta silminnähtävää (yli 2t/ha/v).

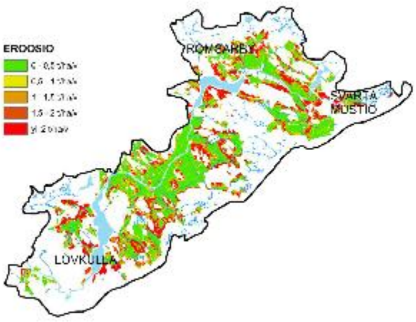
Viljelyn rehevöittävää vaikutusta voi hallita

Raakut kärsivät muun muassa veden nitraattipitoisuuden noususta. Maatalous on yksi tärkeimmistä nitraattipäästöjen lähteistä. Peltojen nitraattipäästöjä voi kuitenkin hallita esimerkiksi suojavyöhykkeillä.

FRESHABIT-hankkeessa tehty analyysi osoittaa, että suojavyöhyke on tehokas keino vähentää nitraatti- ja kokonaistypen päästöjä vesistöön.

Kokonaiskuva valuma-alueen kuormitustekijöistä ja veden laadusta

Mustionjoen veden laatu riippuu koko valuma-alueelta kulkeutuvasta kiintoaineesta ja ravinteista. Freshabit-hankkeessa arvioidaan tiloilla tehtävien vesiensuojelutoimenpiteiden vaikutusta Mustionjoen vedenlaatuun ja raakun elinolosuhteisiin kokoniasuus huomioon ottaen.



Kartalla on esitettynä Mustionjoen valuma-alueen eroosioherkkyys.

Yhteystiedot

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