# automated factsheets for sediment (and phosphorus input) into waterbodies

## project overview & scientific setting

The final goal of this project is to create automated overview factsheets for sediment and phosphorus input in the region of Frienisberg (BE). To make (current and future) programming of factsheets simpler, the sediment and phosphorus input data should first be stored in a clear output folder structure. The methodical realization with Python scripting will only be presented for sediment input, since only these scripts are fully comprehensibly commented. Results will be presented for both sediment and phosphorus input.

Since this project is part of the author's master thesis, the scientific setting of the project within this thesis will be quickly explained: Over a timespan of 20 years, soil erosion risk mapping was done in the region of Frienisberg (Agroscope, 2019). Basically, soil erosion was mapped after every big rainstorm or snowmelt event. In addition, it was recorded for every erosion event how much percent of the eroded soil went into the water and phosphorus field measurements in the region of Frienisberg were done. The mapped soil erosion was transformed in a GIS in 2016 through the works of Fabian Schelbert (see: Schelbert, 2016). The aim of the author's master thesis is now to derive the sediment and phosphorus input on basis of the previously created soil erosion database. This has been already done by the author in advance of this project. The aim of this project is now to create a clear output database for the calculated sediment and phosphorus input and make some first factsheets that help analysing the magnitude and temporal behaviour of sediment and phosphorus input.

## scientific background

Soil erosion is a process that is very variable in time (VOL, 2017). The interplay of factors such as amount of precipitation, soil type, soil over, cultivation and topography determine the extent of soil erosion in a specific area (VOL, 2017). Since the sediment and phosphorus input into waterbodies (calculated from soil erosion) is highly linked to soil erosion, these inputs are also expected to be variable in time and should be determined by the same factors. In addition, the risk that eroded soil reaches waterbodies is dependant on the distance to waterbodies (direct input) or to structures that are shortcuts to waterbodies (e.g. via drainages on field, inlet shafts on streets, so-called indirect input) (see: Geoportal des Kantons Bern, 2019). In this project, only erosion events with sediment (and phosphorus) input into waterbodies will be analysed.

**input data**

Soil erosion was mapped in five regions: Frienisberg, Lobsigen, Schwanden, Seedorf and Suberg. Each region has to main measurement periods: the first one form 1997-2007 and the second one from 2007-2017. Therefore, this project deals with ten so-called region-period-objects like Frienisberg 1997-2007. Within one region-period-event, each recorded soil erosion event has an unambiguous name and the same is true for derived sediment and phosphorus input data.

The naming convention and structure of the input vector and raster data is explained in Figure 1: The soil erosion event “FEKRE01_M1_037” has a vector that’s called FEKRE01_M1_037.shp. This vector file is a polygon with an attribute table where e.g. the field numer, the erosion type or the date is recorded as well as how much percent of eroded soil went into the water (-> GE_Perc). The corresponding soil erosion raster has the extension _ER.tif and shows where the erosion occurred in space. The soil erosion rasters weren’t used for this project, but the derived sediment input (_SE.tif) and phosphurs input (_PE.tif) rasters are the most important input files. The important thing is that corresponding vector and raster files have the same beginning of their name and only their endings differ. With this naming convention, it’s e.g. possible to make references from vector to corresponding raster data.

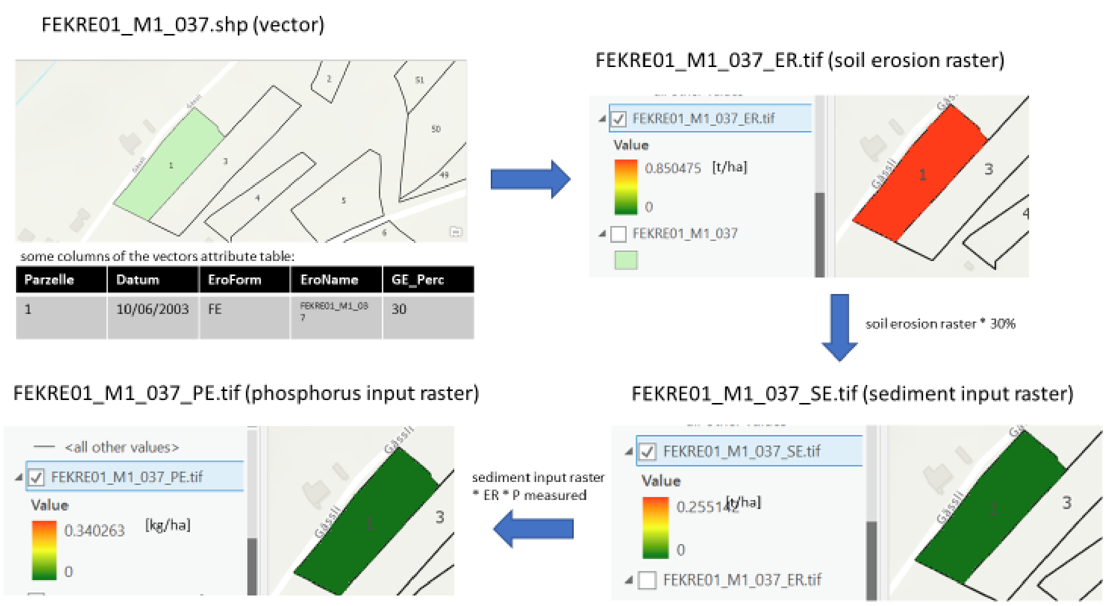


*Figure 1: Example of GIS vector and raster data. The blue arrows show the workflow: First, soil erosion was digitalized as polygon, then a soil erosion raster was created which was then transformed into a sediment input raster and the later was transformed in a phosphorus input raster (by “simple” multiplication). The vector files as well as the sediment and phosphorus input rasters are the most important input for the scripts.*

**methodical realization**

This section is only a quick overview of the methodical realization. For a more detailed documentation, go to https://github.com/DaveRUNIBE/2019-factsheets-sediment-phosphorus.
The goal of making automated overview factsheets is reached in four steps: The first script makes a treelike output folder structure for the input data (see Figure 2). All sediment input rasters in e.g. Frienisberg 1997-2007 should be stored by year, date, erosion form, field number and unsorted (folder "Periode"). This storing system was taken, because one goal of the author's master thesis is to analyse the sediment (and phosphorus) input by time, space, erosion form or magnitude. Not only initial input rasters are stored in the treelike folder structure but also sums and means, which makes it afterwards simpler to create GIS analysis toolboxes (probably the author will program these GIS toolboxes later by his own, to make the treelike folder structure not only a well-arranged storing system but also to make it an interactive analysis tool for the end user).
The second copies initial the sediment (phosphorus) input rasters to the right destination folder in the created treelike output folder structure. Some rasters had to be summed up prior to the copying process. The third script checks if some "strange rasters" have been created during the copying process (probably these strange rasters are temporary storage files). If a strange raster should be detected, then this script deletes them. The fourth and last script calculates afterwards the total sum [t] and the mean annual input [t/ha*a] and makes boxplots as well as timeseries. All the calculated elements are drawn together on a PDF sheet.

The author also tested if the scripts work, when the scripts and input data is moved to a different location on the author's device. Some crucial adjustments had to be made (-> see readme on Github) to make the scripts work and the insights are very useful for the future programming approach of the author. E.g. some code (des.split(os.sep)[6]) extracts the part "Seedorf_2007_2017" out of "E:\David_Remund_Masterarbeit\alle_GE_MA\Gewässereintrag\Sedimenteintrag\Seedorf\Seedorf_2007_2017\Periode\Einzel". When the input data is moved to another location on ones computer the part "Seedorf_2007_2017" might not be extracted by des.split(os.sep)[6] but e.g. des.split(os.sep)[8]. For future programming, the author will try to make such code more dynamic.

**start of the treelike folder structure: foder "Gewässereintrag" (with subfolders "Sedimenteintrag" and "Phosphoreintrag")**

Note: Below is only the folder structure for Frienisberg 1997-2007 sediment input, the same structure is created for other region-period objects and also for phosphorus input!

- Sedimenteintrag
  - Frienisberg
    - Frienisberg 1997-2007
      - **Periode**
        - Einzel
          - FEKRE01_M1_037_SE.tif [t/ha],...
        - Summe
          - sum_Frienisberg_97_07_SE.tif [t/ha],...
        - Mittel
          - mean_Frienisberg_97_07_SE.tif [t/ha*a]
      - **Jahr**
        - 1998
          - Einzel
            - FEKRE01_M1_037_SE.tif [t/ha],...
          - Summe
            - sum_Frienisberg_97_07_1998_SE.tif [t/ha]
        - 1999...
      - **Datum**
        - 1998_02_25
          - Einzel
            - FEKRE01_M1_037_SE.tif [t/ha],...
          - Summe
            - sum_Frienisberg_97_07_1998_09_16_SE.tif [t/ha],...
        - 1999_06_10...
      - **Erosionsform**
        - linear
          - Einzel
            - FEKRE01_M1_037_SE.tif [t/ha],...
          - Summe
            - sum_Frienisberg_97_07_linear_SE.tif [t/ha]
        - flaechenhaft
          - Einzel
            - FEKRE01_M1_037_GE.tif [t/ha],...
          - Summe
            - sum_Frienisberg_97_07_flaechenhaft_SE.tif [t/ha]
      - **Parzelle**
        - Parzelle_01
          - Einzel
            - FEKRE01_M1_037_SE.tif [t/ha],...
          - Summe
            - sum_Frienisberg_97_07_P01_SE.tif [t/ha]
        - Parzelle_02,...
    - Frienisberg 2007-2017
    - ...
  - Lobsigen
    - Lobsigen 1997-2007
    - Lobsigen 2007-2017

*Figure 2: output folder structure*

**results & short interpretation**

The full results are available on Github (sediment_input_overview.pdf, phosphorus_input_overview.pdf). Some first interpretation of the overview factsheets is done in this section. Note that the results only describe data trends: The sum of total sediment and phosphorus input decreased in every region from the period 1997-2007 to the period 2007-2017. The same is true for the mean annual sediment and phosphorus inputs. This decrease was expected since the soil erosion also decreased from the first to the second 10-year-period (see: VOL (2017), chapter 5). One main reason for this decrease is the percentage of soil conserving landuse practices which increased for 6% in the first period to 60% in the second period (Agroscope, 2019). An analysis of the rainfall data revealed no difference between the two 10-years-periods (Agroscope, 2019).

The author made only a first rough qualitative analysis of the water connection map (GAK, 2012, see: Figure 3), because he is still lacking full map access. The water connection map shows the risk of sediment input into waterbodies in a worstcase scenario (permanent fallow land, no buffer strips or construction measures) (see: legend of GAK, 2017). By eye, the author would say that high risk areas are most abundant in Frienisberg and significantly lower in the other regions. The highest risk of sediment input in the water connection map (which is a model) in Frienisberg is in line with the highest mean annual sediment input (calculated from mapped erosion) which also occured in Frienisberg (in both 10-years-periods the highest value). So at least the model and mapping approach produce the same "high-risk region". It is to say that statistical analysis has to be followed to produce more expressive results and that the reasons for the different risk of sediment input have to be analysed. Is it because the region of Frienisberg is e.g. steeper than the other regions or different farming practices are dominant?

The boxplots for sediment input show that sediment input events > 1t are very seldom. The 3th quartile is seldomly over 0.5t. But the few big events make the mean values greater than the means which are often in the range of the 3th quartile or over it. The same patterns are true for the phosphorus input. If one compares the timeseries of the sediment input with the ones of the phosphorus input, one can see that they seem to highly correlate. This is not surprising because phosphorus input was calculated by multiplying each sediment input pixel with a fixed value (enrichment ratio) and the phosphor filed measurement value. Since the P field measurements did not vary greatly along the study area (1$^{st}$ quartile - 3th quartile: 605.5 – 793.3 mg P/kg) and this multiplication factor is to only one that varies, the calculated phosphorus input is not expected to vary much as well. Like already mentioned, sediment and phosphorus input are expected to vary highly over time. This pattern is visible in the timeseries. Also visible is a general decrease from the first to the second 10-years-period (watch the different scaling of the y-axis!).

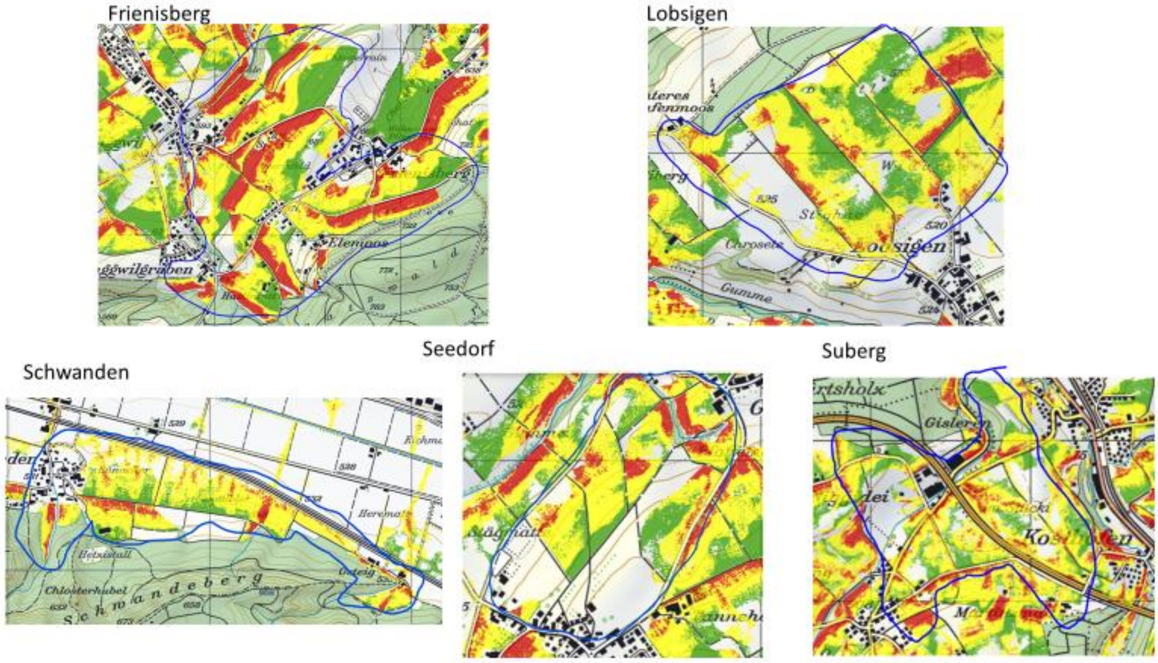


*Figure 3: water connection map of the 5 study regions. Blue encircled are the areas where erosion risk mapping was done.*

To conclude, it can be said that the general observed pattern of sediment and phosphorus input are in line with the literature (and hypothesis derived from it) and the water connection map. But this first qualitative analysis of the spatial and temporal dynamics of sediment and phosphorus input is very limited. Statistical analysis as well as spatial and temporal correlation has to be done to get more expressive results. This first analysis focuses on a comparison with the unit tons, but further analysis should also involve tons/hectare! Although this first analysis has a lot of limitations, this project has shown that the technical realization is possible and further analysis will be much more easier because it can be done on basis of the developed scripts.

**sources**

Agroscope (2019): <https://www.agroscope.admin.ch/agroscope/de/home/aktuell/medieninformationen/medienmitteilungen/medienmitteilungen-2018.msg-id-71573.html> (Zugriff: 26.02.19).

Geoportal des Kantons Bern (2019): Gewässeranschlusskarte. <http://www.geo.apps.be.ch/de/geodaten/suche-nach-geodaten.html?view=sheet&guid=cae82fe1-4064-4f1c-90e2-46f3a352e8a5&catalog=geocatalog&type=complete&preview=search_list> (Zugriff: 30.05.19).

Gewässeranaschlusskarte (GAK) (2012): <https://map.geo.admin.ch/?selectedNode=node_ch.blw.gewaesseranschlusskarte-direkt1&zoom=7&bgLayer=ch.swisstopo.pixelkarte-farbe&layers=ch.blw.feldblockkarte,ch.blw.gewaesseranschlusskarte,ch.blw.gewaesseranschlusskarte-direkt&layers_&topic=ech&lang=en&layers_opacity=0.75,0.75,0.75&E=2590633.39&N=1211542.78&layers_visibility=false,true,false> (Zugriff: 30.05.19).

Schelbert, Fabian (2016): Entwicklung einer GIS-basierten Methode zur Digitalisierung von Erosionsschadenkartierungen im Gebiet Frienisberg (BE). Master thesis.

Volkswirtschaftsdirektion des Kantons Bern (VOL) (2017): Bodenbericht 2017.