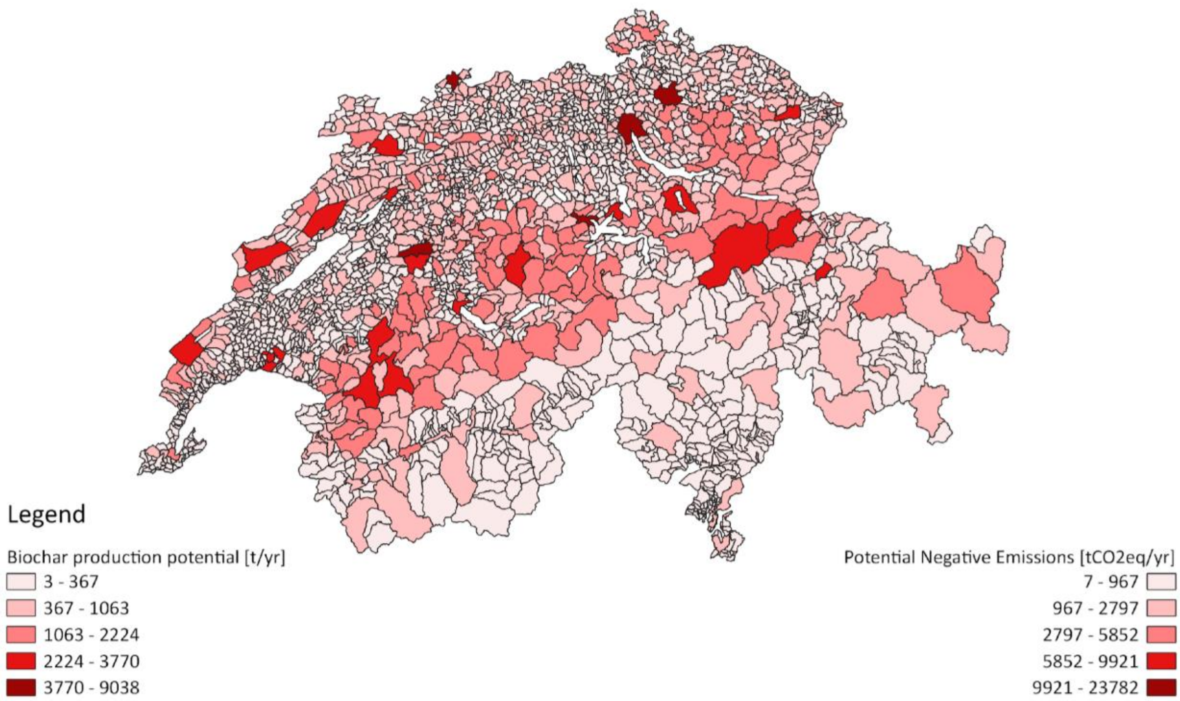
This master thesis explores the role of Biochar production and Peatlands renaturation as Nature-based solution to reach Swiss Net Zero by 2050, by analyzing the historical, socio-economic context, and the scientific phenomena behind these topics. It aimed to build a consistent and robust methodology to estimate the Swiss biochar production capacity from biomass potential at the communal scale, and on the other part, create a robust and configurable model to assess current and future peatlands' GHG emissions at the communal scale, with the emissions savings that a given rewetting scenario would represent compared to a baseline scenario.

Biochar is a stable, porous, carbon-rich material produced by the pyrolysis of biomass, which is interesting for carbon storage, binding carbon captured by biomass via photosynthesis. The "sustainable biomass potential" is defined by WSL as the quantity that can be extracted from the ecosystems in the long-term by taking into account ecological and economic constraints.

On the first hand, an open-source spreadsheet database of the sustainable biomass potential at the communal scale was constituted, in addition to an exploration and visualization tool which offers a user-friendly interface to navigate through it. After the conversion to biochar, it was revealed that this solution could contribute to the Swiss Long Term Climate Strategy by providing ~2 Mt $CO_2$*eq*/yr of negative emissions per year if properly deployed toward 2050, 40% of the remaining Swiss emissions at this time. Regional maps representing the biochar production capacity and related negative emissions potential of all communes were created for each type of biomass, and a cost analysis showed the feasibility of a large-scale deployment. Finally, recommendations were made on where to install the first pyrolysis units to start the deployment, and a critical reflection on the use of biochar was performed, from the non-consensus of its use in agriculture to its promising use in urban construction.

Biochar production and Negative Emissions Potentials from sustainable woody biomass per commune

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Davy--Guidicelli Jean-André – *Biochar and Petland for Swiss Net Zero*
Master Thesis supervised by Prof. Thalmann & Prof. Nick
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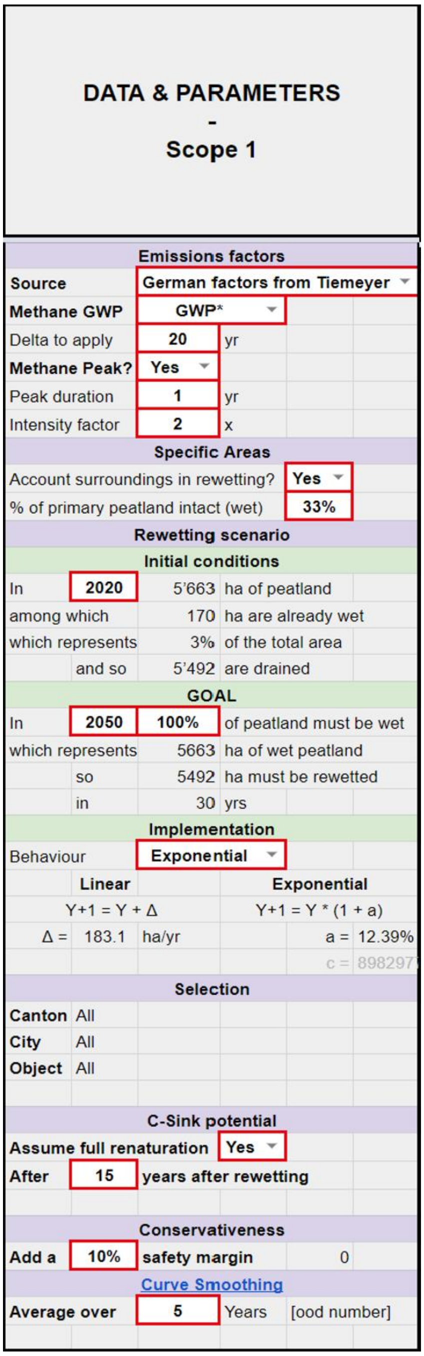
Global peatlands, even if they cover only about 3% of the global land area, store more carbon than is naturally present in the atmosphere, and twice as much as global forest biomass. For thousands of years, peatlands act as natural carbon sinks thanks to bio-geochemical conditions they offer. Under our latitudes, this miracle is possible thanks to sphagnum, a small alga that assumes the role of a real climate engineer, by storing carbon from the atmosphere as organic matter in a wet, anoxic, and acidic environment, which prevents its oxidation and transform it into peat. Unfortunately, peatlands have been severely degraded in the two last centuries for peat extraction as a source of energy, urbanization, or agriculture purposes. Most of them have been converted to croplands and grasslands.

Estimates reveal that original Switzerland's peatlands area before the industrial age were around 1'000-1'500 km². Today, we identify only ~280 km² of the remaining organic soils from these ecosystems. Only 15 km² are currently protected by the law as raised bogs and 5 km² are mapped as "primary peatlands", meaning that there is no human activity such as drainage channels directly visible at their surfaces, but experts estimate that only one third of them, 1.5 km² are really on good health. This means that we destroyed or degraded 99.9% of Switzerland's peatlands in a 250 years' timeframe.

This study assessed the climate effect of renaturating these peatlands by defining 3 scopes :

- Scope 1 : Swiss raised bog inventory in addition to their surrounding forest – 58 km²
- Scope 2 : Swiss identified organic soils derived from former peatlands – 280 km²
- Scope 3 : Estimation of the Swiss total organic soils potentially still existing – 1'250 km²

To transform these spatial inventories into GHG emissions projections, a configurable spreadsheet model called OSMOSE – an Operable Swiss Model for Organic Soils Emissions – was created. For each scope, it computes the emissions resulting from the rewetting of organic soils in Switzerland according to a set of configurable parameters (such as the emissions factors or methane peak intensity or duration, etc.) and a given rewetting scenario (target and years of the objective, rewetting behavior). Finally, a "full renaturation" option models the complete restoration of the ecosystem and its carbon sink capacity by giving the negative emissions potential of the bog. Such a model could be useful for communes, cantons, or even the Federal Office of the Environment, as a planification tool to identify organic soils emissions on their territories and include in their respective Climate Plans an order of magnitude for the emissions reduction potential resulting from their rewetting.



*OSMOSE Dashboard*

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According to this model, the emission of 125 kt $CO_2$*eq* per year could be avoided from raised bogs if they were properly rewetted and generate 50 kt $CO_2$*eq* /yr of negative emissions if fully restored. Those potentials respectively rise to the avoidance of 0.8 Mt $CO_2$*eq* /yr with a possible generation of 0.2 Mt$CO_2$*eq* /yr of negative emissions for Scope 2 (all identified organic soils), and the avoidance of 4 Mt $CO_2$*eq* /yr with a possible generation of 1 Mt $CO_2$*eq* /yr of negative emissions for scope 3 (all non-localised potential organic soils), enough to compensate for 1 million round-trip Paris-NY flights per year, or 20% of the remaining Swiss emissions in 2050.

Similarly to biochar, a cost analysis was performed, and the total amount needed to renaturate all peatlands reach several billions, but such an investment is not unprecedented in Swiss history.

The construction of the research plan for this thesis was carried out with an iterative and inductive methodology, inspired by social sciences research, to collect qualitative data, and identify relevant research gaps to be explored thanks to Swiss stakeholders' interviews working in these fields, and ensure that the computed potentials were rooted in the field reality.

Realizing these potentials could be game-changing, but it implies societal transitions such as a profound modification of our land use, with a change of diet and behavior. Thus, this thesis is an invitation to rethink our agricultural system and the Swiss diet, going from a productivist model to a resilient one. An invitation to also rethink the way we produce energy and construct cities, with the role of biomass in urban metabolism.

Finally, while wetlands are classified as "unproductive vegetation", this thesis invites to redefine the notion of productivity itself with a systemic approach. It emphasizes that the habitability of Earth is due to ecosystems, not to humans, and that ecosystem services are guarantors of human well-being in socio-ecological systems. Nature based Solutions tend to restore them with climate, biodiversity and food sovereignty co-benefits that could allow Switzerland to thrive and appear as a leading example for the ecological transition the world needs.

*Peatland visited in Les Ponts-de-Martel*

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