Supporting Online Material: At the core of the socio-ecological transition: agroecosystem energy fluxes in Austria 1830-2010
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Sensitivity analysis: Effect of most uncertain input indicators

In particular during the 19th century, some of the input data used rely on weak primary sources, or on a high number of assumptions. The least reliable input data are those of wood harvest during the 19th century, where sources are heterogeneous and sparse, making both levels of wood harvest and their temporal trends uncertain. Two other rather uncertain variables are labor input and livestock production, both of which are subject to a high number of assumptions. Here, we judge temporal trends to be robust, because of continuous underlying trends such as increasing livestock numbers, shifts in primary crop cultivation and increasing numbers of agricultural labor force. However, the levels of these values may vary depending on the assumptions used.

For wood production, we tested the potential of varying input data for reversing temporal EROI trends. For livestock and labor, we tested to which degree variations in these values affected EROI levels during the 19th century. We judged the original data’s reliability based on comparisons with later data in our own datasets for wood and livestock. For labor, we compared our accounting with other approaches. Marco et al., 2018 use slightly lower energy content per hour worked, while Guzmán et al., 2018 use distinctly higher values. Table SI1 displays the variations of input data we chose to arrive at a “High” and a “Low EROI estimate” for 1830.
Table SI1: Assumptions used in sensitivity analysis in the period 1830-1915

|                        | High EROI estimate                              | Low EROI estimate                              |
|------------------------|-------------------------------------------------|------------------------------------------------|
| Wood extraction        | Wood extraction 10% above original values        | Wood extraction 25% below original values      |
| Livestock production   | Livestock production 20% above original values   | Livestock production 20% below original values |
| Labor                  | Labor energy 25% below original values           | Labor energy 50% above original values         |

Given the high importance of wood extraction in final produce, variations in wood extraction translate in almost equal variations in final produce: Final produce would be 10% above the original value according to our “High EROI” estimate in 1830, and 23% below the original value in the “Low EROI” estimate. Figure SI1 displays the variations in EROBI and EROLI values with the differing assumptions.

![Sensitivity of EROBI and EROLI](image)

Figure SI1: Sensitivity of EROI estimates to differing underlying assumptions in the least reliable input data. The continuous grey line depicts the trend in indicators according to the original estimate, the dashed grey line is the trend that would emerge using the “wood low” estimate in 1830 and the “wood high” estimate in 1915.

EROBI is less affected by variations in input data than EROLI, with the high and low estimates diverging by factors of +10% and -23%. EROLI on the other hand, where labor, i.e. the denominator, was additionally varied, was much more sensitive to changes, with variations of +46% and -48%,
respectively. These results indicate that diverging assumptions in both labor and wood harvest may significantly alter results, and impacts are higher toward the early 19th century, when wood played a more important role in final produce than in the early 20th century. The uncertainty in wood harvest is found to be significant enough to reverse the observed trends in EROI and EROMI, ceteris paribus. However, the 20th century trend in neither EROBI nor EROI is affected by the proposed variations in early 20th century EROBI and EROI values.

Sensitivity of results to particular accounting choices

The results obtained in this analysis depend on the specific accounting choices made for this analysis. Here we discuss two of the most critical assumptions, and how they affect our results: (1) the choice of including aboveground biomass only in biomass reused rather than aboveground plus belowground biomass and (2) the choice of including as final produce all biomass for human consumption and export, rather than only the fraction ultimately aimed at human consumption.

(1) The delineation of biomass reused to include only aboveground biomass is arguably an arbitrary choice. We conducted a rough reassessment of belowground biomass reused, i.e. roots ploughed into soils. In a simple approach, we applied the factor of 15% to the total aboveground biomass production on croplands (Gingrich et al., 2007). Such expansion results in the substantial increase of stubble ploughed into soils by a factor 9, an increase of total biomass reused by 14-17% through time, depending on the importance of croplands in agricultural land. Under this assumption, the EROI on agricultural land would decrease from 0.13 to 0.10 in 1830 and from 0.31 to 0.23 in 2010. Even more affected is the EROBI indicator, which, by including belowground biomass, would decline by c. a factor 2 throughout the time period (1830: 1.13 to 0.53 and 2010: 1.09 to 0.52). Considering the fact that the ratio of root to shoot decreased with modern plant breeding (Guzmán et al., 2014) a temporally-specific analysis of belowground biomass would result in declining biomass reused values over time, and might impact the temporal trends of EROBI in our analysis.
(2) We reassessed final produce, applying the definition of “socialized biomass” (Guzmán et al. 2018). This definition includes biomass ultimately aimed at human consumption, and excludes exports of fodder crops. In the period since 1963, when the relevant data are available, socialized biomass was below final produce by a maximum of 4% in the early 2000s, the period when Austrian livestock density declined. This translates into a reduction of EROBI, EROMI and EROLI by the same percentage, and a reduction of agricultural land EROI from 0.31 to 0.23 in 2010. The share of fodder crop production for export was still modest at below 10%. Fodder exports did not increase enough to reverse the trends of any of the EROI indicators in recent decades.

References
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