

Interactive comment on “Assessment and quantification of marginal lands for biomass production in Europe using soil quality indicators” by Werner Gerwin et al.

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Dear Referee #2,

We thank you very much for your suggested improvements of our manuscript. We will integrate your remarks into the final paper as follows:

Introduction: . . . However, the authors should put an emphasis in a sentence or two on how innovative is the methodology applied compared to previous studies and models.

=> With regard to the innovative aspect of our approach we would like to suggest adding the following additional paragraph after p. 3, l. 21:

C1

“The SEEMLA approach presented in this paper is thought to contribute to the methodological development of assessment tools needed for step 1 (estimation of biomass technical potentials) of the analytical framework for evaluating sustainable biomass production potentials as proposed in a review by Batidzirai et al. (2012). Previous studies on global or European bioenergy potentials often tried to assess land availability for future bioenergy production mainly based on land use data and detectable changes derived by means of remote sensing methods (e.g., Campbell et al., 2008; Krasuska et al., 2010). However, Fritz et al. (2012) as well as Nalepa & Bauer (2012) demonstrated shortcomings of such approaches due to scaling problems. The here presented approach is based on an assessment of soil quality and related agricultural yield potentials using the SQR methodology. Results can reach a high spatial resolution depending on the availability and quality of input data. For Germany it had been demonstrated that high precision mapping of soil quality and related agricultural yield potentials is feasible (BGR, 2013). Additionally, this SEEMLA approach is supposed to allow for a clear differentiation between fertile agricultural lands and marginal lands with poor soil quality and weak agricultural yield potentials which are considered being still appropriate for bioenergy production. The SQR methodology explicitly includes numerous indicators for site related hazards for agricultural land use so that physico-chemical constraints of marginal lands and their severity can be directly revealed as demanded by Batidzirai et al. (2012).”

Methodology: . . . However some things need clarification: Section 2.1.3: page 5. Comments/questions: concerning soil contamination: only contamination with heavy metals was considered? Why not also contamination with hydrocarbons, pesticides, etc. Please provide an explanation in the manuscript to help readers with the same doubt.

=> Concerning contamination the SQR method refers for a first orientation to a methodology for sensory testing introduced by Lichtfuss (2004). This methodology provides several sensory parameters, e.g., soil colors or odor. Particularly, the latter can give clear indications of significant contamination with organic compounds (smell of petrol,

C2

aromatic or phenolic compounds, etc.). In our case we did not find any suspicious odor within the investigated soil profiles during field assessment. Based on these findings it was concluded to concentrate on contamination with heavy metals which is not directly detectable by sensory testing. We suggest adding the following sentences to the manuscript:

p. 5, l. 24: "According to the SQR method hints for contaminations, particularly signs of artefacts, color or odor, can be tested roughly by means of sensory analysis (Lichtfuss, 2004). Suspicious colors or odor which could indicate possible contamination with organic compounds were not detectable within any of the investigated soil profiles, so that further analysis in the laboratory was restricted to possible inorganic contamination with heavy metals."

Page 5, lines 28.30, the sentence is confuse. Please rephrase.

=> The sentence will be changed as follows:

"Thus, regional project partners provided data on average biomass yields from adjacent field sites with soil conditions comparable to the respective case study sites. These data for the same bioenergy crops as cultivated on the case study sites were used as an estimate of local biomass yields."

Page 7, lines 9-12, but those aspects are also included in this work? Perhaps it is better to indicate that those aspects are currently being studied. Just change the sentence to "that are currently being examined". So that readers understand that is work is still going on.

=> The mentioned socioeconomic investigations are currently in progress and results are expected until the end of this year. We agree to the suggested modification of the sentence.

Results and Discussion/ Conclusion: Results are presented but the discussion needs improvement in some parts. Some examples on how this section can be improved: in

C3

section 3.3, authors should compare the results obtained with other studies that can show similarities or even contradictory aspects. This is important to show the importance of this study and how this study really represent an advancement to knowledge.

=> We suggest adding the following text into l. 4 (p. 12):

"With this area size previous estimates of current land potentials for bioenergy production in Europe are clearly exceeded. Kluts et al. (2017) gave an overview on such studies. According to them , the minimum area of land currently available in Europe for bioenergy production was estimated as being clearly below 10 Mha. The maximum number was 30 Mha. The here presented approach only estimates the potential availability of land with poor or very poor soil quality which is considered not to be suitable for conventional agriculture. It must be assumed that an unknown proportion of this area is most probably also unsuitable for biomass production due to extreme site conditions. Thus, minimum soil quality for sustainable use of marginal lands has to be defined in future steps. For this purpose it will be necessary to further investigate the relationship between soil quality and biomass yield more precisely."

Also in section 3, authors should also debate that not only correlation data between biomass yields and SQR scores are needed but also between biomass characteristics and SQR scores. Even when yields are high enough to be considered a feedstock, if the biomass does not have proper characteristics, processing it may be technically unfeasible. Authors should also debate that more correlations are needed with annual biomass crops. In this study only perennials were considered.

=> This remark is important. In this project we did not investigate the quality of biomass produced at marginal lands. We also did not consider annual bioenergy crops. We suggest the following sentences to be added in section 3.2.1:

p. 10, l. 19: "The presented results are valid for perennial bioenergy crops, mainly for fast growing tree species. Effects of soil quality on the performance of annual bioenergy crops have not been considered. In addition, further research might be needed to

C4

analyze relations between soil quality and characteristics of biomass with regard to its later use in power plants or bio refineries.”

In section 4.2, it would be interesting to give some examples of success stories with other similar initiatives in the EU (concerning financial support to agricultural and agricultural related chains) and also the constraints and limitations derived from those initiatives, in order to show that that will be always pros and cons.

=> We suggest adding the following sentences at the end of section 4.2:

p. 14, l. 23: “Similar funding systems, e.g. the European Regional Development Fund (ERDF) may function as example. However, also in this case, aspects of a sustainable use of marginal lands with special focus on biomass production for bioenergy purposes need to be defined. In any case, it will be essential to bridge differences in agricultural and bioenergy policies in European countries, supporting underdeveloped regions, and avoiding an increase of land degradation by supporting a sustainable land management.”

In section 4, it should be also indicated that some of the regulations that are currently applied to biomass processes should be adapted to biomass processes that use biomass from marginal soils. Examples: targets on GHG emissions reduction.

=> With regard to this remark we suggest modifying the last two sentences of section 4 (this has to be re-numbered to “5”) as follows [additions are shown in brackets]:

Integrating bioenergy production at suitable marginal lands into future European policies (CAP) and the creation of suitable incentive programs might contribute to the objective to reach national and European renewable energy goals [for 2050] and to mitigate the rising land use conflict between the production of food and feed on the one hand and biomass on the other hand. It can be expected that the importance of marginal lands will increase during the next few decades as bioenergy is thought to play an important role for future energy supply in Europe [in terms of being able to

C5

meet the targets on GHG emissions reduction until 2050].

References: Batidzirai, B., Smeets, E.M.W. and Faaij, A.P.C.: Harmonising bioenergy resource potentials – Methodological lessons from review of the state of the art bioenergy potential assessments, *Renew. Sust. Energ. Rev.*, 16, 6598-6630, doi: 10.1016/j.rser.2012.09.002, 2012. BGR, Bundesanstalt für Geowissenschaften und Rohstoffe (Ed.): Map of the agricultural yield potential of German soils, Hannover, Germany, 2013. Campbell, E.J., Lobell, D.B., Genova, R.C. and Field, C.B.: The Global Potential of Bioenergy on Abandoned Agricultural Lands. *Environ. Sci. Technol.*, 42, 5791-5794, doi:10.1021/es800052w, 2008. Fritz, S., See, L., van der Velde, M., Nalepa, R.A., Perger, C., Schill, C., McCallum, I., Schepaschenko, D., Kraxner, F., Cai, X., Zhang, X., Ortner, S., Hazarika, R., Cipriani, A., Di Bella, C., Rabia, A.H., Garcia, A., Vakolyuk, M., Singha, K., Beget, M.E., Erasmi, S., Albrecht, F., Shaw, B. and Obersteiner, M.: Downgrading Recent Estimates of Land Available for Biofuel Production, *Environ. Sci. Technol.*, 47, 1688-1694, doi:10.1021/es303141h, 2013. Kluts, I., Wicke, B., Leemans, R. and Faaij, A.: Sustainability constraints in determining European bioenergy potential: A review of existing studies and steps forward, *Renew. Sust. Energ. Rev.*, 69, 719-734, doi:10.1016/j.rser.2016.11.036, 2017. Krassuska, E., Cadorniga, C., Tenorio, J., Testa, G., and Scordia, D.: Potential land availability for energy 5 crops production in Europe, *Biofuel Bioprod. Bior.*, 4, 658–673, doi:10.1002/bbb.259, 2010. Lichtfuss, R.: Bodenkundlich-Sensorische Ansprache von Bodenproben, Ein Verfahren zur Beschreibung von Bodenproben, *Bodenschutz*, 1/04, 21-24, 2004. Nalepa, R.A. and Bauer, D.M.: Marginal lands: the role of remote sensing in constructing landscapes for agrofuel development, *Journal of Peasant Studies*, 39, 403-422, doi: /10.1080/03066150.2012.665890, 2012.

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C6