

Interactive comment on “Modeling the contributing factors of desertification and evaluating their relationships to soil degradation process through Geomatic techniques” by P. Shoba and S. S. Ramakrishnan

Anonymous Referee #1

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1. General Comments

The manuscript refers to a semi-arid region in India where recovery of land is tested after a drought period. The study revolves around the reversibility of land degradation and the possible prevalence of natural or human driver forces.

The authors assume that “soil degradation” is a reversible process and they oppose this degradation process to land desertification, which is considered as an irreversible situation. This is really not mentioned until page 3742, line 18. (I recommend stating

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this proposal as soon as possible in the paper). Although the statement can be controversial due to lack of clear definitions (see e.g. Vogt et al., DOI: 10.1002/ldr.1075), the authors are free to consider this approach, but it must be clear that this is not the opinion of the whole scientific community working on desertification, for example, soil degradation is considered as one element of desertification, which includes other types of impacts (see e.g. Barbero et al. DOI: 10.1002/ldr.2344), particularly, many types of soil degradation are irreversible. In my opinion the authors should try to elaborate in this approach also in page 3742 line 20, as it is the core of the manuscript.

By the end of the introduction the authors separate the diagonal soil moisture stress index and the diagonal soil salinity index. Due to the high correlation between these two situations, I don't see how they can separate both effects on the ground. This issue deserves some explanation in the discussion.

In some parts of the manuscript the authors describe dense vegetation (page 3743, lines 7-8), it doesn't fit with a desertified or degraded region, please clarify how much area is densely covered or mention that this area has not been taken into account.

I think that the results obtained for this region and this approach deserve publication. I would recommend some improvements in the next sections.

2. Specific comments

* Time frame:

I think that the authors should mention in the Abstract that they are considering a particular period of time where the weather conditions were particularly dry and this offers the opportunity to measure how land is affected and the ability to recover previous productivity.

I would recommend the authors to change the way as they describe the periods of time. In my opinion only 10 years (2001 to 2011) is not really a “long term”. From the point of view of natural changes several decades should be considered long term. Please

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consider to change this by a “longer term” or “after 10 years”, along the whole paper, including the abstract.

There is no explanation about the concept and methods to measure “moisture stress”, and this variable is mentioned several times throughout the paper. Please detail what do the authors mean with this expression in materials and methods, and what are the limits that they consider stress or not stress.

*Human induced degradation:

The authors mention that the region is naturally salt affected due to native fluoride concentration. Please explain when they consider that “Human made soil salinity” is taking place. In Page 3745, line 15 the authors state how to assess “human induced desertification” by spatial correlation analysis performed between evapotranspiration and vegetation (NDVI), in my opinion this is important and is not properly established. Please be more specific to clarify and if possible, present some examples. Particularly, I don't understand how human induced desertification can emerge only from these relationships.

Please be more specific when you mention human induced degradation or human made soil salinity, you have to be consistent through the whole paper.

* Evapotranspiration:

I do not agree with the way as this paper considers evapotranspiration. In Page 3738 (line 7) the authors state that evapotranspiration is “key element to assess water resource scarcity in vegetation and soil as well”. Moreover, at the 2.5 section (page 3743. Line 15 and afterwards) they state that “high ET rate adversely affects the biodiversity of dry land ecosystem and accelerates the desertification process”. Evapotranspiration only takes place when there is water and vegetation, therefore it is an indicator of productivity, as is correctly mentioned in the text (page 3738 line 8-9). The real indicator of water scarcity, and possibly land degradation/desertification is the ration between ac-

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tual evapotranspiration and potential evapotranspiration. Please, delete any sentences considering evapotranspiration as an indicator of desertification or degradation. I suggest reading the paper of Shan et al. (DOI: 10.1002/joc.4566) to clarify the position of this issue.

In section 3.1 (page 3751) the authors identified land degradation by correlation between evapotranspiration and predicted NDVI, i.e., vegetation. This analysis is considering temperature and wind induced degradation. The separation of temperature and rainfall is an artefact and may deliver a spurious experimental result. I mean high temperatures plus high rainfall has not the same result in vegetation than high temperatures and low rainfall, in fact, it has opposite effects. In my opinion we cannot separate in an analysis the effect of temperatures from the influence of rainfall.

In line with the abovementioned concept of evapotranspiration, I do not agree with the statement “The land degradation “due” to evapotranspiration is identified if the negative NDVI observed trend ...” (page 3751, L. 17), similarly, in my opinion it is not correct to qualify that 44982 ha are “affected by evapotranspiration”, as is mentioned in the next sentence of the text. The problem is that the authors identify temperature and evapotranspiration, because they are correlated, but they do not mention water (soil moisture or rainfall), that is an important part of this equation. I suggest changing the concept of evapotranspiration to avoid this inconsistency. This section should be only centered in wind induced degradation.

* Main driving forces of desertification/degradation:

In page 3739, line 5 and afterwards, it is not clear what do the authors mean. I think that they want to describe the environmental factors leading to desertification process: groundwater salinity, high temperatures, wind speed and rainfall scarcity. It is not clear whether there are two main different processes: one involving salinity and another one involving wind. Please clarify here if this is the intention of the authors. I'm not sure, but this is what is followed by the paragraph. In addition the 3rd objective: “to quantify

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and assess the possible soil degradation processes namely soil moisture stress and salinity...” lead us to think that these are the two main points to be addressed in the manuscript. If so, please be more precise in the previous paragraph.

There is no an “above said” theoretical anticipation (Page 3739 line 13), please clarify this theoretical anticipation, related to my previous comments.

The paragraph from lines 13 to 22 should be moved to materials and methods as they introduce some specific variables and concept that need further explanation, e.g.: DSMSI, DSSI, tassled cap transformation etc.

Page 3740, line 11. There are references for soil taxonomy much more updated than this one from 1975. Please refer to the latest one if there are no differences in soil classification. (Soil Survey Staff. 2014. Keys to Soil Taxonomy, 12th ed. USDA-Natural Resources Conservation Service, Washington, DC.)

It would be worth to mention some figures about fluoride concentration and water pH when the site is described by the end of 2.1 section.

Soil moisture stress is considered an indicator of degradation and desertification. The method to measure this variable or the limits to it are not mentioned in materials and methods.

*Location of results:

Several times, results are described in the Materials and Methods section, please delete them if they are repeated, or move them to the appropriate section of the paper. e.g.: Page 3746, line 11: “It was observed that the saline affected regions and human occupancy rate were increased at an accelerated rate from 2001–2014”. Page 3746, line 23 and afterwards; in this section there is a slight confusion between methods and results. Please check it carefully and separate what is considered a procedure that is different from a result. Page 3749, L.20. In my opinion, from “Based on the hypothesis... “ to the end of the paragraph should be moved to results. Page 3750, Line 14 to

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24, please move results of soil EC and salinity to the corresponding section of results. L. 27 to line 6 page 3751 . I think that this description of socio-economic environment should be placed at the introduction. Page 3751, L. 6, to the end of the paragraph corresponds to results.

* Regarding the conclusions:

The authors conclude the paper with some recommendations, weaknesses and further work that would be needed to improve the comprehension of degradation processes in this region. Although this type of conclusions are valuable I think that they also should mention if the objectives have been fulfilled. In my opinion, not all of them have been accomplished.

(i) “to identify and differentiate different zones of degradation and desertification with respect to temperature, wind, rainfall and anthropogenic factors using geo-statistical model.” ok (ii) “To frame the hypothesis in such a way to prove theoretical anticipation of what soil degradation process can be expected from each zone of desertification.” This one needs further work. (iii) “To quantify and assess the possible soil degradation processes namely soil moisture stress and salinity at surface and sub-surface level through remote sensing models and techniques.” Ok (iv) “To validate the work to assure the reliability of the geo-statistical and remote sensing models through in situ observations.” Ok

3. Technical corrections

P. 3736 L.12: please change the sentence, by “soil salinity increased significantly from 16 to 74%”, or “ the rate of salt-affected soils increased significantly from 16 to 74%” . Anyway, it is not clear whether it refers to an increase in soil electrical conductivity, or salt concentration or, in the contrary, the area of salt-affected soils, please clarify it.

L. 14, please avoid “exaggeration”, it would be better to use increase, or aggravation or exacerbation,

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L.1 please delete "event", and change the wording by ", extreme temperature and rainfall events"

L. 4, please explain what the authors mean with "and indigenous geological environmental state prevailing on a longer time frame", or change the sentence; the meaning is obscure.

L.8, please change the sentence: "Drought, a period of unusually dry weather combined with poor land management, can cause..." you can also delete "Drought", in my opinion is not necessary".

L.17, the text is a bit redundant, you can delete "Its replenishment rate is very slow on human time scale" and continue with the rest of the sentence: ", hence termed as non-renewable resource" in a longer sentence, united to the previous one.

P 3740 L.18: "The drought is the visible evident of a degrading ecosystem in which land is a main component (Budihal et al., 2005)". What is the meaning of this sentence?. If the authors mean that drought can be a driving force for land degradation, it has already been mentioned several times above. I recommend deleting this unclear sentence.

L.21, I don't see why "territory" is in quotes, I suggest to change this by "The entire region"

L.22. the referred "tehsils" needs some explanation, please add (an administrative area in parts of India) in brackets after this word, for instance.

L. 24, please change "F" by "fluoride concentration"

L. 25, please delte "So" when you mention that ground water in aquifers are slightly alkaline. This is a fact, not a consequence from the sentence above.

P. 3741 L. 16, please delte "as"

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P. 3742 L. 14. What is the meaning of "the phase", can you use another word or explain?

L.16, ... the period when the desertification invokes." The sentence is confusing, please clarify it.

L.18. "If the land degradation is not responding to the immediate high rainfall...". I think that the authors mean that If land is not recovered/is not responding; please delete "degradation". In any case, this term "is not responding" is too vague. I guess that the authors mean that a higher productivity is expected after rainfalls, but it is not evident from the wording. I suggest rephrasing the whole sentence.

P. 3473 L. 11 to 12, the sentence is not clear, please modify.

P. 3746 L. 18, please delete "event" or replace it by "events"

P. 3748 L. 12, salinization due to occurrence of low rainfall and high evaporantion and evapotranspiration.

P. 3750, L.13, please state the soil depth for these soil samples. Please explain what do you mean with "and dissolved with ground water of that region"

P. 3752, L.6, please change "Rainfall induced degradation..." by "Rainfal scarcity induced degradation...". Rainfall only induces soil degradation when you have extreme events. As this is not really the case, and you are not studying erosion, I think that you have to mention that is the lack of rainfall what is problematic.

L. 15, due to the particular approach of this paper, I think that the authors should add: "As discussed earlier, in this study, if the degraded..."

L.16, please use "sufficient" or "enough", not both.

Page 3753 L. 3. How are these four crucial factors "validated" in the present study?, I think that this needs further explanations as this is one of the objectives of the paper. Please be more specific here.

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In this paragraph the authors refer to the “temperature affected region” I think that it would be more correct to refer to the “drought affected region”, please consider this change, in this way you are considering both temperature and lack of water.

L. 17. Please clarify the sentence “Hence the anticipation was carried in the temperature zone “ and “ground truth measures” (line 21) and in line 28 “has got renewed in the temperature induced desertified zone”

Page 3754, L. 12, please change “invoked” by produced

L. 14, Please consider changing “rainfall induced desertification” by “lack of rainfall...”, otherwise it seems a contradiction in terms. Please change it here and in the whole paper if necessary.

Page 3755 L., 5. Please explain how nitrates are the main source of fluoride concentration or add a reference.

L. 8. This relationship between fertilization and soil salinity is not “demonstrated” by the survey. Please change the sentence. I suggest, “ may be supported by the opinions obtained by farmers “ or something similar. Please change affirmative sentences by others like “may be due to”, e.g. in line 11.

L. 14, human occupancy “has” significantly increased

L. 19, please check English wording, I suggest “due to the prevalence of drought in these years”.

L. 28, please change sentence, “than values found at the surface level which showed highly fluctuating levels (Table 1), particularly at the human affected zone”. Please read again the last lines of this paragraph, I think that it is repetitive.

Page 3756 L. 8. The sentence “This new method evaluates...” is confusing, please clarify the meaning. I suggest splitting it in two different sentences.

Table 2, please add the number of observations per region

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Interactive comment on Solid Earth Discuss., 7, 3735, 2015.

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