Solid Earth
Discussions

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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

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We really appreciate the reviewer suggestion on the main core and other contents of our paper. The valuable comments will emphatically enhance the quality of the paper. We agree with some technical issues and will definitely refine the paper according to the reviewer comments.

1. General comments

1.1. The authors assume that "soil degradation" is a reversible process and they op-

pose 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 this proposal as soon as possible in the paper).

Correction Made:

We agree with the comments and elaborate the core theme of the manuscript in section 2.3 page 3742 as mentioned below. Soil has the direct relationship with desertification than other environmental parameters. The degraded soil cannot be reversed when the natural degradation component and anthropogenic activities are prolonged more than a decade. There are many soil degradation processes which are irreversible in nature may have the direct association with desertification. The possible soil degradation processes suspected in the study region are salinity and soil moisture stress. The anticipation is based on the climatic prevalence (less rainfall and extreme temperature events), geological functions (Fluoride nature) and human pressure. Hence, the kind of soil degradation processes progressed and prolonged during both the periods were analyzed and quantified with respect to the prime inducing components of desertification.

1.2. 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.

We have not discriminated the effects on the ground as these two situations are dependent to each other as you commented. The model was developed in such a way that, the extreme zone of the scatter plot (TIR -NDVI) has the effect of soil moisture stress which may also contain effect of salinity. Scatter plot resulted in three zones starting from healthy (zone 1), soil moisture stress (zone 2) and salinity with moisture stress (zone 3). After analyzing the spectral plot of satellite imageries for 15 years the MID-IR region was included in the base model to separate the zone 3 from zone 2 and building

roof tops, and enhance (0.7-1 range in MID-IR) the values of soil salinity. The presence of extreme fluoride concentration is observed in the study region for more than 3 decades. Since the soil salinity in the temperature/drought affected region is majorly through capillary action, the saline ground water has been persistently raised to surface level and during the extreme temperature event the saline water is evaporated and salt remains accumulated. Saline soils of the temperature affected zone make the plant difficult to absorb the moisture content present on the soil which resulted in soil moisture stress especially at the root zone. So, the zone 3 (salinity induced moisture stress) is solely considered as saline affected. Still the values of zone 3 are merged with extreme soil moisture stress which cannot be separated in multi-spectral remote sensing models. But can be possible through Microwave remote sensing by studying the dielectric properties of the soil (mentioned in conclusion section). Similarly the values of soil moisture stress in zone 2 of the diagonal are enhanced with the inclusion of wind speed. And the model is only applicable for dry conditions. It was employed for climate affected regions (temperature/drought affected region, Wind and Rainfall). In the case of human affected region the salinity was measured from LULC maps not from the model as the uncertainty developed from the distribution of Nerium Oleander (Nerium Oleander L.) plants on the saline track (mentioned in section 2.13) and water logging condition.

1.3. 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. Correction Made:

Some locations of the eastern part of the region are occupied by shadow because of the slight elevation and dense vegetation (2%).

2. Specific comments

2.1. Time frame

Moisture stress Concepts and limitation

The core concept has been discussed by the graphical, theoretical and mathematical illustrations so as to limit the size of the paper. We included the limitation of the model at section 3.4 of the result and discussion as suggested by reviewer. We also consider the limits for wetness and moisture stress at the end of the section 2.10. Since the model yields the result in percentage (0 – 100%) as ground observation, it is not difficult to identify the stress affected region. The present study considers the soil as a stress affected if DSMSI >= 60% (incorporated in the paper as suggested).

2.2. Human induced degradation

Thank you for the suggestion. We definitely elaborate this point in the revised version as commented.

For reviewer's clearance:

The human made degradation cannot be directly acquired from the geo-statistical model because of its dynamic nature. Once the possible climatic degradations (temperature, wind and rainfall) were extracted from the correlation analysis, the remaining area (Positive correlation between ETref - NDVIpred; negative correlation between rainfall - NDVIpred with decreasing NDVI trend) is declared as human affected. Though the region receives adequate rainfall, the vegetal status of this region is low (hence low ET) because of the human intrusion. We prepared LULC maps in order to assess the kind of human activities taken place over a period.

2.3. Evapotranspiration

Evapotranspiration = Evaporation + transpiration

The study has estimated only reference evapotranspiration (without the inclusion of rainfall) not crop reference evapotranspiration. Since the western part of the region is located in rain shadow region of the Western Ghats, the rate of reception is steadily hampered over a period, hence resulted in less vegetation. Hence the ET of the west-

ern part is highly influenced by evaporation. Thus, the correlation coefficient analysis is again performed for ET ref – temperature (R2 = 0.8) and ET ref - wind speed (R2=0.83) which elucidates the fact that the evaporation rate from soil (temperature and wind) is dominant rather than transpiration (less NDVI) in ET ref. In desertifying area the contribution of transpiration to evapotranspiration is very less. During crop growing season the evaporation from the soil surface will reach upto 50% of the evapotranspiration (Peters 1960- Mediterranean Desertification- Mosaic of Processes and Responses). The observation of long term high ET in the sparsely vegetated area (Western part of the study region), indicates that the higher evaporation rate keeps on increasing from the soil and transpiration from plants decreasing which makes ET (dominated by evaporation) to get negatively correlated with NDVI. And when analyzing it with recent NDVI trend, the desertified region can be identified. Again the correlation analysis was performed in order to know the temperature induced evaporation and wind induced evaporation. Evaporation due to temperature will significantly increase the salinity. The combined effect of winds and high temperature results in significant evaporation and causes high soil salinity. (Remote sensing of soil salinization: Impact on Land management Page 143).

Comments : it is not correct to qualify that 44982 ha are "affected by evapotranspiration"

That is rightly pointed out. So we changed the sentence as "among 44982 hectares of evaporation affected area, 55% (24869 hectares) of land parcel was affected by temperature and 45% (20113 hectares) were affected by wind".

3. Technical Corrections

3.1. 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.

It was written to mean the salt-affected soils.

3.2. "and indigenous geological environmental state prevailing on a longer time frame" – Native Geological aspect of the region such as fluoride concentration etc. . . so when the desertification is combined with these geological functions, it gets accelerated.

3.3. P. 3742 L. 14. What is the meaning of "the phase", can you use another word or explain? Phase was used here to specify the stage or the period.

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

As commented we will change the sentence appropriately as follows

"The time span of land degradation / drought has to be identified in order to recognize the progress of desertification".

3.5. 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".

Soil depths are mentioned as recommended. As discussed in the paper, the sub surface salinity is somewhat fluctuating in nature. So the soil samples collected at the site have been dissolved with the ground water of the same location to avoid the spurious results. The chemical parameters were measured after dissolving the soil with the ground water.

3.6. P. 3753, 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".

line 17-The sentence written to mean the initial anticipation carried out before formulating the hypothesis. As pointed out, it is wrongly placed there. We will replace the sentence in a right place where it should be.

line 21- Ground truth measurements are nothing but in-situ measurements; general term used in remote sensing.

line 28-We agree the mistake and values are also wrongly mentioned by mistake. Since the sentence is not suitable in that place, we will delete it from there.

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

Kindly note that the reference is already placed Dissolved nitrate is the main source for the concentration of fluoride in the ground water. There is no evidence for the geological source of nitrate (Ramesh and Vennila, 2012).

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

The sentence is changed as mentioned below The successful directional hypothesis has assisted the research to identify the highly influential soil degradation process in all four affected zones. This approach of desertification modeling will enable the future research to weight each soil degradation process based on their influence at each region while quantifying the desertification.

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