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Interactive comment on "Soil fertility along toposequences of the East India Plateau and implications for productivity and sustainability" *by* Peter S. Cornish et al.

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We thank the referee for their extensive, thoughtful comments that will lead to an improved manuscript. We will address the general and substantive specific comments here, and deal with other specific comments when we revise the manuscript.

The referee notes that the title refers to sustainability, but then says "this very important concept is never addressed in the paper and it is not clear in which terms sustainability is taken into consideration in this work". In response, we note that the Abstract reports the low and evidently declining concentrations of soil P and K, and concludes that "Fertiliser-use must increase substantially to sustain the system". This argument

regarding the sustainability of the cropping system is fully developed in lines 260-316 of the Discussion. In the Conclusions we say the present cropping system is 'unsustainable' because the soil fertility is mostly low and continuing to decline because fertiliser rates are too low. We need to specify in our revision that here we are referring to P and K.

The referee also notes reference to "productivity" in the title and goes on to say that "rice productivity . . . is limited to only few yield data that are mainly mentioned in the discussion". Yields were not actually measured in the study and this is why they are not referred to in the results; however, the Introduction (lines 48-57) makes it clear that the context for the work is the general low rice productivity on the Plateau that is related to soil fertility rather than a lack of rainfall. This is low "water productivity", a theme that is taken up at line 287-289 and again at line 345 where we conclude that "The present cropping system is clearly unsustainable and unable to efficiently use the available water".

The referee notes that ". . . a description of the rationale backing the selection of the analysed soil parameters is missing". The rationale is given in the Methods that state "Earlier research in Purulia District, West Bengal (Cornish et al., 2010) led to a focus on soil pH, organic carbon (OC), cation exchange capacity (CEC) and the macronutrients phosphorus (P) and potassium (K) as indicators of chemical fertility". We will add into the Discussion that the 1:50,000 soil maps we refer suggest that boron might be widely deficient (and variable), but we did not assess this.

The referee suggests that "the figures depicting the final results should clearly show such soil parameters variability when instead now is limited to differences between Rice areas and Non-Rice areas". We note that all of the figures in the paper are box and whisker plots that provide detail on the variability within the aggregated land use categories of rice and non-rice, whilst the tables all give standard errors for each analyte that apply to land class, watershed, and the data overall.

The referee refers to areas of text that are unclear – these will be attended to when we revise the paper. Referee 2 also cited instances where the text could be clearer. Regarding specific comments on the paper, we plan to respond positively to all of the suggestions when we revise the paper, but offer the following comments on a few of the more substantive matters.

Line 103. Non-degraded uplands provide an indication of inherent fertility because they have not been subjected to nutrient removal through cropping or extensive soil erosion that is evident on degraded uplands. They are certainly not a perfect indicator of inherent soil fertility, but under the circumstances they provide a useful indication.

Line 106. As a matter of general interest for readers, the fields referred to are generally very small, sometimes less than 200 m2 in the case of rice on bunded hillslopes, and infrequently more than 1,000 m2. Families own or lease multiple fields, the number, location and quality of which depends on family wealth.

Line 111. Soil acidity is not confined to surface soils, but our resources did not allow for subsoil sampling in the present study. However, extensive soil pH measurements through the profile made in the smaller, preceding study (Cornish et al., 2010) had not been published, so they were included here with a description of the methods. In the absence of complete data, this restricted dataset allowed us to suggest a tentative but important conclusion that remediation of soil acidity may concern only surface soil (line 153). We will expand on this in the revised text.

Line 140. The referee raises a good point. In the text, values were rounded to one decimal point (both 4.4), but the means were actually 4.35 (non-rice) and 4.44 (rice). The 0.9 difference evident in figure 2a is the actual difference. We will amend the text to 2 decimal places.

Line 164. Interesting point. In our previous work we measured yields in hundreds of farm fields and in experiments, with around 7 t/ha as the maximum in both, but rarely in farm fields. Also, in our previous research, we estimated that annual ET of medium

duration rice (125 days) in this region is around 460 mm. If we assume transpiration is around two-thirds of ET, then T is around 280 mm. If transpiration efficiency is 25 kg grain/ha/mm then a potential yield would be around 6.9 t/ha for this class of land and crop duration. We will mention this in Discussion.

Line 172. WE think the referee is asking for a box plot for CEC. This is already given in Fig 3c.

Line 204. The referee requests data, but we did not study crop responses to added P. We discuss the significance of observed P values by referring to the literature (4 references cited).

Lines 236-245. The referee is right that that soil fertility may include a large number of variables, of which OC, CEC, pH, P, K are some – these being selected in our study either because they are universally accepted as being important (OC, CEC) or shown in previous research to be particularly important in the region (pH, P, K). We will clarify this in the Introduction and return to this point in Discussion at lines 236-245.

Line 248. No specific observations were made of site geology. Rather, watersheds representing diverse geologies were selected, based on the descriptions found in the cited reference 'Soil maps, Department of Agriculture, Animal Husbandry and Cooperative. http://agri.jharkhand.gov.in/default.asp?ulink=resources/soilmap.asp. We will explain this in the Methods.

Line 251-252. The point we are making here is that our results were quite consistent across sites, unlike in other studies, and we attribute this to the relative homogeneity of watersheds notwithstanding differences in geology. That is, although geologies varied, the fertility trends generally did not. We will clarify this in the text.

Lines 257-259. Good point. We will elaborate on this in the revised paper.

Line 266. Animals carcases are a nutrient 'sink', where nutrients accumulate and are effectively removed from nutrient cycles. The fate of these nutrients depends on

whether they are sold (exported from watershed) or die and are disposed of within the watershed, but in most cases the nutrients are lost from the nutrient cycle, at least in timeframes relevant to farm management. We will expand on this in Discussion.

Lines 293-210. Noted and will be revised

Lines 318-331. We will comment on this briefly at around line 56 in the Introduction and return to fertiliser types in the Discussion, where appropriate, noting where DAP is most commonly used (DAP being associated with soil acidification).

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