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Optimisation of a parametric land evaluation method for cowpea and pearl millet production in semiarid regions

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Abstract – Crop-specific land evaluation as proposed by FAO and refined by the International Training Centre (ITC-Ghent) requires the detailed definition of crop requirements with respect to climate and soil conditions and an optimisation of the evaluation approach. To evaluate the suitability of semiarid regions in NE-Brazil for cowpea production and of SW-Niger for millet production, the parametric ITC-Ghent method was applied after carrying out some modifications. When the modified evaluation method was used, the calculated land index for cowpea correlated reasonably well with observed yield data (R² = 0.53). Modifications of the general ecological requirements of cowpea with respect to soil pH and organic carbon content in the topsoil slightly increased the coefficient of determination (R² = 0.71). In the case of pearl millet in SW-Niger, the correlation between observed yield and land index proved to be unsatisfactory (R² = 0.39), even when the modified ITC-Ghent method was used. The coefficient of determination improved when the crop requirements were adapted to the characteristics of local millet varieties tolerant to low soil acidity (R²=0.77). In connection with adjusted crop requirements, the parametric ITC-Ghent land evaluation method proved to be sufficiently accurate for the assessment of land suitability and yield for cowpea and millet at the regional level.

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1. INTRODUCTION

Agriculture in both the Sahelian Niger with mean annual rainfall of 500 mm and the semiarid Northeast of Brazil with on average 700 mm is based on small-scale, low-input farming with pearl millet (Pennisetum glaucum L.) in Niger and cowpea (Vigna unguiculata L. Walp) in Brazil as main staple crops. The significant extension of the cultivated land indicates a trend towards declining productivity and therefore increasing food deficiency. Studies carried out during the last 30–40 years have showed that declining soil fertility, erratic rainfalls, recurrent droughts and the poor economy are major constraints to development. Knowledge of the agricultural potential and the ecological limitations in relation to the cultivation of specific crops in both regions is poor. So far only a few crop-specific land evaluation studies for rainfed crops have been undertaken in these regions on a local or regional scale [14, 15, 17]. In Thailand [22], China [7, 21] and Cameroon [23], quantitative land evaluation methods have been applied to rainfed and irrigated crops, focusing on the evaluation of land for maize, winter wheat or rubber production.

In order to evaluate land according to its suitability for the production of a specific crop, FAO [3] proposed a framework of land evaluation for rainfed agriculture. This framework has been refined by the International Training Centre (ITC) at the Ghent University, providing detailed threshold values for various crops concerning their requirements with regard to climate and soil conditions [20]. However, these crop requirements have to be considered as guidelines, implying that the limitation levels for the different characteristics should be adapted to local conditions and local crop varieties. The objective of this investigation was, therefore, to adapt the crop requirements for pearl millet and cowpea and to adjust the parametric ITC/Ghent evaluation method for evaluating yield potentials in semiarid SW-Niger and NE-Brazil [19].

2. MATERIALS AND METHODS

2.1. Calculation of crop-specific land indices

A soil and terrain database was established according to the SOTER approach [8], which contained a total of 475 soil profiles for Niger [5] and 194 for Brazil. Furthermore, a separate climate database containing monthly data of rainfall, temperature, relative air humidity and radiation from various climate stations had been implemented. Database queries were used for retrieval and evaluation of specific data from the databases. The land evaluation was carried out after modifying and adjusting the parametric ITC-Ghent method described by Sys et al. [19] to the local setting. The ITC-Ghent method matches the requirements of a specific land use (e.g. crop requirements) with the characteristics of the land unit (defined as a combination of climate, terrain and soil characteristics) that is to be classified. The following ecological groups of land characteristics were considered in the modified evaluation procedure:

I. Climate factor groups: (a) rainfall (total amount of rainfall during the growing period, rainfall per month), (b) temperature (mean temperature during the crop cycle, monthly means (mean, minimum, maximum), (c) air humidity (relative humidity during the crop cycle) and (d) radiation (sunshine hours during the crop cycle).

II. Terrain and soil factor groups: (a) topography (terrain slope), (b) wetness (terrain flooding risk, profile drainage conditions), (c) soil physical properties (soil depth, texture/structure, gravel, carbonate and gypsum content), (d) soil chemical properties (base saturation, pH, total organic carbon, CEC of clay fraction), (e) salinity/alkalinity (electrical conductivity and exchangeable sodium percentage in the topsoil).

Depending on the matching of land characteristics and crop requirements, ratings from 0 to 100 are attributed to the individual characteristics. The soil and terrain index and the climate index are calculated separately by first specifying the minimum factor rating within each ecological group and then multiplying these ratings (four for the climate factor groups and five for the soil and terrain factor groups), representing the most limiting factor within each ecological group, according to Storie [16]:

\[ I_{s,i} = A \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \ldots \]  

(I_{s,i} = climate index, I_{s,i} = landscape and soil index; A, B, C, D = rating of the most limiting factor within each factor group).

This means, all factors are evaluated, but only the minimum factors of each factor group are selected for the calculation of the indices, thus implying a distinct modification of the original “parametric method” of Sys et al. [19]. The original parametric method proposes for the humid (sub)tropics to multiply eight numeral ratings related to climate, topography, drainage, flooding, apparent CEC, organic carbon and the minimum rating among base saturation / basic cations / pH as well as the minimum rating of the texture / depth / coarse fragments group. For arid environments the three fertility parameters (apparent CEC, organic carbon and the minimum rating among base saturation / basic cations / pH) are
Land evaluation for cowpea and pearl millet

replaced by the ratings of CaCO₃, CaSO₄ and salinity-alkalinity. However, findings in semi-arid Niger [5, 6, 12] and Brazil [2, 13] contradict the omission of the fertility parameters, because in these regions even with annual rainfall below 500 mm soil fertility characteristics like organic carbon or base saturation were most determining for crop productivity. Therefore, we propose under these environmental conditions to multiply the above mentioned nine minimum ratings including the salinity-alkalinity group regardless of the climate type. The original method which considers the three fertility parameters separately would have resulted in land indices below 15 (unsuitable for pearl millet), especially for acid sandy soils, which indeed produce moderate yields. This led us to replace the original single factor ratings of the fertility parameters [18] by the minimum factor rating.

Compared to other calculation methods like the “maximum limitation method” [19], the parametric approach proved to be the most suitable for quantification and correlation of crop yields with climate, soil and terrain factors, because it considers the synergistic interactions of the limitations [4, 18]. For the total land evaluation the climate index is transformed into a climatic rating according to the following relations [19], which is an internal adaptation of the climate evaluation and contributes to the overall model performance:

\[ R_c = \begin{cases} I_c \times 1.6 & \text{when } I_c < 25.0 \\ I_c \times 0.9 + 16.67 & \text{when } 25 \leq I_c \leq 92.5 \end{cases} \]

where \( I_c \) = climate index and \( R_c \) = climate rating. The climatic rating and the soil and terrain index, \( I_s \), were then multiplied to obtain the final land index, \( LI \), as

\[ LI = R_c \times I_s / 1000 \]

with \( LI \) ranging between 0 (“not suitable”) and 100 (“very suitable”).

2.2. Crop requirements

The crop requirements used in the calculation procedure of the land index were drawn from Sys et al. [20], who presented climatic and soil requirements for millet and cowpea (Tabs. I and II).

2.3. Soil and climate characteristics

The evaluation included mainly well drained sites, which are representative for a large part of the cultivated areas in South-West Niger and in North-East Brazil. Detailed soil descriptions are given in Graef [5] and

\begin{table}[h]
\centering
\begin{tabular}{lcccccc}
\hline
\textbf{Rating} & \textbf{100} & \textbf{90} & \textbf{72.5} & \textbf{50} & \textbf{32.5} & \textbf{12.5} \\
\hline
\textbf{Precipitation of growing cycle (mm)}
Precipitation 1st month & 75–100 & 50–75 & 25–50 & 50–75 & 75–100 & 50–75
100–150 & 150–255 & 155–400 & 50–75 & 75–100 & 150–255 & <400
Precipitation 2nd month & 125–150 & 100–125 & 75–100 & 50–75 & 75–100 & <400
150–175 & 175–255 & 155–400 & 50–75 & 150–255 & 175–255 & >400
Precipitation 3rd month & 125–150 & 100–125 & 75–100 & 50–75 & 75–100 & <400
150–175 & 175–255 & 155–400 & 50–75 & 150–255 & 175–255 & >400
Precipitation 4th month & >75 & 75–135 & >135 & & & \\
\hline
\textbf{Physical characteristics}
Coarse fragments (Vol%) & 0–3 & 3–15 & 15–35 & 35–55 & 50–60 & >55
>75 & 60–75 & 50–60 & 20–50 & 100–125 & 150–255 & >20
Soil depth (cm) & 0–3 & 3–15 & 15–35 & 35–55 & 50–60 & >55
>75 & 60–75 & 50–60 & 20–50 & 100–125 & 150–255 & >20
\hline
\textbf{Chemical characteristics}
Base saturation (%) & >50 & 35–50 & 20–35 & <20 & & \\
>4 & 2.8–4 & 1.6–2.8 & <1.6 & & & \\
Sum of basic cations (cmol(+)/kg) & 6.2–6.6 & 6.0–6.2 & 5.5–6.0 & 5.0–5.5 & <5.0 & \\
6.6–7.0 & 7.0–7.8 & 7.8–8.0 & 8.0–8.2 & >8.2 & & \\
Organic carbon (%) & >2 & 1.2–2.0 & 0.8–1.2 & <0.8 & & \\
>6.6 & 7.0–8.0 & 8.0–8.2 & & & & \\
\hline
\textbf{Salinity/Alkalinity}
Electr. conductivity (dS/m) & 0–2 & 2–3 & 3–5 & 4–7 & >7 & \\
\hline
\end{tabular}
\caption{Selected climate and soil requirements of cowpea [20].}
\end{table}
Most sites are evaluated for at least two different years each to take into account the high climatic variability of these regions. The evaluated site and crop management combinations are listed in Table III.

### 2.4. Calculation of the yield index

Land indices were calculated for different sites in Niger and Brazil with available climate, soil, terrain and yield data (Tab. III) in relation to their suitability for cowpea and millet and compared to observed yield data. In order to compare the evaluation results of different crops with real yields, yield indices defined as:

\[
Y_{Ii} = \frac{Y_i}{Y_{poti}} \times 100
\]  

were calculated where \(Y_{Ii}\) is the yield index, \(Y_i\) is the observed yield and \(Y_{poti}\) is the potential yield of crop \(i\) (Tab. IV) for either low or high input systems.

Most yield data were observed in small holder farming systems with virtually no inputs of improved land and crop management practice like improved seeds, herbicides, pesticides, etc. In these cropping systems the yield index was calculated by relating the observed yield to the potential yield of low input systems. Some yield data of cowpea were drawn from research experiments (good seed quality, high plant density, application of agrochemicals, timing of field operations, etc.). In these cases the observed yield was related to the potential yield of high input systems to calculate the yield index.

For the calculation of the soil indices different soil management conditions had to be considered:

1. In millet cropping systems with the application of large amounts of crop residues, the soil pH had to be adapted, since the pH drops down 0.3–0.5 units during growing periods in the sandy soils tested [6].

2. If adequate amounts of NPK fertilisers were applied (with or without crop residue recycling) limitations due to low organic carbon content (an indicator for insufficient N and P supply) were disabled. If NPK fertilisers were combined with liming, the limitations due to low base saturation, low sum of basic cations and low pH were disabled.

3. In irrigated systems, cowpea was planted on ridges with large amounts of water, but low fertiliser rates (optimal water supply and aeration, suboptimal nutrient supply). Hence, the soil indices for cowpea in these systems were calculated based on the soil chemical requirements only.

The yield data were gathered mostly from traditional, locally selected varieties. In researcher-managed cowpea experiments an improved variety (EPACE 10) with a shorter life cycle had been used. Therefore, when soil characteristics were compared with crop requirements, the following crop requirements of Tables I and II were

---

**Table II.** Selected climate and soil requirements of pearl millet [20].

<table>
<thead>
<tr>
<th>Rating</th>
<th>100</th>
<th>90</th>
<th>72.5</th>
<th>50</th>
<th>32.5</th>
<th>12.5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Precipitation of growing cycle (mm)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precipitation 1st month</td>
<td>&gt;150</td>
<td>100–150</td>
<td>75–100</td>
<td>50–75</td>
<td></td>
<td>&lt;50</td>
</tr>
<tr>
<td>Precipitation 2nd month</td>
<td>&gt;150</td>
<td>100–150</td>
<td>75–100</td>
<td>50–75</td>
<td></td>
<td>&lt;50</td>
</tr>
<tr>
<td>Precipitation 3rd month</td>
<td>&lt;60</td>
<td>60–120</td>
<td>&gt;120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Physical characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse fragments (Vol%)</td>
<td>0–3</td>
<td>3–15</td>
<td>15–35</td>
<td>35–55</td>
<td></td>
<td>&gt;55</td>
</tr>
<tr>
<td>Soil depth (cm)</td>
<td>&gt;90</td>
<td>50–90</td>
<td>20–50</td>
<td>10–20</td>
<td></td>
<td>&lt;10</td>
</tr>
<tr>
<td><strong>Chemical characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base saturation (%)</td>
<td>&gt;50</td>
<td>35–50</td>
<td>15–35</td>
<td>&lt;15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic cations (cmol(+)/kg)</td>
<td>&gt;5</td>
<td>3.5–5</td>
<td>2–3.5</td>
<td>&lt;2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH(H₂O)</td>
<td>6.0–6.5</td>
<td>5.6–6.0</td>
<td>5.4–5.6</td>
<td>5.2–5.4</td>
<td>&lt;5.2</td>
<td></td>
</tr>
<tr>
<td>Organic carbon (%)</td>
<td>&gt;1.5</td>
<td>0.8–1.5</td>
<td>&lt;0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Salinity/Alkalinity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electr. conductivity (dS/m)</td>
<td>0–2</td>
<td>2–4</td>
<td>4–6</td>
<td>6–8</td>
<td>8–12</td>
<td>&gt;12</td>
</tr>
<tr>
<td>ESP (%)</td>
<td>0–10</td>
<td>10–25</td>
<td>25–35</td>
<td>35–45</td>
<td>8–12</td>
<td>&gt;45</td>
</tr>
</tbody>
</table>
(1) Millet varieties used in Niger are more tolerant to poor chemical soil factors [10] than indicated in Sys et al. [20], so the requirements were reduced by 0.4 units for the pH and 0.4% for the organic carbon. Soil texture requirements were fully modified, inverting the texture suitability sequence and giving sandy soils higher ratings than loamy or clay soils, as experienced throughout Niger [18].

(2) In the cowpea cropping systems the cowpea varieties evaluated are less susceptible to soil acidity [4] and to low nitrogen and phosphorus availability [2] (expressed by the soil organic carbon content). pH < 5.5 was therefore attributed a rating of 50 instead of 35 and the organic carbon content <1.2% obtained the rating 72.5 instead of 50.

Table III. Site, management and crop combinations used in the evaluation procedure.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Location</th>
<th>Soil type (classified acc. to [9])</th>
<th>Rainfall year</th>
<th>Crop management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpea</td>
<td>Tauá*</td>
<td>Chromic Luvisol (LVx)</td>
<td>1997, 1998</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>Picos*</td>
<td>Ferric Acrisol (ACf)</td>
<td>1997, 1998</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eutric Fluvisol (FLe)</td>
<td>1999</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alumi-Haplic Acrisol (ACa)</td>
<td>1998, 1999</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ferric Luvisol (LVf)</td>
<td>1999</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eutric Fluvisol (FLe)</td>
<td>1999</td>
<td>yes</td>
</tr>
<tr>
<td>Millet</td>
<td>Hamdallaye**</td>
<td>Eutric Fluvisol (FLe)</td>
<td>1996, 1997</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>Kirtachi*</td>
<td>Luvic Arenosol (ARI)</td>
<td>1992, 1993</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Areni-Plinthic Acrisol (ACpa)</td>
<td>1995, 1996</td>
<td>no</td>
</tr>
</tbody>
</table>

* own soil and yield data; ** soil and yield data from [12].

Table IV. Potential yield (kg·ha⁻¹) for cowpea and pearl millet in relation to the intensity of the management.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Low input systems</th>
<th>High input systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpea*</td>
<td>1000</td>
<td>2500</td>
</tr>
<tr>
<td>Pearl Millet**</td>
<td>2000</td>
<td>–</td>
</tr>
</tbody>
</table>

* own data; ** see [12].

The calculated land indices in relation to crops, management and year were correlated with the respective yield index and regression analysis was performed. In addition, the mean error (ME) was calculated as

\[
ME = \frac{1}{n}\sum_{i=1}^{n}(y_i - x_i)
\]  

(5)

and the mean absolute error (MAE) of the land index as

\[
MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - x_i|
\]  

(6)

where n is the number of observations, x is the yield index and y is the calculated land index. Values of the mean error close to zero show that the mean difference between land index and yield index is small, thus indicating little systematic deviation or bias. The mean absolute error (MAE) gives an indication of the mean absolute magnitude of error. Small values indicate little difference between predicted and measured values.

3. RESULTS AND DISCUSSION

The parametric ITC-Ghent method was modified and optimised in two steps. First the rating procedure was modified and secondly the requirements of the evaluated crops were adapted to the local setting as indicated above. The modified evaluation method produced higher and far more realistic land indices for pearl millet and cowpea regarding the available yield data (see Figs. 1 and 3) than the original procedure, which tended to underestimate the land indices. For pearl millet cropping...
in Niger sandy soils with low pH (Luvic Arenosols, classified according to [9]) or sand covered loamy soils (e.g. Areni-Plinthic Acrisols) are most frequently used [12]. Figure 1 shows that millet yield indices and land indices are only poorly correlated ($R^2 = 0.39$), when the crop requirements provided by Sys et al. [20] are used in calculating the land index. The great variability in yield is due to various factors such as climate variability, soil heterogeneity and crop management differences (sowing date, crop residues, weeding), which cannot be accounted for on that scale. This variability is shown e.g. by the wide range of yield indices (between 3 and 22) for land indices around 20. The input parameters of the evaluation method pH, organic carbon and soil texture were iteratively adapted following the information of [6], [10] and [12] and thereby optimised fitting the expected land indices to the calculated yield indices. As indicated by the closer land / yield index correlation in Figure 2 with modified crop requirements, the original crop requirement settings are poorly adapted to the local millet varieties used in Niger. The input modification (crop requirements were reduced by 0.4 units for the pH and 0.4% for the organic carbon) resulted in an improvement of the relationship between calculated land index and observed yield index of millet. The intercept of the regression decreased from +27.9 to +15.9 and the coefficient of determination increased from 0.39 to 0.77. The mean absolute error also decreased significantly from 9.0 to 5.1. Since the millet varieties in Niger are more pH-tolerant, require coarser textured soils and cope well with a poorer nutritive soil status than indicated in Sys et al. [20], the modifications seem to be justified. The evaluation results indicate only marginal to intermediate suitability for millet cropping in SW-Niger, which is due to the overall unfavourable ecological conditions. Most farmers in Niger, however, use soil amendments such as crop residues or manure to achieve at least intermediary millet yields [11], whereas maximum yield levels are hardly ever attained.

The comparison between calculated land index and observed yield index for cowpea in Brazil shows that the calculated land index fits reasonably well with the observed yield index (Fig. 3). The coefficient of determination of 0.53 reflects, as in the case of millet, a somewhat temporal and (micro-)spatial variability of climate, soil and management. In years with sufficient water supply and when not fertilised or limed, the Acrisol sites (ACf and ACha) show considerably higher yields compared to the calculated land index. These sites are characterised by low pH (e.g. pH of 4.1 in the Alumi-Haplic Acrisol ACha) or low organic carbon content (ACf: 3.9 mg C kg$^{-1}$ in the topsoil). The same low organic carbon content holds for the intensively cropped Ferric Luvisol (LVf) in Tauá (2.5 mg C per kg soil in the topsoil). Probably, the cowpea varieties cultivated in the region are less susceptible to soil acidity and to low nitrogen and phosphorus availability [2] (expressed by the organic carbon content in the soil). It has been suggested, therefore, to change the minimum requirements proposed by Sys et al. [20] with regard to soil pH and...
carbon as indicated above. This modification resulted in an improvement of the relation between calculated land index and observed yield index of cowpea (Fig. 4). The intercept of the regression decreased from $+10.8$ to $+1.1$ and the coefficient of determination increased from $0.53$ to $0.71$. Under the assumption that the land index should be correlated 1:1 with the yield index, the improvement of the relation between yield index and land index can also be demonstrated in a slight reduction of the mean absolute error (Tab. V).

The results indicate that the modified parametric method leads to reasonable estimations of land indices and yield potentials for cowpea and millet, particularly when adjusted crop requirements are used. This is in agreement with Huajun and Van Ranst [7] who found that the parametric method is less precise than a fuzzy set based classification method, but it produces coefficients of determination above 0.80 for the correlation between land index and observed maize yields in China. On the other hand, the ME and MAE of both crops suggest that the evaluation method cannot account, for example, for rainfall variability within a monthly scale or management fine tuning such as weeding frequency or partial resowing. The climate requirements, so far available only for monthly periods, should be adjusted to and calculated on a decadal basis, because especially in these dry areas the rainfall is extremely erratic and dry spells of only 15 days during the growing cycle of only three months may have a significant impact on crop yield. Probably the most critical problem is generated through the simplified multiplication of minimum factors, which thus “account for” the interactions between agro-ecological factors [1]. However, in view of the great climate and soil heterogeneity, more detailed numerical models were not expected to yield better results on the regional scale.

### 4. CONCLUSIONS

The parametric FAO/ITC-Ghent evaluation method is essentially based on mathematical functions and a large range of single climate and soil factors. Depending on the climatic zone, different factors are rated and multiplied for a final land suitability index. Since neither the factor sets proposed for humid nor for arid zones provided reasonable land indices for pearl millet and cowpea in the semi-arid regions of Niger and Brazil, a modification of the original method was applied. When the modified evaluation procedure in connection with crop

<table>
<thead>
<tr>
<th>Crop</th>
<th>Crop requirements used to calculate the LI</th>
<th>ME</th>
<th>MAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpea</td>
<td>Sys et al. [20]</td>
<td>$-0.8$</td>
<td>$+14.2$</td>
</tr>
<tr>
<td></td>
<td>modified</td>
<td>$+2.9$</td>
<td>$+12.1$</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>Sys et al. [20]</td>
<td>$+5.9$</td>
<td>$+9.0$</td>
</tr>
<tr>
<td></td>
<td>modified</td>
<td>$+5.1$</td>
<td>$+5.1$</td>
</tr>
</tbody>
</table>

**Table V.** Mean error (ME) and mean absolute error (MAE) of the land index (LI) in relation to the yield index (assuming that land index and yield index should be equal).
requirements provided by Sys et al. [20] was used for calculating the land index for locally adapted cowpea and millet cultivars, the calculated land indices were still too low and the correlation between land index and crop yield was unsatisfactory, particularly in the case of pearl millet. The coefficient of determination for the relationship improved when the crop requirements where adapted to the characteristics of local crop varieties. After modifying the evaluation methodology and adjusting the crop requirements to the local settings, the modified parametric method proved to be sufficiently accurate for the assessment of land suitability and yield for cowpea and millet at the regional level. It is most likely that the accuracy of the evaluation in semiarid environments would improve further by increasing the resolution of the crop requirements for precipitation from monthly to weekly time steps. However, when new crops or specially adapted varieties are to be evaluated, recalibration based on local knowledge is required.

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