

The determination of the natural agricultural potential of Benin

Détermination du potentiel agricole naturel du Bénin

Röhrig J., Menz, G. & H.-P. Thamm

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The Aim

Agricultural productivity is determined and limited by a combination of the natural environment and technical measures. In Benin, where non-capital intensive management can be assumed, natural potentials and constraints are of specific importance for agricultural land use and its productivity. CASSEL-GINTZ et al. (1997) have developed the so-called *marginality index for agricultural land use* to assess the naturally based agricultural potential of a region and the risk of environmental degradation due to agriculture on a global scale with a spatial resolution of $0.5^\circ \times 0.5^\circ$ (about 50 km in Benin). This index is used to evaluate the natural agricultural potential of Benin. This study focuses on the appropriateness of the input variables and the fuzzy-logic based algorithm on a national scale using an iterative approach. To increase the spatial resolution and incorporate actual processes and trends, high temporal and spatial resolved data achieved from remote sensing are interesting and embedden tools.

The Approach

For the evaluation of the marginality index, several natural constraints limiting agriculture were quantified and summed in one integrative index: low natural plant production, restrictions in order to temperature or light, high aridity, precipitation uncertainty, water limitation, poor soils and the risk of erosion due to the steepness of slopes. Beyond these constraints, irrigation capacity near inshore waters (to overcome natural aridity) has been taken into account, as it can be implemented even with low capital input. Following CASSEL-GINTZ et al. (1997), for the incorporation of the variables, these six input data sets were used:

1. Net primary productivity of potential natural vegetation (NPP)
2. Aridity coefficient μ_{α}
3. Internal variability of the seasonal precipitation pattern (PV)
4. Potential irrigation capacity
5. Soil fertility
6. Slope

In a first step of the iterative approach (see Fig.1), comparable input data sets in a higher resolution were set up. In a second step, these six base variables had to be fuzzyfied. This means that a degree of membership of linguistic categories (high or low) have to be defined for each limiting factor in order to its contribution to the marginality of agricultural production (see Fig. 2). In a third step these variables are implemented within a decision tree summarising the qualitative arguments for or against marginality (Fig. 3).

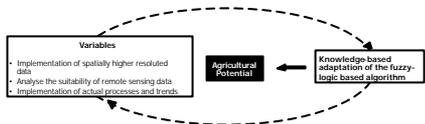


Fig. 1: The iterative approach to evaluate the agricultural potential

Fig. 1: L'approche itérative pour évaluer le potentiel agricole naturel du Bénin

Knowledge-based adaptation of the fuzzy-logic based algorithm

Knowledge gathered within the IMPETUS-Project together with information from the literature was used to adapt the fuzzy-logic based algorithm for the higher resolved input data. Figure 2 illustrates the adaptation of the algorithm exemplary for the variable 'soil fertility'. LEEMANS AND VAN DEN BORN (1994) have developed a soil properties database based on the soil classification of the global soil map by ZOBLER (1986). From this classification scheme, the fertility factor S_f was chosen to determine the soil marginality.

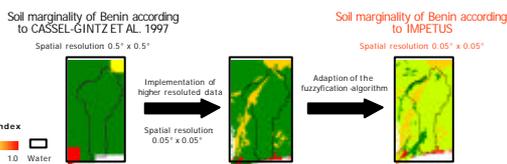
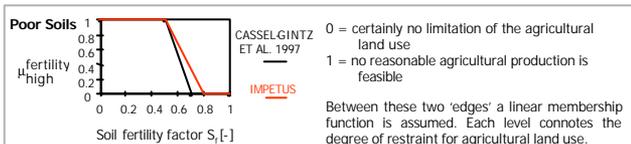


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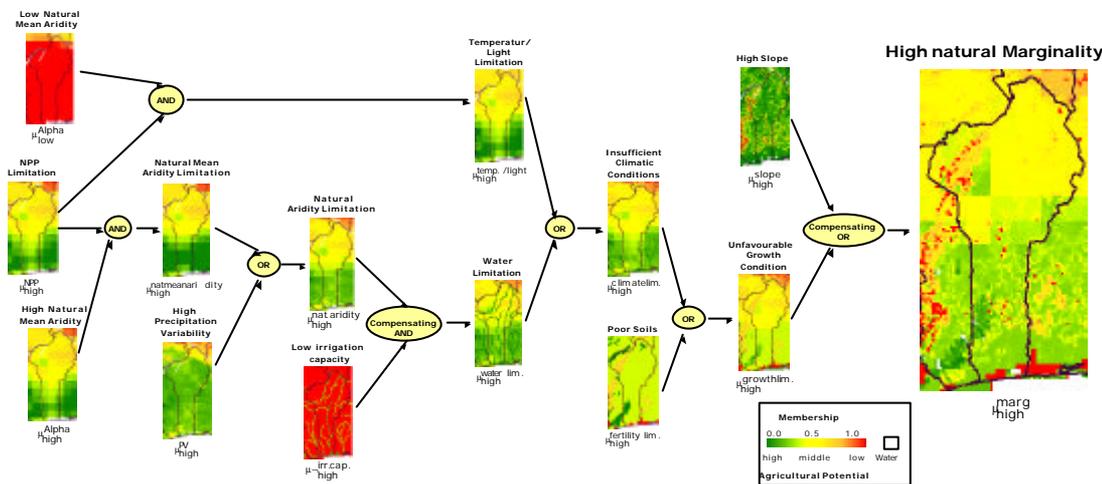


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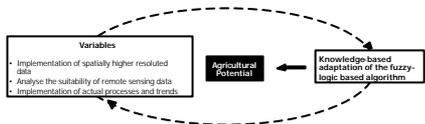


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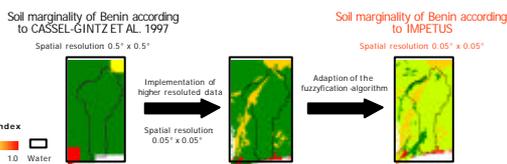
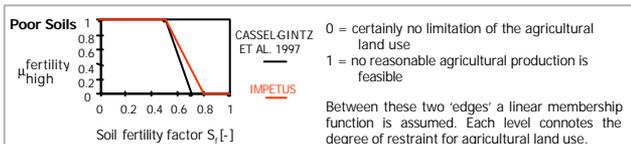


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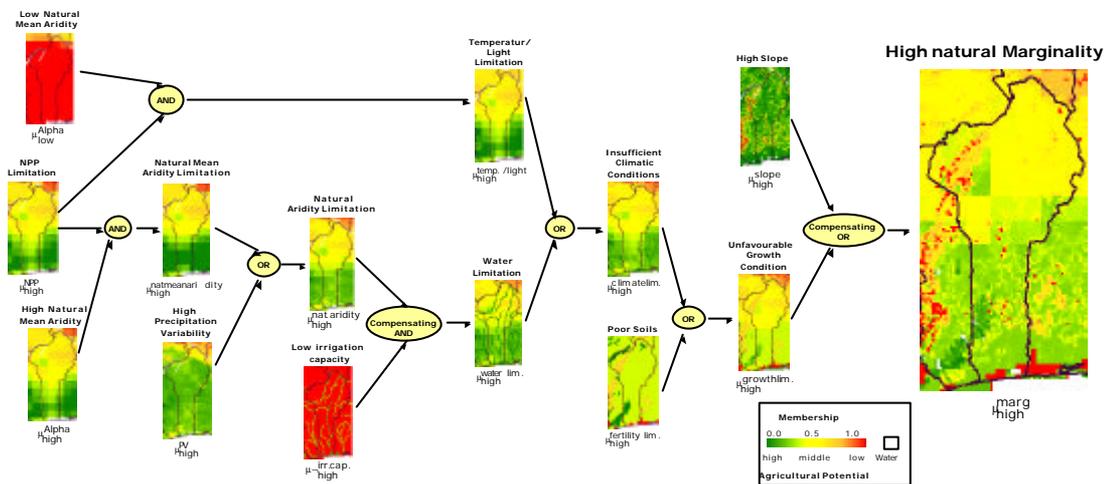


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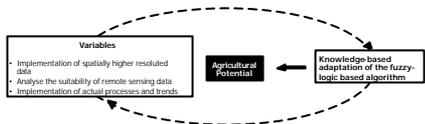


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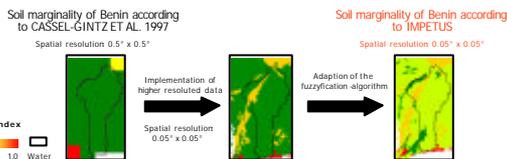
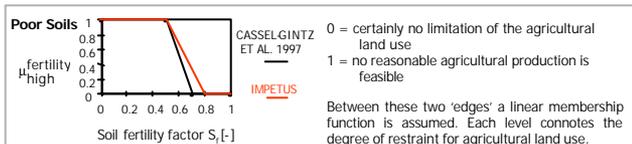


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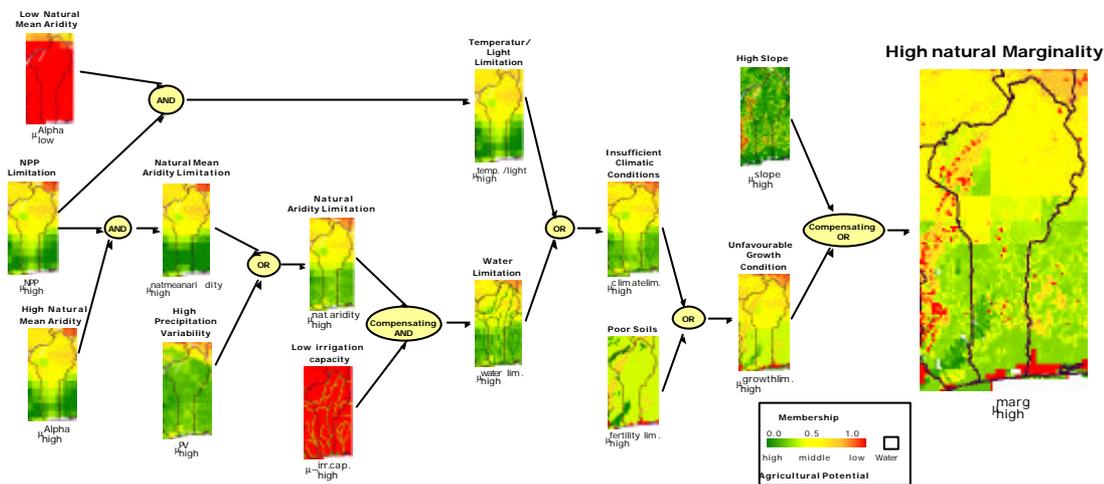


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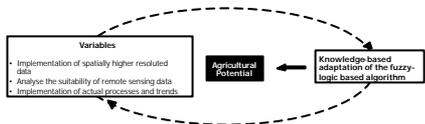


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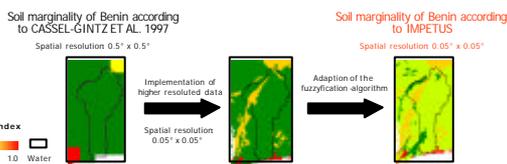
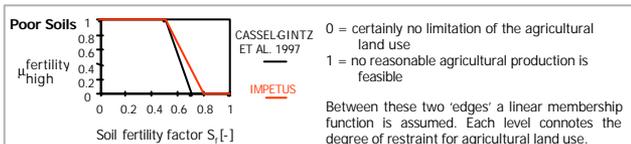


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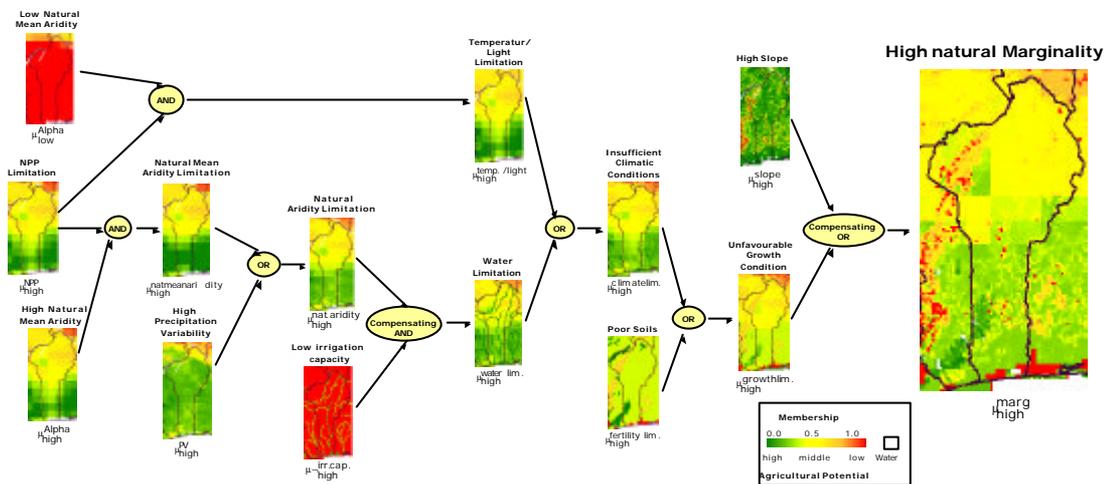


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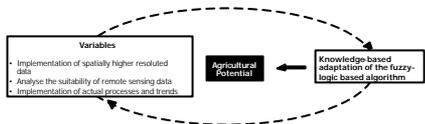


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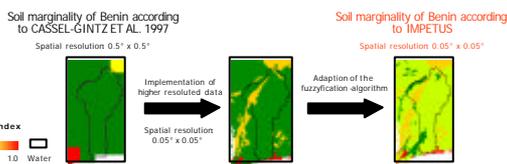
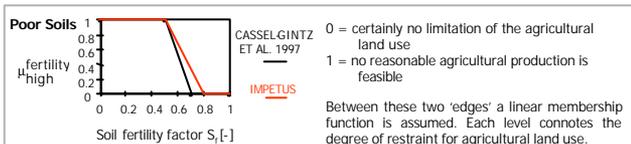


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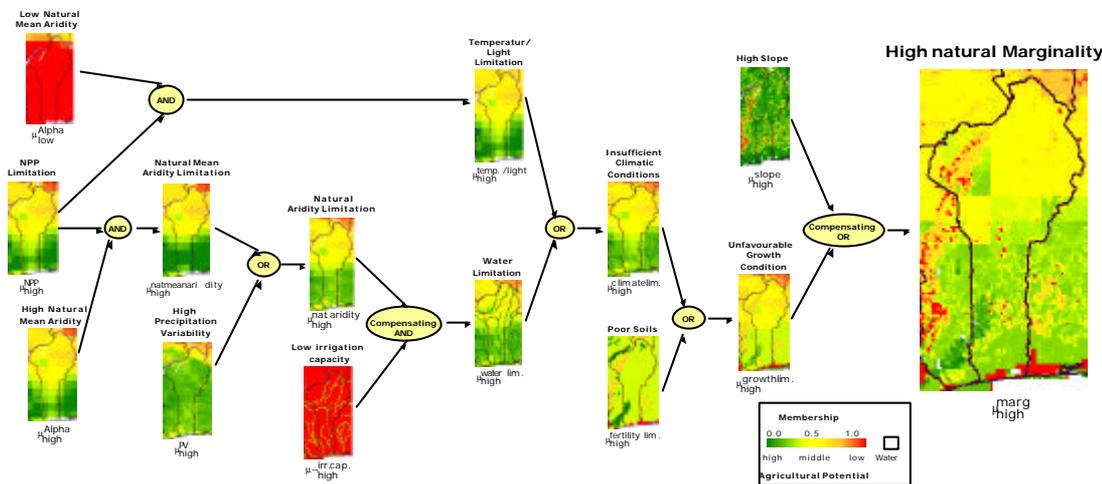


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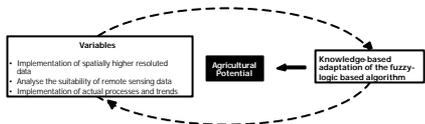


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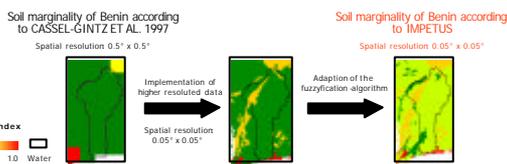
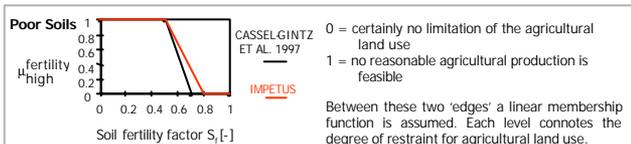


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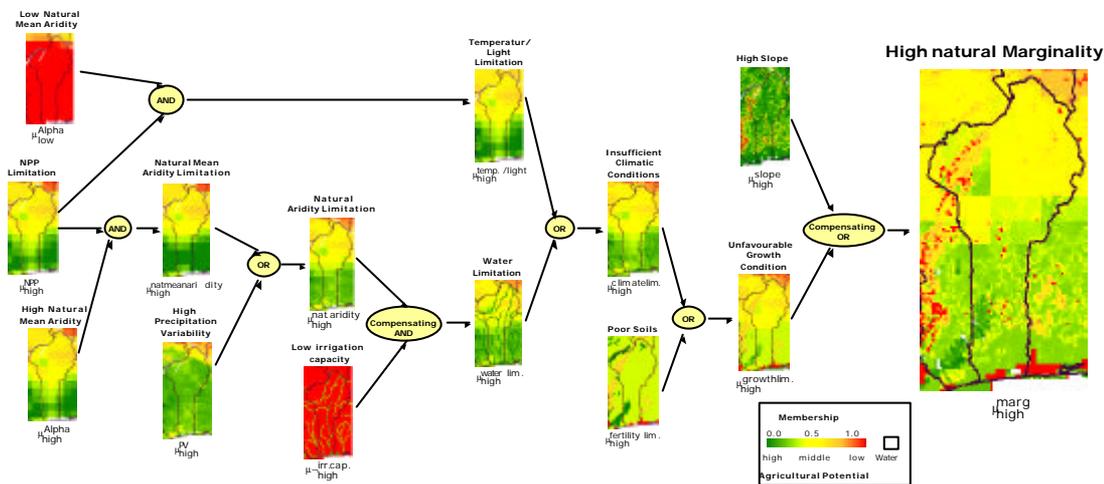


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Détermination du potentiel agricole naturel du Bénin

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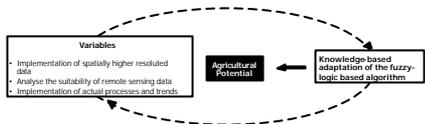


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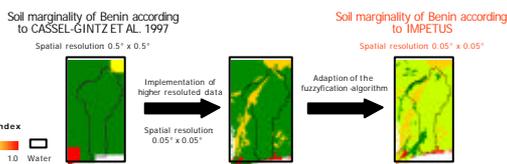
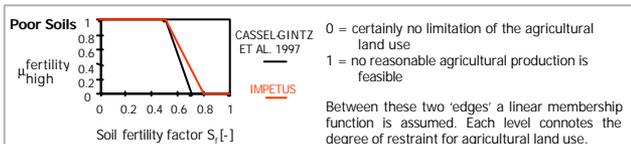


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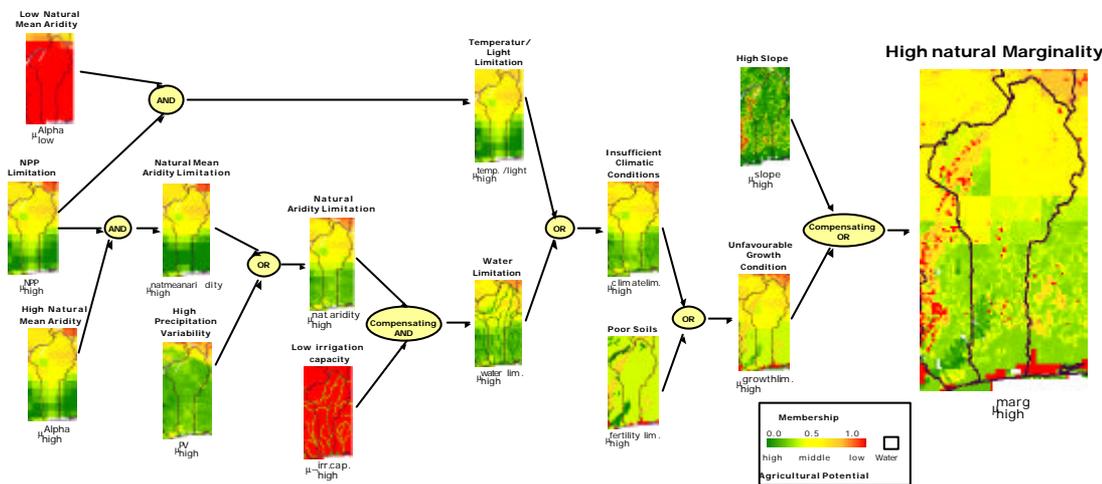


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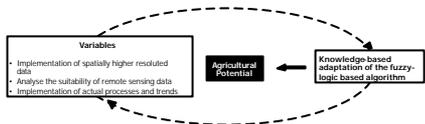


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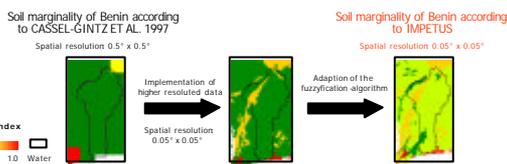
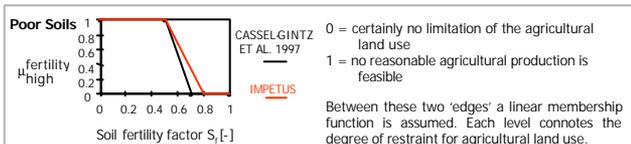


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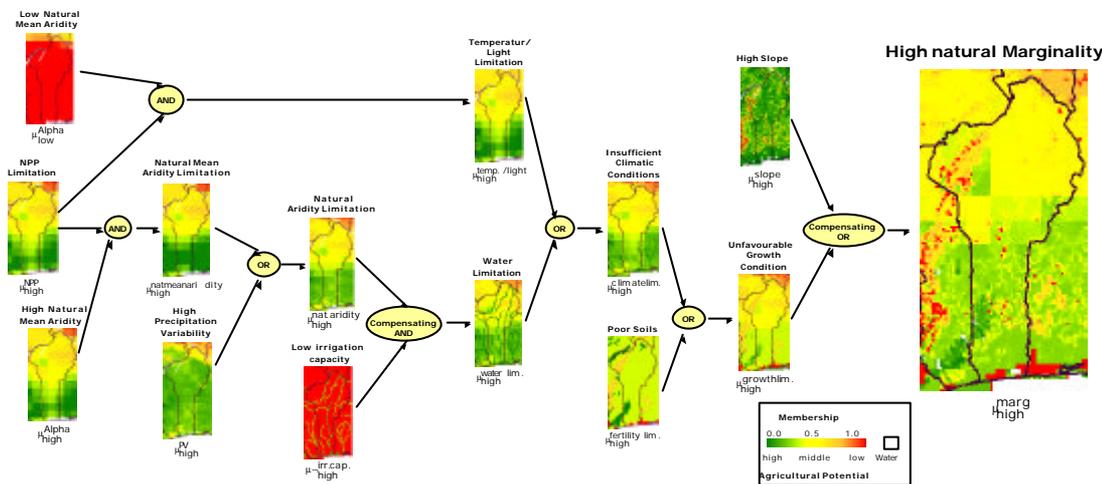


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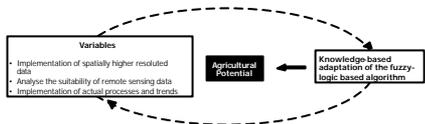


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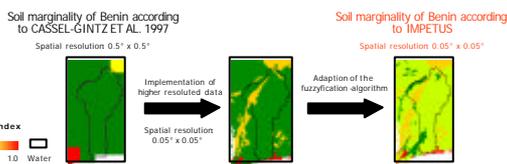
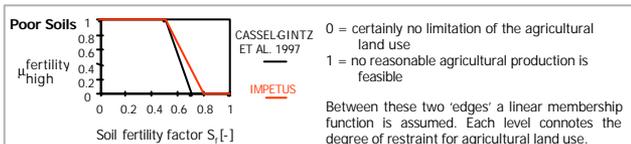


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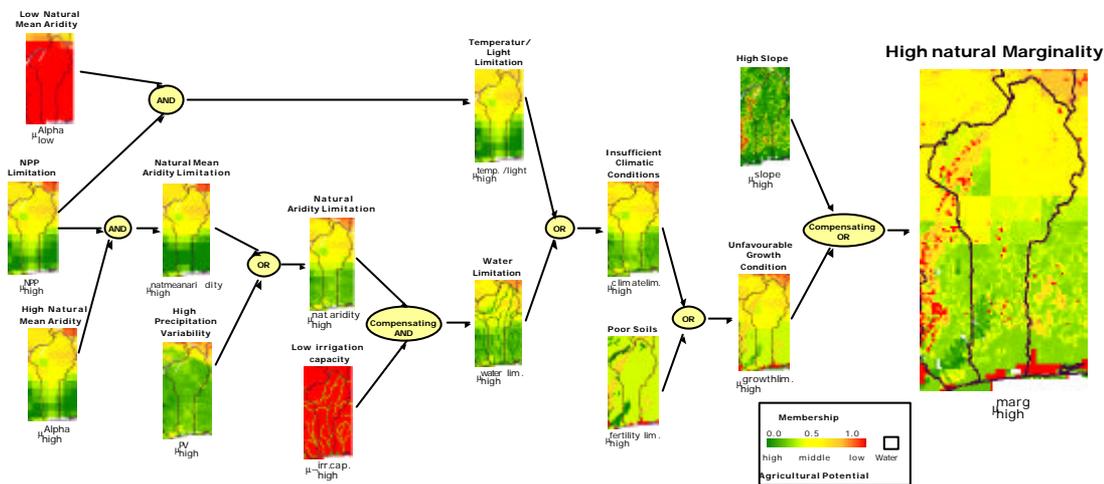


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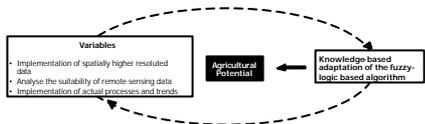


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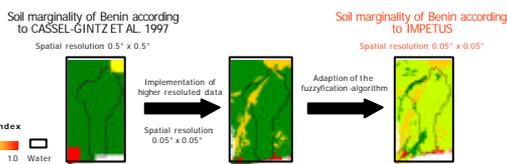
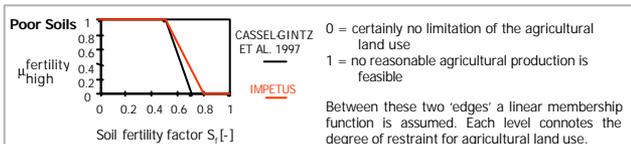


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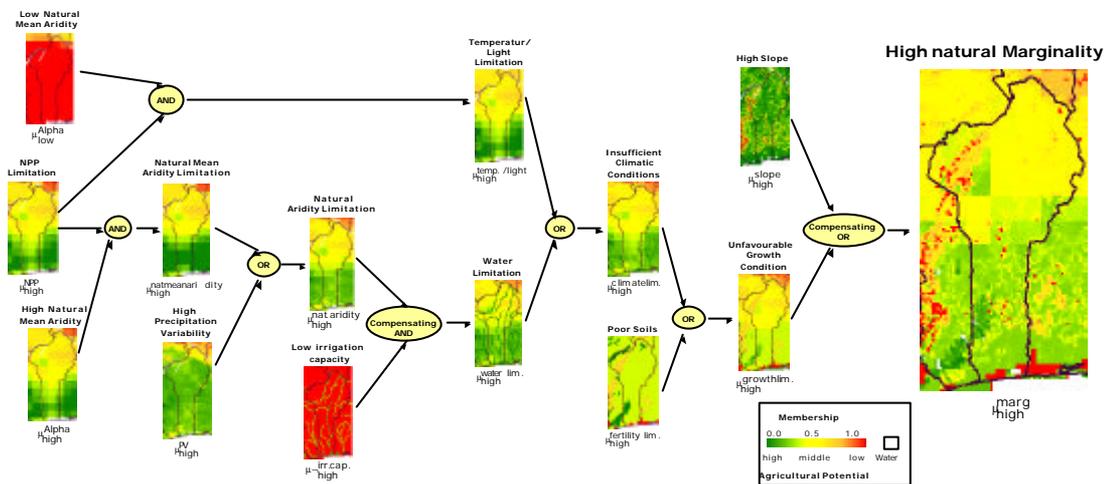


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1. Net primary productivity of potential natural vegetation (NPP)
2. Aridity coefficient μ_{α}
3. Internal variability of the seasonal precipitation pattern (PV)
4. Potential irrigation capacity
5. Soil fertility
6. Slope

In a first step of the iterative approach (see Fig.1), comparable input data sets in a higher resolution were set up. In a second step, these six base variables had to be fuzzyfied. This means that a degree of membership of linguistic categories (high or low) have to be defined for each limiting factor in order to its contribution to the marginality of agricultural production (see Fig. 2). In a third step these variables are implemented within a decision tree summarising the qualitative arguments for or against marginality (Fig. 3).

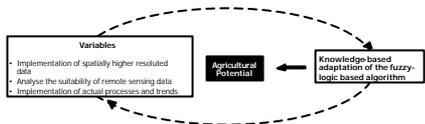


Fig. 1: The iterative approach to evaluate the agricultural potential

Fig. 1: L'approche itérative pour évaluer le potentiel agricole naturel du Bénin

Knowledge-based adaptation of the fuzzy-logic based algorithm

Knowledge gathered within the IMPETUS-Project together with information from the literature was used to adapt the fuzzy-logic based algorithm for the higher resolved input data. Figure 2 illustrates the adaptation of the algorithm exemplary for the variable 'soil fertility'. LEEMANS AND VAN DEN BORN (1994) have developed a soil properties database based on the soil classification of the global soil map by ZOBLER (1986). From this classification scheme, the fertility factor S_f was chosen to determine the soil marginality.

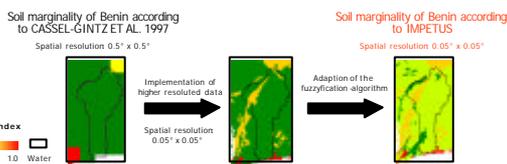
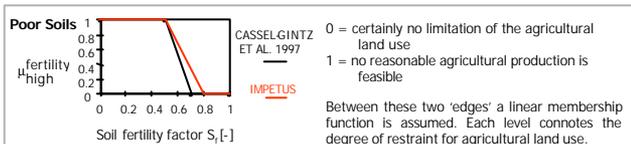


Fig. 2: Knowledge-based adaptation of the variable soil fertility

Fig. 2: Adaptation de la variable fertilité du sol à partir des connaissances

Results

The agricultural potential were calculated using the marginality index of agricultural land use for Benin with a spatial resolution of $0.05^\circ \times 0.05^\circ$. Whenever possible higher resolved input variables had been used than those of the original determination by CASSEL-GINTZ et al. (1997). In comparison with the global results, theregionalization comes out with a more detailed representation of the natural conditions and constraints of the agricultural production. Variables derived from remote sensing like NDVI images or digital elevation models are due to their high temporal and spatial resolution interesting and embolden tools.

Nevertheless, the determination process has to be considered as an iterative method, which is still in progress. Further investigations will be the evaluation of the results and the implementation of socio-economic variables to model the agricultural potential.

Reference:

- CASSEL-GINTZ, M. A. ET AL. (1997): Fuzzy logic based global assessment of marginality of agricultural land use. In: *Climate Research* 8 (2), P. 135-150.
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Acknowledgement

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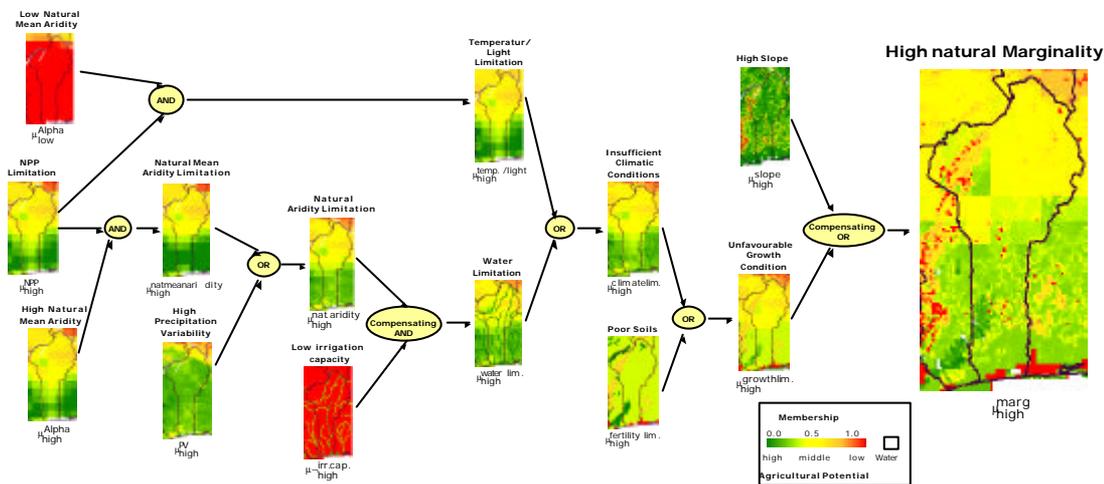


Fig. 3: Decision tree for the determination of the marginality index (Source: modified after CASSEL-GINTZ et al. 1997:138)

Fig. 3: Arbre de décision pour la détermination de l'indice de marginalité (Source: adapté de CASSEL-GINTZ et al. 1997:138)

The determination of the natural agricultural potential of Benin

Détermination du potentiel agricole naturel du Bénin

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The Aim

Agricultural productivity is determined and limited by a combination of the natural environment and technical measures. In Benin, where non-capital intensive management can be assumed, natural potentials and constraints are of specific importance for agricultural land use and its productivity. CASSEL-GINTZ et al. (1997) have developed the so-called *marginality index for agricultural land use* to assess the naturally based agricultural potential of a region and the risk of environmental degradation due to agriculture on a global scale with a spatial resolution of $0.5^\circ \times 0.5^\circ$ (about 50 km in Benin). This index is used to evaluate the natural agricultural potential of Benin. This study focuses on the appropriateness of the input variables and the fuzzy-logic based algorithm on a national scale using an iterative approach. To increase the spatial resolution and incorporate actual processes and trends, high temporal and spatial resolved data achieved from remote sensing are interesting and embolden tools.

The Approach

For the evaluation of the marginality index, several natural constraints limiting agriculture were quantified and summed in one integrative index: low natural plant production, restrictions in order to temperature or light, high aridity, precipitation uncertainty, water limitation, poor soils and the risk of erosion due to the steepness of slopes. Beyond these constraints, irrigation capacity near inshore waters (to overcome natural aridity) has been taken into account, as it can be implemented even with low capital input. Following CASSEL-GINTZ et al. (1997), for the incorporation of the variables, these six input data sets were used:

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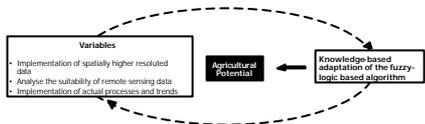


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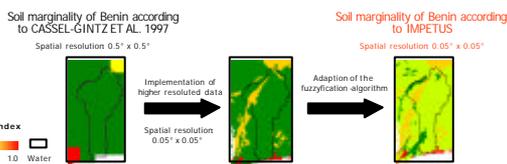
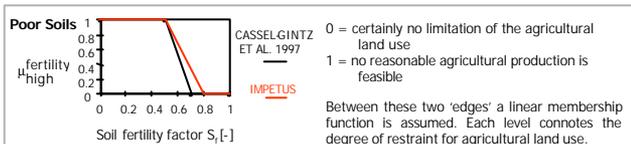


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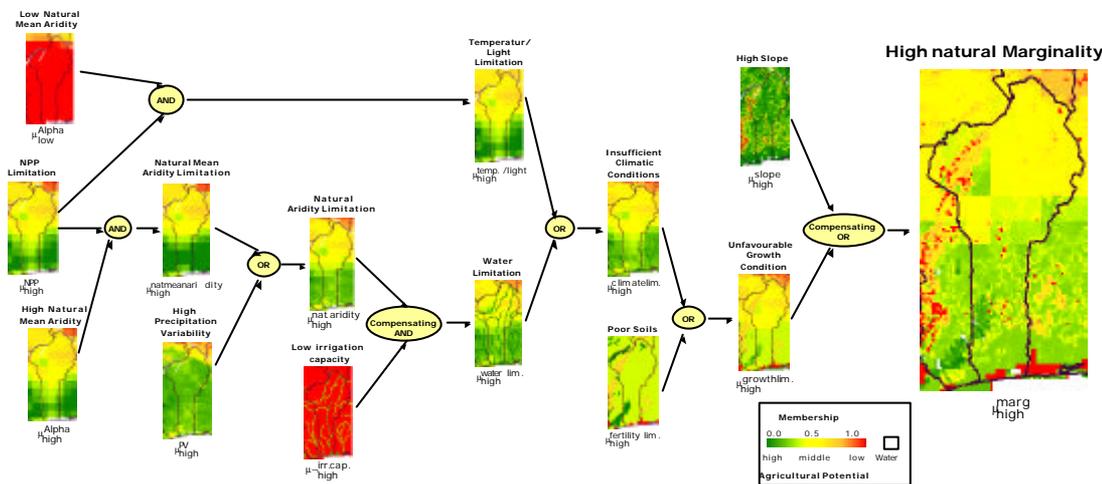


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