A Conceptual Framework to Quantify the Influence of Soil, Land Use and Vegetation Heterogeneity on Soil Water Balances and Dynamics along the Okavango River Basin

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Introduction and aim of this framework

In the semiarid and arid regions of the Okavango Basin, leading from the central highlands of Angola over the Kavango Region in Namibia to its delta in Botswana, the Soil-Plant-Atmosphere Continuum (SPAC) plays a predominant role in the modification and partitioning of the soil water dynamics and balances. Several studies showed that up to 98% of the water input will be transferred back to atmosphere where only minor parts remain in deeper soil horizons or lead to groundwater recharge. The aim of this study is to develop a framework to analyse and asses the soil hydrological impact of site specific soil types and their distribution in combination with vegetation and land use characteristics. To derive soil hydrological properties, onsite soil surveys and soil hydrological measurement techniques together with laboratory experiments are applied. A nested modelling (1-D in 2-D) approach calibrated with field measurements (1-D) and validated with model outputs (2-D) give detailed information about point and site specific soil water balances.
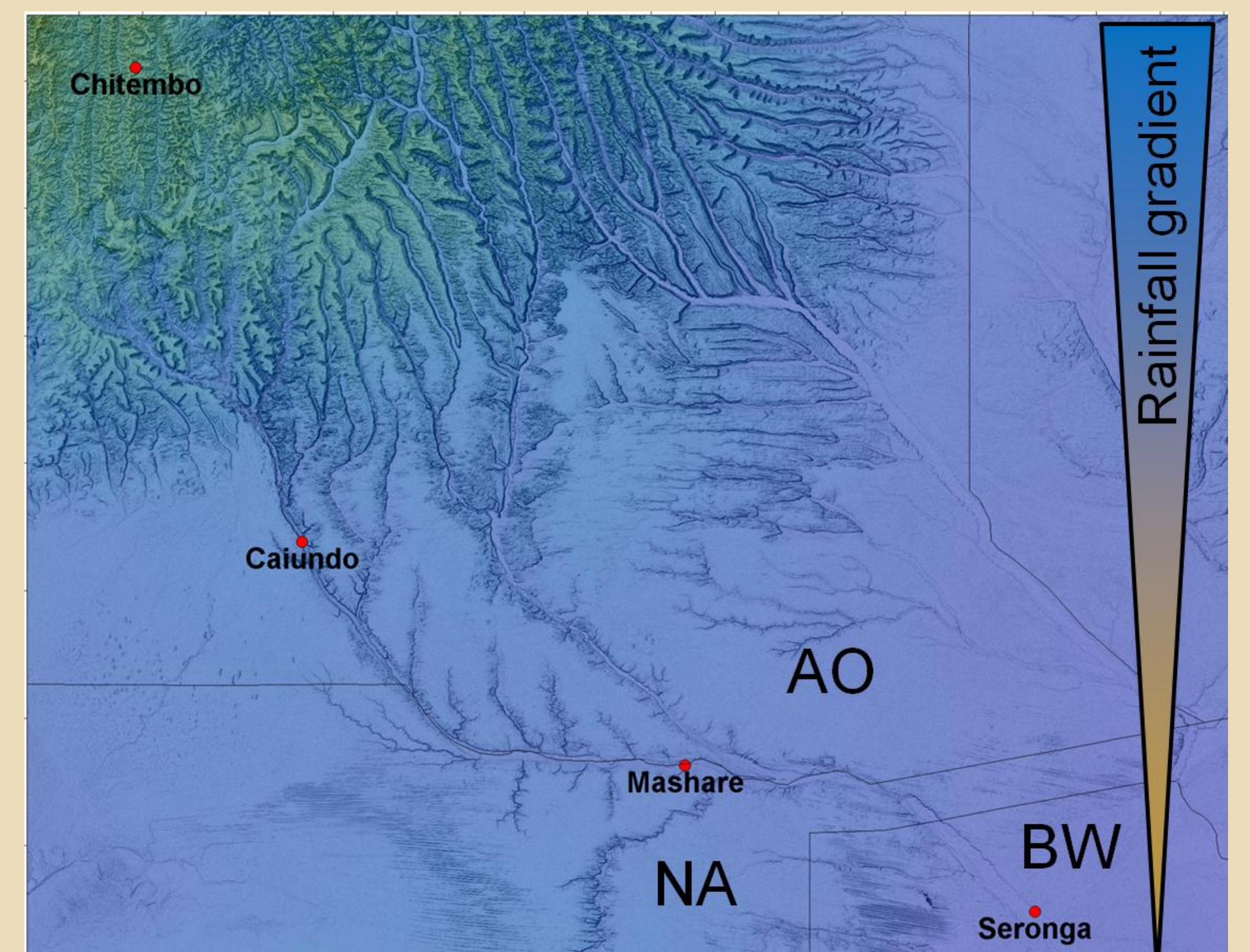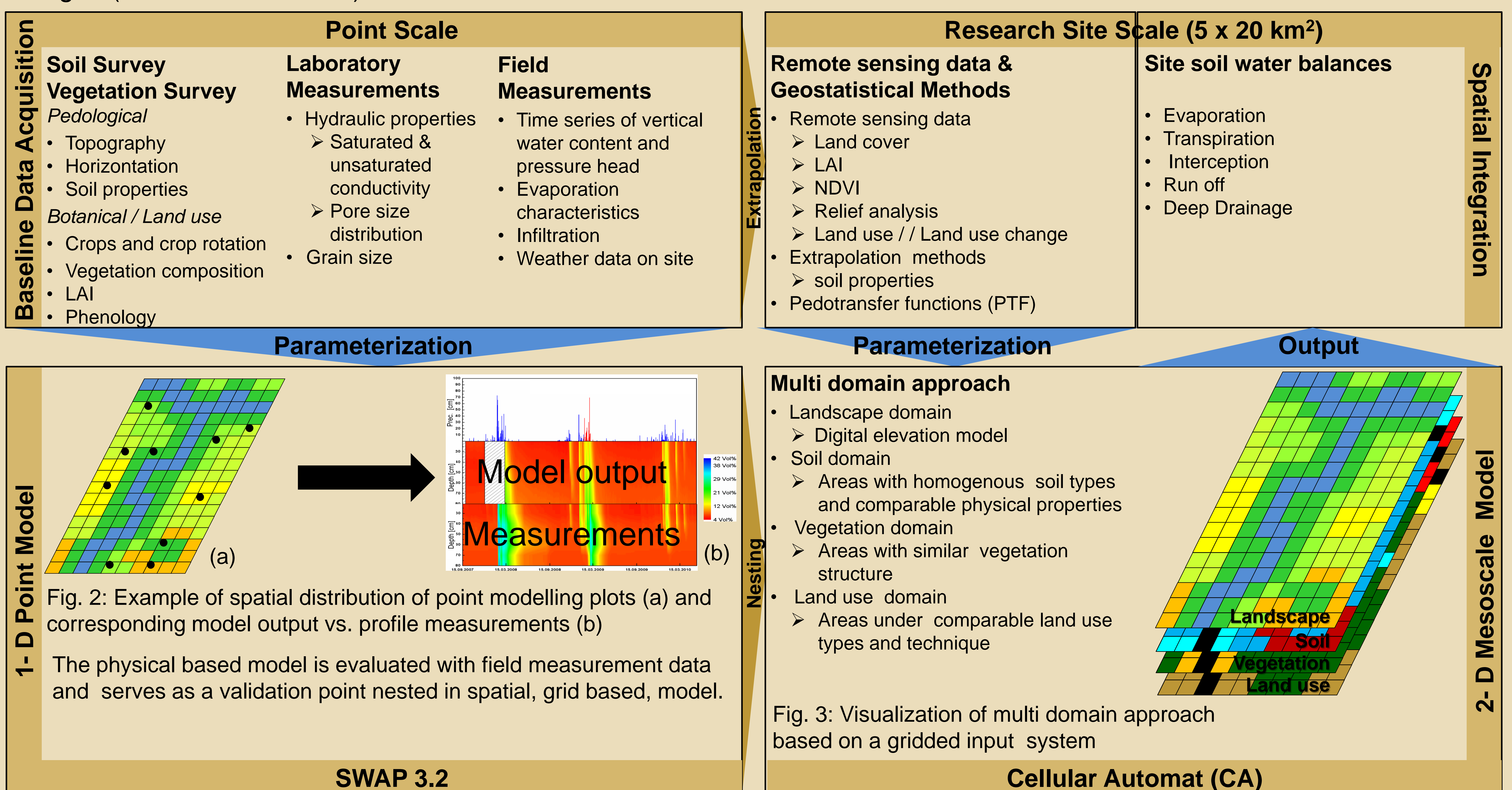

Fig. 1: Map showing the four research sites

Study sites

The study sites with 5 x 20 km² extend each are located along the Okavango riverside near *Chitembo* (northern Angola), *Caiundo* (southern Angola), *Mashare* (Namibia) and *Seronga* (Botswana) following a precipitation gradient with appr. 1500 mm in Chitembo and 350 mm in Seronga (Fig. 1). Soil substrates are dominated by deep Kalahari Sands in Botswana, southern Angola and Namibia where the north Angolian site shows tropical weathering of granites.

Methodology

All research sites are prestratified according to their geomorphological landscape structure as basis for the soil survey and the field measurements. The stratification based on a 300 m point grid over up to date areal photographs or satellite images (SPOT and Landsat).

Point Scale

Baseline Data Acquisition

Soil Survey
Vegetation Survey
Pedological
- Topography
- Horizontation
- Soil properties

Botanical / Land use
- Crops and crop rotation
- Vegetation composition
- LAI
- Phenology

Laboratory Measurements
- Hydraulic properties
  - Saturated & unsaturated conductivity
  - Pore size distribution
- Grain size

Field Measurements
- Time series of vertical water content and pressure head
- Evaporation characteristics
- Infiltration
- Weather data on site

Research Site Scale (5 x 20 km²)

Extrapolation

Remote sensing data & Geostatistical Methods
- Remote sensing data
  - Land cover
  - LAI
  - NDVI
  - Relief analysis
  - Land use / / Land use change
- Extrapolation methods
  - soil properties
- Pedotransfer functions (PTF)

Site soil water balances

Spatial Integration
- Evaporation
- Transpiration
- Interception
- Run off
- Deep Drainage

Parameterization

1- D Point Model

(a)

Model output

Measurements

(b)

Fig. 2: Example of spatial distribution of point modelling plots (a) and corresponding model output vs. profile measurements (b)

The physical based model is evaluated with field measurement data and serves as a validation point nested in spatial, grid based, model.

SWAP 3.2

Parameterization **Output**

Nesting

Multi domain approach
- Landscape domain
  - Digital elevation model
- Soil domain
  - Areas with homogenous soil types and comparable physical properties
- Vegetation domain
  - Areas with similar vegetation structure
- Land use domain
  - Areas under comparable land use types and technique

Landscape
Soil
Vegetation
Land use

Fig. 3: Visualization of multi domain approach based on a gridded input system

2- D Mesoscale Model

Cellular Automat (CA)

Outlook

Within the project "The Future Okavango" the modelled as well as the measured soil hydrological data will be used as input parameter for a socio-economic valuation of Ecosystem Services and Functions (ES&F) in the Okavango catchment. The ongoing data acquisition started in 2010 and will be carried out the next two years.