Development of land-cover classification focusing on wetlands impacted by subsistence farming using satellite remote sensing

Matze Riedel¹, T. Schneider², J. Kollmann¹, N. Guerrero Moreno¹, J. Simonis³, L. Pretorius⁴

¹Chair of Restoration Ecology, Technische Universität München
²Institute of Forest Management, Technische Universität München
³Department Hydrology, University of Zululand
⁴Centre for Environmental Management, University of the Free State

National Wetlands Indaba 2015, Worcester, South Africa
23.10.2015

Outline

Study Area Manguzi / Maputaland Coastal Plain

State of wetlands and their meaning for local population

Objectives for and of land-cover classification

Details on classification of imagery

Details on land-use and its patterns

Improvements & Applications
Maputaland / Manguzi

Climate

hot, wet summer - mild, drier winter -> (sub)-tropical

60% of rainfall in summer - mean annual sum of 960 mm

Pretorius (2012), Grundling (2014)
Biodiversity hotspot and human population

Maputaland Centre -> African biodiversity hotspot

Population depending on wetlands: food, building material, ...

Wetland degradation through intensified land-use

Pretorius (2012), Grundling (2014)

Lancover classification objectives

Assess the possibility of classifying particularly wetlands according to an adapted classification system using multitemporal, multispectral and multisource satellite imagery

(1) Complete land-cover classification

(2) Wetland specific classification

(3) Overview of land-cover/-use in area

(4) Assessment of land-use patterns
Methods, Systems and Models

(1) Classification system

(2) Imagery preprocessing and selection
Campbell and Wynne (2011)

(3) Supervised pixel-based classification via RandomForest
Ozesmi and Bauer (2002), Geranreche, Lefebvre et al. (2010), Adam, Mutanga et al. (2010).

(4) Evaluation of land-use and its patterns

(1) Classification system
Based on Thompson (1996), with extension for wetlands by Rivers-Moore & Goodman (2010)

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Definition (summarised)</th>
<th>Source</th>
<th>Code name</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wetlands</td>
<td>Full topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Thompson (1996)</td>
<td>B</td>
<td>A1</td>
</tr>
<tr>
<td>10</td>
<td>Non-wooded wetlands</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Rivers-Moore &amp; Goodman (2010)</td>
<td>Z</td>
<td>A1</td>
</tr>
<tr>
<td>110</td>
<td>Tall grassland / reed / sedge wetland</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage differs between grass, sedge and bulrush.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Z</td>
</tr>
<tr>
<td>111</td>
<td>Short grassland / reed / sedge wetland</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Z</td>
</tr>
<tr>
<td>123</td>
<td>Swamp Forest</td>
<td>12-17 m tall forests with two main strata (canopy and shrub layers). The dominating tree is Ficus trichopoda. It may include Barringtonia racemosa, Casearia gladiiformis, Cassipourea gummiflua, Syzygium cordatum, Phoenix reclinata and groups of Raphia australis.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Z</td>
</tr>
<tr>
<td>20</td>
<td>Cultivation, subsistence, dryland</td>
<td>Identifies areas of scattered or clustered, small-scale, dryland cultivation for local or household consumption, typically associated with rock outcrops or river courses. Cultivation of e.g. potatoes on rock outcrop soils.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Z</td>
</tr>
<tr>
<td>21</td>
<td>Cultivation, subsistence, wetland</td>
<td>Areas of scattered or clustered, small-scale, wetland cultivation for local or household consumption, associated with wetland classes. Cultivation of e.g. bananas on wetland soils.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Z</td>
</tr>
<tr>
<td>30</td>
<td>Residential/</td>
<td>Residences located and built up areas, preferably of individual residential, commercial or industrial use, defined in terms of local high density.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Found typically along edges of other seasonal pools or marsh depressions as well as fringing channels. Foliage distinguishes reed/bulrush from sedges.</td>
<td>Z</td>
</tr>
</tbody>
</table>
(2) Satellite and training data

2x SPOT4 - 4x SPOT5 - 1x WorldView2

Field data: 409 training areas - 202 validation areas

(3) Supervised pixel-based classification

52 bands --> 40 index bands of 8 different indices (NDVI, NGRDI, NDMI, NHFD, ...)

Final prediction via RandomForest (R) using 25 variables

Take the output of random forests not as absolute truth, but as smart computer generated guesses that may be helpful in leading to a deeper understanding of the problem.

Breiman A Cutler
General land-cover classification

Accuracy: 77.8%
\[ \kappa = 0.7438 \]

Wetland specific classification

Accuracy: 87.06%
\[ \kappa = 0.7927 \]
(4) Wetland use

Refinement of wetland classification with probability based 'wetland seeds' and 'wetland systems'

- Wetland cultivation in 13.6% of the total wetland area
- 45.0% of wetland systems under agricultural use
- 23.2% of wetland systems dominated by agricultural use

(4) Wetland use and landcover patterns

Monte Carlo CSR analysis using Ripley's K and pcf function

Assessing spatial interdependence of 'settlement' and 'wetland cultivation' features

Reflection of socio-ecologic survey: Increased settlement density 5 minutes walking from wetland gardens

Guerrero Moreno (2014)
Improvements & Applications

Confusions in (swamp) forest classes
Delineation of wetland gardens

Analysis regarding Eucalyptus plantations

von Röder (2014)

Ngiyabonga ngokuqaphela
Dankie vir jou aandag
Thank you for your attention

Thanks also to all partners and supporters of this project and study:
References


