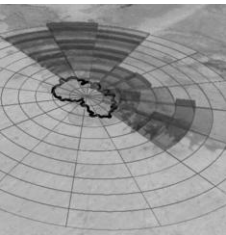
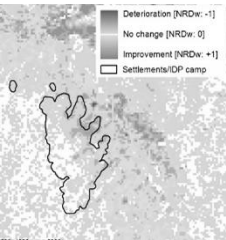


A modular approach for the assessment of LULC changes around refugee and IDP camps by remote sensing

Michael Hagenlocher^{1,2}, **Lorenz Wendt**¹, Dirk Tiede¹ and Stefan Lang¹

¹Department of Geoinformatics – Z_GIS, University of Salzburg / Austria

²Institute for Environment and Human Security (UNU-EHS), United Nations University / Germany



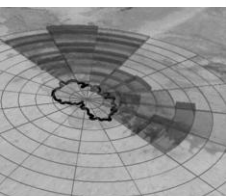
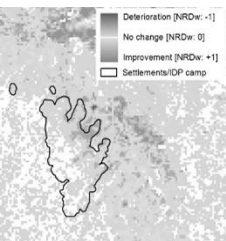
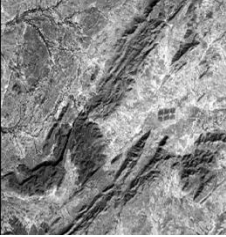
The EO4HumEn project

→ support humanitarian action by geospatial information products
 Cooperation of ZGIS + FB GEO SBG, MSF Austria, Uni Tübingen

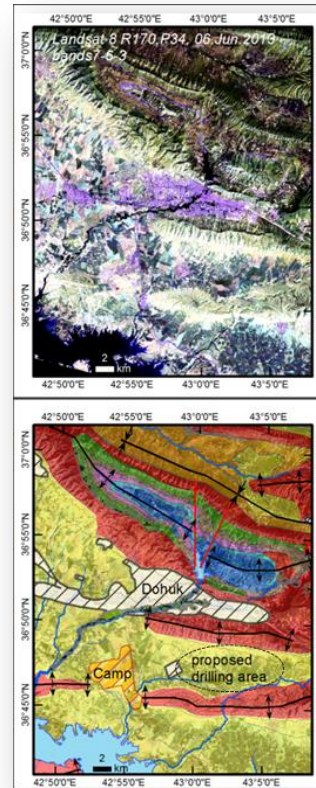
Population Monitoring

Groundwater

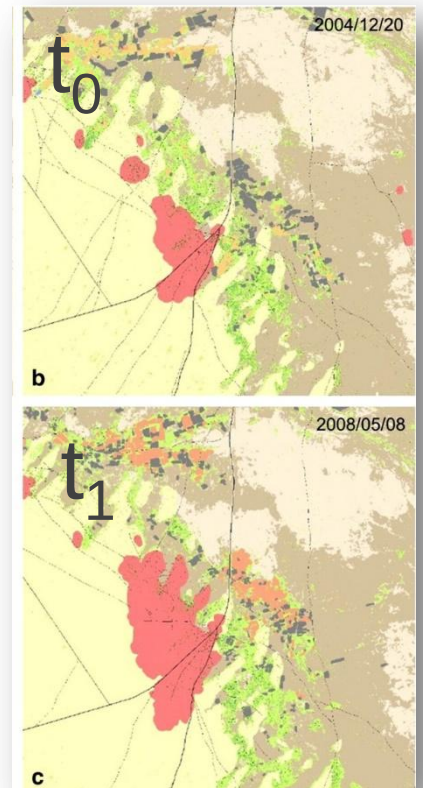
Environment



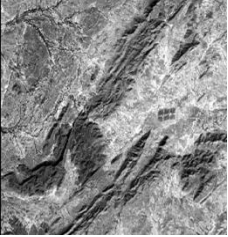
OBIA on VHR data



Geological mapping



LULC change



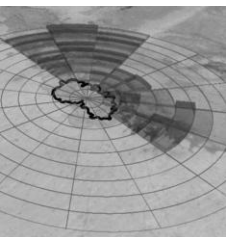
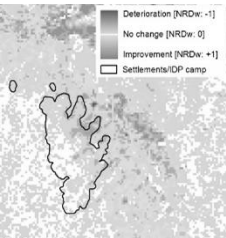
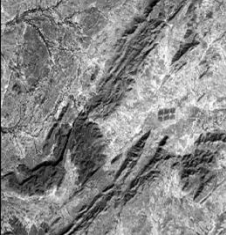
Environmental Impact of Refugee/IDP Camps



- **Natural resources play a vital role for the well-being of the population** of refugee and internally displaced persons (IDP) camps.
- Living conditions in camps are often characterized by **limited availability of these resources** (e.g. construction materials, fuel for cooking, etc.)
- Inhabitants are **forced to rely on available natural resources in the vicinity of the camps** to sustain their living (if allowed)
- Evidence has shown that for these reasons such camps often have **significant impacts on the environment**:
 - Severe deforestation, desertification, land degradation, unsustainable groundwater extraction and water pollution are impacts that can be observed in the surroundings of many camps, often within a radius of up to 15 km.
- Next to contributing to suffering and violence in these camps, the **continued overuse and the uncontrolled exploitation of resources** may **lead to conflict with the host community** and cause severe damage to local ecosystems.

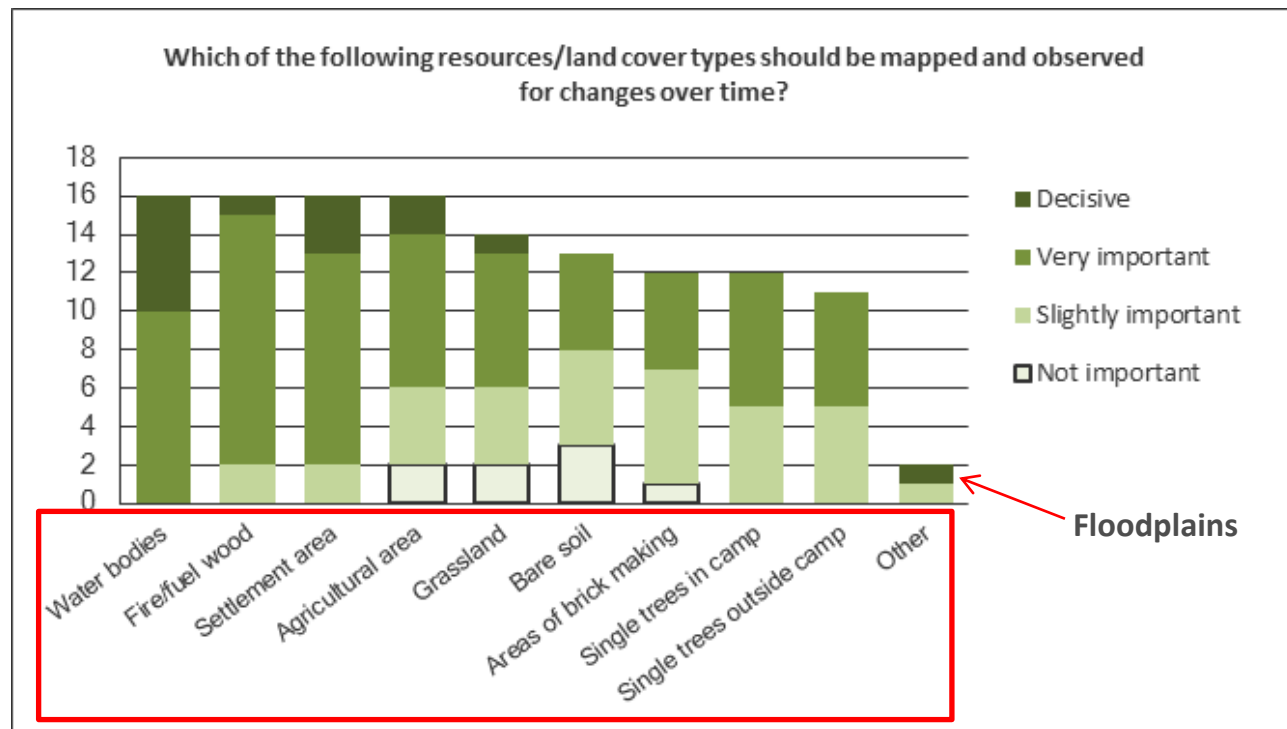
Environmental Impact of Refugee/IDP Camps

- Therefore, the assessment of the environmental impact of refugee/IDP camps is important to
 - organize the use of natural resources in a sustainable manner
 - mitigate possible conflicts with host communities due to uncontrolled exploitation of natural resources
- Within EO4HumEn a multi-stage EO-based approach is developed to assess and monitor environmental changes in the surrounding of refugee/IDP camps:
 1. Rapid overview analyses
 2. Detailed land cover change investigations
 3. Evaluation of the implications of observed environmental changes for human well-being and ecosystem integrity



Which land cover classes should be monitored?

Result from survey (n=16 (of 80); MSF and others (UN, Red Cross)):



Objectives

What do we ideally want to find out? What are we able to find out?

Example: Wood (construction materials, fuel for cooking)

Land cover classes (e.g. woody vegetation) or estimation
through simple ratios (e.g. NDVI)

HR imagery



Canopy Cover
(tree crown area/surface area)

VHR imagery



Biomass

Can be assessed by remote sensing

Cannot be easily measured

Available amount of fuelwood,
wood for construction

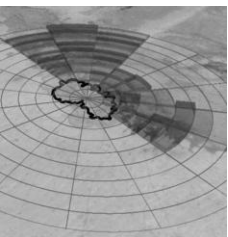
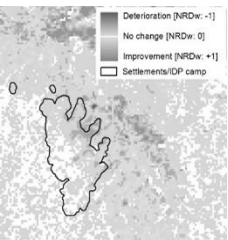
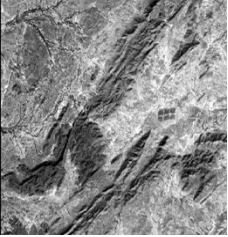


Restrictions (e.g. security restrictions)

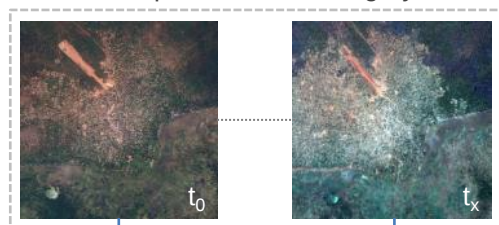
Cannot be measured

Impact on "human well-being"

- Different stages, build-upon each other depending on
 - (1) user needs (e.g. NGO's/camp management)
 - (2) data availability / data quality / data resolution (spatial and temporal)
-with different degree of automation and expert input:
 - From fully automated change analyses to
 - Use of expert weighting of changes in land cover classes to assess importance for environment and human wellbeing



Calibrated optical satellite imagery



Pre-classification

**VEGETATED VS.
NON-VEGETATED AREAS //
IN- /DECREASE OF
VEGETATION INTENSITY**
[$t_0, \dots, t_x$]

Change detection

SPATIOTEMPORAL CHANGE
[Vegetation change]

STAGE 1 PRODUCTS

Identification of
LULC target
classes

Expert input if possible
(e.g. in-situ data, situation
assessment)

(Online) user questionnaire /user
request



OBI
A

**LAND USE/LAND COVER
(LULC) TARGET CLASSES**
[$t_0, \dots, t_x$]

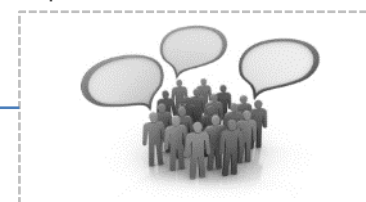
Change detection

SPATIOTEMPORAL CHANGE
[LULC target classes]

STAGE 2 PRODUCTS

Relevance of
LULC classes for
human well-being
and ecosystem
integrity

Expert consultation



NRD_w
index

**IMPACT ON
HUMAN
WELL-
BEING
&
ECOSYSTEM
INTEGRITY**

**HUMAN
WELL-BEING**
**ECOSYSTEM
INTEGRITY**

STAGE 3 PRODUCTS

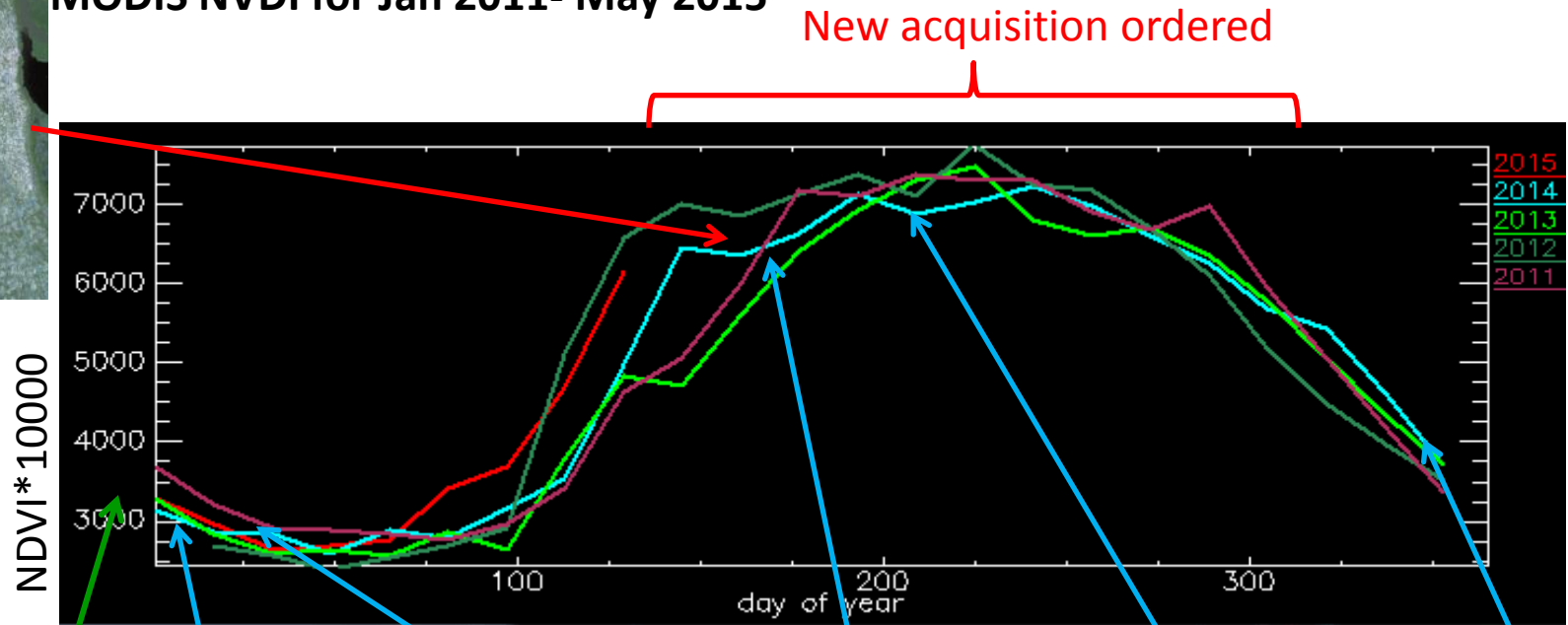
Degree of automation

Degree of expert input

Stage 0: Selection of images guided by MODIS

12.Jun.2015 Are available images comparable?

MODIS NVDI for Jan 2011- May 2015



28.Dec.2013

10.Jan.2014

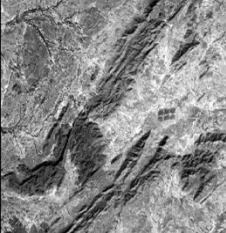
29.Jan.2014

22.Jun.2014

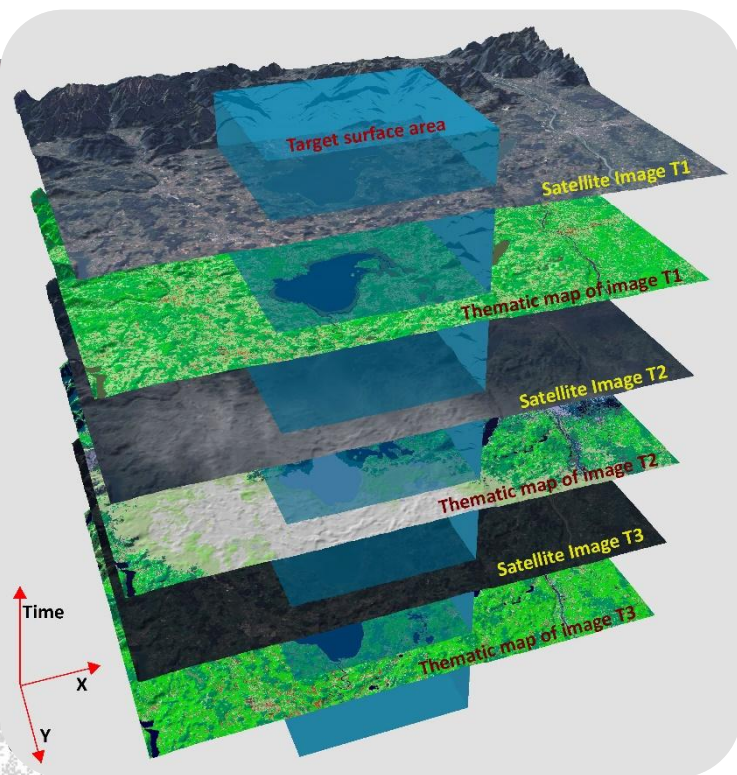
08.Aug.2014

07.Dez.2014





Stage 1 – fully automated pre-classification and change: related project



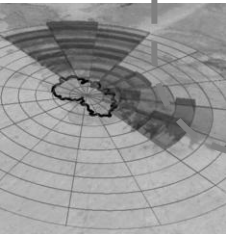
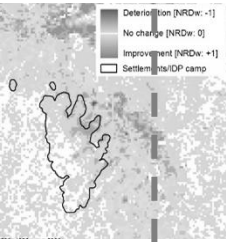
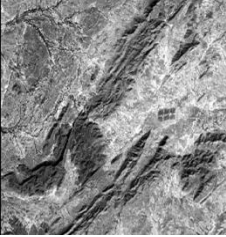
AutoSentinel 2/3

Knowledge-based pre-classification of
Sentinel-2/3 images for operational, timely
and comprehensive product generation and
content-based image database retrieval

Dirk Tiede (Project Coordinator), Andrea Baraldi, Stefan
Lang, Mariana Belgiu, Martin Sudmanns

*Interfaculty Department of Geoinformatics - Z_GIS
Paris-Lodron University Salzburg*

Autosentinel 2/3 Geospatial semantic querying image archives



Geospatial Semantic Query Interface

Search results based on

- pre-classification statistics
- Based on geospatial semantic queries

AOI request

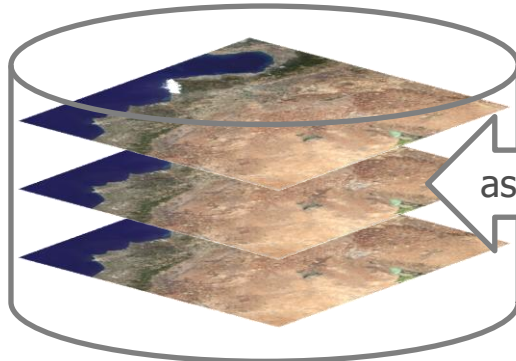


Semantic query-based statistics per AOI calculated on the fly (multi-temporal)

Semantic query	
Cloud cover	15%
Vegetation	25%
Water bodies	30%

Data and information download

Image database (e.g. S2)

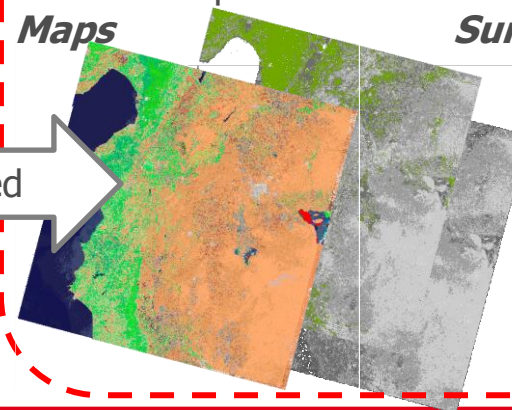


associated

Pre-classifications

Data-derived continuous and categorical geospatial information products

Maps



Summary statistics

Class	N.pix	Percentage
SVVHNR	3148	0.439
SVHNIR	3885	0.542
SVMNIR	249	0.035
SVLNIR	0	0.000
AVVHNR	7103	0.991
AVHNIR	92417	12.893
AVMNIR	74388	10.378
AVLNIR	806	0.112
WVHNIR	1	0.000
WVLNIR	334	0.047
WE	502	0.070
SHV	372	0.052
SSR	1	0.000
ASVHNR	553	0.878

Stage 1 – fully automated pre-classification and change

- **Stage 1 pre-classification and change products:**
 - based on **time series of calibrated satellite imagery**, an **automatic pre-classification** is conducted. Calibration includes geometric registration and radiometric calibration into TOARF.
 - We use a **feature space categorisation approach implemented in the SIAM**

Image Automatic Mapper; BARALDI et al., 2010

Semantic information achieved is inferior to traditional

changes in vegetation cover
classification change cover

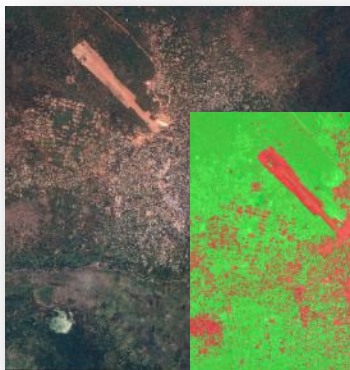
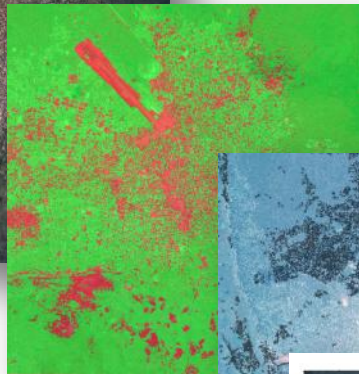


Image t_0



Vegetation mask
from SIAM, t_0



Change of vegetation
cover between t_0 and t_1

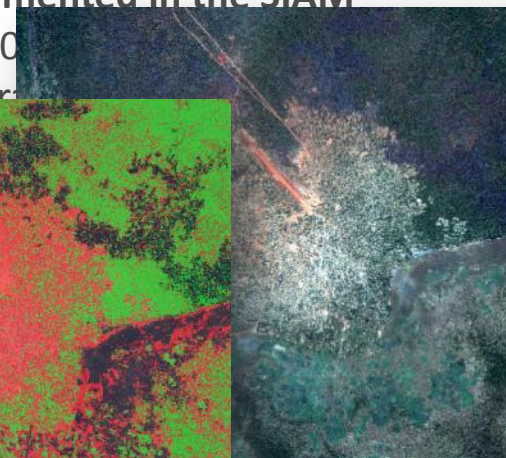
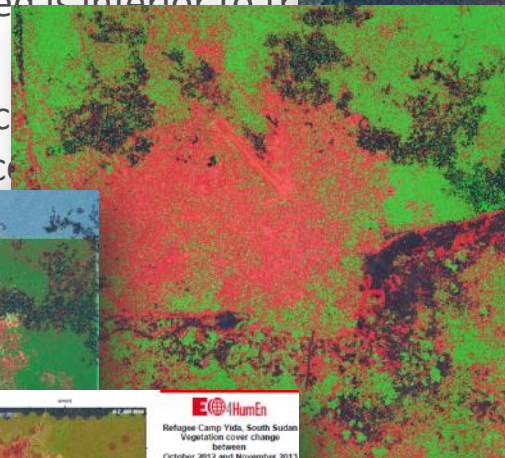
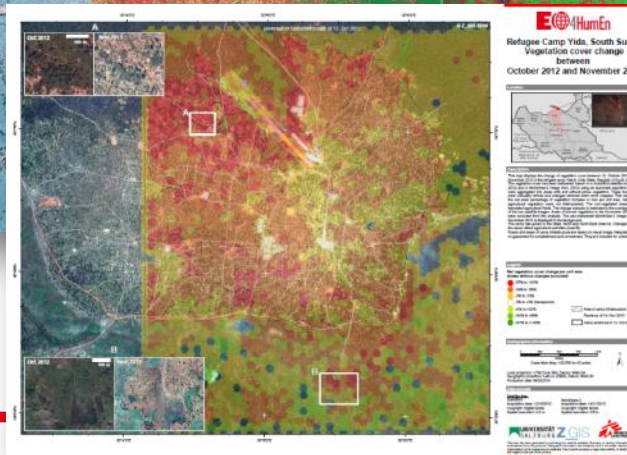


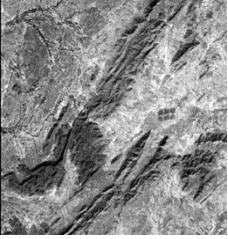
Image t_1



Vegetation mask
from SIAM, t_1



Aggregation to
hexagons, map
production. Refugee
Camp Yida, South Sudan



Stage 2 – specific LULC/LCC products

Example of a Stage 2 product: Here: Woody vegetation for three time steps

28.Dec.2013

Minkaman, South Sudan



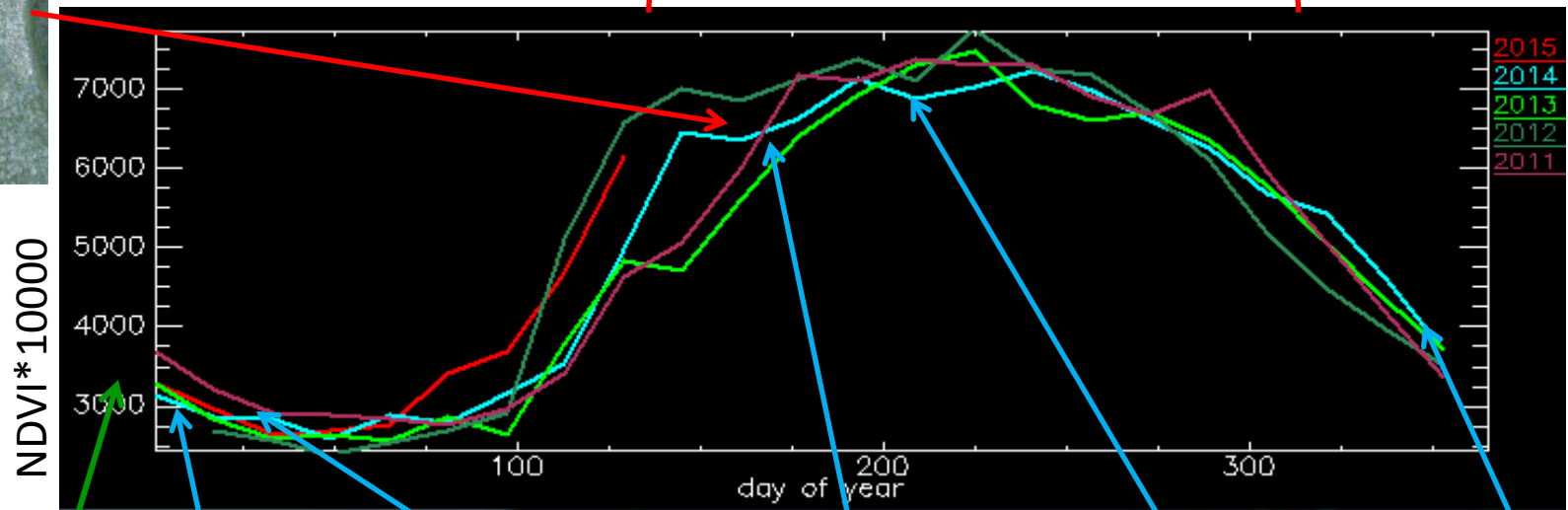
- Based on user request or questionnaires relevant LULC target classes are identified (here: woody vegetation).
Focus on dry period
 - **Stratification based on the Stage 1** pre-classification [here: Water, wetland, dry soil from]. (Expert-) selection of candidate SIAM classes for woody vegetation
 - Semantical enrichment by expert rule-sets in an object-based image analysis (OBIA) environment [here e.g. *neighbourhood to water* class] and/or integration of in-situ data/expert data
 - Separation of **woody and grassy vegetation** [here: mainly based on form and spectral ratios/pre-classification to delineate patches of trees]
 - Repeated for three time slices (same dry season, same year)
- ➔ **scene/area specific approach, semi-automated, difficult to transfer to other areas.**

Influence of image acquisition date

12.Jun.2015 Are available images comparable?

MODIS NVDI for Jan 2011- May 2015

New acquisition ordered



28.Dec.2013

10.Jan.2014

29.Jan.2014

22.Jun.2014

08.Aug.2014

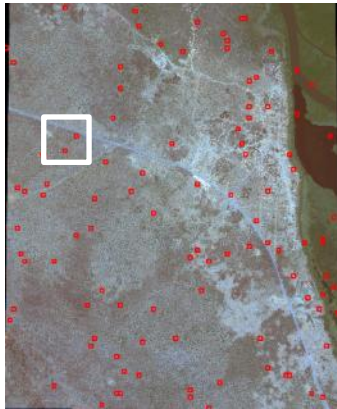
07.Dez.2014



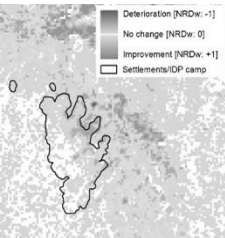
Stage 2 – specific LCC product

Quality assessment

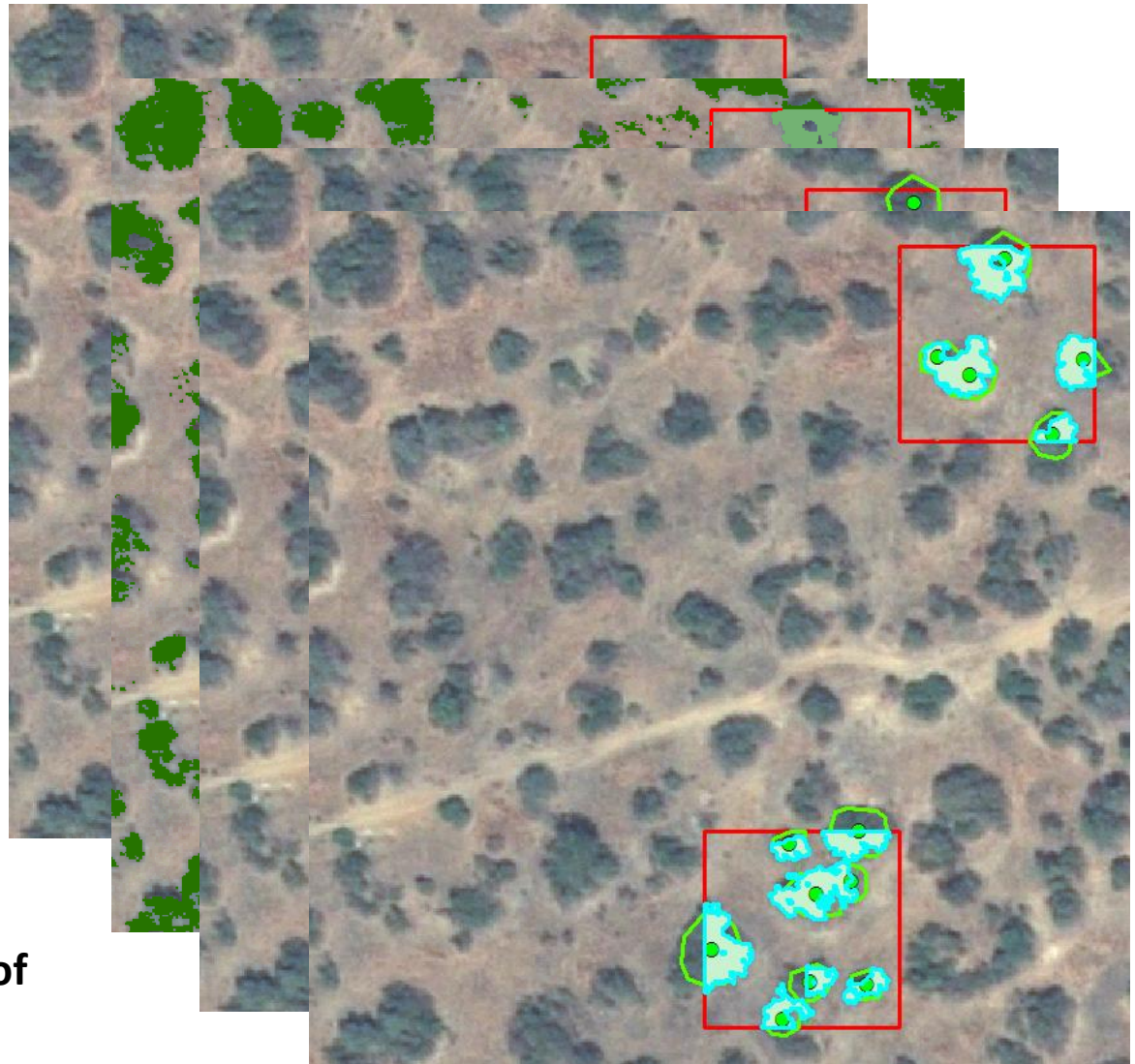
28.Dec.2013



Random selection of
100 cells 50mx50m



Test of extraction of
woody vegetation

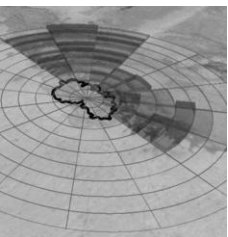
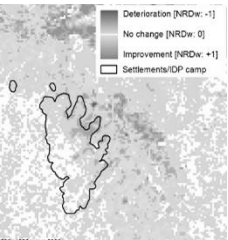
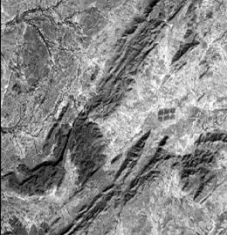


Stage 2 – specific LCC product

Comparison of results three images in same dry season; low human impact

	28.Dec.2013	10.Jan.2014	29.Jan.2014
Trees/bushes Manually digitized	551	515	478
Of which automatically detected	508	481	462
Producer's accuracy	92%	93%	97%
Objects classified as trees/bushes	614	626	672
Of which are truly trees	508	481	462
User's accuracy	83%	77%	69%

Stage 2 – specific LCC product



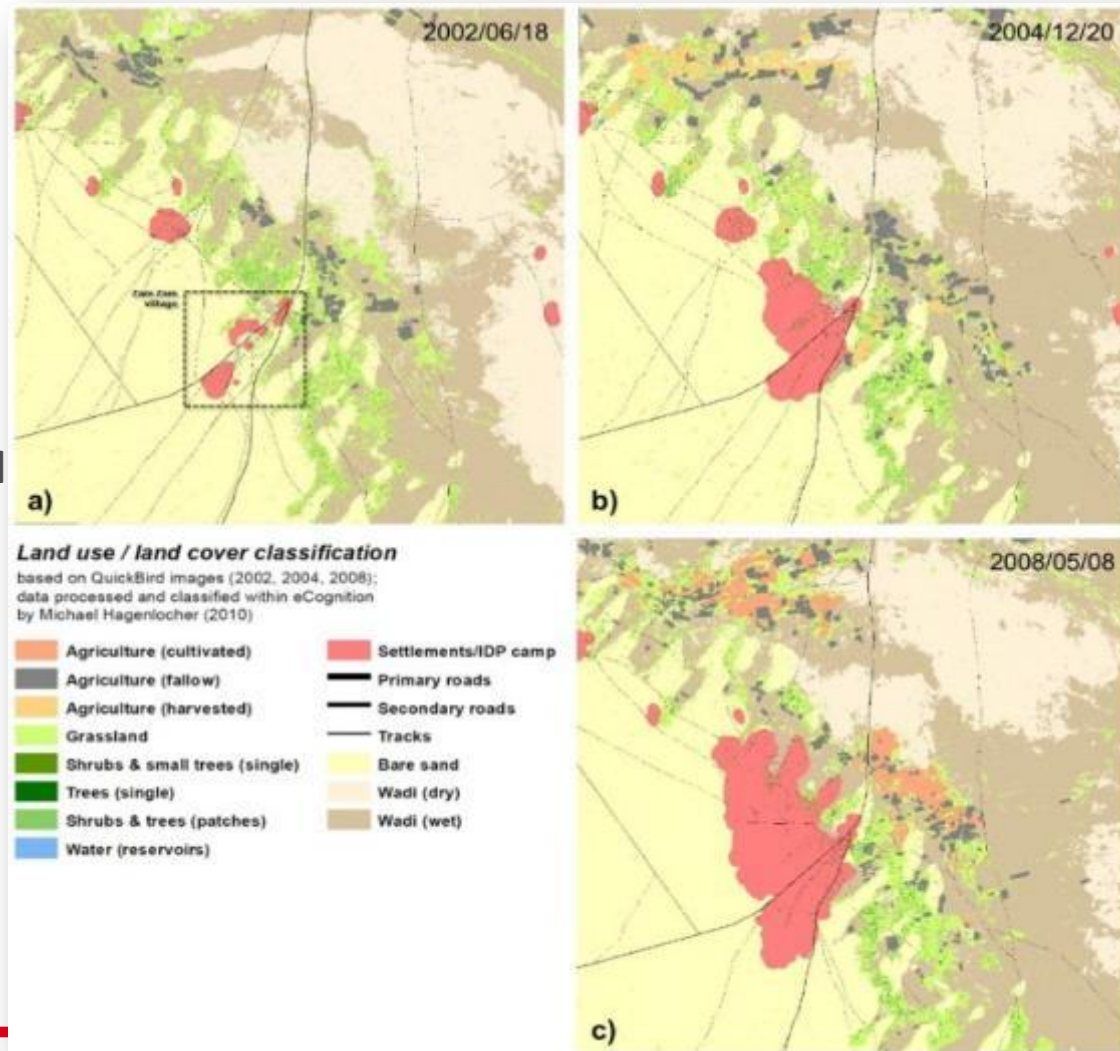
- Comparison of results of three images in same dry season; low human impact
 - Validation shows that the approach/algorithm works +/- the similar on all three images (user accuracy is improvable, area of woody vegetation is in general overestimated)
 - **But:** even in this short period (1 month) seasonal change is influencing the analysis [problems in tree cover extraction versus number of trees]
 - **Selection of adequate images is very important** to make clear statements about human impact versus seasonal influences
 - **Selection of adequate images very difficult** (costs, availability, seasonal shifts between years), especially under semi-arid conditions
- ➔ **Introduction of a "Stage 0" analysis** based e.g. on MODIS time series to support data selection and also data ordering (acquisition) process (experimental)

Stage 3 – expert evaluation

Stage 3 product:

- Evaluation of the implications of **observed changes** for human well-being and ecosystem integrity
- Evaluation is based on an **analysis of spatiotemporal changes** of pre-defined LULC target classes, while taking into account their **relative importance** for human well-being and ecosystem integrity as identified by local experts.

Zam Zam ,IDP camp, Sudan



Stage 3 – expert evaluation

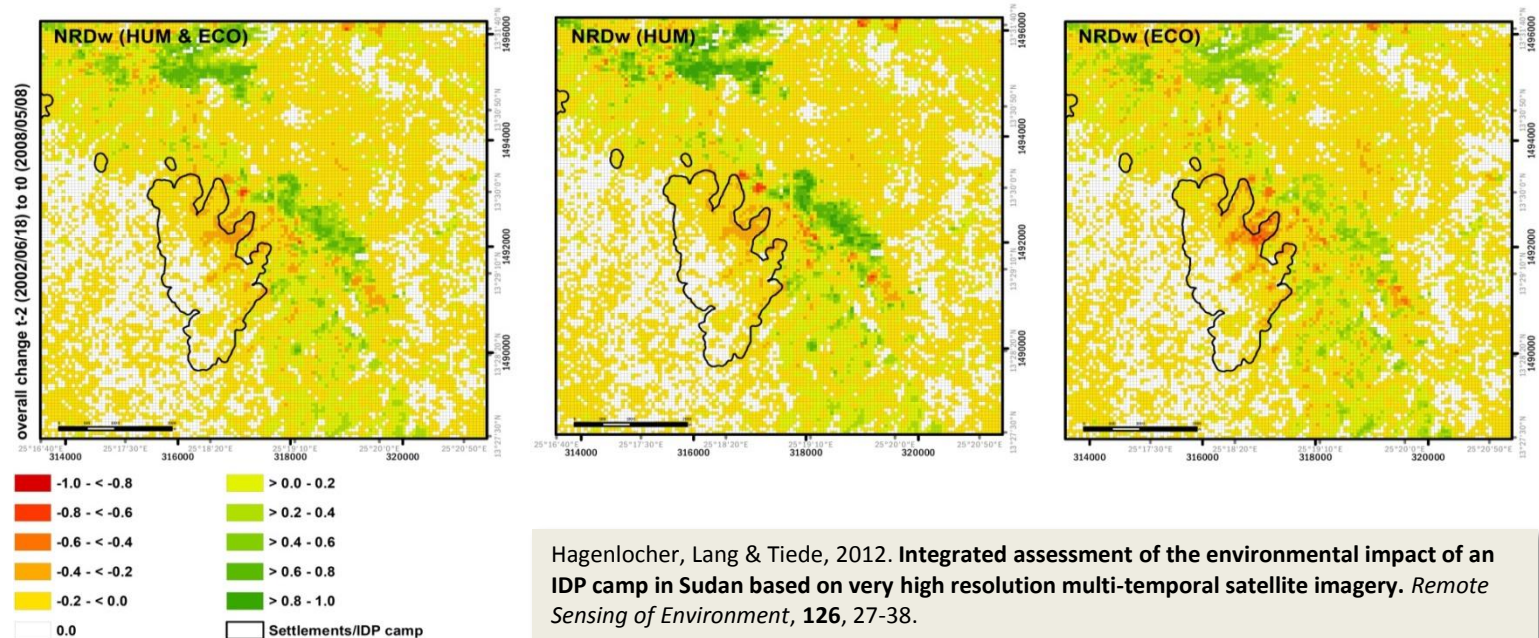
- Based on the so called Weighted Natural Resource Depletion (NRD) index (Hagenlocher et al., 2012), these products enable users to identify and evaluate the impact of observed environmental changes on human well-being (i.e., food and livelihood security) and ecosystem integrity (i.e., state of ecosystems).

Weighted natural resource depletion (NRD) index

$$RI \left(\begin{matrix} \text{HUM} \\ \text{ECO} \\ \text{HUM\&ECO} \end{matrix} \right) = \sum_{i=1}^n P_i * W_i \quad (2)$$

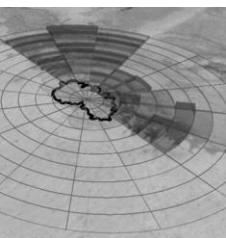
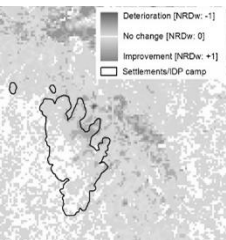
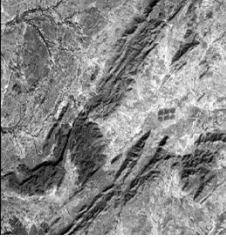
Where

RI	Relative importance of the grid cell (60 m × 60 m) to HUM, ECO or HUM and ECO
i -n	LULC categories
P	Relative area of the LULC categories per grid cell
W	Expert-based standardised weighting factors (W_{stand})



Hagenlocher, Lang & Tiede, 2012. Integrated assessment of the environmental impact of an IDP camp in Sudan based on very high resolution multi-temporal satellite imagery. *Remote Sensing of Environment*, 126, 27-38.

- A survey among potential users has revealed that the **assessment and monitoring of environmental changes is of high importance for humanitarian organizations**
- Our approach aims to come up with a **standardised product portfolio for analysing the environmental impact of refugee/IDP camps** based on the respective needs of the humanitarian organizations in the field
- Different products can be provided, ranging from a **rapid (i.e. automatic, Stage 1) assessment of vegetation/LC change, over detailed LULC change investigations (Stage 2), to an evaluation of the implications of observed changes for human well-being and ecosystem integrity (Stage 3).**



- Best practice examples have shown that:
 - Given a sufficient data situation, **Stage 1 products are fully automatic** and are suited for long term monitoring tasks **to cope with the increasing data situation especially in the HR domain** (Sentinel 2A/B)
 - Building-upon **physical model based pre-classifications on calibrated data aims** on the long run **for increased automation and higher accuracies of Stages 2 and 3**
 - **Selection of adequate data / assessment of the data used is important for distinguish between human impact and seasonal changes.** An additional "Stage 0" (e.g. evaluation of MODIS NDVI time series) improves the data selection / acquisition process.
 - **Expert input can help to counterbalance an imperfect data situation**
 - **Expert knowledge is essential for qualitative Stage 3 products and can improve Stage 2 products**

