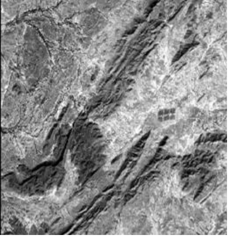

EO4HumEn

EO-based services to support humanitarian operations: monitoring population and natural resources in refugee/IDP camps

FFG

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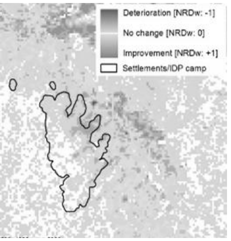
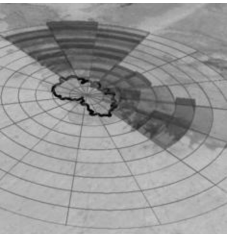
Bundesministerium für Verkehr, Innovation und Technologie

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 Tiede[1] and Stefan Lang[1]

[1]Department of Geoinformatics – Z_GIS, University of Salzburg / Austria
[2]Institute for Environment and Human Security (UNU-EHS), United Nations University / Germany





Z_GIS

UNIVERSITÄT SALZBURG

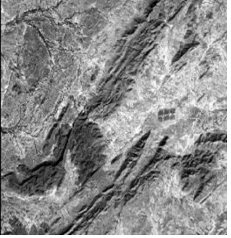
MEDECINS SANS FRONTIERES
ÄRZTE OHNE GRENZEN

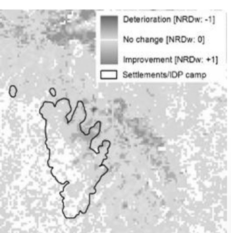
EO4HumEn | ASAP 9, Proj.Nr. 840081
Duration: Oct 2013 – Mar 2016

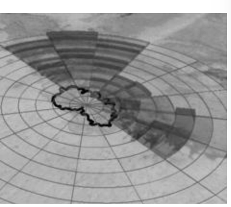
The EO4HumEn project

→support humanitarian action by geospatial information products

Cooperation of ZGIS + FB GEO SBG, MSF Austria, Uni Tübingen



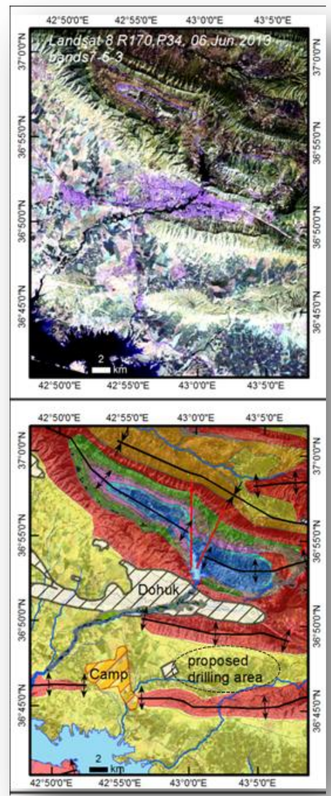




Population Monitoring

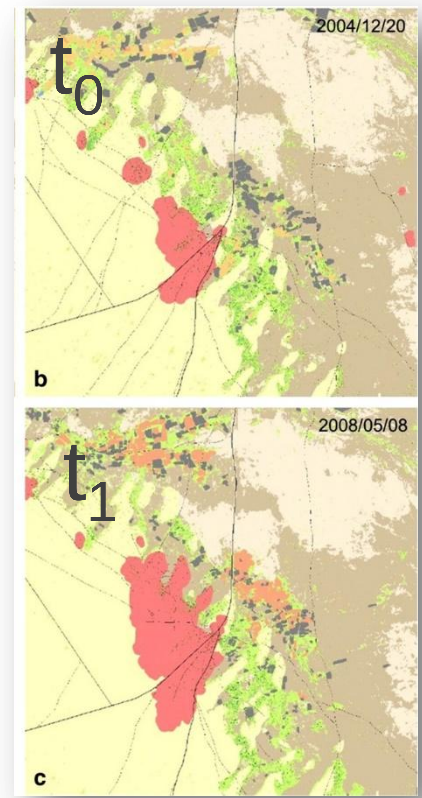
OBIA on VHR data

Groundwater



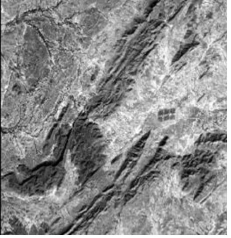
Geological mapping

Environment



LULC change

Source: UNEP 2006

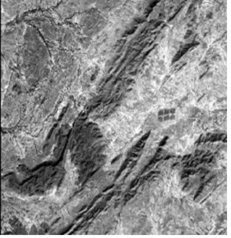


Environmental Impact of Refugee/IDP Camps

- **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.

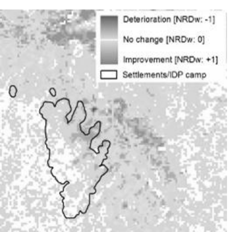
Source: UNEP 2006

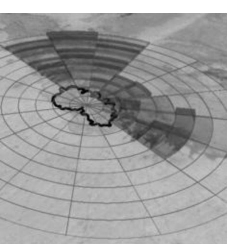
Environmental Impact of Refugee/IDP Camps

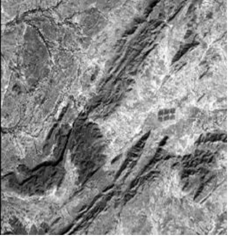


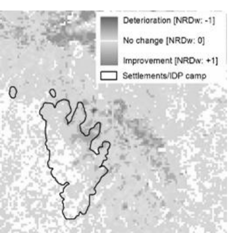
- Therefore, the assessment of the environmental impact of refugee/IDP camps is important to
  - **organize the use of natural resources in a sustainable manner**
  - **mitigate possible conflicts with host communities due to uncontrolled exploitation of natural resources**

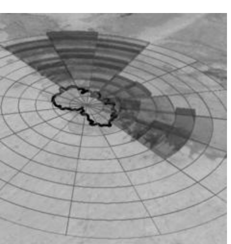
- Within EO4HumEn a multi-stage EO-based approach is developed to assess and monitor environmental changes in the surrounding of refugee/IDP camps:
  1. Rapid overview analyses
  2. Detailed land cover change investigations
  3. Evaluation of the implications of observed environmental changes for human well-being and ecosystem integrity





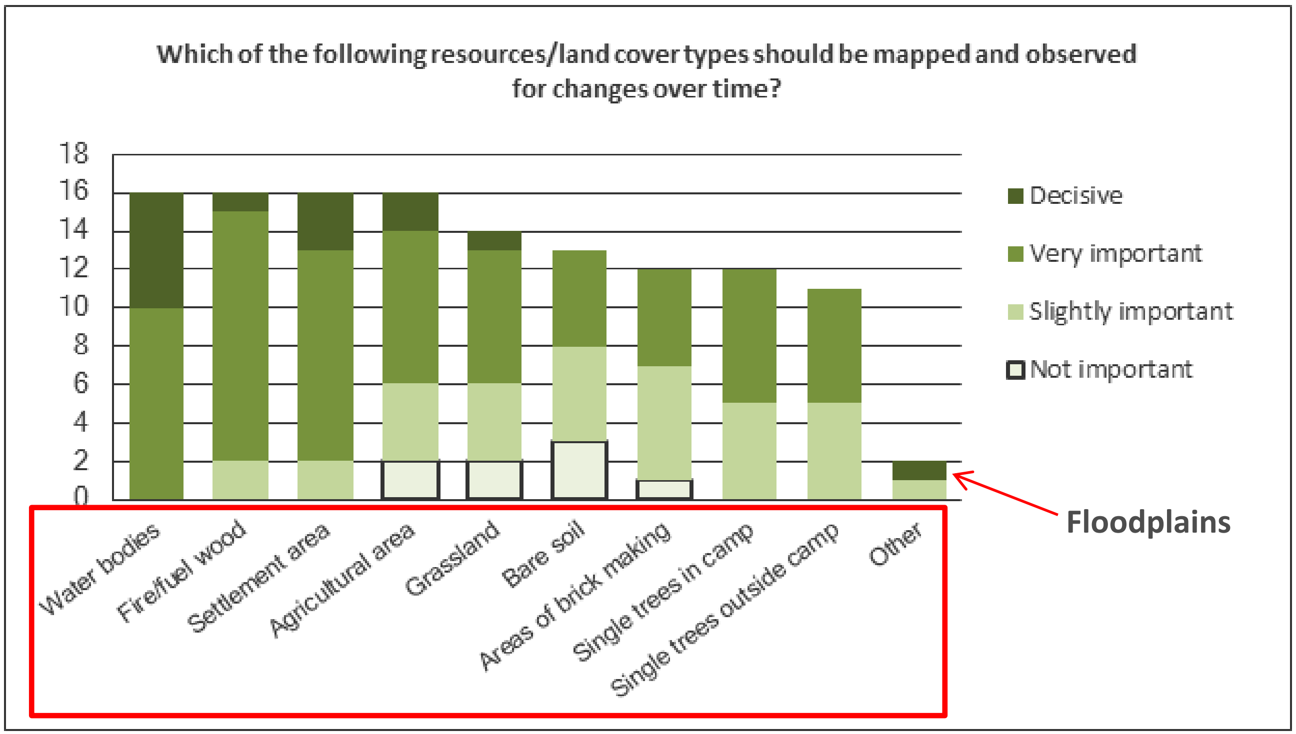




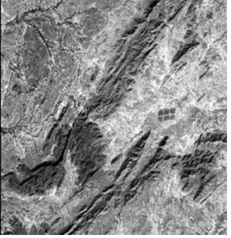


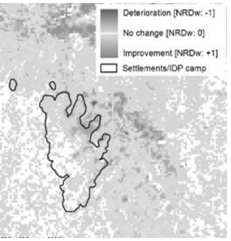
Which land cover classes should be monitored?

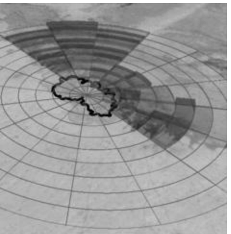
Result from survey (n=16 (of 80); MSF and others (UN, Red Cross)):



EO4HumEn ZGIS







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

↕

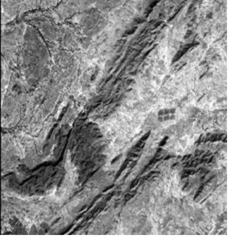
Restrictions (e.g. security restrictions)

Cannot be measured

↕

Impact on "human well-being"

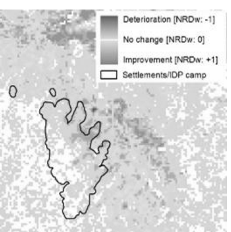
EO4HumEn Z_GIS

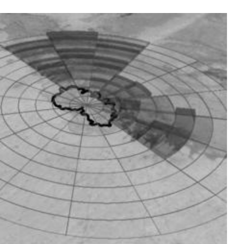


Approach

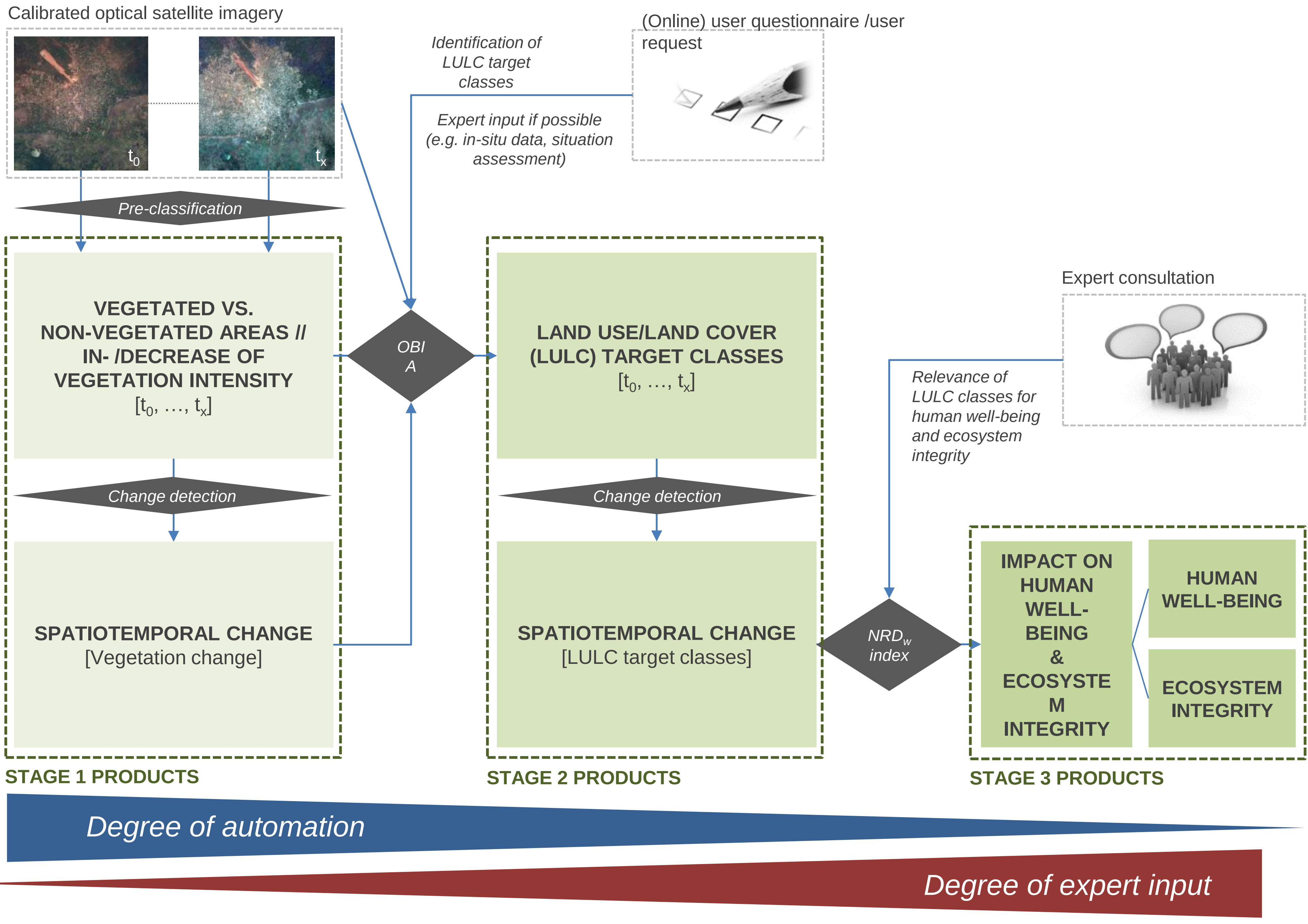
- Different stages, build-upon each other depending on
  (1) user needs (e.g. NGO's/camp management)
  (2) data availability / data quality / data resolution (spatial and temporal)

- …..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



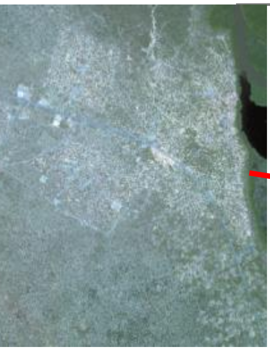


EO4HumEn Z_GIS


Calibrated optical satellite imagery
t0
tx
Pre-classification
Identification of LULC target classes
Expert input if possible (e.g. in-situ data, situation assessment)
(Online) user questionnaire /user request
VEGETATED VS. NON-VEGETATED AREAS // IN- /DECREASE OF VEGETATION INTENSITY
[t0, …, tx]
Change detection
SPATIOTEMPORAL CHANGE
[Vegetation change]
OBIA
LAND USE/LAND COVER (LULC) TARGET CLASSES
[t0, …, tx]
Change detection
SPATIOTEMPORAL CHANGE
[LULC target classes]
Expert consultation
Relevance of LULC classes for human well-being and ecosystem integrity
NRDw index
IMPACT ON HUMAN WELL-BEING & ECOSYSTEM INTEGRITY
HUMAN WELL-BEING
ECOSYSTEM INTEGRITY
STAGE 1 PRODUCTS
STAGE 2 PRODUCTS
STAGE 3 PRODUCTS
Degree of automation
Degree of expert input

Stage 0: Selection of images guided by MODIS

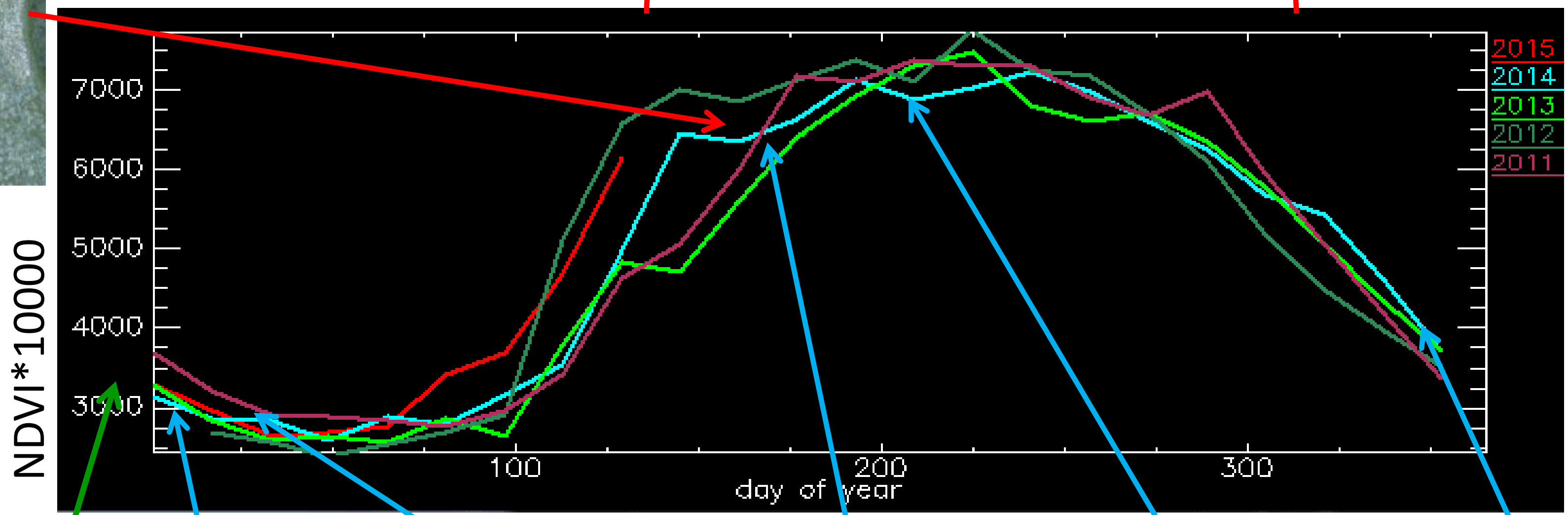
12.Jun.2015



Are available images comparable?

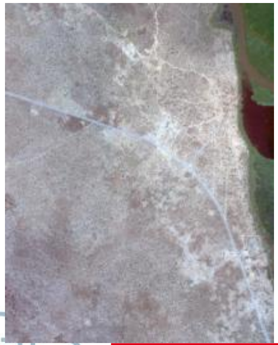
MODIS NVDI for Jan 2011- May 2015

New acquisition ordered

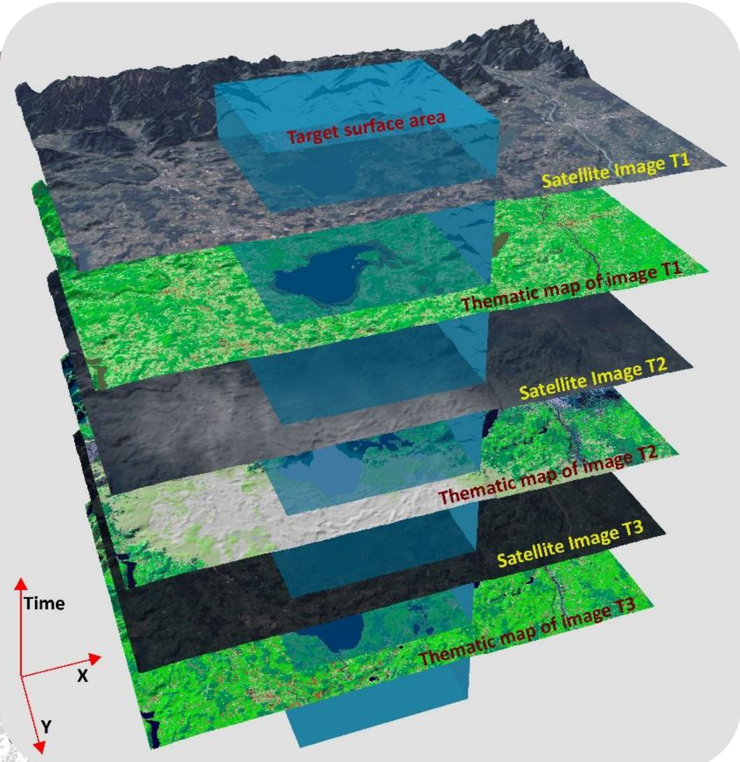


28.Dec.2013 | 10.Jan.2014 | 29.Jan.2014 | 22.Jun.2014 | 08.Aug.2014 | 07.Dez.2014






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



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Innovation und Technologie

AutoSentinel 2/3

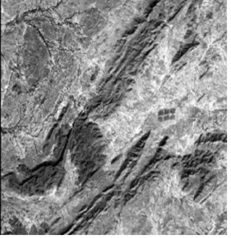
Knowledge-based pre-classification of Sentinel-2/3 images for operational, timely and comprehensive product generation and content-based image database retrieval

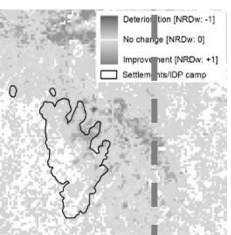
Dirk Tiede (Project Coordinator), Andrea Baraldi, Stefan Lang, Mariana Belgiu, Martin Sudmanns

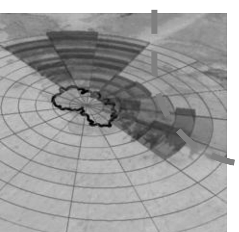
Interfaculty Department of Geoinformatics - Z_GIS
Paris-Lodron University Salzburg

UNIVERSITÄT SALZBURG Z_GIS

Autosentinel 2/3 Geospatial semantic querying image archives







User

Search results based on
- pre-classification statistics
- Based on geospatial semantic queries

Geospatial Semantic Query Interface

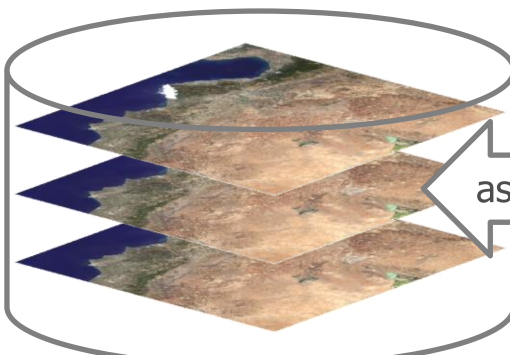
AOI request

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)

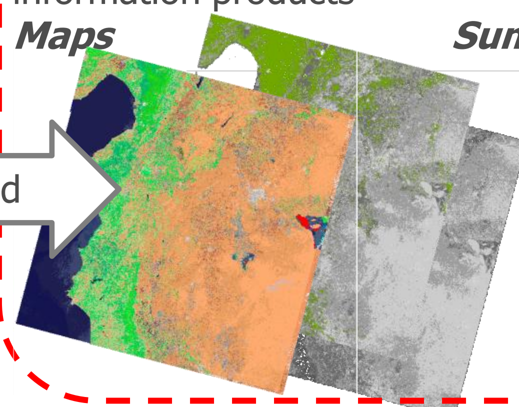


associated

Pre-classifications

Data-derived continuous and categorical geospatial information products

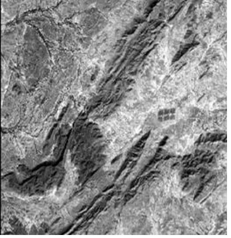
Maps

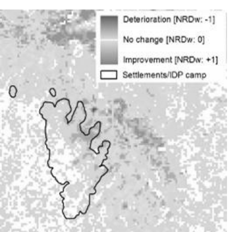


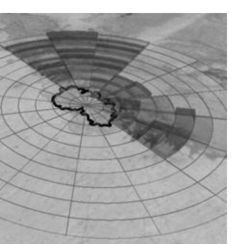
Summary statistics

Class	N.pix	Percentage
SVVHNIR	3148	0.439
SVHNIR	3885	0.542
SVMNIR	249	0.035
SVLNIR	0	0.000
AVVHNIR	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

EO4HumEn Z_GIS





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** … ***age Automatic Mapper***; BARALDI et al., 2010 … mantic information achieved is inferior to tr…
  - … s in vegetation c… cation change c…

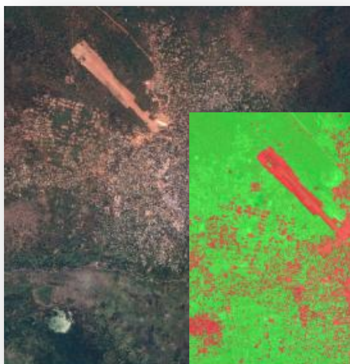
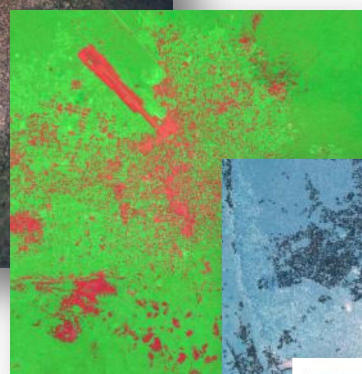
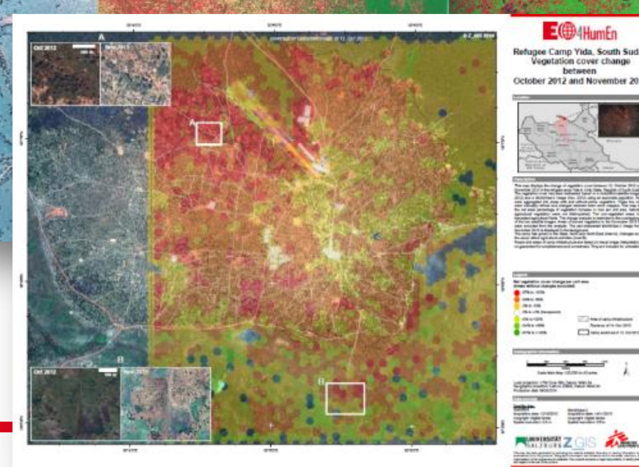


Image t_0

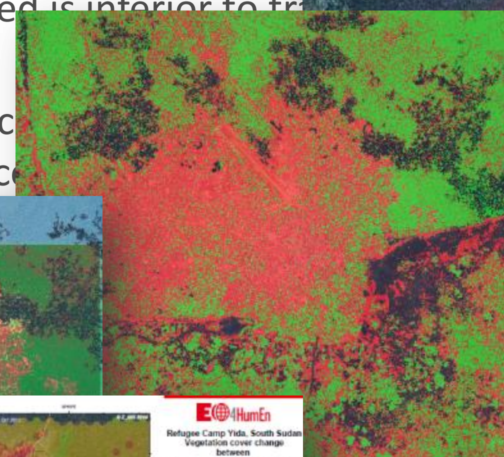


Vegetation mask from SIAM, t_0

Change of vegetation cover between t_0 and t_1

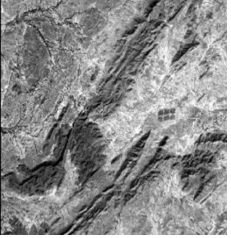


Aggregation to hexagons, map production. Refugee Camp Yida, South Sudan



Vegetation mask from SIAM, t_1

Image t_1



Stage 2 – specific LULC/LCC products

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

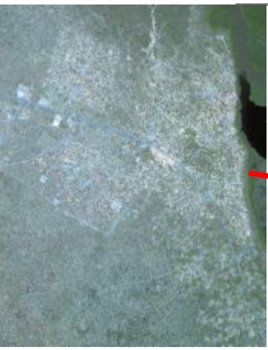
28.Dec.2013
Minkaman, South Sudan

- 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

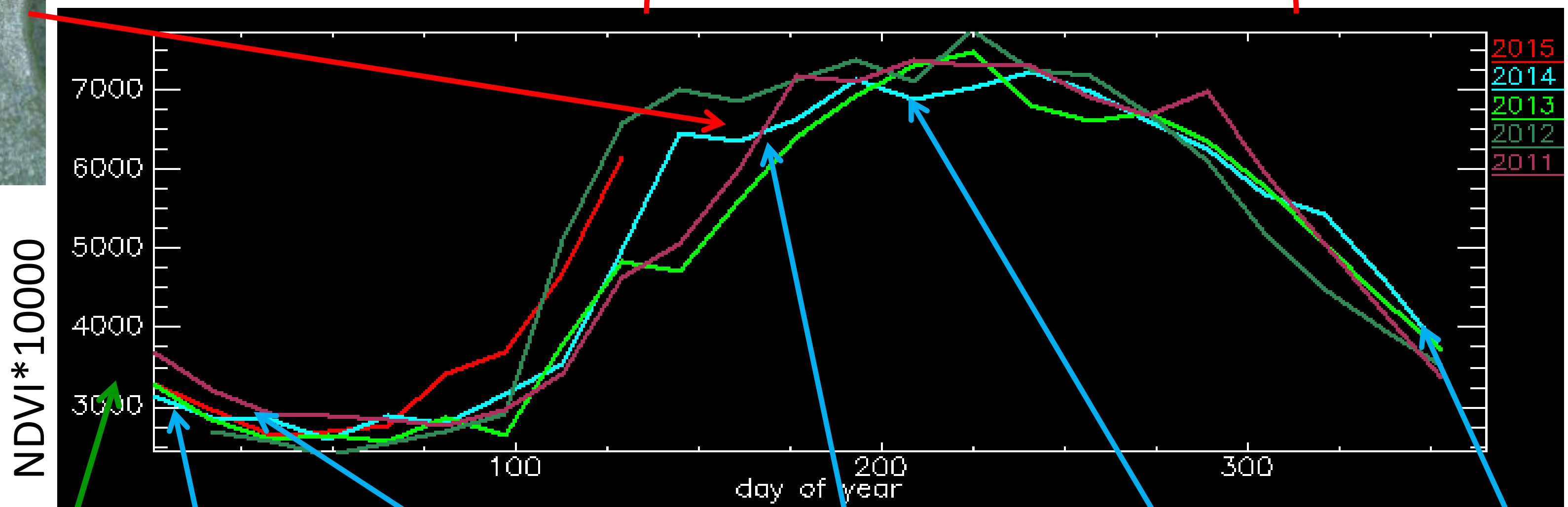
12.Jun.2015



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

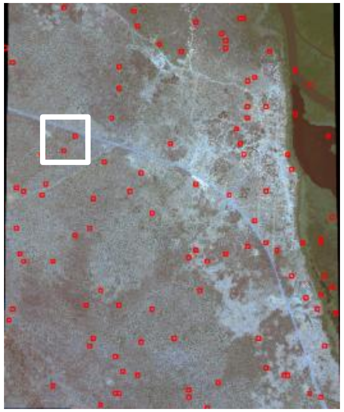
08.Aug.2014

07.Dez.2014

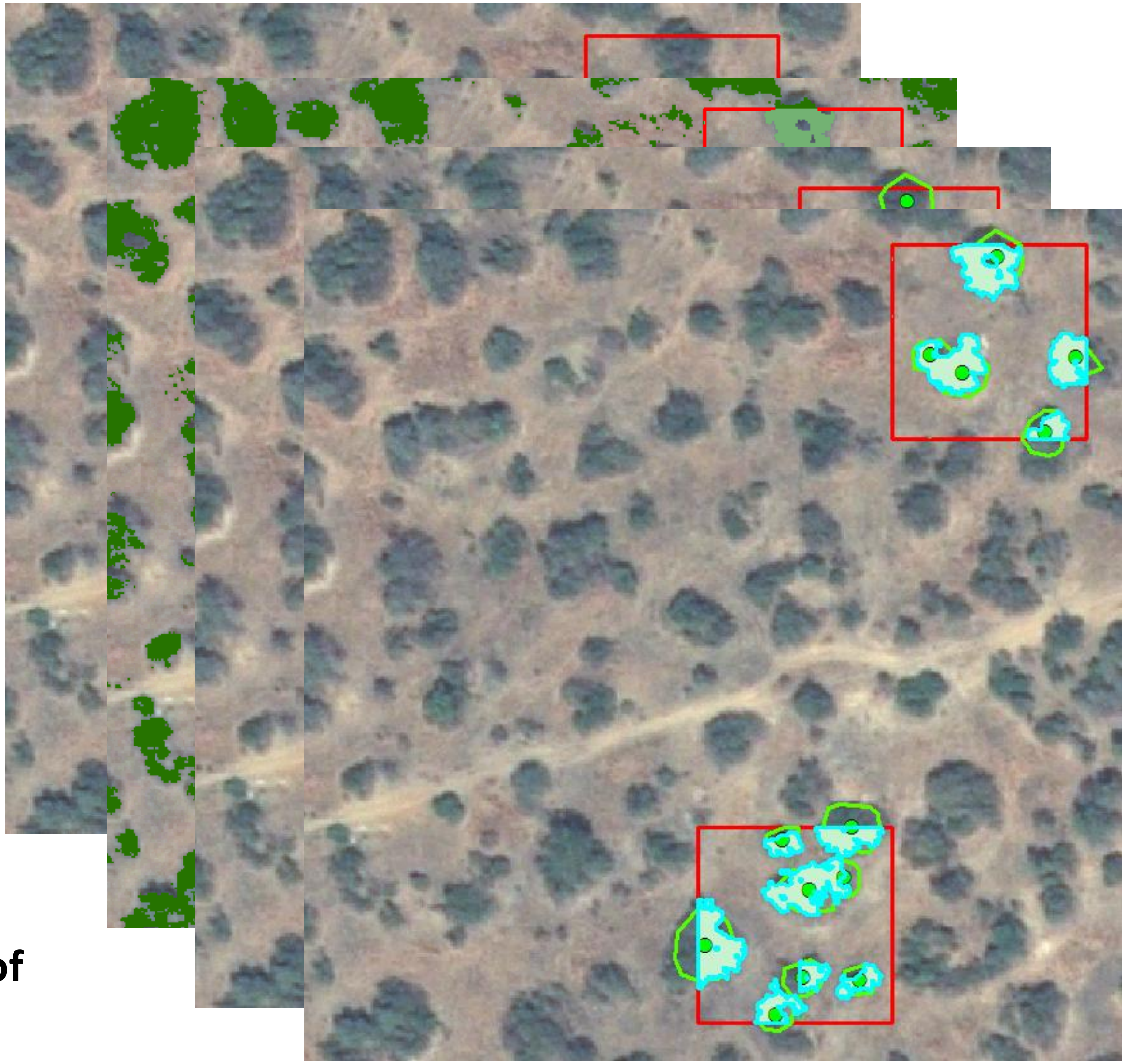
Stage 2 – specific LCC product

Quality assessment

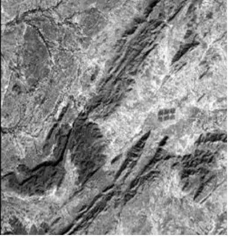
28.Dec.2013



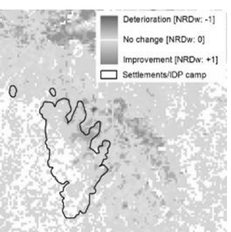
Random selection of 100 cells 50mx50m

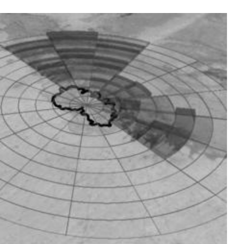


Test of extraction of woody vegetation



Stage 2 – specific LCC product

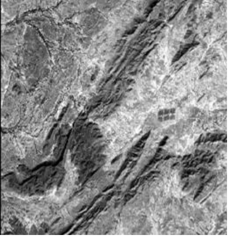


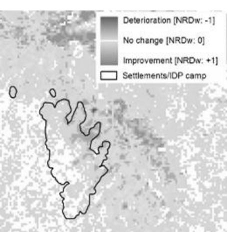


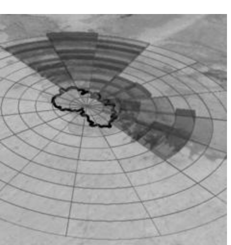
Comparison of results three images in same dry season; low human impact

	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



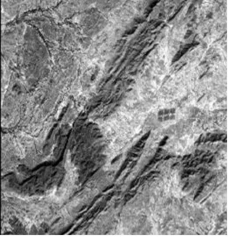


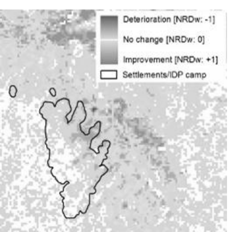
- Comparison of results of three images in same dry season; low human impact
- Validation shows that the approach/algorithm works +/- the similar on all three images (user accuracy is improvable, area of woody vegetation is in general overestimated)
- **But:** even in this short period (1 month) seasonal 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

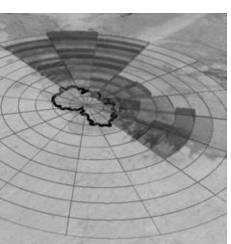
➔ **Introduction of a "Stage 0" analysis** based e.g. on MODIS time series to support data selection and also data ordering (acquisition) process (experimental)

EO4HumEn Z_GIS

Stage 3 – expert evaluation



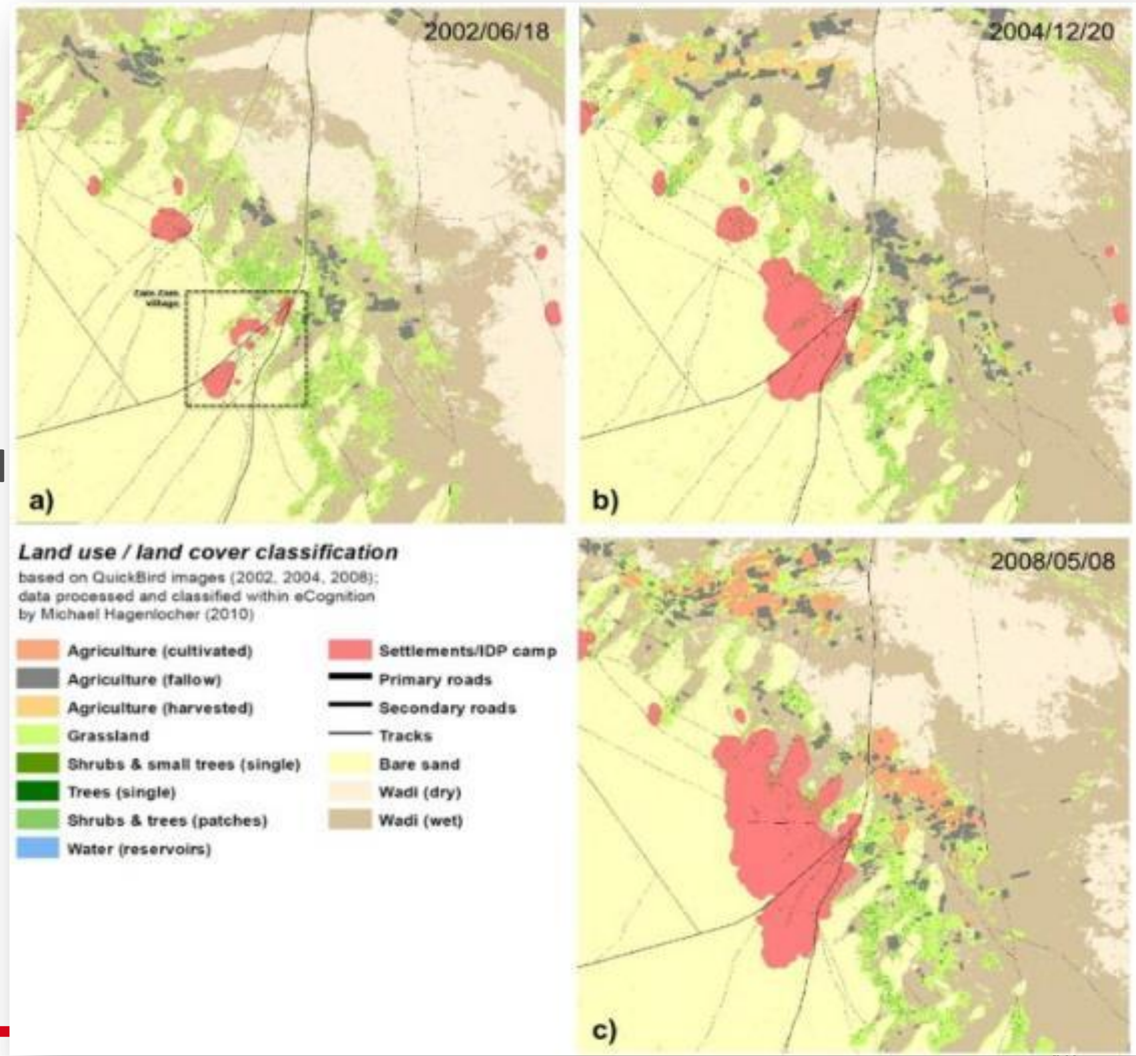




Stage 3 product:

- **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



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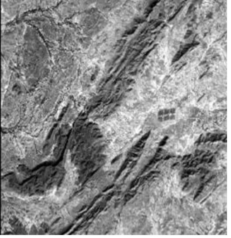
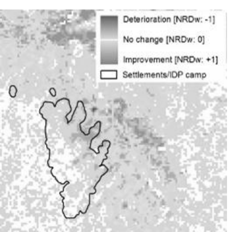
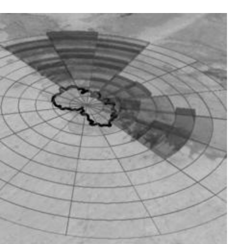




Stage 3 – expert evaluation

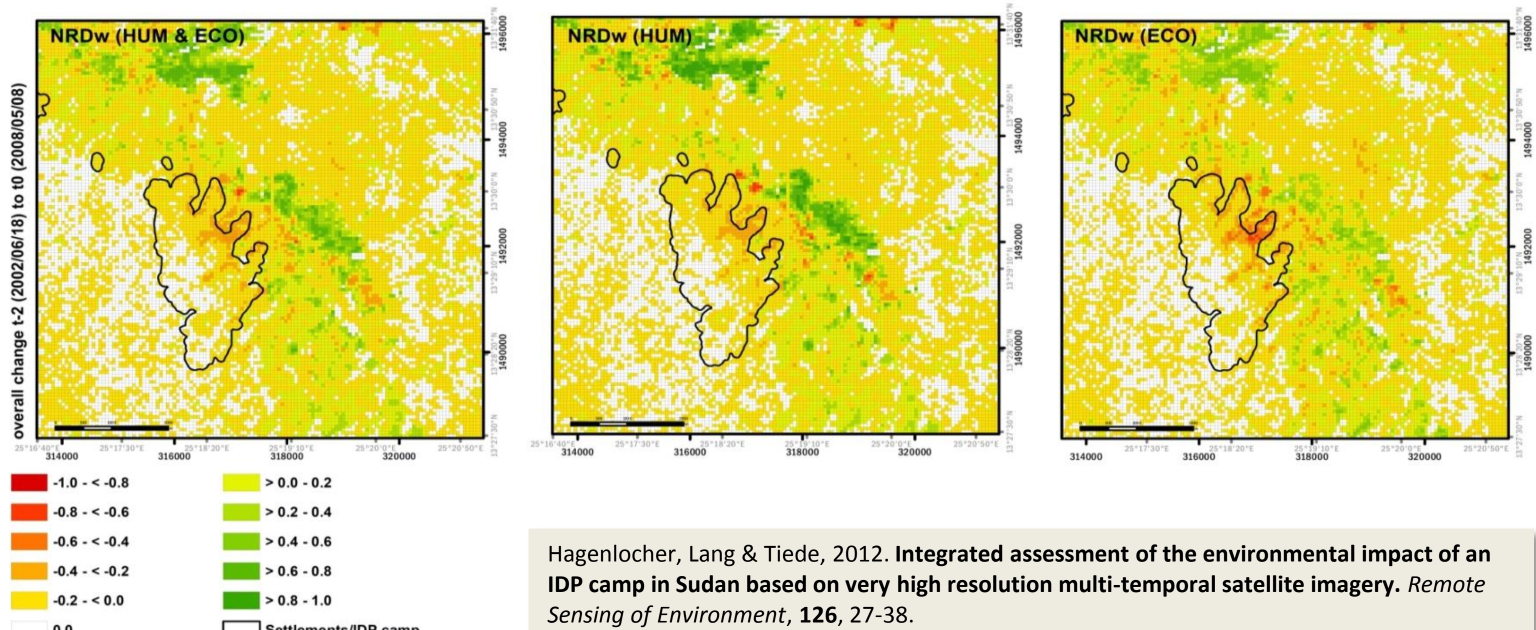
- Based on the so called Weighted Natural Resource Depletion (NRD) index (Hagenlocher et al., 2012), these **products enable users to identify and evaluate the impact of observed environmental changes on human well-being** (i.e., food and livelihood security) **and ecosystem integrity** (i.e., state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

Weighted natural resource depletion (NRD) index

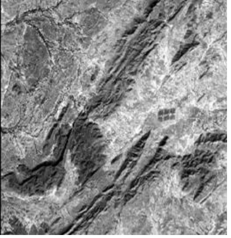
$$\mathrm{RI}\begin{pmatrix}\mathrm{HUM}\\ \mathrm{ECO}\\ \mathrm{HUM\&ECO}\end{pmatrix} = \sum_{i=1}^{n} P_i * W_i \qquad (2)$$

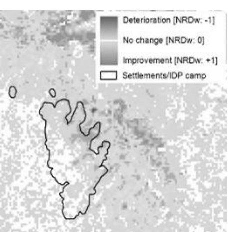
Where

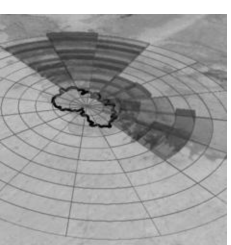
RI	Relative importance of the grid cell (60 m × 60 m) to HUM, ECO or HUM and ECO
i-n	LULC categories
P	Relative area of the LULC categories per grid cell
W	Expert-based standardised weighting factors (W_{stand})



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.







Wrap-up

- 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).

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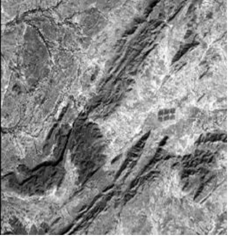


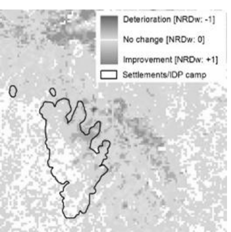

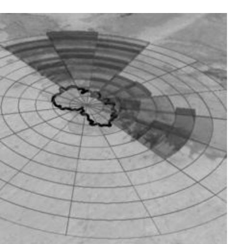

Conclusions

- 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