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Resilient Agro-landscapes to Climate Change in Tanzania

- Stefan Sieber, Karen Tscherning

on behalf of the consortium -

Leibniz Centre for Agricultural Landscape Research e.V.

World Agroforestry Centre

Potsdam Institute for Climate Impact Research

Sokoine University of Agriculture (SUA)

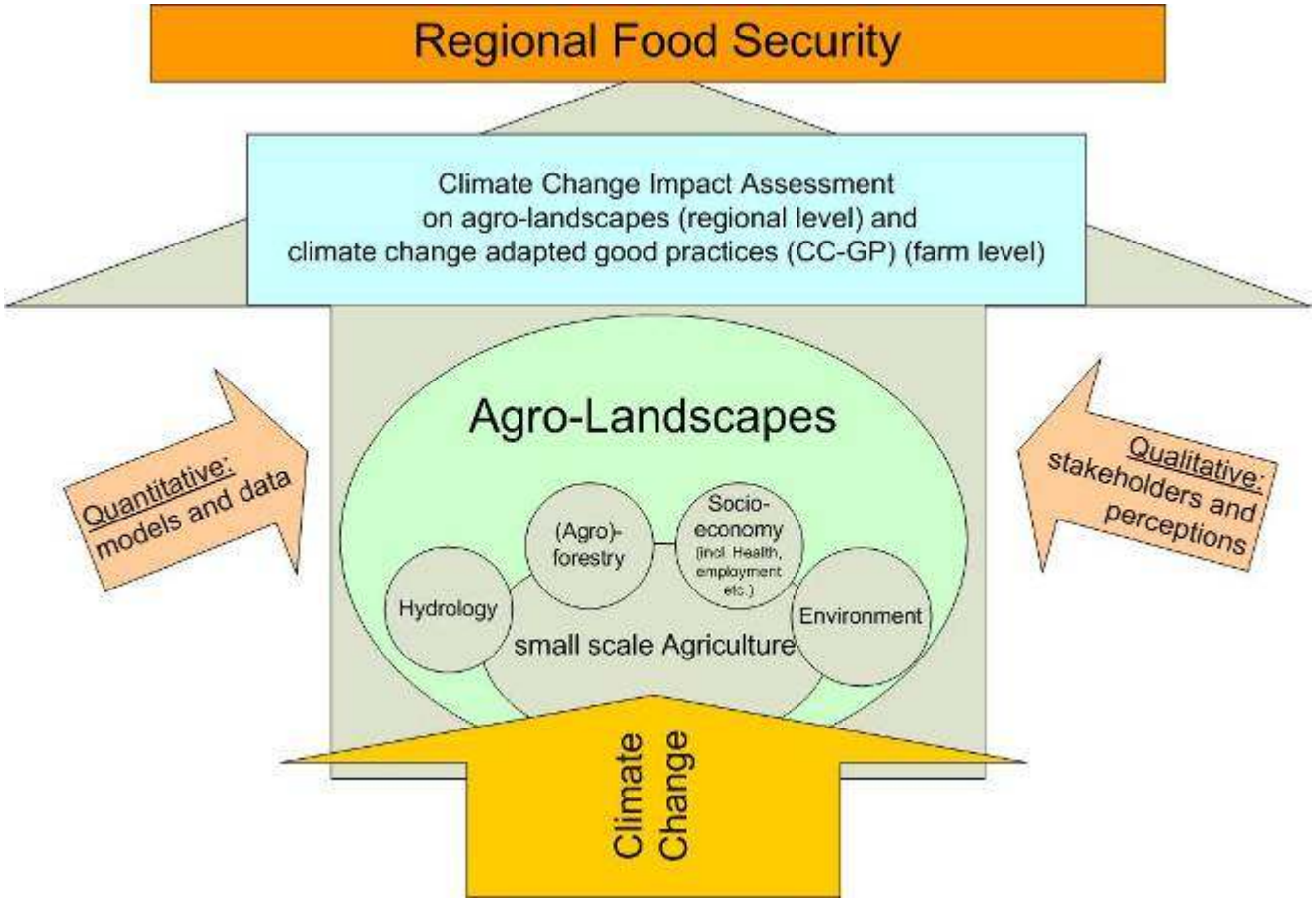
Müncheberg, 20. August 2010

gtz Im Auftrag des Bundesministeriums für wirtschaftliche Zusammenarbeit und Entwicklung

- **Outline**

1. Overview REACCT
2. Activities per Output
3. Overview Timing
4. Outcome beyond Outputs
5. Overview Budget

Overview REACCT



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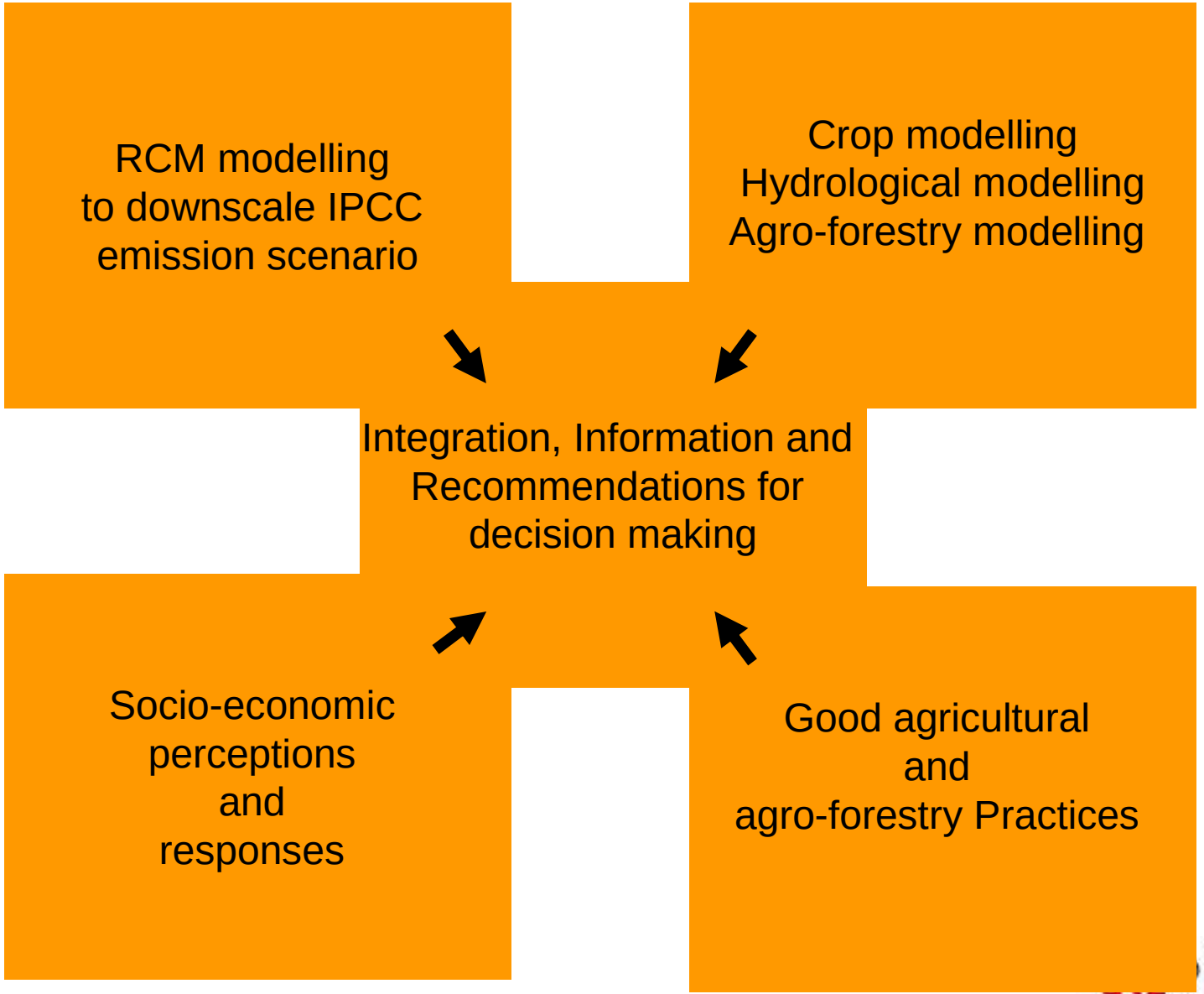
wirtschaftliche Zusammenarbeit
und Entwicklung

Overview REACCT



Overview REACCT

- **Unique features**

1. Installed infrastructure ↑↓
2. Equipment of 130.000 US$ ↑
3. Agricultural, agro-forestry GP ↑
4. Turn-over of personnel ↓
5. Input/output Integration ↑

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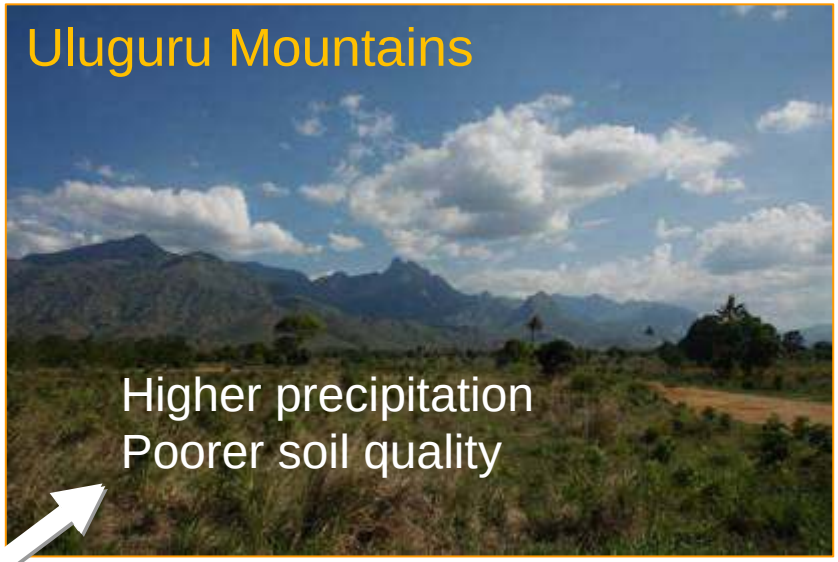
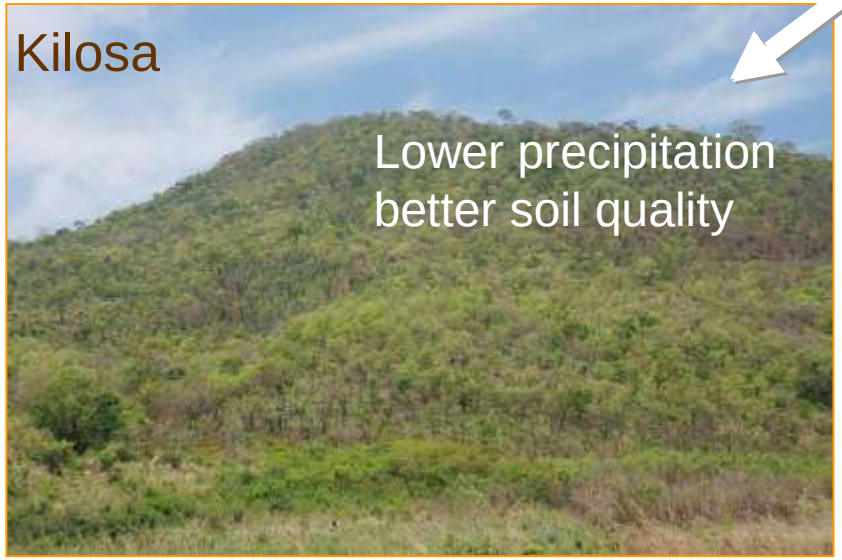
Overview REACCT

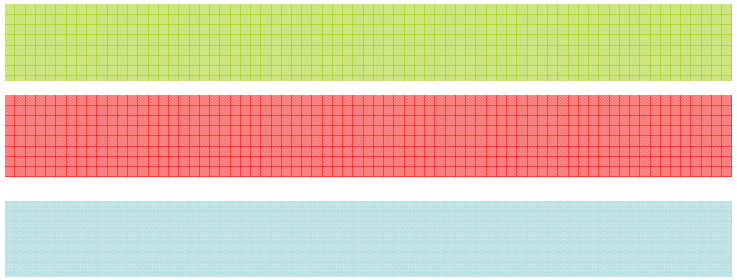




Overview REACCT

Activities per Output

Estimation on Activities per Output:



In time

Delay: To be refined and / or in progress

Still time

Activities per Output

O1: Regional downscaled climate change scenarios

- Output 1 Regional downscaled climate change scenarios for different **emission scenarios**
- The **non-hydrostatic regional climate model** CLM (Böhm et al. 2006a, b) will be used to generate spatial (7 km grid) and temporal (daily to hourly) high resolution climate change scenarios as drivers for the hydrological and agro-ecosystem models in output 2). This physically based model considers the complex land surface-atmosphere interactions, is suitable especially regions with structured relief and allows to generate climate data sets also for regions without historical climate time series. Climate conditions in remote areas will be additionally restructured through dendrochronology.
- Activities:

PIK	• Activity 1.1 Fixation of nesting strategy to embed the model into the GCM boundary and data collection and parameterisation of land surface properties for the regional adaptation of the regional **climate model CLM**.
PIK	• Activity 1.2 Test of the adapted model to reproduce the current regional climate and reconstruction of **historical climate data** (1971-2000). The model output will be compared to historical data and model performance will be statistically analysed.
PIK	• Activity 1.3 Generation of regional climate change scenario according to the **GCM projections** (2001-2100) and statistical analysis of historical and future generated data to estimate trends. Generated time series will be converted into a suitable data format for hydrological and agro-ecosystem modelling.
ICRAF	• Activity 1.4 Reconstructing climatic conditions from remote areas for the past decades through **dendrochronology** as a climate monitoring option for such remote areas and as calibration option for downscaling and decision support tool for adequate agroforestry tree species.

Activities per Output

O2: Model based estimations of CC impacts on current land use systems

- Output 2 Model based estimations of **climate change impacts** on current land use systems and practices
- The estimations will emphasise environmental pressures, which feed into the development of climate change adapted production systems embedded into resilient agro-landscapes (output 3).
- Activities:

ICRAF SUA ZALF
- Activity 2.1 Review of former **experimental data on cropping systems** of the region to extract data sets for model testing under conditions and to identify model and data set gaps.

ICRAF SUA ZALF
- Activity 2.2 Establishment of intensively **investigated field experiments** for most relevant cropping systems to provide consistent data sets from experimental sites including weather data, site descriptions (soil properties) and time series measurements of relevant status variables on soil water and nutrient distribution, crop phenology and biomass, yields and crop nutrient status for model calibration.

ICRAF
- Activity 2.3 Trees with dbh > 5 cm will be equipped with sap-flow sensors and their active xylem area will be established subsequently through a tree core. Measurements for leaf area index (LAI) will be conducted together with crop-soil modelling. An albedometer will render radiation data. Collected data will be fed into the **WaNuLCAS** model and analysed.

ICRAF ZALF
- Activity 2.4 Establishment of a **hydrological monitoring system**. Installation of groundwater observation wells and gauging stations at river streams to monitor long term trends of water resources under climate change.

Activities per Output

O3: Stakeholder based scenarios of potential future “agro landscapes

- Output 3 concentrates on developing stakeholder based **scenarios of potential future “agro landscapes”.** Output 3 Scenarios of sustainable livelihoods and resilient agro-landscapes under climate change
- Based on presented climate scenarios, stakeholder options of potential future agro-landscapes in their regions. All three sustainability dimensions (social, environmental and economic) will be taken into account by different groups of decisions makers.
- Activities

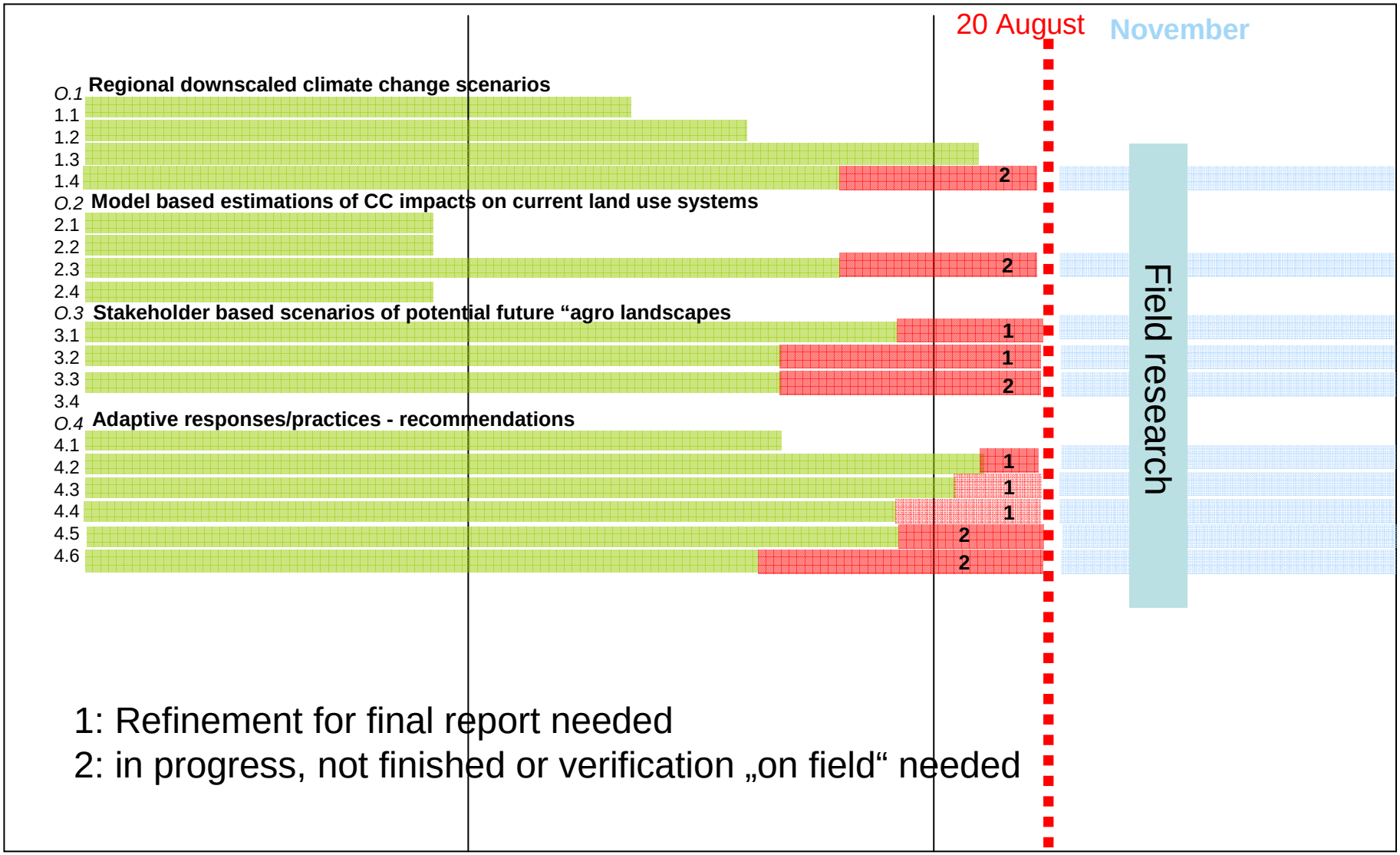
ZALF	• Activity 3.1 Survey on relevant existing **land use and management systems** and on the current state of the agro-landscapes and important land use sectors and drivers for land use change (DPSIR approach). Semi-structured interview will be held with farmers and perceptions and values of the current landscape will be analysed through participatory appraisal methods.
ZALF	• Activity 3.2 Most important **land use issues** will be identified together with different stakeholder groups. Interrelationships between will be explored and outlined. Trade offs and side effects due to changes in land use sector share will be made explicit.
ZALF ICRAF	• Activity 3.3 Scenarios of potential future **land use options (agro-landscapes**), allowing for local constraints and opportunities concerning climate change, will be developed and tested a) from empirical data on tree growth patterns (stable isotope analysis), useful tree species selection and upscaled model results on water use of tress in tree-crop systems (WaNuLCAS) b) through participatory methods with stakeholders from different decision levels (from farm to district) through different appraisal methods.
ZALF	• Activity 3.4 A methodological framework for the elaboration of an **ex-ante assessment tool** (indicators, applied methods, scenario building) to support decision-making will be developed.

Activities per Output

O4: Adaptive responses/practices - recommendations

	• Output 4: Assessment of **adaptive responses/practices** and criteria for best adaptation practices. Driven by the generated climate change scenarios (output 1) the model-based simulations calculate (through soil hydrology, nutrient cycling) crop responses on yields (output 2). These results reflect principally environmental pressures that serve as input for conducting Sustainability Impact Assessments (SIA), in particular on the social and economic consequences.
ZALF	• Activity 4.1 Land use **management systems** and related societal values / cultural habits for livelihood systems are explored
ICRAF	• Activity 4.2 List of **suitable agroforestry tree species** for the case study region. Overview on or tree related good practices and potential consequences of future climate change conditions concerning food security, protection of natural resources and sustainability.
ZALF	• Activity 4.3 Survey of existing **land use and management systems**, current state of the agro-landscape by expert knowledge and local stakeholder involvements (farmers, local decision makers, NGOs).
ICRAF	• Activity 4.4 Survey of **tree species distribution within farming system** in the case study region; Decision-support maps for selection of important tree species under present and future climates; commonly identified with different stakeholder groups.
ZALF	• Activity 4.5 **Sustainability Impact Assessment** (including indicator development by farmers and with local experts) of identified activities / sustainability indicators will predict potential consequences of occurring climate change pressure.
ZALF ICRAF	• Activity 4.6 Developing a methodological framework of **adaptation potentialities on existing agroforestry tree species** in close collaboration with local stakeholder applying participatory research approaches. Arrangement of appropriate sets of tree species options related to the different climate change scenarios; based on modelling simulation approaches under output 2.

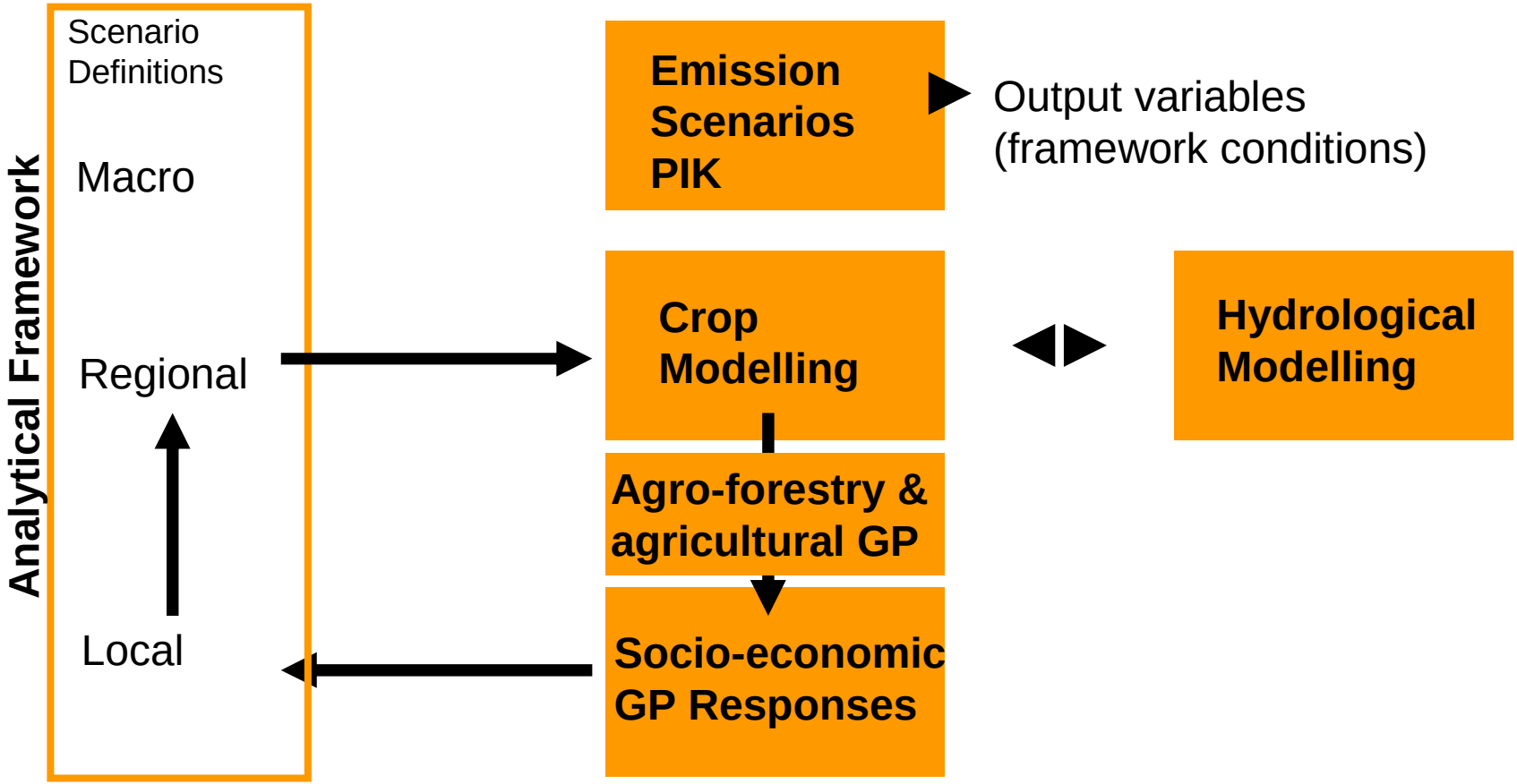
Overview timing



1: Refinement for final report needed

2: in progress, not finished or verification „on field“ needed

Outcome Integration



Outcome beyond Outputs

- Networking with Norway (University of Oslo)
- Memorandum of Understanding
- Four Master Theses
- Two project proposals (CCIAM, Bioinnovate Africa Concept)
- Publication initiative (subcontract SUA)

Outcome 4 Master Theses

Topic: Social economy

1 Title: Farmer's perception and adaptation to climate variability in Morogoro rural and Kilosa districts, Tanzania
Name of Master student: Daninga Phillip
Duration: 10 October 2009 to 30th June 2010
Expected data delivery: Dissertation and publications
Responsible Institution /Co-Institution: Sokoine University of Agriculture
Supervisor: Prof. E.M Mlambiti
Status: Thesis submitted for examination

Topic:Water use efficiency and agroforestry

2 Title : Simulation of water productivity for maize under drip irrigation in Morogoro Tanzania
Name of Master Student: Richard Festo
Duration: 10 October 2009 to 30th June 2010
Expected data delivery: Dissertation and publication
Responsible institution/Co-institution Supervisor: Prof. Henry Mahoo
Status (Thesis submitted for examination)

Outcome 4 Master Theses

Topic: Soils/hydrology

3 Title: Spatial prediction of soil water retention for selected soils in the Ngerengere catchment, Morogoro-tanzania
Name of master student: Jacob Kaingo
Duration: 10 October 2009 to 30th June 2010
Expected data delivery: Dissertation and publication
Responsible Institution /Co-Institution Sokoine Univeristy of Agriculture
Supervisor (Name, position). **DR Peter Wilson Mtakwa, department of soil science and Prof. Henry Mahoo Department of Agriculture Engineering**

Topic: Hydrology

4 Title: **Impacts of land use/cover changes on stream flow:** a case study in Morogoro river catchment
Name of master student: Augustina Alexander
Duration: 10 October 2009 to 30th June 2010
Expected data delivery Dissertation and publications
Responsible Institution /Co-Institution: University of Dar es Salaam - Department of Water resources Engineering
Supervisor (Name, position): Prof. F.W. Mtalo and Dr. P. Ndomba
Status: No cost extension requested

Outcome Decision Support Tool

Cross-project development with tool developed by funding of

- BMVEL
- GTZ Sustainet
- GTZ Sektorvorhabens „Nachhaltige Ressourcennutzung in der Landwirtschaft“
- BETTER-iS
- REACCT

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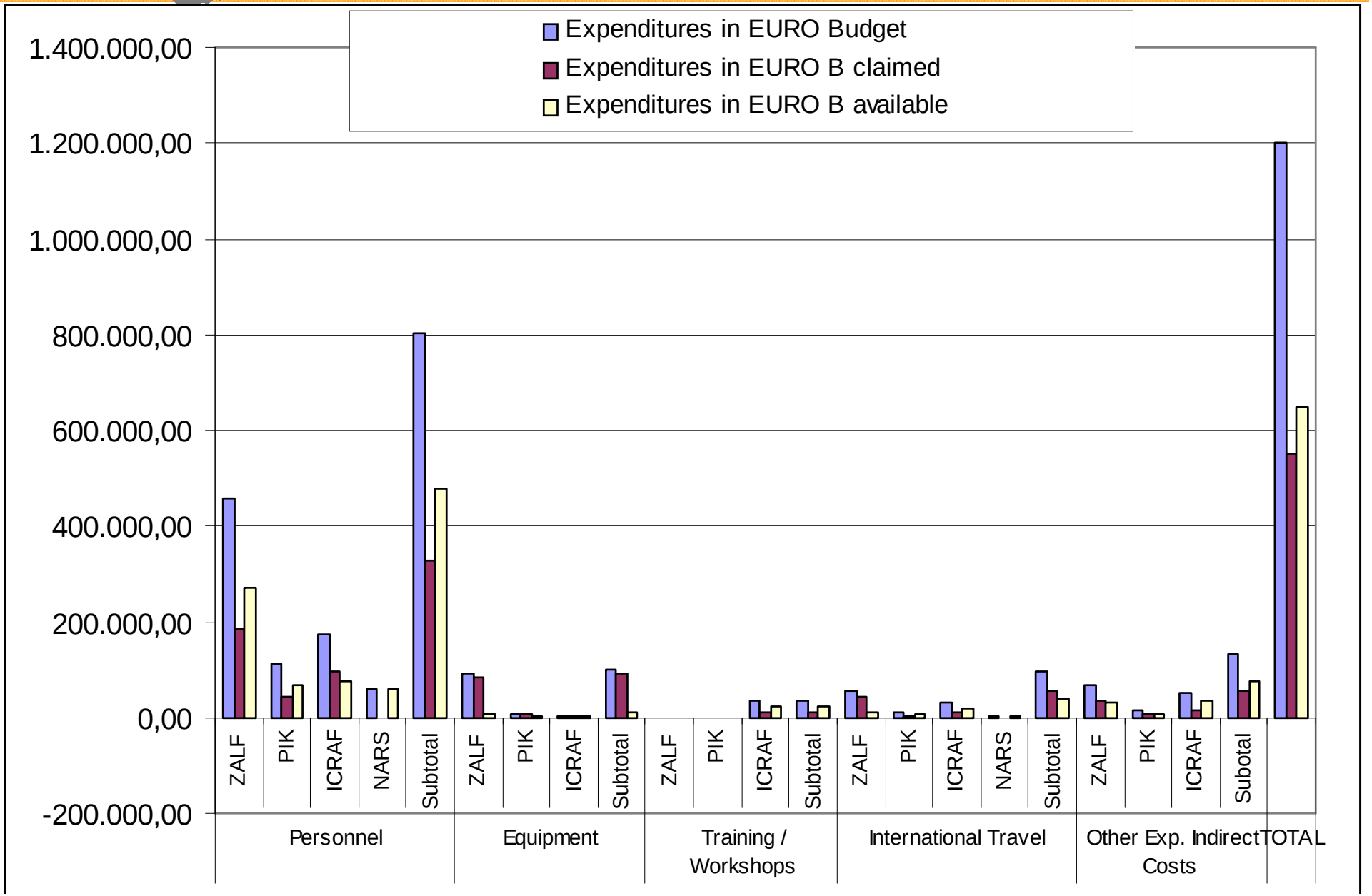
Budget spent



Thank for your attention!

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- **Output 1 and 2: Models and data**
- **Output 1 Regional downscaled climate change scenarios for different emission scenarios**
- **The non-hydrostatic regional climate model CLM (Böhm et al. 2006a, b) will be used to generate spatial (7 km grid) and temporal (daily to hourly) high resolution climate change scenarios as drivers for the hydrological and agro-ecosystem models in output 2). This physically based model considers the complex land surface-atmosphere interactions, is suitable especially regions with structured relief and allows to generate climate data sets also for regions without historical climate time series. Climate conditions in remote areas will be additionally restructured through dendrochronology.**
- **Activities:**
- **Activity 1.1 Fixation of nesting strategy to embed the model into the GCM boundary and data collection and parameterisation of land surface properties for the regional adaptation of the regional climate model CLM.**
- **Activity 1.2 Test of the adapted model to reproduce the current regional climate and reconstruction of historical climate data (1971-2000). The model output will be compared to historical data and model performance will be statistically analysed.**
- **Activity 1.3 Generation of regional climate change scenario according to the GCM prediction (2001-2100) and statistical analysis of historical and future generated data to estimate trends. Generated time series will be converted into a suitable data format for hydrological and agro-ecosystem modelling.**
- **Activity 1.4 Reconstructing climatic conditions from remote areas for the past decades through dendrochronology as a climate monitoring option for such remote areas and as calibration option for downscaling and decision support tool for adequate agroforestry tree species.**
- **Output 2 Model based estimations of climate change impacts on current land use systems and practices**
- **The estimations will emphasise environmental pressures, which feed into the development of climate change adapted production systems embedded into resilient agro-landscapes (output 3). These results determine the social and economic consequences investigated in output 4.**
- **The hydrological catchment models supply boundary conditions for agro-ecosystem models, water availability and water management planning. Hydrological catchment models are used to determine the impact of climate and land use change on the hydrological cycle in landscapes, primarily in river basins. Important indicators are discharge in rivers, ground water levels and water levels in lakes and wetlands. The models consider the relevant processes of the hydrological balance of the project study region: surface runoff, percolation, lateral subsurface flow and evapotranspiration. The hydrological models subdivide complex basins into sub-areas to reflect differences in evapotranspiration for various crops, soils, water levels, etc. Thus, runoff is predicted separately for each sub-area and routed to obtain the total runoff for the basin. Results from the more detailed SVAT models will be used for calibration and validation of the vegetation-soil water part of the hydrological model and results from the hydrological model are important boundary conditions for the SVAT models. The calibration and validation for the whole basin will be performed based on streamflow records at the outlet of the basin. Experiences with hydrological models were gathered in comparable tasks with the models SWAT (Arnold et al. 1998) and WASIM ETH (Schulla & Jasper 2006).**
- **The integrated agro-ecosystem models (SVAT models) include soil water and nutrient dynamics and soil-crop-atmosphere-management interactions to assess yield and soil fertility effects under climate change and to evaluate management options. The models will be linked closely to the hydrological models providing surface runoff, seepage, erosion and nutrient leaching as their input and using their output (groundwater level, water availability) as boundary conditions. Process-oriented SVAT (Soil-Vegetation-ATmosphere) models are required, which are able to simulate the bio-geophysical interactions between climate, soil and vegetation. Driven by the generated climate change scenarios these models are sensitive to changes concerning soil hydrology (water availability, seepage, runoff), nutrient cycling (mainly C and N) and crop response (biomass, yield) and will be used to assess combined climate change and management effects on crop (including fodder) production, water resources (quantity and quality) and soil fertility (e.g., soil organic matter, water holding capacity) and to evaluate best management (cropping systems, irrigation, fertilization) practices for future climatic conditions. The required models need be robust and operative under limited data availability. Integrated crop models should be generic to allow a relative easy extension for new crops by parameter calibration.**
- **Results from these experiments will be used to refine agro-ecosystem models and enhance their capacity to simulate changes that are likely to affect crop growth and productivity and enhance their ability to contribute to assessments of sustainability.**
- **Activities:**
- **Activity 2.1 Review of former experimental data on cropping systems of the region to extract data sets for model testing under African conditions and to identify model and data set gaps.**
- **Activity 2.2 Establishment of intensively investigated field experiments for most relevant cropping systems to provide consistent data sets from experimental sites including weather data, site descriptions (soil properties) and time series measurements of relevant status variables on soil water and nutrient distribution, crop phenology and biomass, yields and crop nutrient status for model calibration. Measurements will be performed at investigation sites of local experimental stations. Sites will be equipped with automatic weather stations, TDR probes in different depths and/or a neutron probe for soil water distribution measurements. Frequent auger sampling will be performed to calibrate the measurements by gravimetric methods and to measure soil nutrient distribution (N, P, K). Different treatments concerning irrigation and fertilization will be performed. A series of experiments of improved practices will be setup and their ability to reduce land degradation will be evaluated using rainfall simulation.**
- **Activity 2.3 Trees with dbh > 5 cm will be equipped with sap-flow sensors and their active xylem area will be established subsequently through a tree core. Measurements for leaf area index (LAI) will be conducted together with crop-soil modelling. An albedometer will render radiation data. Collected data will be fed into the WaNuLCAS model and analysed.**
- **Activity 2.4 Establishment of a hydrological monitoring system. Installation of groundwater observation wells and gauging stations at river streams to monitor long term trends of water resources under climate change.**