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Technical and socio-political shortcomings leading to sub-optimal performance of farmer-managed small-scale irrigation schemes in the Lake Tana Basin, Ethiopia

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In this study, technical and socio-political attributes that lowers the performance of small-scale irrigation schemes were investigated in the Lake Tana Basin of Ethiopia. Two representative farmers managed small-scale irrigation schemes (Shina and Bebeks) were selected in the floodplains of the Lake Tana Basin. The irrigation application efficiency and irrigation water use efficiency were measured during each irrigation event at nine experimental fields (three maize and three onion fields in Shina and three onion fields in Bebeks). The irrigation application efficiency varied from 20 to 80% but mostly it was between 40 and 60%. The irrigation water use efficiency, i.e. the ratio between the crop production and the amount of applied water varied from 1.9 to 7.2 kg m^{-3} for onion and 0.9 to 1.2 kg m^{-3} for maize fields. The lined and earthen canal conveyance loss in Shina were 0.033 and 0.044 l s^{-1} m^{-1} whereas in Bebeks they were 0.037 and 0.047 l s^{-1} m^{-1}. The overall consumed ratio of water for Shina varied from 0.73 to 1.2 indicating 20% deficit and in Bebeks it was 0.58. The experimental schemes are performing below the standard based on the technical performance indicators. The Irrigation Water User Associations were not implemented but Irrigation Committees are managing both schemes, though their capacity to maintain the schemes is weak. Canal and reservoir sedimentation in relation to erosion in the upstream catchments during the rainy season is the major problem identified. The performance of small-scale irrigation schemes like in the study areas require proper sediment control design, optimum irrigation scheduling as well as implementing and empowering Water User Associations that are trusted by the farmers.

Key words: irrigation, performance indicators, water use efficiency, social network

The resilience and biodiversity of wetlands in Lake Tana Basin

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The wetlands surrounding Lake Tana are hotspots of biodiversity and they supply a plethora of ecological and socioeconomic functions. However, increased anthropogenic pressure such as grazing, overharvesting *Cyprus papyrus* and invasion of alien plant species (*Eichhornia, Sesbania*, and *Eucalyptus*) and sedimentation are posing a challenge to their well-being. As a result, the wetlands are undergoing unprecedented changes, yet their exact extent has never been quantified and their areal change over the years is unknown. Little is known about the functional diversity of the major communities, which is critical to understand and predict their resilience. This project aims at understanding spatial and temporal change of *Cyprus papyrus* dominated wetlands and the major communities' functional diversity for selected wetlands in the basin. To estimate the *Cyprus papyrus* wetlands extent and change over the decades (from 1970 to 2017), past and recent satellite data and primary data (field survey, interview and focus group discussions) will be used. To determine the functional diversity of major communities of the selected wetlands (20 different wetlands), fish, benthic invertebrates, birds and macrophyte samples will be taken during dry and wet seasons of the study period using standard techniques and methods for each group of organisms. To assess fish, benthic invertebrates and bird species functional diversity, traits related to their feeding habits, habitat, r*esilience,* reproduction, locomotion and life history will be measured in the field or laboratory and will be extracted from existing databases. To assess macrophytes functional diversity, plant height, specific leaf area, leaf dry matter content, leaf greenness, leaf nutrient concentrations, absolute and relative abundance (above-ground biomass, coverage) and coverage of individual species will be measured. To examine the growth response of *Cyprus papyrus* to water level fluctuations and sediment load, mesocoms experiment will be conducted in the laboratory. To determine *Cyprus papyrus* potential for water quality improvement (turbidity and nutrient removal), the ex situ experiment will be also conducted.

Key words: Functional diversity, traits, Lake Tana Basin, Wetlands, Fish, benthic invertebrates, birds, macrophytes

Unravelling the land cover and hydrological changes of Mt. Guna through integration of field inventory and remote sensing

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The land cover change and hydrological system of high-elevation catchments in most part of the world is poorly known. Mt. Guna is chosen as study area, a distinct Miocene shield volcano on the Ethiopian plateau reaching an altitude of 4200 m a.s.l. Historical and current land cover maps of Mt. Guna have been prepared from 1957 aerial photographs and high resolution Google Maps of 01/02/2015 respectively. To investigate the hydrological behaviour of Mt. Guna, springs, wells, natural ponds and rivers were inventoried. According to the land cover change analysis, grass land cover declined (from 40.1 % to 34.2 %) as well as afro-alpine forest (from 5.8 % to 2.3 %), while the cover by eucalypt plantation (from 1.1 % to 2.9 %), built-up area and crop land (from 31.2 % to 42 %) increased between 1957 and 2017. The hydrological inventory shows that most of the springs (17 out of 41) are found at elevations between 3600 and 3700 m a.s.l. and have an average discharge of 0.15 L/s (SD=0.07). Out of 5 ponds inventoried, 3 ponds are also found in the same elevation which have on average 40 cm of water depth. Two hand dug wells investigated in the western part of Mt. Guna showed a difference of 6 meter of water depth. This clearly implies there is a dynamic hydrological behaviour which needs to be investigated in detail.

Key words: Mt. Guna, land cover, hydrology, water balance, inventory, GIS data portal

Hydrogeological characterization and surface-groundwater interaction of Lake Tana basin, Northwestern Ethiopia

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Lake Tana basin, one of the major sub-basins of Upper Blue Nile River basin, covers about 15,077 km^2 of which 3156 km^2 is the lake water body. The basin is rounded in shape with a central depression; it is geologically complex and thought to be formed by the junction of three grabens, dipping to a central depression, which was dammed afterwards by the deposition of quaternary volcanic rocks. More than forty rivers are draining to the lake from which four are the major ones. Previous water balance quantifications have been done by considering negligible interaction between surface-groundwater bodies without clear scientific evidence. Characterizing the different aquifer systems and their hydrological connectivity with the lake and river water bodies fill the knowledge gap in understanding the hydro(geo)logical system of the basin, and in upgrading the water balance studies. A number of automatic and manual measuring stations for monitoring of shallow groundwater (64), surface water (16) and meteorological (13) variables (rainfall and temperature) have been established, and were distributed based on a subdivision of the area into three classes considering geology and topography: recent alluvial-lacustrine deposits in the flat flood plain areas, weathered basalt dominated middle part with medium elevation, and mostly volcanic tuff covered, steep sloping highland part. The preliminary results show that the groundwater level for tuffaceous top aquifers has a strong response to the rainfall compared to the middle and flood plain aquifer systems. The upper system is characterized by sharp water level rises for the early rainfalls and immediate decline following the offset of the rainfall. In the middle and flood plain aquifer systems, subsurface recharge from the surrounding hill areas occurs. River stage and surrounding shallow aquifer groundwater measurements show that surface-groundwater interaction strongly depends on season as well as topography. Spring inventories show that most of the high discharge springs (estimated discharge of 70-80 l/s), concentrated along the contact between the flat flood plain area and the middle part, are emerging through master joints, with high velocity, and the spring water would have seen limited water-rock interaction.

Key Words: Tana basin, hydrogeology, shallow aquifer, water level, spring

The BDU-IUC gender component

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The BDU-IUC has a Gender component under TISP that is planned to reduce gender inequalities. Gender inequity is one of the key development issues in Ethiopia and thus gender inequalities at BDU are the reflection of the reality at national level.

A huge gap has been observed between men's and women's participation in BDU's academic staff profile. Women's share from the total academic staffs is currently only 16%. A large (69%) number of female academic staff are in the rank of lecturer, whereas only 6.6% are assistant professors, 0% are associate professors and 0% full professors. They are also poorly represented in leadership positions (22%) as well as their participation in research and publication is extremely low. The number of female students admitted to the University is 34 % in undergraduate programs, 17% in graduate MA/MSc programs, and only 9.2% in PhD programs.

The specific objectives of the Gender component under TISP project are: providing training to staffs of BDU's Gender office; organizing a workshop for gender action plan; developing Gender policy of BDU; follow–up of the planning and implementation of the gender component within the BDU-IUC projects. Intermediate results of the Project will be that gender inequalities are reduced at Bahir Dar University and gender is mainstreamed in all IUC projects.

The Flemish experts help to address these capacity gaps through short-term skill training and long-training such as seven female pre-docs; three female PhD students have started their studies. The Gender component under TISP is extremely relevant to build BDU's capacity. The Gender component under TISP contributes directly to empower female staffs of BDU but also to mainstream gender in different project activities of the BDU-IUC programme implementation of the university. The empowered female academic staff can also help BDU to better address its governmental and societal responsibilities as development actor. Therefore, the Gender component under TISP is the core project to achieve the programme objectives.

Perceptions of farmers, traders and consumers on tef (*Eragrostis tef (Zucc.* Trotter) quality indicators in Central and Northwestern Ethiopia

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Tef is an indigenous crop and a preferred food crop for many Ethiopians. Its quality and price are mostly determined by the grain color. The Ethiopian Standard Agency classified tef grain quality as very white (*magna),* white (*nech*), mixed (*sergegna*) and brown (*key*). The price variability of tef is also determined by tef production area. There is no clear evidence and study on tef quality variability due to production area or soil type. Farmers have developed knowledge about quality tef production through long term on farm observations and traders and consumers' knowledge on the value chain improved the likelihood of success. Therefore, these studies were conducted to asses and understand tef quality indicators and environmental factors that could influence or hinder good quality tef production and to explore how to combine local and scientific knowledge to achieve good quality tef production system. Hundred sixty farmers in eight main tef producing *Kebeles,* 43 tef traders (retailers) in five major tef markets and 36 consumers in 4 cities of the Amhara and Oromiya Regional States (East Gojam, East Shewa, North Shewa and West Gojam zones) were interviewed in the 2017 cropping season to asses tef quality parameters. Respondents classified quality parameters as grain color, weight (density), seed size, purity (mixture of different tef varieties), cleanness (against dirt), hulled grain and shininess. Sixty percent of the interviewed farmers, 77% of the traders and 97% of the consumers perceived grain color or whiteness as best indicator for best quality Injera making. Farmers listed temporal rainfall distribution, particularly its amount, onset and cessation dates, as the main climatic factors affecting tef quality. Farmers and traders believed seven factors (soil type, frequency of weeding, hand weeding, seed cleanness, seed rate, agronomic practices, quality of threshing ground and harvesting time) that affect tef quality. From these factors, the contribution of soil type for tef quality differences was perceived by > 82% of the respondents. Among the different soil types, black (vertisols) and brown (probably cambisols) soils are preferred by 78% and 69% of the interviewed consumers and farmers, respectively. Whereas, from the interviewed traders, 97.7% perceived that better quality tef grain is produced in brown soil. Red soil (Nitisols) teff is not preferred by all respondents. This study revealed that tef quality can not only be judged by color, but also grain size, grain density, hulled grain, shininess, purity and cleanness are also important parameters. Tef grain quality is also governed by some environmental factors like soil type, initial seed purity, cleanness (free of weed seeds and other dirt), agronomic practices and distribution and amount of rainfall in tef growing

season. Especially, tef grown in black soils (vertisols) perceived as best quality but, red soil (Nitisols) as poor quality. Experiments should also be conducted to evaluate different soil types and agroecologies on tef grain quality.

Key words: Tef, Perception, Quality, Farmers, Traders, Consumers

Water Balance of Beles Basin

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The Beles basin is one of the least studied basins in Ethiopia, which is attributed to scarcity of data, poor distribution of hydro-meteorological stations and poor quality of available data. In addition, the Beles basin is characterized by a heterogeneous and complex geological setting with artificial and possibly natural and inter-basin water inflows from the Tana basin that makes the Beles basin complex to study. Despite this knowledge gap, huge irrigation and hydropower project activities are under development. Understanding the groundwater - surface water interaction and dynamics of the water system of this basin based on appropriate data will help to establish water management plans to avoid erroneous water use practices. In Beles basin, since April 2017, 4 river discharge measuring stations (2 on Main Beles and 2 on Gilgel Beles river), 18 groundwater monitoring stations (4 automatic and 14 manual) and 5 meteorological stations (rainfall and temperature) have been installed. Some preliminary results show that rainfall, temperature, groundwater response with precipitation, are highly spatially variable within the basin. There are high discharge springs along the water divide with Tana which hint to inter-basin flow. Intake flow data from Lake Tana-Beles hydropower project show that there is a gradual increase of artificial surface water transfer from Tana basin to Beles basin since the hydropower started operating in 2011. The recently developed small scale irrigation practice in the upper Gelgel-beles also creates new ecohydrology such as wetlands. The Great Ethiopian Renaissance Dam (under construction) will impound the lower reaches of Beles basin. For the better understanding of the Beles basin water balance, additional hydrometric stations will be installed, rating curves for the river discharge measuring stations will be developed, the geological map will be updated using field and remote sensing data, water points (wells and springs) will be inventoried and water will be sampled and analyzed both on site and in the laboratory to understand water dynamics within the basin.

Key words: Beles basin, Water balance, Inter-basin flow

Microbial community composition and water quality of Lake Tana

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Lake Tana and its tributary rivers account for more than half of freshwater reserves in Ethiopia. The lake is a hotspot for biodiversity and economic development. However, untreated wastewater from Bahir Dar city and river discharges carry pathogens, nutrients and pesticides into the lake. These pollutants put the lake's resources and ecosystem services at risk, such as water use for domestic purposes, food production or recreation. In spite of these facts, little is known about the water quality and microbial community structure of Lake Tana. The objectives of the study are to investigate the physio-chemical and microbial pollution of waste water effluents of Lake Tana, and determine the microbial community structure of the Tana Lake. For water quality monitoring, water samples will be collected on monthly basis at five selected stations near the inflow of the tributary rivers. Moreover, other sites will be sampled biannually during the dry and wet seasons on the south shore of the lake. Onsite measurement of turbidity, temperature, specific conductance, pH and dissolved oxygen and chlorophyll a will be carried out. Total nitrogen, total phosphorus and biological oxygen demand (BOD)$_5$ will be determined. Furthermore, water samples from effluents in the south shore of the Lake will be analyzed bacteriologically to determine microbial pollution. Microbial community composition will be investigated based on 16S rRNA and 18S rRNA genes of prokaryotes and eukaryotes, respectively. Therefore, water samples will be filtered, frozen and transported to Ghent University, Belgium. From water samples, DNA extraction and polymerase chain reaction (PCR) will be carried out using universal 16S and 18S rRNA primers.

Key words: Lake Tana; water quality; microbial community structure;16S rRNA; 18S rRNA

A Current Research Information System for Bahir Dar University

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The world of information is changing. In the past the library was the local access point to information. In the time of internet information is distributed over a network worldwide. Every university is becoming a node in the information grid. The management of the research output is therefore becoming a crucial tool for internal research management as well as for external output presentation. In the framework of the TISP project the research office of BDU is setting up a CRIS (Current Research Information System) with DSpaceCRIS. A workflow is being created to gather all information about researchers, research units, projects, publications, community activities. This information is needed for a modern research management. It is at the same time a showcase of the research output of the university.

Key words: Data sets, Information management, Research output, Research management, CRIS

Research Management Capacity Building Internship for Bahir Dar University and the lessons learnt

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In the framework of the Institutional University Cooperation (IUC) programme between Bahir Dar University and Flemish universities (programme coordinated by prof. dr. Jan Nyssen (Ghent University) and prof. dr. Enyew Adgo, Bahir Dar University)), a collaboration was set up to investigate the research-related support that is offered by the central administration to the research community at the universities mentioned. In this regard, an internship was held from January 15 to February 5, 2018, by a visit of dr. Bezuayehu Kerisew, Research Director of Bahir Dar University, Ethiopia. Four Flemish Universities (Universiteit Gent, Vrije Universiteit Brussel, Universiteit Hasselt and Universiteit Antwerpen) were involved. The internship focused on gaining experiences of Flemish Universities on the research co-ordination activities and the research data management platforms used to support these activities. Among the topics which were investigated include:

- the management of the external calls for research proposals and the ways this information is distributed among the researchers;
- the management of internal research funds and the mechanisms to distribute the funds to researchers;
- the university policy measures to stimulate and support staff to perform excellent research;
- the criteria used to evaluate submitted research proposals and/or to assess the research achievements of staff members in the framework of promotion opportunities;
- the research and the research information management systems that are in place to collect, monitor, and visualise all kinds of research performances at the level of an individual, a research group, a faculty, a research institute, and the university as a whole;
- the visualisation of the research expertise of all staff as a helpful means to attract external partners;
- the criteria, steps and management of valorization (formation of spin offs and incubation centers) based on the research outputs;
- the financial management of the research projects from the beginning to their completion;
- the automation of all administrative, financial and output-generating activities related to research;
- the ways to monitor effectiveness and efficiency of research policy measures and to design new or alternative policy measures in order to reach the research-related goals set by the university.

In general, important experience was gained from the Flemish Universities visited and this will be a valuable input for the effort being done to improve the research activities, the research co-ordination activities and the research information management activities of Bahir Dar University.

Keywords: Research management, Institutional University Cooperation (IUC), Bahir Dar University, Flemish universities, Collaboration

Improving Agricultural Water Productivity in the Beles Watershed, Northwestern Ethiopia

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The Beles watershed is one of the Ethiopian growth corridors because of its considerable potential for irrigation development. However, this potential is adversely affected by unimproved water and soil management practices, low water productivity and soil erosion. Thus, optimizing the efficient use of rainwater by taking appropriate water and soil conservation measures as well as improving irrigation practices are of paramount importance to fill the gap. In this study, it is hypothesised that water is a major limiting factor for crop growth in Tana Beles watershed and that higher crop yields per unit of water consumed can be attained by using the available water resources more effectively. A way forward to help improving water productivity and taking appropriate and sound decisions is the use of computer - simulated crop models such AquaCrop model. This study will be conducted in the upper part of Beles River which is situated in the southwestern direction of Lake Tana between 10° 56' to 12° N and 35°12' to 37° E. The total area of the basin is about 14,200 km². The topography of the area is mainly flat with altitude from 458 to 2729 m a.s.l. The specific objectives are: (i) Identifying the local farming practices including soil and water conservation measures, irrigation practices, tillage operations, weed controls, and fertilizer management; (ii) Testing different soil and water conservation measures that enhance infiltration and minimize soil evaporation; (iii) AquaCrop model validation under rain-fed, full and deficit irrigated conditions for major irrigated crops; (iv) Developing scenarios through the assessment of crop response to water management using AquaCrop model to improve water productivity; (v) Assessing the impact of farm level agricultural water management on a wider watershed scale and on the available water resources. Experiments on farmers' fields will be conducted using treatments including (i) rain-fed + conventional land management practices (RF-CLM) of the local communities as a control; (ii) RF + selected sustainable land management practices (SLM); (iii) fully irrigated + CLM, and (iv) deficit irrigation conditions + SLM. The type of crops and fertilizer application will be the same for all treatments. The treatments will be arranged in randomized complete block design with three replicates. Meteorological, crop and soil data will be used to calibrate and validate the AquaCrop model. To calculate *ETo* meteorological data will be collected at a meteorological station which will be installed in the project site. Pedotransfer function will be used to predict soil-hydraulic properties. Overall, this research will contribute to improving water productivity by optimizing soil health which

in turn enhances infiltration and water holding capacity of the soil, and by improving irrigation management in the study area.

Key words: Water productivity, AquaCrop model, improved water management, pedotransfer function, Tana Beles Watershed

Hydrogeology and water chemistry of Infranz catchment springs, Bahir Dar Area, Lake Tana Basin, Ethiopia

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The major springs in the Infranz catchment are a significant source of water for Bahir Dar city and nearby villages, while they help to sustain Infranz River and the downstream wetlands. The aim of the research was to understand the hydrogeological conditions of these high-discharge springs, and to explain the hydrochemical composition of spring waters. Water samples from rainwater and springs were collected and analyzed and compared for major cations and anions**.** The hydrochemical data analysis showed that all water samples of the springs have freshwater chemistry, Ca-HCO_3 type. This indicates limited water-rock interaction and short residence time for the spring waters. The rise of NO_3^- and PO_4^{3-} may indicate future water quality degradation unless the anthropogenic activities upgradient and nearby are restricted. The uptake of 75% of spring water for water supply of Bahir Dar results in wetland degradation.

Influence of patch and landscape-level characteristics on woody species composition and canopy structure of church forests east of Lake Tana, Ethiopia

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We hypothesize that the ecological integrity of church forests in north-western Ethiopia depends both on characteristics at patch level (area, shape, and year of establishment) and landscape level (type of surrounding landscape matrix, distance from the nearest permanent road, and level of isolation from other church forests). To test this hypothesis, we examined how these characteristics influence woody species communities and structure in a total of 24 church forests, located in the area east of Lake Tana, and ranging in altitude from 1800m to 2200m. Woody species communities were sampled in four 20m x 20m plots per forest, and plots were selected along four cardinal directions (north, east, west, south) at different distances from the forest, following a stratified random sampling design. In each plot, all woody plants with a Diameter at Breast Height (DBH) of more than 7 cm were identified, counted and measured, whereas seedlings and canopy cover were assessed in subplots. In 17 forests that have already been sampled, a total of 96 woody species representing 49 families were recorded. A total of 50% of these species were trees, 48% were shrubs, and 2% were lianas. Species composition differed between forests, with 31 species being exclusive to only one of the forests. Fabaceae is the dominant family represented by 10 species, followed by Apocynaceae and Myrtaceae, which are represented by 3 species each.

Economic impact of dam driven irrigation on smallholder farming in Ethiopia: an efficiency approach

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Ethiopia is in the midst of rapid economic development. Agriculture, accounting for almost 73% of total employment, forms a key part of the economic development strategy of the government. The added value per worker in agriculture is only 485 USD, which indicates that the agricultural productivity remains very low. Agricultural development is therefore essential to achieve sustainable economic growth and food security. One of the strategies towards increased agricultural productivity consists of dam construction for large scale irrigation projects for smallholder farming. An illustrative and probably the most successful example of such projects is the Koga dam irrigation project located in the Lake Tana catchment of North-Western Ethiopia which provides water for 7,000 hectares of smallholder owned land irrigated during the dry season. However, the economic impact of such dams is not yet fully understood. This research analyses the impact of dam driven irrigation water on the productivity and efficiency of smallholder farmers in the Koga dam irrigation scheme. The effects of irrigation water and other factors on yield are quantified through the construction of a production function and efficiency analysis for which primary data have been collected by means of a structured household survey. The variables included in the production function are based on a literature study. The efficiency analysis is based on the stochastic frontier method. Parameters for both models are estimated using the maximum likelihood method. The survey was executed on a sample of 450 smallholder farming households. The sample was randomly distributed over different municipalities based on population with 254 households having access to irrigation water and 196 not having access. The preliminary results show that the use of irrigation water for one season increases productivity by a factor of more than 7. Irrigating an additional season however increases productivity by an additional factor of only around 1,18. On average, households having access to irrigation water have 60% more total value of livestock and use 3 times as many modern farm inputs. The results of the research can be used to propose better strategies to increase agricultural productivity using irrigation water.

Key words: Irrigation, Koga Dam, production function, efficiency, stochastic frontier

Analyzing the Role of Geotourism in Northwestern Ethiopia

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Geotourism is a new, niche form of sustainable tourism which focuses on geological and geomorphological characteristics of an area, and any accompanying cultural resource. Northwestern Ethiopia is one of the main tourism destinations in the country. It possesses a variety of unique natural and cultural tourism resources with a great potential for geotourism development. However, there are several critical socioeconomic development needs and environmental problems in the area which call for balancing development and conservation of the fragile natural and cultural assets. The main objective of this research is to analyze the role of geotourism for sustainable socio-economic development and environmental management in Northwestern Ethiopia. Specifically, this study will explore the supply and demand sides of geotourism, i.e. resource inventory and profile of national and international visitors and their travel patterns. In addition, the needs of the local communities will be mapped to allow them benefit from tourism development. Based on the mapping of the geotourism resources, visitors and community needs, the study will develop appropriate policy guidelines to support the development of sustainable tourism. To successfully achieve the objectives of this study, surveys of local communities, and domestic and international visitors will be conducted. In addition, to get insights about tour itineraries, attractions and services in the destination, websites of tour operators and TripAdvisor will be reviewed. Furthermore, semi-structured interviews will be carried out with experts working in the areas of tourism, socio-economics and environment, and periodic field observations will be held. Relevant policy and planning documents, reports, research outputs, maps and photographs will also be consulted. For analyzing these multiple data gathered, quantitative and qualitative techniques, and triangulation will be used.

Key words: Geotourism, Northwestern Ethiopia, Sustainability.

Floodplain sedimentation history of the Gumara and Ribb rivers in Ethiopia

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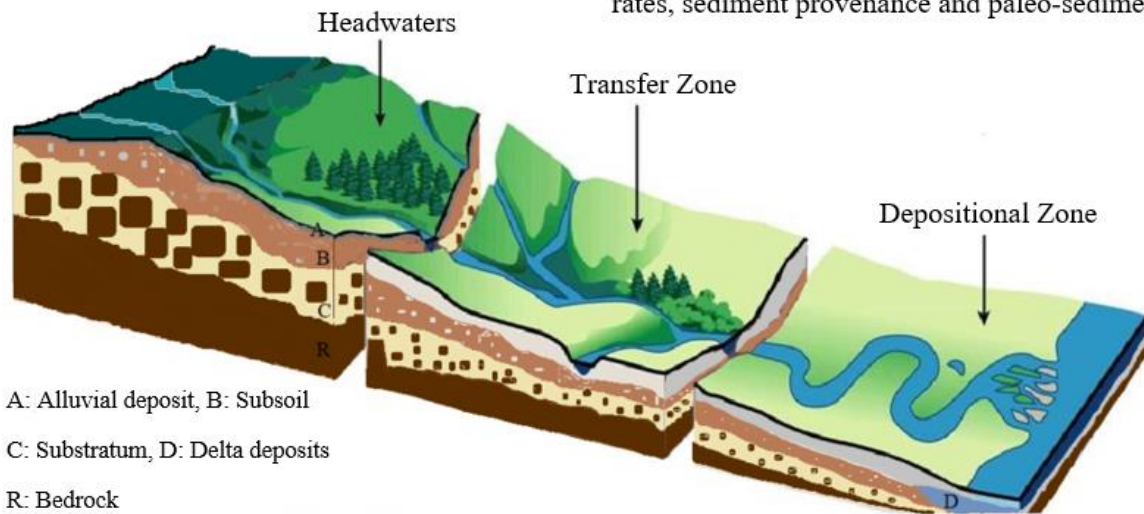[6]Department of Geography, Ghent University, Belgium

Floodplains act as a sink for the material transported by the fluvial system and thus aid to understanding the sedimentation history within the catchment. The Fogera Floodplain in the eastern of Lake Tana buffers sediments transported by the River Gumara (catchment area: 1595 km^2) and River Ribb (catchment area: 1992 km^2) that originate from the slopes of Mount Guna (4120 m) and drain westwards to Lake Tana, and which will form the focus of this study.

The sediment load of both rivers has been measured directly at gaging stations in their lower sections, in proximity to Lake Tana. Whilst these data allow to assess how much sediment is being delivered to the lake, it does not provide a quantitative estimate of the total amount of eroded soil material that is being delivered from degraded hillslopes to the fluvial system, nor does it show where the sediment comes from as it is single-point measurements. Furthermore, these sediment load data only span a relatively short period of time and thus do not allow to test whether the agricultural expansion of the last decades can be held responsible for the rapid siltation of Lake Tana. The quantitative and spatial-temporal analysis of floodplain sediments, however, may provide a response to these unknowns and will be addressed in this research.

Within this study, data will be collected from intensive corings at centrally laid cross-valley transects which are thought to represent homogenous zones of the alluvial plains. The coring data will be used to establish the sediment stratigraphy, define the alluvial floodplain architecture and eventually quantify the amount of material buried in the alluvial plains that occur in confined valleys in the headwaters and transfer zone, and that cover older lacustrine deposits in the Fogera plain along Lake Tana. Furthermore, the efficacy of sediment tracers such as compound-specific stable isotope (biomarker), sediment color (physical tracer) and phytoliths (silica-chemical tracer) in apportioning potential sediment contributors to the fluvial system in terms of land use categories will be examined. The establishment of sediment chronologies through ^{14}C AMS dating will be used to define the aggradation rates and identify periods of increased floodplain sediment dynamics. Furthermore, the coupling of the sediment chronology with the sediment fingerprinting will enable inferring and reconstructing past land use/land cover changes in the headwaters.

Process (P): Anthropogenic deforestation, sediment and nutrient export, deposition and reworking

Research Topics (RT): Quantification of floodplain material (sediment plus carbon) storage, aggradation rates, sediment provenance and paleo-sedimentation

Headwaters

Transfer Zone

Depositional Zone

A: Alluvial deposit, B: Subsoil

C: Substratum, D: Delta deposits

R: Bedrock

Key words: floodplain storage; aggradation rates; sediment fingerprinting; sedimentation history; Gumara and Ribb

Land degradation processes and its relationship to landscape connectivity and resilience in the Lake Tana Basin, Ethiopia

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Lake Tana Basin, which covers a total area of 15,114 km^2 is dominantly characterized by an agricultural landscape which is affected by land degradation due to soil erosion. However, soil erosion processes in the upland sediment source areas are not properly understood. We will investigate the process of soil erosion at different spatial scales, covering different erosion types, and analyzing its relationship to landscape connectivity and resilience in an eastern sediment source area of Lake Tana (Enkulal and Agonafir catchment, 10.2 km[2] in total). Weirs have been installed at 20 outlets of micro- and sub-catchments which represent the area's variability in topography, land-use and management. At the scale of these small to medium source areas, runoff discharge, soil loss/sediment yield and sediment fixed nutrient export will be determined on an event and a daily basis. Moreover, gully erosion and volumetric changes will be analyzed through field measurement and 3D modeling. Sediment source areas will also be identified through compound specific stable isotope analysis (CSSIA) fingerprinting using δ13C from plant derived fatty-acids. The RUSLE soil loss model will be calibrated and validated to allow the prediction of soil erosion under different scenarios, including evaluation of the effectiveness of existing soil conservation practices. Preliminary results of September, 2017 showed variable runoff responses of different land-uses. Runoff yield increases in the order of natural forest (runoff coefficient of 29±17%), farmland (44±23%), fallow (60±28%) and badland (46±20%). This indicates that in the late rainy season runoff coefficient is less from farmland than from fallow. In addition, annual gully erosion has been estimated to be 58.5 Mg ha^{-1}. As the preliminary results were based on late rainy season data, the findings will further be strengthened with full season data in the coming years.

Key words: Land degradation, Landscape connectivity, Soil erosion, Resilience

Multi–site calibration of SWAT to identifying erosion hotspots at basin scale as a plan for catchment management

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Soil and water resources are crucial for food production, productive and sustainable economies and environments, but both resources are threatened by erosion and sediment redistribution. In Ethiopia, 5 to 300 t ha^{-1} of soil is being lost every year mainly by water erosion, which also imperils food security. Recent studies in Lake Tana Basin (LTB) also revealed that average observed suspended sediment yield (SY) is ca. 53 t ha^{-1}y^{-1} (18–155 t ha^{-1}y^{-1}), where the eastern and southern catchments generate and deliver more sediment. As erosion can adversely affect ecosystems on-site and off-site, estimating the geographic distribution runoff and soil loss in catchments is becoming the most important information required for soil conservation and management. However, previous studies on identifying erosion hotspots in and around LTB have several limitations, mainly their outputs were not validated with observed sediment data and they were analyzed based on old and coarser scale land use/cover, soil and DEM data.

Despite erosion processes are very complex, management of the soil loss problem essentially needs catchment level modelling. There are a number of modelling tools developed for different spatial scales and using different concepts. One of the models intensively used for hydrological and erosion simulations, with an objective to determine the effect of soil and water management strategies, is SWAT. As a physical-based model, SWAT is relatively improved in SY prediction, eliminates the need for sediment delivery ratio, can simulate sediment yield for a single storm and has been used in several soil and water management impact studies worldwide.

This paper demonstrates the ability of the SWAT model to evaluate SY and transport at the basin scale with the objectives to delineate the area of erosion/sediment sources within the LTB, produce vulnerability map of LTB to assess the risk possibilities and evaluate soil and water management options. Precipitation and temperature (1999-2016) of 20 nearby weather stations, DEM, soil and land use/cover data were used to divide the basin into subbasins and then into Hydrologic Response Unit (HRU) so as to calculate SY. Observed discharge (2001-2016) and sediment (2012-2016) data of four main rivers were used for calibration and validation of the model. Then, the validated model calculates the soil erosion and SY within each HRU in each sub-basin within LTB so that the rate of soil erosion can be understood. Finally, land management options (e.g. Acacia decurrens-based *taungya* system) will be

evaluated. The study output may help planners and stakeholders to take relevant soil and water conservation measures and thereby reduce the alarming soil loss problems in LTB.

Key words: Lake Tana Basin, Acacia decurrens, Soil and water management

The Beles basin: part of Ethiopia's core or periphery?

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In the Beles basin, a lowland border area of Ethiopia, important investments have been made. They require an evaluation of their socio-economic and ecological impacts in the light of Ethiopia's Climate-Resilient Green Economy (CRGE) strategy. Also, do such investments change a "peripheral" area of Ethiopia, into a part of the "core"? The "core" area consists of those places that wield the greatest economic power and have accumulated the highest levels of affluence. The "periphery" lacks a stable power base, is characterised by a lack of wealth, and serves as supplier of capital, labour or commodities to the core. The very core-periphery thinking provides us with a useful analytical framework, as it highlights that uneven development needs to be understood from a relational point of view. We contrasted literature of different periods with field observations. In the middle and lower basin, the Gumuz people traditionally practiced shifting cultivation. Resettlement of highlanders is particularly linked to water and land resources. A large irrigation project was initiated in the 1980s, but vegetables and fruits face post-harvest losses. Large water transfers from Lake Tana since 2010 affect the movement of people, the hydrogeomorphology and ecology of the river and initiated further expansion of irrigation, among others for a large sugar estate. In several parts of the basin, the settlers' economy now dominates. Many Gumuz became sedentary but maintained their agricultural system, particularly in the south of the lower basin. Land titling allowed allocation of "vacant" areas to transnational or domestic investors. As a result, the semi-natural vegetation is frequently replaced by open cropland, leading to decreased carbon storage and increased soil erosion. This, and water abstraction for irrigation will jeopardise hydropower production, in contradiction with the CRGE objectives. Despite the recent developments, the contrasts in economic activity make the core-periphery dichotomy to

remain actual in the Beles basin. The resettlements and permanent cropping tend to make the upper basin part of the core. However, the installation of a transit road and commercial farms in the lower basin do not allow to consider that a non-peripheral integration has taken place.

Key words: Africa South of the Sahara, peripheralisation, non-peripheral integration, Gumuz, sustainable development, water, internal migration

Economic value of farming around the Koga Dam irrigation scheme

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Ethiopia has, recently, constructed a number of dams so as to boost agricultural production, including Koga dam in the Lake Tana basin of northwest Ethiopia. However, from a global perspective, the construction of dams to improve agricultural production has become a controversial issue. For instance, some authors warn that dams may actually have cut agricultural production. To gain a better understanding about the impact of dam construction on agriculture in Ethiopia, primary data has been collected from a randomly selected sample of 450 households. Among this sampled household, 254 are supported by the Koga dam irrigation water and the remaining 196 depends only on rainfed farming around the irrigation scheme. The preliminary survey of 2016/2017 cropping season showed that crop revenue per hectare of smallholder farmers practicing dry season irrigation is much higher (24,904.27 Ethiopian Birr) than that of the rainfed crop production (3,958.20 Ethiopian Birr). This difference remains significant, even when we compare only the summer season crop production, when crops are produced without irrigation water. Similarly, the average market value of the livestock of the smallholder farmers with irrigated land is significantly higher (76,706.33 Ethiopian Birr) than the farmers with no irrigated land (48,043.99 Ethiopian Birr). This may be because the farmers with irrigated land are more acquainted with modern farming techniques and have more farming assets. In this study the reasons behind this difference will be investigated.

Key words: Koga Dam, Irrigation Water, Crop Revenue, Northwest Ethiopia.

Impact of fast-paced urbanization in governance and urban fringes of Ethiopia; case studies of Bahir Dar and Gilgel Beles

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Fast-paced urban expansion has become an essential feature of the urban experience of many developing countries, including Ethiopia. This urban expansion has not only created more urban fringes, but also expropriated farmers, induced migration, and led to less farmland for agriculture. Against this backdrop, the main purpose of this research is to examine the impact of urban expansion on land use and land cover (LCLU) dynamics. Based on this analysis, we will also explore the broader impacts of urban expansion processes on city governance and the residents' perception of a range of socio-economic changes associated with them. The research will focus on the cases of Bahir Dar and Gigel Beles. Because both cities are characterized by different spatial and demographic patterns, this research allows to demonstrate and compare the impacts in very different contexts. The analyses will utilize and combine different data sources such as satellite images, interviews, and focus group discussions, which will be used as the input into a mixed method research approach that includes a cellular automata model, perception-based analysis, and stakeholder analysis. In doing so, the research will enlist ArcGIS, R, Nvivo, and SPSS software. The expected outcomes are a clearer understanding of urbanization trends and their impact on land use and land cover change, a dissection of the governance issues associated with rapid urban expansion, and a wholesale evaluation of the urban dwellers' perception of these changes.

Key words: Horizontal urban expansion, Urban fringes, Land use land cover, Governance

Analysis of Ecosystem Services and Human Well-Being in Lake Tana Basin, Ethiopia

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All economic activity and most of the human well-being are based on a healthy functioning environment. Despite this, maintaining sustainable development is under question, given a high level of environmental variability and biodiversity reduction at the global level witnessed in the last four decades. Nevertheless, until recent years, policymakers were focusing on poverty alleviation without giving concomitant attention to the knowledge of ecosystem functions and processes. In addition, we cannot also assess the benefits of ecosystem services without understanding who the beneficiaries are and how they respond to ecosystem service provision. In line with this, there is a growing interest of identification, characterization and ranking of the ecosystem services offered by nature at the micro level based on households' preference for the services. Thus, the purpose of this study will be to**:** identify stakeholders and their level of familiarity with ecosystem services, identify and rank ecosystem services based on stakeholders' preference. This will be done under the framework of Toolkit for Ecosystem Services Site based Assessment (TESSA) as the toolkit provides practical guidance on how to identify which services may be significant at a site of interest and what data are needed to measure them, in one of the UNESCO biosphere reserve area (Lake Tana basin, Ethiopia). Such application of new ecosystem services identification technique will help to replace an age old practice of using ecological- economic analysis to identify and measure ecosystem services which mainly focuses at a macro level and communicate the true value of nature to decision-makers so that it is possible to build public and government support for evidence-based policy with the ultimate goal of maintaining biodiversity and associated ecosystem service delivery in the study area.

Key words: Ecosystem services, human well-being, sustainable development, rapid assessment, TESSA

How river diversions impact hydrogeomorphology and local communities – the case of the Beles hydropower project

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In the context of its Climate-Resilient Green Economy strategic plan, the Ethiopian government increasingly focuses on hydropower, and has constructed several large dams in the past decade. Such large-scale projects have important impacts on natural and socioeconomic environments upstream and downstream of the dams, and are assessed in pre-construction feasibility studies. The question is if enough attention is paid to downstream communities in practice? To answer this, we consider the downstream impacts of the Beles multipurpose hydroelectric project (460 MW). This project transfers water from Lake Tana to the Beles river (since 2010), transforming the river from 'seasonal' with mostly low discharges, to 'regulated' with nearly constant high discharges (≈ 90 m³/s at outlet). To obtain information on the changing downstream systems (from the outlet down to Jawi bridge; river kilometer (RK) 328-268), interviews with local people (n = 65) and local to federal authorities (municipal and district chairmen, EEP, MoWIE, etc.) are combined with hydro-geomorphic field observations and GIS-analyses of aerial photographs and high-resolution satellite imagery. Results show that, besides the intended consequences (e.g. the start of large-scale irrigation agriculture), the project entailed unintended consequences for downstream communities, especially in the first two years after dam commissioning. The unequal spread of the bridges (located at RK 268, 291, 323, 324, and 326) and the insufficient awareness raising (through radio) has led to the loss of life of over 250 people in 11 municipalities. Important livestock losses (> 500 cattle and goats) have occurred as well. In addition, bank erosion and river pattern adjustments have led to significant losses of arable land, which are not compensated to the farmers. Other hydropower schemes in Ethiopia are anticipated to have consequences of lesser magnitude, as they regulate discharges and do not transfer water from other basins. In that view, Beles is an atypical case. However, important lessons are the need for a sufficient number of foot bridges, better awareness raising, compensation for loss of land considering long time-frames, and a good follow-up of downstream situations - including field visits to areas that are only accessible on foot.

Key words: hydropower project, river pattern adjustments, bank erosion, socioeconomic impact, Beles river

Virtual Research Environments: another way of cooperation in research

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The VLIR-UOS programmes make it possible that researchers from the South can be working together with researchers of Flemish universities. The distance has always been an issue to share activities, data and information. Long-term visits, the use of email, Dropbox and other drive solutions are addressing these problems up to a certain level. Virtual research environments can change this dramatically and enhance the cooperation over distance. D4Science is an Italian scientific service provider that has developed through different European projects a powerful infrastructure for research. Different organizations worldwide including FAO of the United Nations are using their virtual research environments. It is not only a platform where data and other information can be shared by a specific research group. It includes tools like an R-studio to process data and visualize it in for example maps. Also access to data from ESA and other providers can easily be accessed. In short, a new way to di research without distance barriers.

Keywords: Research communication, Data processing, R, Information management, Virtual research environment

Modelling of heat and mass transfer in onion bulbs as a basis for designing sustainable field curing systems

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Onion is an indispensable part of the daily Ethiopian dish and thus it is one of the most economically important vegetable crops produced by smallholder or commercial farmers for both local and export markets. However, the postharvest losses of onion in Ethiopia are extremely high mainly due to poor postharvest practices including inappropriate curing practices as well as lack of cold storage facilities. Curing is the most common postharvest treatment employed by farmers to extend the storage life of onion in the country. During curing excess moisture is removed from the outermost scales and neck of onion, thereby minimizing the incidence of rotting of bulbs and physiological weight loss in the storage. In Ethiopia where the time of harvesting coincides with dry season, onion curing is carried out naturally in the field. Curing of onion can be also done in artificial dryers by blowing of hot dry air. Onions cured naturally in the field have generally lower shelf life compared to those cured artificially. On the other hand, artificial curing methods are expensive and thus not affordable by small-scale onion producers in a developing country like Ethiopia. The objective of this research is therefore the development of an alternative technology to the field curing system, for the improvement of onion storage life. For that purpose, first a model of heat and mass transfer in onion bulbs will be developed. In a next step, a sustainable mechanical onion curing system with solar energy supply will be designed, constructed and tested.

Key words: Onion, postharvest loss, mechanical onion curing system

Willingness to pay for water hyacinth control in villages around Lake Tana, Ethiopia

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Lake Tana is the most important source of fresh water in Ethiopia and by extension the Horn of Africa. Besides other pressures on water quality resulting from urbanization and deforestation, the invasion of the exotic water hyacinth poses new threats to the ecosystem. Water hyacinth or *Eichhornia crassipes* – endemic to South America – is widely considered as the worlds' worst aquatic weed. In 2011, the weed appeared on the northern shores of Lake Tana. It rapidly expanded in north-eastern direction. The lake area covered by water hyacinths is currently estimated at 50,000 ha. Different methods (biological, mechanical and chemical) are known to reduce infestation. In Africa considerable amounts of money are spent on the control of the weed. Quantifying costs and benefits of countering this type of invasion aids policy decisions. In this research, the benefits of water hyacinth control for the rural population inhabiting the northern and north-eastern kebeles bordering Lake Tana, is investigated. In the areas studied, the population largely depends on farming and (less importantly) fishing. The assessment of total economic value to inhabitants of infested shores of Lake Tana is conducted through survey-based questionnaires. Willingness to pay was measured in labour or cash money. Contingent valuation methods were utilized to express this willingness to contribute. The study site selected contains one Kebele in each of the three Woreda (Dembia, Gonder Zuria and Dera) where water hyacinths have appeared. A total of 240 households were interviewed in order to assess the value of water hyacinth control to the ecosystem services provided by Lake Tana. The willingness to contribute was questioned for two scenarios: status quo and improvement (complete removal of infestation). Nearly all respondents were willing to contribute labour or cash in order to control and improve the current situation. With over 50% of respondents stating to be willing to contribute the proposed yearly amounts 500 ETB for status quo and 1000 ETB for improvement scenario and over 80% willing to contribute 20 man-days of labour annually for status quo and 40 man-days of labour annually for improvement scenario. The benefits of control obtained by the study can be compared with potential costs to provide potential justification for decision-making.

Key words: Water hyacinth, *Eichhornia crassipes*, willingness to pay, contingent valuation, Lake Tana

Fish spawning migration, Young-of-the-Year fish survival and food web modelling in Lake Tana, Ethiopia

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Lake Tana, the largest lake in Ethiopia, is a home to four fish families; Cyprinidae, Cichlidae, Clariidae and Nemacheilidae. The *Labeobarbus* spp., an intact species flock of large cyprinid fishes, are seriously threatened by anthropogenic activities. Most of these species migrate to tributary rivers for spawning and they are highly vulnerable to exploitation during their spawning aggregations in the river mouths and upstream migrations. The species are threatened by climate change and water extraction, hence drying of rivers. This project is aimed to determine the stock status of commercially important fish taxa, and toxin concentrations from pesticides, metals and algal sources of the most abundant *Labeobarbus* fish species in the lake. Also the spawning migration and distribution patterns of *Labeobarbus* species and the energy flow across the trophic levels in the lake's food web will be determined. To develop a species habitat suitability model, fishing effort data (number of fishers, number of vessels by gear types, size of net, and catch data) and habitat data will be collected from the local fishers monthly. In the wet season, reproductively mature *Labeobarbus* spp. will be caught by electrofishing or fyke nets, radio-tagged and tracked to the spawning grounds in the major spawning river (Gumara). Later in the season, young-of-the-year *Labeobarbus* will be caught using point abundance sampling by electro-fishing and seine netting. For some poorly studied *Labeobarbus* species, specimens will be collected, tagged and tracked in the shore areas of the Southern Gulf of Lake Tana in order to gain more insight in the life cycle of strictly lacustrine *Labeobarbus* spp. To investigate diet composition of the different *Labeobarbus* species and their food preference in different periods of the year, gut content analysis will be performed for fishes of different length or year-classes. This will be combined with C and N stable isotope analysis of the different components of the food web, including the detritus and the dissolved organic carbon pool. Stable hydrogen isotope will also be used in separating terrestrial and aquatic food sources. Isotopic compositions will be explored in different functional groups considering species and body size.

Key words: *Labeobarbus*, radio telemetry, functional group, Lake Tana, food web analysis

Take out the farmer: An economic assessment of local land deals around Bahir Dar, Ethiopia

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In Ethiopia the demand for land for urbanization tends to be met primarily by converting rural land through local land deals. The local land deals are adversely affecting the previous land holders in terms of reduction in the amount of production and their income. Bahir Dar is one of the fastest growing cities in Ethiopia where yearly on average about 300 local land deals are concluded for infrastructures development, housing construction, and investment projects. The aim of this study was to assess the economic impact of local land deals due to urbanization in Ethiopia, particularly around Bahir Dar. Local land deals concluded between 2007/8 and 2016/17 are analyzed. Data on land expropriation and its payment of compensation were obtained from the Bahir Dar City Administration Land Administration and Management Office. Data were analyzed using a stochastic budgeting technique in which Monte Carol Simulations are performed. In this period more than 1500 ha of land were included in the city's boundary and 2900 land deals were made. Our simulation results show that the affected farmers were receiving a compensation which is less than the amount of compensation that considers the current crop prices and yields, leave alone the land lease price that the new dwellers in the area will pay. The reasons for such low compensation were ignoring the impact of inflation on the prices of crops, the assumption of constant yields and exclusion of the value of crop residuals in the estimation of compensation. The government shall utilize this understanding of the economic impacts of the phenomenon to adjust the compensation framework in such a way that can incorporate the current crop prices and yields. This can improve the amount of compensation and make the affected farmers better off or at least the same position.

Key words: Local land deals, urbanization, compensation, economic impacts

Understanding innovation and the role of agricultural extension in North West Amhara Region, Ethiopia

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Agricultural growth and rural development require continuous and up-to-date innovation, which is an interactive process through which knowledge is generated, accessed, and put to use. Innovation can no longer be considered as mere Transfer of Technology, a linear process of science developing new knowledge and transferring it on to extension for wider dissemination. It rather requires a systemic approach, combining technical, organizational, and institutional adaptation in a multi-level and multi-actor context. The research will examine the nexus extension - innovation among different categories of farmers; and the implications for mechanisms of inclusion and exclusion.

Making agricultural extension demand driven remains a challenge in Ethiopia. Several studies have been conducted on the extension system of the Amhara region. However, at district level, the agricultural innovation system and the role of extension remain unexplored. The study will be conducted in Fogera and Mecha Districts of Amhara region, Ethiopia. The two districts are involved in innovative farming practices and both are categorized as development strips of the country. The former excels on rice production. The latter one has a huge irrigation project downstream the Koga dam, where institutional innovation is practiced and implemented. There remain questions about the role of multi-stakeholder platforms; the contribution of farmers' knowledge, experience and skill to innovation; the mechanisms of farmer-to-farmer extension; the challenge of effective participation; the organization of institutional innovation; and the mechanisms of inclusion and exclusion in innovation processes.

Key terms: Agricultural Extension; Innovation; North-West Amhara; farmer-to-farmer extension;

Dormancy, flower bud quality and fruit quality under conditions of insufficient chilling in apple (*Malus domestica*)

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Apple (*Malus domestica* Borkh.), a temperate fruit species belonging to the family Rosaceae, has got a lot of interest in Ethiopia, due to its economic importance. Apple goes into endo-dormancy during the winter period. And in order to get out of dormancy and resume active growth, it requires sufficient amount of chilling. Apple production in Ethiopia has a major problem due to insufficient chilling, that affects the period of endo-dormancy, manifested in irregular bud break, flower bud development, flowering, fruit set, fruit development and fruit quality. This doctoral study is designed to get a better insight in to the genetic control of the process of endo-dormancy starting from onset of endo-dormancy until early fruit set under conditions of insufficient chilling by concentrating on the molecular and morphological aspects underlying these processes. We will gain insights on the genes regulating the process of endo-dormancy. Identification of candidate genes will be undertaken via transcriptome approach and their validation will be performed through reverse transcription qPCR (RT-qPCR). Hundred apple trees of two cultivars (50 Gala and 50 Golden Delicious) that are grown under two chilling conditions, in Debre Tabor, Ethiopia (insufficient chilling, with a minimum temperature of 10°C in the coldest month) and Belgium (sufficient chilling with temperatures below 0°C in the coldest month) will be used in this experiment. RNA samples will be collected at ten time points to study differential gene expression. Flower bud quality parameters like size and number of flowers, bud break percentage, number of anthers, ovule longevity, pollen germination will also be studied under the two conditions and related to differential expression of genes involved in these processes. In addition, rest breaking treatments like defoliation, water stress, and a chemical application will be investigated to introduce effective rest breaking treatments suitable for Ethiopian climate. In a preliminary experiment in our lab, genes such as *DAM, DHNs, GAST1, HTA8, HTA12 and NAC* were investigated, whereby *DAM, DHNs, HTAs* and *NAC* showed differential gene expression in the two chilling conditions. Consequently, these genes will be considered in a first step as candidate genes for our gene expression experiment. In conclusion, by a large-scale differential gene expression experiment, we will further strengthen the preliminary results obtained in our lab and this will lay the ground for understanding the genetic control of insufficient chilling during endo-dormancy.

Key words: Insufficient chilling, endo-dormancy, gene expression, transcriptome analysis

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