Institutional University Cooperation with Bahir Dar University - Year 3 Joint Steering Committee Meeting

Excursion Guide

(21-22 March 2019)

Jan Nyssen & Enyew Adgo (eds.)

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Chapter 1: The diversity of wetlands in Lake Tana and surroundings

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The wetlands of Lake Tana and its lacustrine plain are among the largest and ecologically most important in Ethiopia. They are crucial habitats for plants and animals and expected to provide important ecosystem services, such as sediment retention and the maintenance of water quality. Despite this, these wetlands are under heavy pressure due to harvesting, livestock grazing, farming, irrigation developments, sedimentation, water extraction and the introduction of alien species. Surprisingly, the exact extent of different wetland types has never been quantified and temporal changes in areal coverage are largely unknown. In addition, large-scale inventories of their taxonomic and functional diversity are largely lacking.

Within the aquatic ecology project of the IUC program, we aim to study the diversity and functional attributes of the major taxonomic groups in different types of wetlands in the Lake Tana basin. To achieve this, water quality, water depth, sediment depth, macrophyte diversity and functional properties, and the phytoplankton, zooplankton and macrophyte community structure were analyzed during the dry and wet season of 2018 in 20 different wetlands belonging to five different types, i.e., 4 in the littoral zone of the lake, 4 riverine, 4 Cyperus papyrus dominated, 4 four infested with water hyacinth, and four urban wetlands (Fig 1). Plant functional traits such as above water wet weight of grass species and water hyacinth and plant height, stem diameter, stem density and flowering individuals of *Cyperus papyrus*, *Typha latifolia* and *Cyperus latifolius* were measured.

Mean values of chlorophyll concentration, sediment depth and turbidity were higher in riverine wetlands. The mean values for dissolved oxygen and pH were higher in lacustrine wetlands. Water depth and specific conductance were higher in Cyperus papyrus dominated wetlands and water hyacinth infested wetlands, respectively (Table 1). The phytoplankton communities were dominated by Chlorophyceae members (over 50 species) followed by Bacillariophyceae (Table

2). A total of 28 species of zooplankton were recorded which includes 16 species of Rotifer, 8 species of Cladocera and 4 species of Copepoda (Fig 2).

Keywords: Water quality, functional traits, Lake Tana sub basin, wetlands, phytoplankton, zooplankton, macrophytes

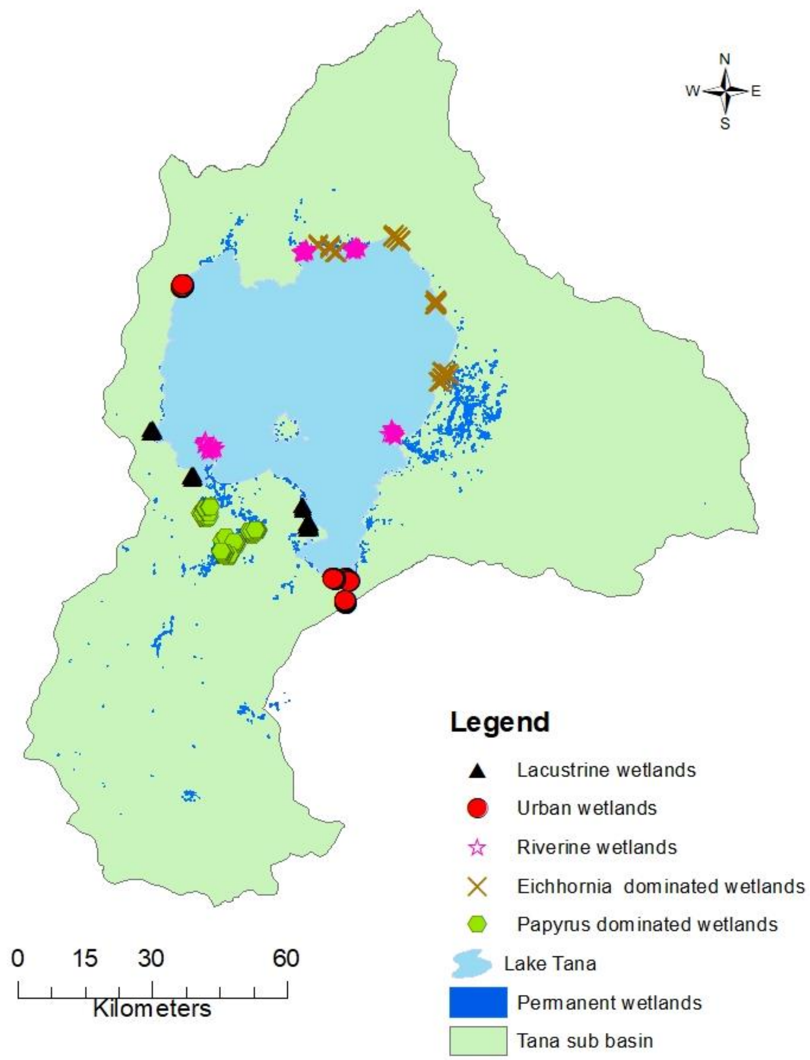

Fig 1. Map of the studied wetlands within Lake Tana sub basin (Abrehet *et al*., 2019)

Table 1. Water quality parameters, water depth and sediment depth for Lake Tana sub basin wetlands during study period (Mean ± Standard Error) (Abrehet *et al*., 2019)

Wetland type and season	**N**	Chll mg/L	Temperature °C	DO saturation %	DO mg/L	Specific conductance µS/cm	pH	Water depth cm	Sediment depth cm	Turbidity NTU
Cyperus papyrus dominated	99	5(±0.8)	21 (±0.3)	34(±3.7)	2(±0.3)	219(±9.3)	7(±0.1)	142(±13.1)	34(±3.3)	59(±9)
Lacustrine	51	4(±0.6)	22 (±0.4)	65(±4.7)	5(±0.3)	172(±8.7)	8(±0.1)	126(±12.9)	22(±2.2)	45(±10.9)
Riverine	65	7(±0.7)	22.6(±0.5)	56(±6)	4(±0.4)	249(±12.7)	8(±0.1)	75(±8.7)	48(±5.5)	133(±15.8)
Urban	87	6(±1.1)	22.7(±0.3)	34(±3.7)	2(±0.3)	211(±15.2)	7(±0.1)	121(±13.5)	21(±2.1)	60(±11.1)
Water hyacinth dominated	70	4(±0.4)	20.6(±0.3)	37(±3.4)	3(±0.3)	329(±29.6)	8(±0.1)	59(±3.5)	31(±2.2)	118(±11.5)
Dry season	108	4(±0.3)	23 (±0.3)	51(±4)	3(±0.3)	235(±13.1)	8(±0.7)	103(±8.9)	30(±2.5)	93(±12.7)
Wet season	264	6(±0.4)	22 (±0.2)	43(±2.2)	3(±0.1)	237(±9.7)	8(±0.0)	108(±6.8)	31(±1.9)	81(±5.6)
Total	372	5(±0.4)	22 (±0.2)	43(±2)	3(±0.1)	237(±7.9)	8(±0.0)	108(±5.5)	31(±1.6)	81(±5.5)

Table 2. The most frequently encountered species list of phytoplankton during the study period from Lake Tana sub basin wetlands (Abrehet *et al*., 2019)

Cyanophyeae	**Bacillariophyceae**	**Dinophyceae**	**Chlorophyceae**	**Chlorophyceae continued**
Anabaena constricta	Aulacoseira granulata	Peridinium cinctum	Ankistrodesmus angustus C.Bern.	Pediastrum duplex Meyen
Anabaena sp.	Acnanthes spp	Peridinium gatunense Nyg.	Ankistrodesmus falcatus	Pleurotaenium trabecula
Chroococcus sps	Asterionella formosa HASSALL	Peridinium sp.	Ankistrodesmus nannoselene	Scenedesmus sps
Gomphospaeria natans	Aulacoseira distans (Ehr.) Simon.	Peridinium volzii Lemm.	Chlamydomonas floscularíae	Schroederia setigera (Schröd.) Lemmer.
Leptolyngbya boryana	Coscinodiscus spp		Chlamydomonas sp.	Selanstrum sp.
Leptolyngbya foveolarum	Coscinodiscus lacustris		Closterium subulatum	Sorastrum sps
Microcystis sps	Cyclotella comta		Closterium acutum Bréb.	Spirogra labyrinthiformis
Oscillatoria brevis	Cyclotella radiosa (Grun.) Lemm.		Closterium kuetzingii	Spirogyra spp
Oscillatoria geminata	Cymbella minuta Hilse		Closterium sp. (limneticum)	Staurastrum johnsonii
Oscillatoria lacustris	Cymbella ventricosa		Coelastrum microporum	Staurastrum gracile
Oscillatoria lauterbornii	Diatoma vulgaris Bory	**Euglenophyceae**	Coelastrum reticulatum	Staurastrum gracile Ralf ex Ralfs
Oscillatoria limosa	Fragilaria capucina	Euglena cf. viridis	Cosmarium archerianum	Staurastrum longebrachiatum
Oscillatoria tenuis	Fragilaria sps	Phacus acuminatus Stokes	Cosmarium circulare	Staurastrum teliferum
Phormidium tenne	Gomphonema gracile Ehr.	*Euglena acus*	Cosmarium contractum O. Kirch.	Staurastrum triangularis var. triangularis
Phormidium valderiae	Gomphonema minutum		Cosmarium granatum Breb	Staurodesmus convergens
Planktolyngbya limnetica	Gomphonema venusta passy		Cosmarium quadrum	Staurodesmus curvatus var. latus
Pseudoanabaena sp.	Aulacoseira italicas		Cosmarium rectangulare	Tetraedron arthrodesmiforae
Synechococcus sp.	Navicula cospidata		Eudorina elegans	Treubaria crassispina
	Navicula cryptocephala Kutz.		Geminella sps	Treubaria sps
	Nitzschia closterium		Gonatozygon kinahanii	Treubaria triappendiculata
	Nitzschia minuta		Gonatozygon monotaenium	Tribonema minus hazen
	Nitzschia reversa		Haematococcus sp.	Xanthidium cristatum
	Nitzschia sps		Micrasterias radiate Hass	
	Pinnularia sp.		Microspora quadrata	
	Pleurosigma elongatum		Monoraphidium contortum	
	Raphidiopsis mediteranea Skuja		Mougeotia laetevirens	
	Rhoicosphenia abreviata		Oedogonium sp.	
	Rhopalodia gibba		Oocystis eremosphaeria G. M. Smith	
	Rhopalodia gibba(Ehr.) O. Müll.		Oocystis sp.	
	Stephanodiscus spp		Pediastrum.boryanum(Turp.)Menegh.	
	Synedra sps(synedra affinis)		P. simplex Meyen	
	Synedra ulna (Nitz.) Ehr.		Volvox globator	

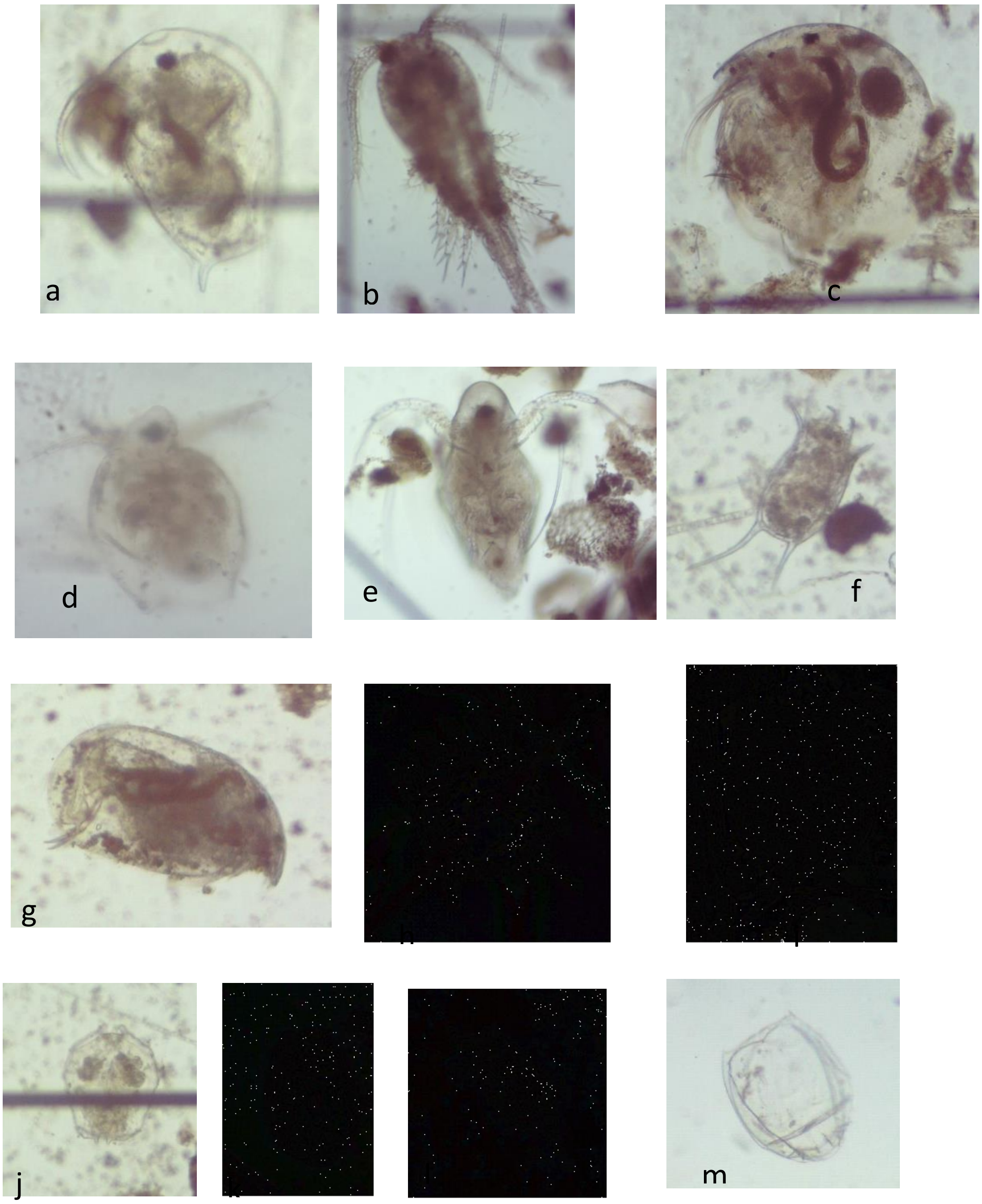

Fig 2. Frequently observed zooplankton from sampling sites: *Bosmina longirostris* (a), Mesocylops spp. (b), *Chydorus sphaericus* (c), Ceriodaphnia spp. (d), *Diaphanosomaexcisum Sars* (e), *Keratella tropica tropica* (f), Chydoridae (g),*Branchionus patulus* (h), *Lecane luna* (i), *Brachionus angularis (j),* Lecane spp. (k), *Keratella cochlearis* (l), Lecane spp. (m) (Abrehet *et al*., 2019)

Table 3. Mean values for some traits of emergent macrophytes from sampling sites during study period. In brackets are minimum and maximum values (Abrehet *et al*., 2019)

Wetland type	**Species name**	**Plant height (cm)**	**Stem diameter (mm)**	**Flowering individuals**	**Stem density green**	**Stem density dry**
Urban	*Cyperus papyrus*	224 (90-410)	7 (3-13)	27 (2-49)	29 (10-54)	14 (0-13)
Cyperus papyrus dominated	*C. papyrus*	254 (70-493)	8 (2-49)	29 (2-137)	28 (2-135)	7 (0-31)
	Cyperus latifolius	241 (100-412)	7 (2-16)	38 (5-138)	37 (5-138)	11 (0-80)
	Typha latifolia	261 (110-410)	7 (3-12)	13 (5-32)	17 (9-36)	2 (0-11)
Riverine	*C. papyrus*	267 (96-402)	10 (4-21)	23 (9-42)	23 (10-42)	2 (0-5)
	C. latifolius	176 (110-335)	5 (3-8)	23 (6-36)	25 (10-37)	2 (0-4)
	T. latifolia	271 (150-400)	7 (4-10)	14 (10-20)	15 (10-20)	2 (0-4)
Lacustrine	*C. papyrus*	283 (110-495)	9 (2-17)	21 (1-41)	22 (1-41)	3 (0-20)
	C. latifolius	248 (100-350)	7 (3-11)	22 (5-50)	27 (13-50	4 (0-4)
	T. latifolia	232 (90-390)	6 (2-12)	16 (4-30)	19 (5-32)	3 (0-8)

References

Geremew, A., & Triest, L. (2017). Hydrological connectivity and vegetative dispersal shape clonal and genetic structure of the emergent macrophyte *Cyperus papyrus* in a tropical highland lake (Lake Tana, Ethiopia). *Hydrobiologia*, 1-18.

Wondie, A. (2006). *Dynamics of the major phytoplankton and zooplankton communities and their role in the food web of Lake Tana, Ethiopia* (Doctoral dissertation, Ph. D thesis. Addis Ababa University, Ethiopia. 162pp).

Wondie, A., Mengistu, S., Vijverberg, J., & Dejen, E. (2007). Seasonal variation in primary production of a large high altitude tropical lake (Lake Tana, Ethiopia): effects of nutrient availability and water transparency. *Aquatic Ecology*, *41*(2), 195-207.

Chapter 2: Physical and chemical limnology of Lake Tana and its tributary rivers

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Lake Tana is the largest lake in Ethiopia. It is very likely that anthropogenic activities in the lake's catchment, such as agriculture, urbanization and degradation of wetlands already affected the water quality of the lake and its rivers. Large-scale limnological survey for assessing its water quality are however still largely lacking. We aim to study the physical and chemical limnology of the lake and their effect on prokaryotic and eukaryotic planktonic communities. In this preliminary study we report on the physical and chemical parameters measured during the dry (April-May 2018) and wet season (September 2018) in 22 stations, including eight sites in the littoral zone (LT1-LT8), two pelagic sites and at three rivers mouths in the lake, as well as in two sampling locations from six rivers (Fig.1), and combined this with monthly measurements in an open water site. Dissolved oxygen, pH, temperature, turbidity and specific conductance were measured using a multi-parameter YSI PRO DSS probe. Biochemical oxygen demand, total phosphorus, orthophosphate, nitrate, total nitrogen and total organic carbon were analyzed using a Hach-Lange spectrophotometer (DR6000, USA). The concentrations of orthophosphate, nitrate, total phosphorus and total nitrogen, as well as turbidity were significantly ($P<0.05$) higher, while temperature and chlorophyll concentrations were lower in the wet compared with the dry season (Fig.2). Particularly the sites in the rivers showed a relatively high seasonal variability in their chemical limnological properties. The mean turbidity of the lake was 115.7 NTU (Nephelometric Turbidity Units) during the wet season and 34.6 NTU during the dry season. The values during the dry season are comparable with similar previous measurements taken in 2000 (Dejen et al., 2004) but higher compared with data obtained in 2011 (Goshu et al., 2017). These preliminary findings suggest yearly and seasonal variations in water transparency in the lake.

Keywords: Physical and chemical limnology, water quality, nutrients, tributary river

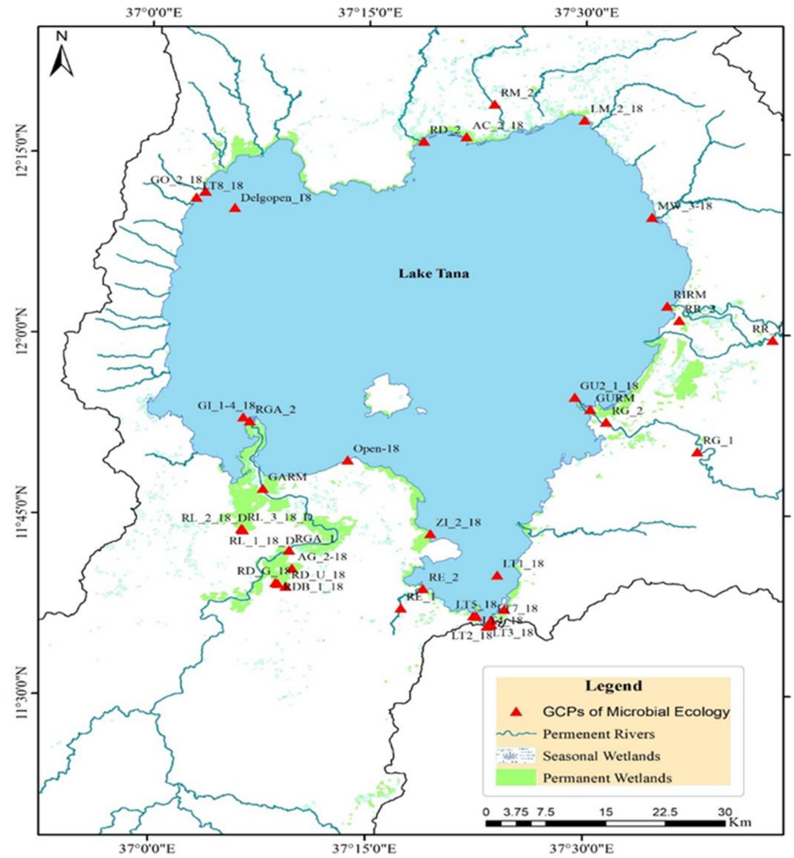

Figure 1. Map of the Lake Tana basin showing sampling locations (red colour) of Lake Tana, tributary rivers and linked wetlands. The green colour indicates permanent wetlands. D and W refer to samples taken during dry and wet season, respectively. The number underscore 1 and 2 indicate upstream and downstream stations in the rivers, respectively, RM indicates Megech river sites; RR= River Reb; RG= River Gumara; RD= River Direma; RGA= River Gilgel Abay; RE= River Enfranze. GARM= Gilgel Abay river mouth; GURM= Gumara river mouth; RIRM= Reb river mouth. LT1 to LT7= littoral zone in the southern part of the lake; LT8= littoral zone north near Delegi town; Open-18= pelagic site between Bahir Dar and Deke Island which is monitored monthly; Delgopen= pelagic site of north part of Tana.

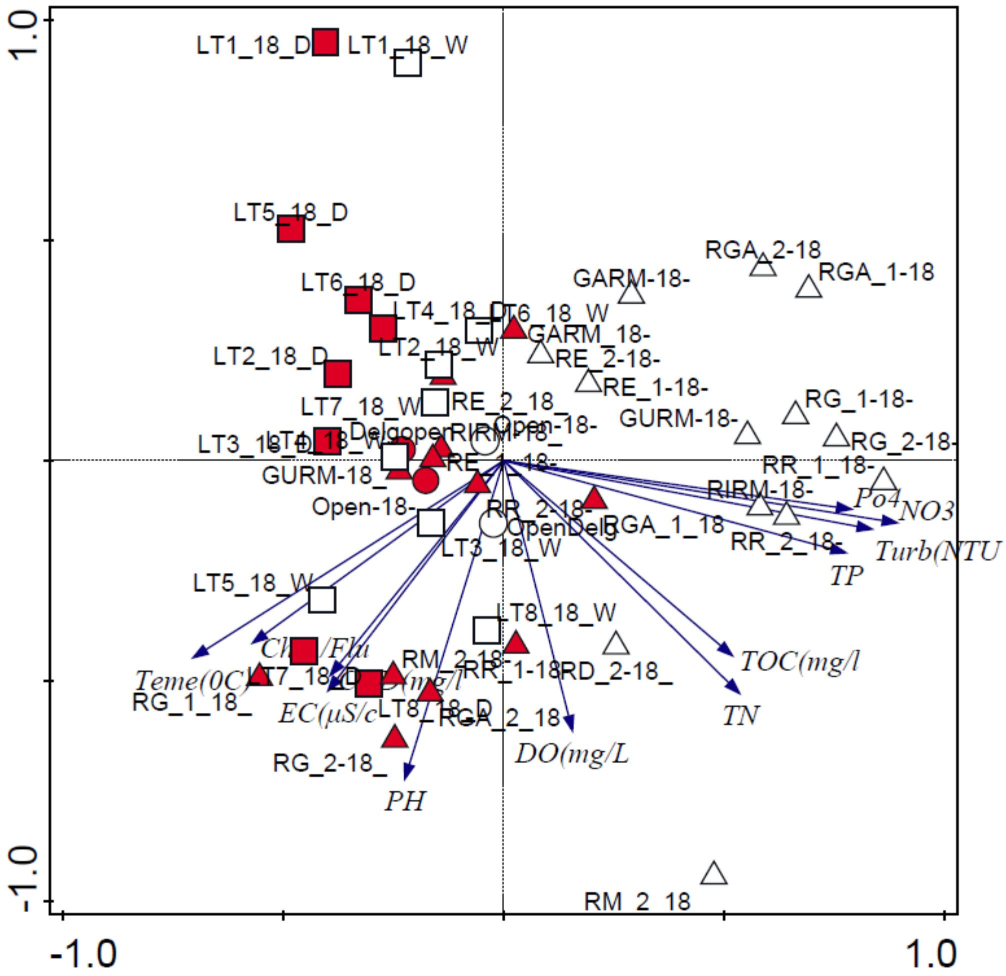

Figure 2. Principal component analysis (PCA) biplot of TN, TP, NO_3^-, PO_4^{3-}, DO, TOC, COD, chlorophyll and turbidity of Lake Tana and tributary rivers. Full symbols denote the dry season and open symbols the wet season. Squares = littoral sites; triangles = River sites; Circles = open water sites.

References

Dejen, E., Vijverberg, J., Nagelkerke, L. A., Sibbing, F. A. (2004). Temporal and spatial distribution of microcrustacean zooplankton in relation to turbidity and other environmental factors in a large tropical lake (L. Tana, Ethiopia). Hydrobiology, 513(1-3), 39-49.

Goshu G., Koelmans A.A., de Klein J.J.M. (2017) Water Quality of Lake Tana Basin, Upper Blue Nile, Ethiopia. A Review of Available Data. In: Stave K., Goshu G., Aynalem S. (eds) Social and Ecological System Dynamics. AESS Interdisciplinary Environmental Studies and Sciences Series. Springer, Cham.

Chapter 3: The impact of urbanization on Dibankie hill

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Bahir Dar is the capital city of Amhara National Regional State. It is located on the southern shores of Lake Tana (Fig. 1). The city has been rapidly expanding and is now home to about 350,000 people, according to the Central Statistics Agency (CSA, 2013) projection. In the past ten years, the expansion of the city has mainly been taking place in the northeastern and southwestern directions. Nonetheless, the city expansion has also affected Dibankie hill, which can be found some 4 km to the west of the city center. One major implication of this is that the hill has been losing its vegetation cover due to the continuous and largely unplanned urban expansions in the area. For example, over the past three decades, roughly 25% of the natural vegetation cover on or around the hill has been converted into rangeland and badland as consequence of residential expansions at the northwestern side and southern of the hill. In recent years, the landscape on and around the hill have also been changing due to expanding quarry activities on the western parts of the hill, which is thus being gradually eroded. In addition, at the eastern side of the hill, a new church is being constructed. All of these activities are in one way or another related with what is now constant and unkempt urban expansion, and it is therefore of the utmost importance that we expand our scientific understanding of these fast-unfolding processes in the wider Bahir Dar region, including Mount Dibankie.

References

Central Statistics Agency. (2013). *Population Projection of Ethiopia for All Regions at Wereda Level from 2014 – 2017.* Addis Abeba, Ethiopia.

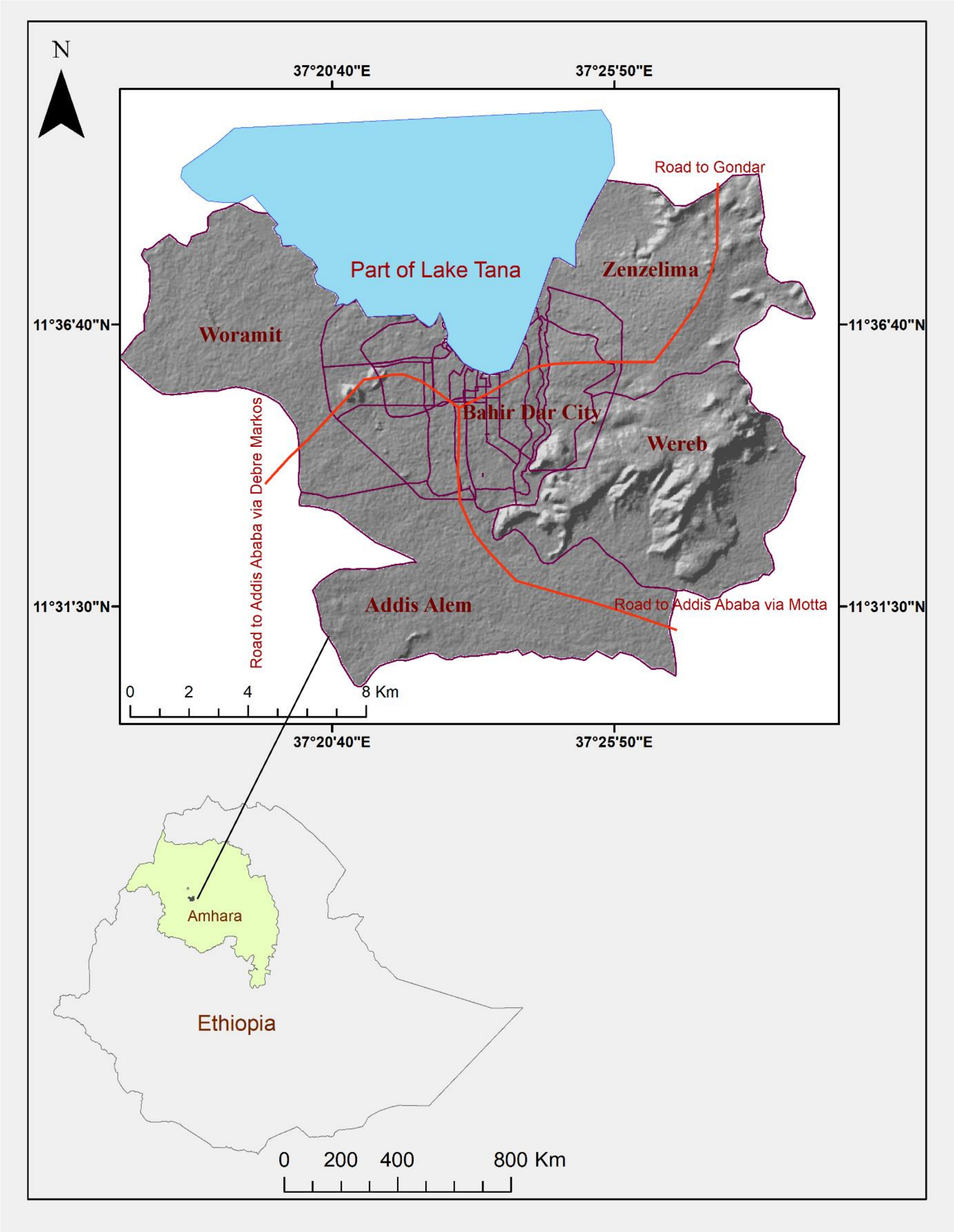

Fig. 1. Overview map of Bahir Dar

Chapter 4: Uncovering ecosystem services on expropriated land: A participatory assessment in the case of urban expansion in Bahir Dar

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In developing countries, urban expansion happens at high rates and results in land expropriations often at a cost of agriculture and forests. Direct effects for the farmers are usually considered in the frame of compensation schemes, but not the indirect effects such as its contribution for water provision, water quality regulation, and others. This has been causing unintended environmental problems. This study basis our earlier findings that demonstrate the absence of consideration of some of the ecosystem services (ES) in land expropriation for urbanisation. The study aims to uncover the perceived value of ES of three most important land uses (crop land, agroforestry and grass land) that are threatened by urban expansion. The study applied a participatory approach that included local community perception (98 respondents) and expert judgements (10 experts) that are considered as appropriate for data poor regions like Ethiopia. Respondents include households in the study suburban districts including households who are members of natural resources management and irrigation committees. Experts include natural resource managers at city administration and suburban district level. Respondents were asked to locate their perceptions on the uses of 35 different ES into four categories, and then to evaluate the potentials of the three land uses. In our analysis, the most important ES are identified, prioritised and compared in different suburban districts (Fig. 1). Only 7% of the ES were perceived as very high usage at least in one of the land uses, while 35 % were in the scale of very low usage. Food, fodder, timber, firewood, fresh water, energy, compost, climate regulation, erosion prevention, and water purification and treatment were identified as the ten most important services. Agroforestry is expected to have a high relevant potential to deliver 31% of the ecosystem services, cropland 20% and grass land only 14%. Our results confirmed that it is not only the provisioning services that are lost due to land expropriation for urbanization, but also regulating, supporting and cultural services that are not compensated for.

To ensure sustainable development, we suggest the consideration and compensation for main ES in other categories too.

Key words: ecosystem services, land expropriations, land uses, urban expansion, community perception.

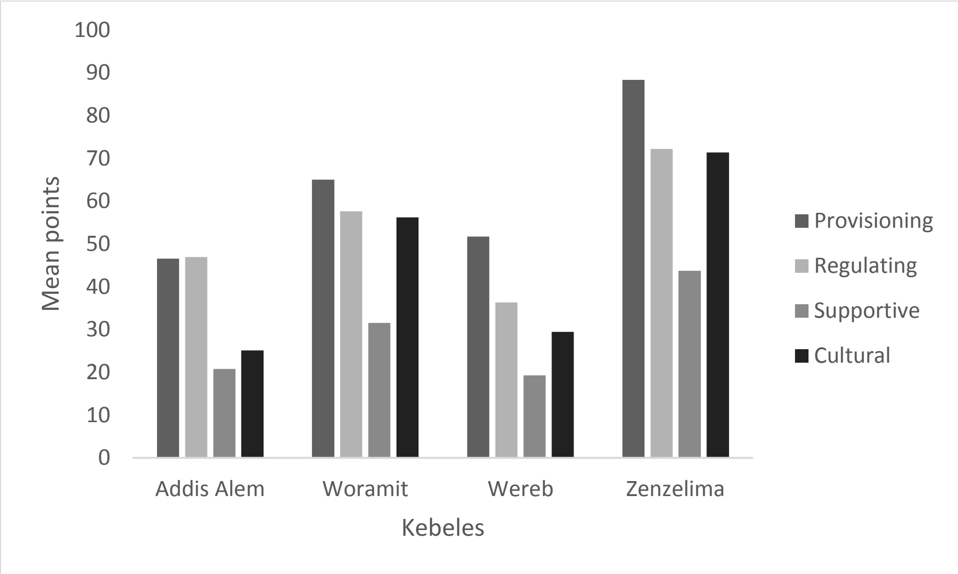

Fig. 1. *Comparisons of relative uses (using aggregate mean points) of ES by kebeles.*

Key references

Burkhard, B., Kroll, F., Müller, F., & Windhorst, W. (2009). Landscapes' capacities to provide ecosystem services-a concept for spatial planning. *Landscape Online*, *1*(06), 1-30.

He, C., Zhang, D., Huang, Q., & Zhao, Y. (2016). Assessing the potential impacts of urban expansion on regional carbon storage by linking the LUSD-urban and InVEST models. Environmental Modelling & Software, 75, 44-58.

Krause, M. S., Nkonya, E., & Griess, V. C. (2017). An economic valuation of ecosystem services based on perceptions of rural Ethiopian communities. Ecosystem Services, 26 (Part A), 37-44.

Paudyal, K., Baral, H., Burkhard, B., Bhandari, S. P., & Keenan, R. J. (2015). Participatory assessment and mapping of ecosystem services in a data-poor region: Case study of community-managed forests in central Nepal. Ecosystem Services, 13 (Supplement C), 81-92.

Raymond, C. M., Bryan, B. A., MacDonald, D. H., Cast, A., Strathearn, S., Grandgirard, A., & Kalivas, T. (2009). Mapping community values for natural capital and ecosystem services. *Ecological Economics*, *68*(5), 1301-1315.

Wubante Fetene, Van Passel, S., Amare Sewnet, Nyssen, J., Enyew Adgo, 2019. Take out the farmer: an economic assessment of land expropriation for urbanisation in Bahir Dar, northwest Ethiopia (under review).

Chapter 5: Inventory of potential geosites in the Lake Tana area: the case of Dibankie Mountain

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Geodiversity, which includes geological, geomorphological, mineralogical and other abiotic natural futures, is an important resource for geotourism development. The Lake Tana area of Ethiopia has rich geodiversity, including waterfalls, lakes, hot springs, wetlands, islands and island monasteries, caves and cave churches, rock hewn churches, volcanic necks, volcanic mountains, volcanic columns, potholes, viewpoints and scenic beauties. One of these geodiversity sites is Dibankie, an inactive volcanic crater (Poppe et al., 2013) located at the western outskirts of Bahir Dar, at about 4.8 km from the city center. It is about 80 m high above Bahir Dar City level, and about 100 m above Lake Tana. Dibankie has two major features that can be of interest for visitors: its geology and geomorphology, and its function as a viewpoint. In relation to the former feature, Dibankie is a stratovolcano. Excursion to the site can help to spot volcanic ash, lapilli and volcanic bombs (see Figs. 1 and 2).

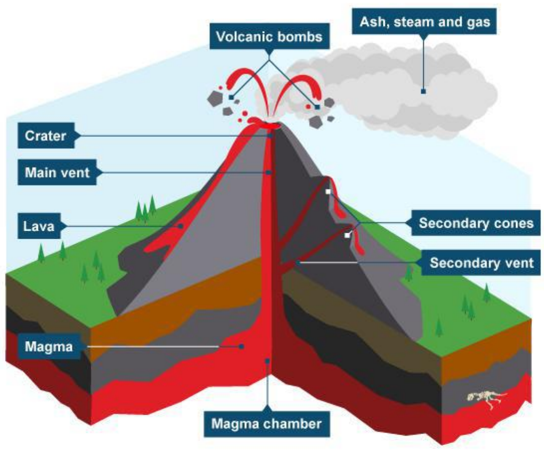

Fig. 1: Example of a stratovolcano such as Dibankie volcanic mountain (data.allenia.org)

The quarry site in the north and northeastern side of the hill clearly shows these features. In places created due to stratovolcanic process, the center of volcanism is near where the biggest volcanic bombs are located. Although it is now difficult to find the volcanism epicenter for

Dibankie mountain due to gravel quarrying activity in the northern side, big boulders can still be seen at the top of the mountain.

Fig. 2: The gravel quarry site at the north and northeastern side of Dibankie Mountain

Another major feature of Dibankie is that it can serve as an important viewpoint. Like Bezawit hilltop, which is quite famous in the tourism itinerary in Bahir Dar, Dibankie mountain also provides a spectacular view over Bahir Dar City, Zegie peninsula, Lake Tana and its island monasteries, volcanic mountains and other landscapes in the area. Small-sized birds such as red-cheeked cordon-bleu (*Uraeginthus bengalus*) can also be spotted in Dibankie.

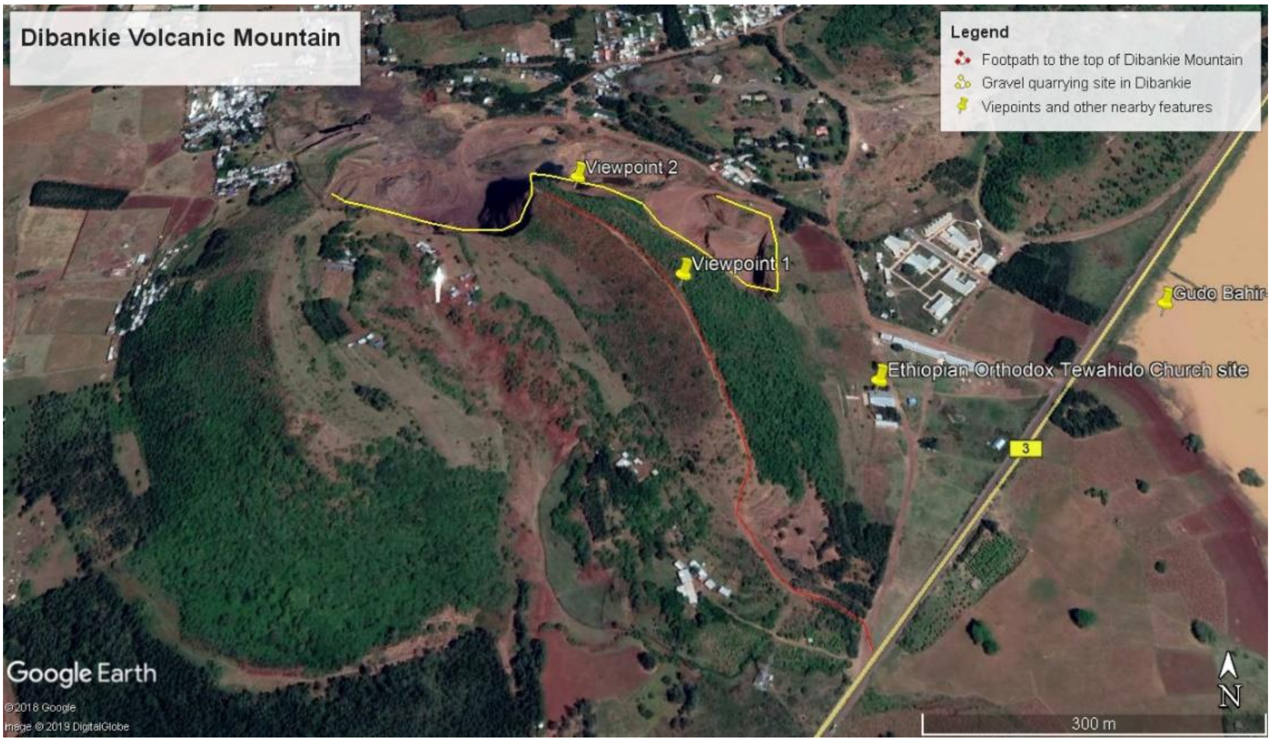

Fig. 3: Google Earth view showing important features on and near Dibankie Mountain

In addition, visitors traveling to Dibankie can also see a small lake, locally known as Gudo Bahir during the wet season and its aftermaths (Fig. 3). The lake is located to the east and southeast of Dibankie. This shallow lake of Gudo Bahir is most likely formed as a result of lava blocking a low-lying valley, as evidenced by the lava flow remnants at the northern shore of the lake. This lake hosts birds such as Egyptian goose (*Alopochen aegyptiaca*), spur-winged goose (*Plectropterus gambensis*) and Spur-winged plover *(Vanellus spinosus).* Furthermore, in 2017, the Ethiopian Orthodox Tewahido Church started constructing a new church at the southeastern foot of Dibankie, and will erect a big Holy Cross near the peak (see Fig 3). Currently, due to gravel quarrying activity in the northern side, Dibankie is highly affected. In addition, in the middle of the mountain, erosion has affected Dibankie (Fig. 3).

Key words: Inventory, Geodiversity, Dibankie Mountain, stratovolcano, viewpoint.

Reference

Poppe, L., Frankl, A., Poesen, J., Teshager Admasu, Mekete Dessie, Enyew Adgo, Deckers, J., Nyssen, J., (2013). Geomorphology of the Lake Tana basin, Ethiopia. *Journal of Maps*, DOI:10.1080/17445647.2013.801000

Chapter 6: Improving agricultural water productivity in the Lake Tana basin

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Field experiments on deficit irrigation integrated with management of acidic soils to improve water productivity were undertaking in Koga irrigation scheme, south of Lake Tana basin. Prior to the start of the experiment, a baseline study was carried on the selected experimental field to assess its soil properties and groundwater level. The quality of irrigation water serving the field was measured and soil management problems were identified. After having removed the litter layers, disturbed and undisturbed soil samples (n = 36) were taken from nine representative locations within the field using diagonal pattern. Depending on the plant root length, samples were taken at 0-20, 20-40, 40-60 and 60-90 cm using auger and core sampler and analyzed for bulk density, organic carbon, pH, Exchangeable acidity (H^+, Al^{3+}), and electrical conductivity (EC) using standard procedures. Infiltration tests were done using a double ring infiltrometer (Eijkelkamp, 1999). The groundwater level was measured from piezometers installed at 5.50 m depth in the experimental fields, using Divers®. Under the irrigated wheat crop (variety *picaflor#1*), soil moisture before and after irrigation was measured gravimetrically on samples taken at 0-20, 20-40, 40-60 and 60-90 cm soil depth. Soil structure and the degree of soil compaction were assessed semi-quantitatively using the Visual Evaluation of Soil Structure (VESS) method and quantitatively with a penetrologger. The soil microbial activity was semi-quantitatively evaluated by placing new cotton cloth in the plough layer at 15-20 cm depth. The soil analysis showed that the texture is clayey and is strongly acidic with a pH (H_2O) value of 5.14. The result of dry bulk density reveal that the surface soil (0-20 cm) had relatively low bulk density (0.98±0.04 g/cm^3) compared to sub-surface soil (20-90 cm), which had 1.19±0.03 g/cm^3, indicating that the occurrence of soil compaction below 20 cm soil layer. The compaction test result and the photos taken at the experimental site confirmed the availability of soil compaction. Asmamaw et al. (2012) and Temesgen et al. (2012) confirmed the availability of hard pan below 15-20 cm soil layer in Chemoga watershed, northwestern

Ethiopia. The mean EC of the soil and the irrigation water were (0.075 dS/m) and (0.082 dS/m), respectively. As it can be seen in Figure 1, the soil shows a moderate infiltration capacity of 0.045±0.002 cm/min.

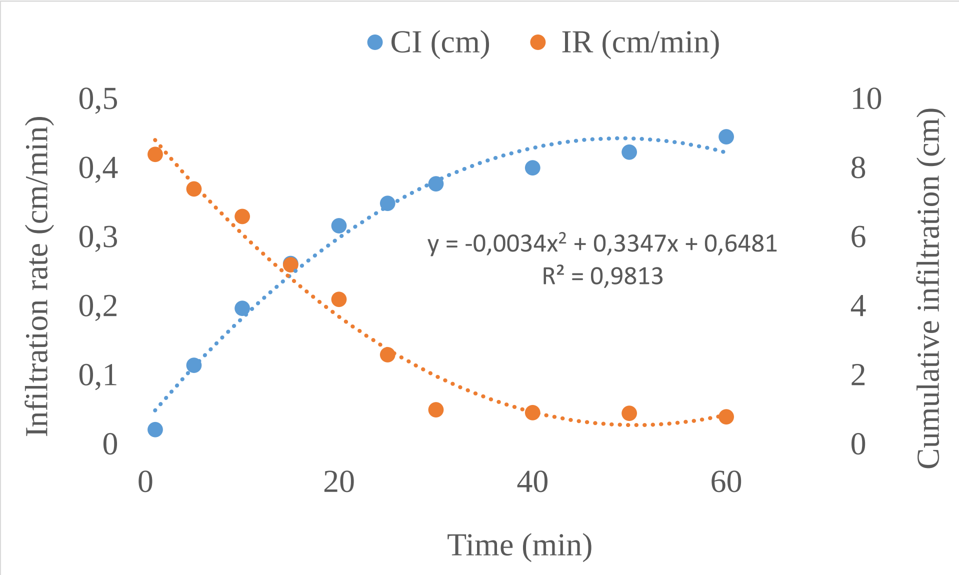

Figure 1: Infiltration rate (IR) and cumulative infiltration capacity (CI) of the study soil

Key words: Bulk density, exchangeable acidity, infiltration capacity, infiltration rate

References

Desale Kidane Asmamaw, Melesse Temesgen Leye, and Abdu Abdulkadir Mohammed, 2012. Effect of Winged Sub-soiler and Traditional Tillage Integrated with Fanya Juu on Selected Soil Physico-Chemical and Soil Water Properties in the Northwestern Highlands of Ethiopia. *East African Journal of Sciences, 6 (2): 105-116.*

Eijkelkamp,1999. Operating instructions for Double Ring Infiltrometer set M10904. Agrisearch equipment.

Melesse Temesgen., Uhlenbrook, S., Belay Simane., van der Zaag, P., Mohamed, Y., Wenninger J. and Savenije, H. H. G. 2012. Impacts of conservation tillage on the hydrological and agronomic performance of Fanya juus in the upper Blue Nile (Abbay) river basin. *Hydrol. Earth Syst. Sci., 16: 4725–4735.*

Chapter 7: Role of public extension performers' as source of information and knowledge to smallholder farmers - the case of northwest Ethiopia

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Currently, there are four actors in agricultural extension: public agencies, private service providers, Producer Organizations (POs), and Non-Governmental Organizations (NGOs). Farmers need the latest information on an array of issues such as, pest outbreaks, inputs, markets, meteorological forecasts, agronomic practices, pest and disease management. This paper explores the role of public sector actors in information and knowledge arena. The study was conducted in two districts of northwest Ethiopia, namely North Mecha and Fogera. For the research design, Key Informant Interviews (KII) and Focus Group Discussions (FGD) were used as the main data collection tools. A total of 16 KII and 20 FGDs were administered.

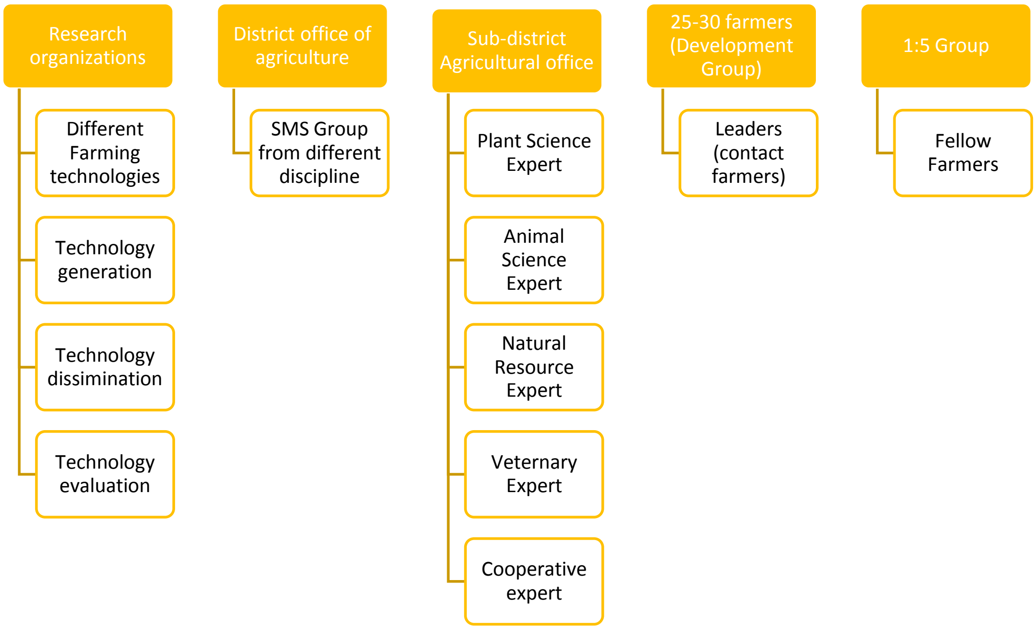

Fig 1. Information and knowledge dissemination performers

The results show that the performers have the role to induce knowledge and information which is specific to rice and vegetables. Public agencies are the most primarily origins of information and knowledge (Fig. 1). The Office of Agriculture of the Sub-districts is considered as the main source of information and knowledge for smallholder farmers. Regional and national agricultural research institutes are liable to create and pilot technologies to end users along with information and knowledge. For instance, the two research centers, namely, Adet and Fogera are perceived as the main sources of information and knowledge. Thus, it is concluded that smallholder farmers' use multiple sources of information from public extension agencies.

Key words: Public extension, Information, Knowledge, Northwest Ethiopia

Performers' role, in view of the respondents (KII (n=16); FGDs (n=20))

Research Organizations (ROs)

The Fogera rice and Adet are the two research organizations in the districts aiming at transferring actionable messages and technologies. However, they do not satisfy the technological need of the end users. They are slow in responding to problems raised by farmers and extension agents. For example, the former X-jigna rice variety in Fogera has not until now been complemented by potentially better varieties, though some attempts are carried. Mecha farmers are facing market problems for their vegetables. They are forced to sell at lower prices and brokers are much benefited, because ROs have not contributed much to overcome weaknesses in the value chains and value addition so far. Yet, substantial efforts such as the introduction of improved rice varieties and post-harvest technologies are currently undertaken by both research organizations.

District Office of Agriculture (DOA)

The DOA rarely visited farmers. However, they are considered as a source of information. They disseminate information on new technologies, advice on marketing, product quality, and environmental challenges. Still, the quality and dependability of information is under interrogation. It is criticized for disorganization, ineffectiveness, and deficiency of quality information.

Sub-district Agricultural Office (SAO)

They are the Frontline development practitioners executing development and extension programs at the bottom level. However, they are required to be taken in various non-extension activities including credit distribution, collection of credit repayments and delegate of government officials. This inhibits them from providing information and knowledge to farmers genuinely. Lack of transport limits EAs to travel from one village to another in the sub-district.

Moreover, Extension Agents (EAs) are not more responsive to farmers. Political commitment has highly influenced the activities of EAs and burdened their primary jobs.

Development Groups (DG)

25-30 farmers are grouped together and called Development Group. It is a government organizational arrangement and structure in agricultural extension. Nevertheless, it is not only used by the agriculture sector. Other agencies like health, land administration and environment affairs use this structure to implement their programs at grass root level. The purpose of this group is to close gaps between EAs and farmers because EAs could not address all growers and livestock keepers in the villages. The DGs are working as a bridge to transfer knowledge, technologies and relevant agricultural messages to the majority of farmers.

1:5 Group

This is the lowest structure in the dissemination of information and knowledge. The structure was expected to share information and knowledge on farm issues. However, because of various reasons such as lack of interest to come together, boredom due to frequent meetings, farmers were busy when they were called and they preferred to conduct their own job than to go to the meetings; it is not performing as it is expected.

References

Abesha, D., Waktola, A., & Aune, J. B. (2000). Agricultural Extension in the drylands of Ethiopia: Drylands Coordination Group.

Adamo, A. K. (2001). Participatory agricultural research processes in Eastern and Central Ethiopia: using farmers social networks as entry points.

Aker, J. C. (2011). Dial “A” for agriculture: a review of information and communication technologies for agricultural extension in developing countries. Agricultural Economics, 42 (6), 631-647.

Anderson, J. R., & Feder, G. (2004). Agricultural extension: Good intentions and hard realities. The World Bank Research Observer, 19(1), 41-60.

Birner, R., & Anderson, J. R. (2007). How to make agricultural extension demand driven? The case of India's agricultural extension policy (Vol. 729): Intl Food Policy Res Inst.

Kassa, B., & Alemu, D. (2016). Agricultural research and extension linkages: Challenges and intervention options. Ethiopian Journal of Agricultural Sciences, 27(1), 55-76.

Sanginga, P. C., Tumwine, J., & Lilja, N. K. (2006). Patterns of participation in farmers’ research groups: Lessons from the highlands of southwestern Uganda. Agriculture and Human Values, 23(4), 501-512.

Chapter 8: Direct and indirect effect of irrigation water availability on crop revenue: A Structural Equation Model

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The development of a clear understanding of the links between dam-driven irrigation water uses and crop revenue is important for poverty reduction and food security. As a result, large research efforts are devoted to the development of a link between crop production and irrigation water (irrigation water availability causes high crop revenue). However, with the application of a structural equation model, this paper argues that a one-sided argument of irrigation water availability that causes high crop revenue is incomplete, as irrigation water availability not only directly contributes to crop revenue but also indirectly conduces to crop revenue via receptivity of the farmers to use improved farm inputs. In this study, the direct and indirect effect of irrigation water on crop revenue is decomposed and quantified specifically for the Koga irrigation scheme, located south of Lake Tana (northwest Ethiopia). A primary data set was collected from a randomly selected sample of 450 households (254 farmers have access to irrigation water and 196 haven't). The results showed that, in addition to its direct effect, availability of irrigation water indirectly affects crop revenue. This indirect effect is about 27 percent of the total effect and mediated by the receptivity of the farmers to use improved farm inputs. The results suggested that irrigation water is essential to improve both crop revenue and receptivity of the farmers to use improved farm inputs. This finding also drives a strategic framework that the receptivity of the farmers to use modern farm inputs is crucial for utilizing the positive effects of irrigation water availability on crop revenue. To achieve high crop revenue, our model suggests that it is important not only to work on the provision of irrigation water, but also on the farmers' willingness to use other improved farm inputs.

Keywords: Koga Dam; Irrigation Water; Crop Revenue; Farmers' Receptivity; Improved Farm Inputs.

References

Anderson, J.C., Gerbing, D.W., 1988. Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach. Psychol. Bull. 103, 411–423. https://doi.org/10.1037/0033-2909.103.3.411

Barker, R., Van Koppen, B., 2000. A Global Perspective on Water Scarcity and Poverty: Achievements and Challenges for Water Resource Management, International Water Management Institute Water Brief N°3. Colombo, Sri Lanka.

Olayide, O.E., Tetteh, I.K., Popoola, L., 2016. Differential impacts of rainfall and irrigation on agricultural production in Nigeria: Any lessons for climate-smart agriculture? Agric. Water Manag. 178, 30–36. https://doi.org/10.1016/j.agwat.2016.08.034

Silalertruksa, T., Gheewala, S.H., 2018. Land-water-energy nexus of sugarcane production in Thailand. J. Clean. Prod. 182, 521–528. https://doi.org/10.1016/j.jclepro.2018.02.085

Wakeyo, M.B., Gardebroek, C., 2013. Does water harvesting induce fertilizer use among smallholders? Evidence from Ethiopia. Agric. Syst. 114, 54–63. https://doi.org/10.1016/j.agsy.2012.08.005

Zewdie, M., Van Passel, S., Tenessa, D., Cools, J., Ayele, Z., Minale, A., Tsegaye, E., Nyssen, J., 2018. Direct and indirect effect of irrigation water availability on crop revenue: a structural equation model. Manuscript submitted for publication.

Illustrations

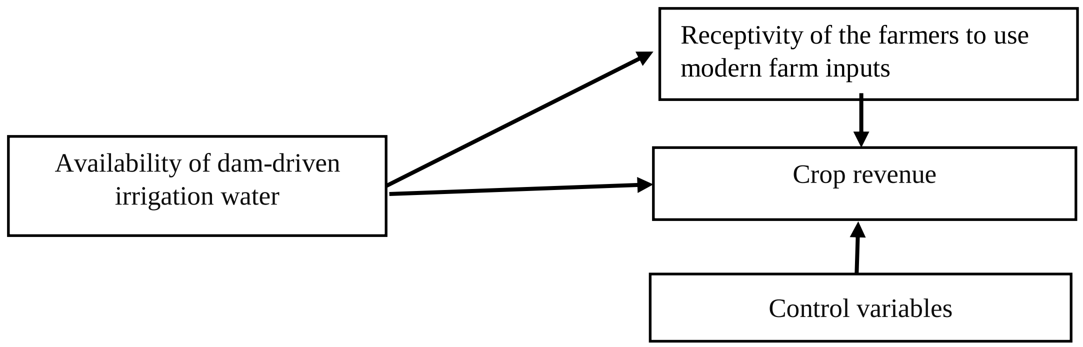

Figure 1: A proposed model of causal relationship among the study variables. Potential control variables of this study are: education (education level of the household head); farm experience (farm experience of the household head); marital status (marital status of the household head); loan (household heads' access to loan); soil quality (soil quality of the household's farm plot); crop type (cash or staple crops) (Zewdie et al., 2018).

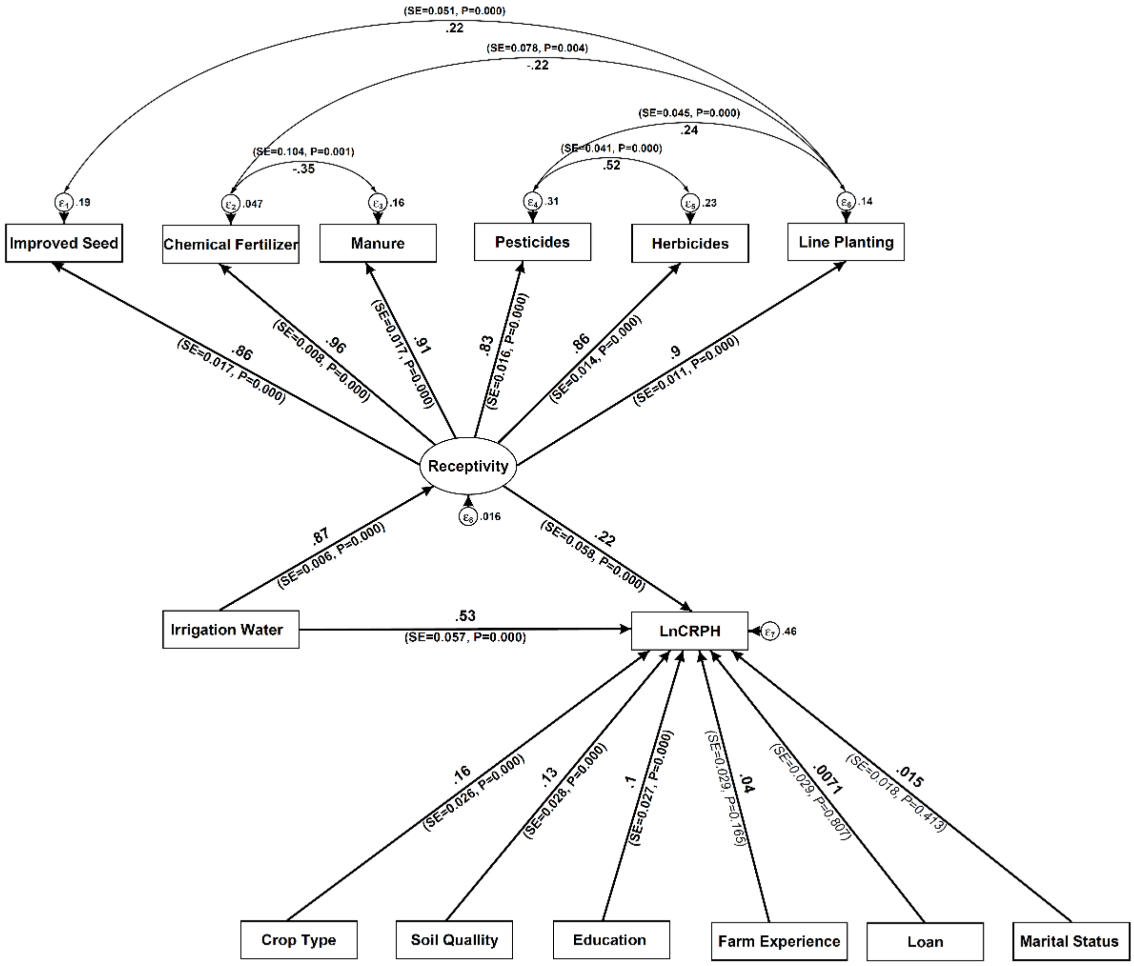

Figure 2: Partially mediated structural equation model (N = 450). All the estimated parameters are standardized, and the standard errors (SE) and p-values are for the standardized estimates of the parameters. Receptivity: willingness of the farmers to apply modern farm inputs; irrigation water: availability of dam-driven irrigation water; LnCRPH: crop revenue per hectare (after transformation); education: education level of the household head; farm experience: farm experience of the household head; marital status: marital status of the household head; loan: household heads' access to loans; soil quality: soil quality of the households plot; crop type (cash or staple crops). The path with light (not bold) standard error and p-value are statistically insignificant (Zewdie et al., 2018).

Chapter 9: Water balance of Tana basin: progress

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Lake Tana basin, one of the major sub-basins of Upper Blue Nile River basin, covers 15,077 km^2 of which 3,156 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. Characterizing the different aquifer systems and their hydrological connectivity with the lake and river water bodies will fill the knowledge gap in understanding the hydro(geo)logical system of the basin, and in upgrading the water balance studies. Hence, constant rate pumping tests on shallow groundwater wells representing different aquifer systems have been executed. Accordingly, an average transmissivity value of 2.73 m^2/day has been estimated for pyroclastic tuff, 10.38 m^2/day for Oligocene-Miocene basalt, 365.2 m^2/day for Quaternary basalt, 2.55 m^2/day for highland residual-alluvial soil, and 2.99 m^2/day for floodplain alluvio-lacustrine aquifers. A number of automatic and manual measuring stations for monitoring of shallow groundwater (69), surface water (14) and meteorological (14) variables (rainfall and temperature) have been established. Results show that the groundwater level for tuff and basalt top aquifers has a strong response to the rainfall compared to the middle and floodplain aquifer systems (Figure 2, Gilgel W4 and W7 vs Gilgel W5, respectively). In general, the upper sloping mountain-front and highland aquifers are characterized by sharp water level rises for the early rainfalls and immediate decline following the offset of the rainfall (Figure 2, Gilgel W4 and W7). In aquifer systems located at the foothill or at mountain-front, subsurface recharge from the surrounding mountain areas occurs.

Keywords: Water balance, pumping test, transmissivity, groundwater level, aquifer

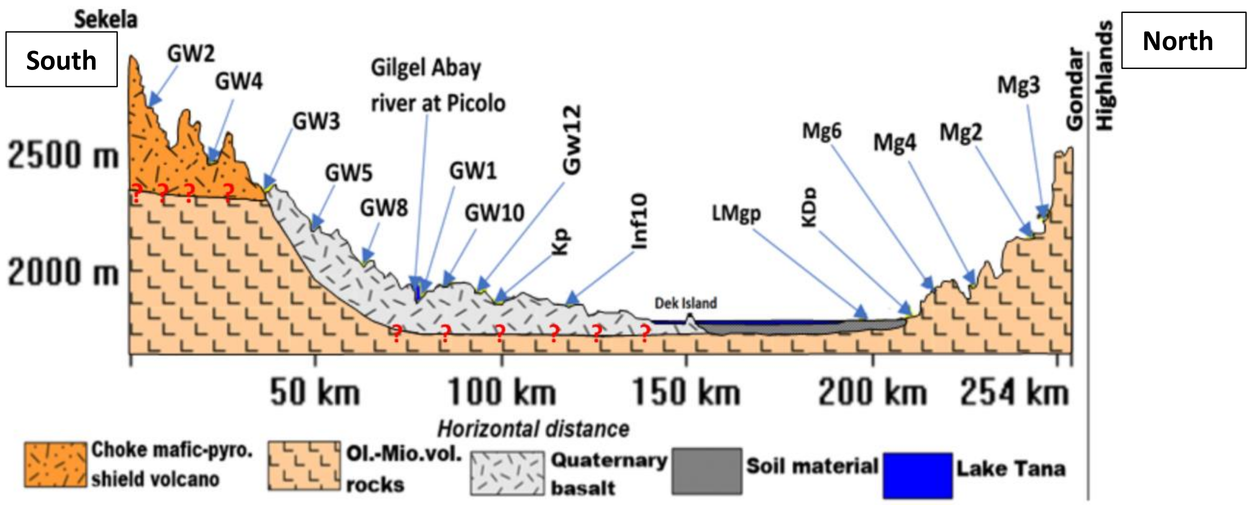
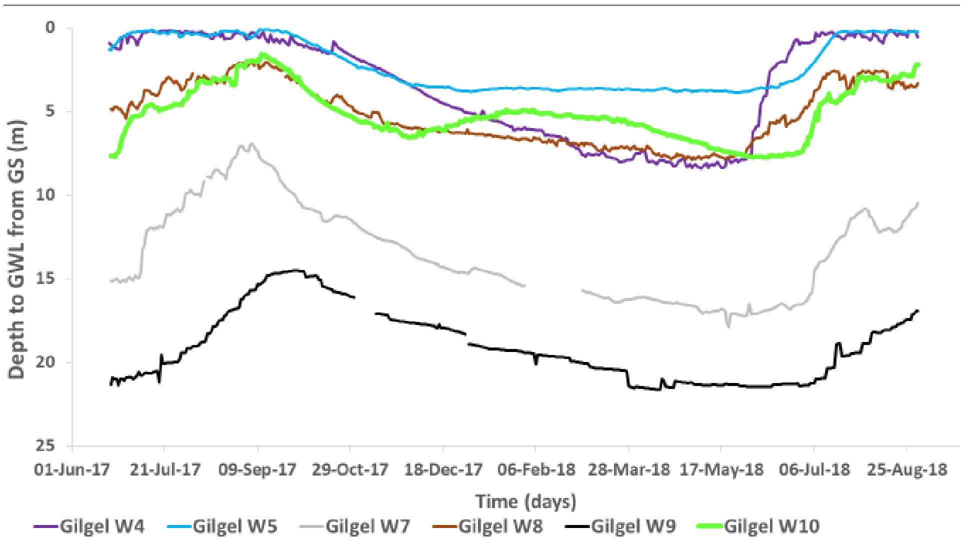


Figure 1: Geological cross- section line from south end (Sekela mountains) to north end (Gondar highlands): along groundwater level measuring stations.



Groundwater level fluctuation with yearly fluctuation values:

High: W4 = 8,29 m, W7 = 10,97 m

Intermediate: W9 = 7,14 m

Low: W5 = 3,8 m, W8 = 5,85 m, W10 = 6,19 m

Figure 2: Depth to groundwater level (GWL) for 2017-2018 at some monitoring hand-dug wells in Gilgel Abay catchment representing aquifers at different topography and geology. Gilgel W4 is at rolling topography and Oligo-Miocene basaltic aquifer in the highlands; Gilgel W5 on flat alluvial aquifer, showing low GWL fluctuation; Gilgel W7 on tuffaceous mountain-front aquifer, showing high GWL fluctuation; Gilgel W8 is on gently sloping topography and tuffaceous aquifer located at the middle of the catchment; Gilgel W9 is on gently sloping, mixed

(layers of both tuff and basalt) aquifer; and Gilgel W10 on Quaternary basalt at Koga command area where rise in the dry season is due to recharge by irrigation water.

References

Alemu Yenehun, Fenta Nigatie, Ashebir Sewale, Minyahil Teferi, Marc Van Camp, Kristine Walraevens, 2019. Groundwater recharge estimation and aquifer response to rainfall and evapotranspiration: Case of Upper Kliti River, Tana Basin, North West Ethiopia (submitted).

Alemu Yenehun, Mekete Dessie, Mulugeta Azeze, Fenta Nigate, Ashebir Sewale, Marc Van Camp, Ann van Griensven, Enyew Adgo, Jan Nyssen, Kristine Walraevens, 2019. Water balance and hydro(geo)chemistry of Lake Tana Basin, Northern Ethiopia: Review (in preparation).

Dessie, M., Verhoest, N.E.C., Admasu, T., Pauwels, V.R.N., Poesen, J., Adgo, E., Deckers, J., Nyssen, J., 2014. Effects of the floodplain on river discharge into Lake Tana (Ethiopia). J. Hydrol. 519, 699–710. https://doi.org/10.1016/j.jhydrol.2014.08.007.

Dessie, M., Verhoest, N.E.C., Pauwels, V.R.N., Adgo, E., Deckers, J., Poesen, J., Nyssen, J., 2015. Water balance of a lake with floodplain buffering: Lake Tana, Blue Nile Basin, Ethiopia. J. Hydrol. 522, 174–186. https://doi.org/10.1016/j.jhydrol.2014.12.049.

Nigate, F., Van Camp, M., Kebede, S., Walraevens, K., 2016. Hydrologic interconnection between the volcanic aquifer and springs , Lake Tana basin on the Upper Blue Nile. J. African Earth Sci. 121, 154–167. https://doi.org/10.1016/j.jafrearsci.2016.05.015.

Chapter 10: Water balance of Beles basin

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The Beles basin in northwestern Ethiopia is one of the water resources development (irrigation and hydropower) corridors in the country. The scarcity, distribution and quality of available data is a major problem for establishing the water balance study of the basin. Understanding the groundwater-surface water interaction and dynamics of the water system in this basin with appropriate data will help to establish water management plans to avoid erroneous water use practices. Under the Hydro(geo)logy project of BDU-IUC program, since April 2017, 4 river discharge, 24 groundwater monitoring (8 automatic and 16 manual) and 11 meteorological (5 manual rainfall and temperature, 6 automatic rain gauge) measuring stations have been installed, and also 45 water samples have been collected. In addition, validated CHIRPS satellite rainfall data for the period 1981–2017 have been used as an alternative source of rainfall data on poorly gauged Beles basin, to assess the spatial and temporal variability of rainfall across the basin. The result from CHIRPS revealed: mean annual rainfall of the basin is 1490 mm (ranging from 1050 to 2090 mm), an average 50 mm increase of mean annual rainfall per 100 m elevation rise, periodical and persistent drought occurrence every 8 to 10 years, and a significant increasing trend of rainfall (~5 mm $year^{-1}$) observed at the lowland and drier parts of the basin. The high coefficient of variation of monthly rainfall in March and April reveals occasional years with bimodal rainfall in Beles basin (Fig. 1 & Fig. 2). The north-eastern part of the study area experiences relatively low rainfall despite its topographically high position which could be the effect of Mount Belaya's rain shadow (Fig. 1). Preliminary results from monitoring stations reveal that groundwater response with precipitation is spatially highly variable within the basin, while dry season artificial recharge through small scale flood irrigation is significant (at some place it creates wetlands). The distribution of high discharge springs (more than 5 with > 40 l/s) along Tana escarpment indicates a natural interbasin water transfer from Tana basin to Beles basin. Additionally, there is artificial water transfer from Lake Tana to Beles river, for the Tana-Beles hydropower project.

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

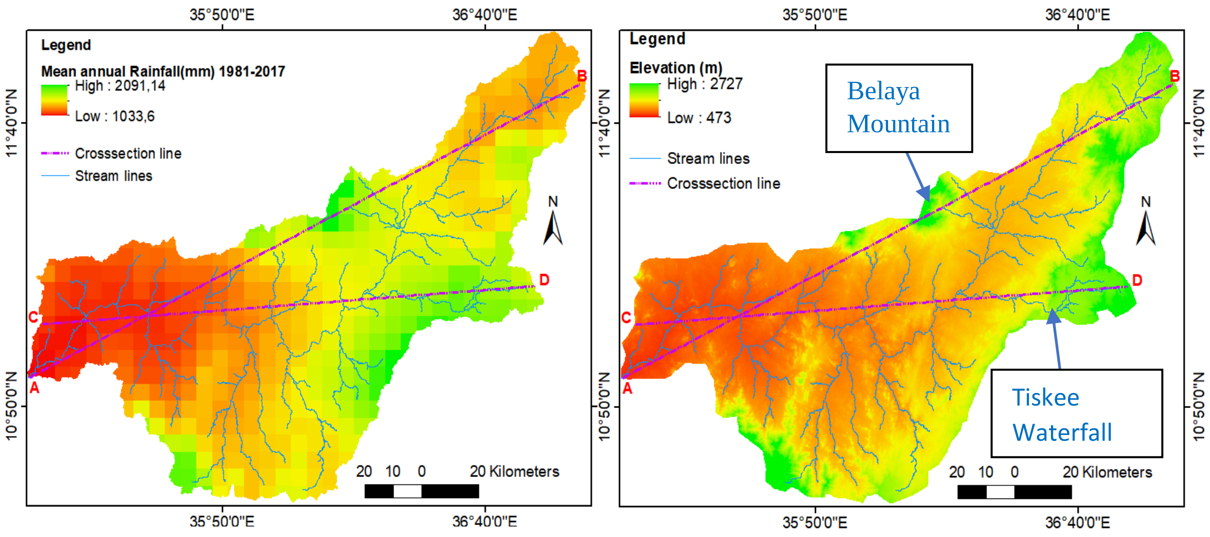

Figure 1 *CHIRPS long-term mean annual rainfall (mm) for 1981 to 2017 (left) and Digital elevation model (SRTM 30m) for Beles Basin.*

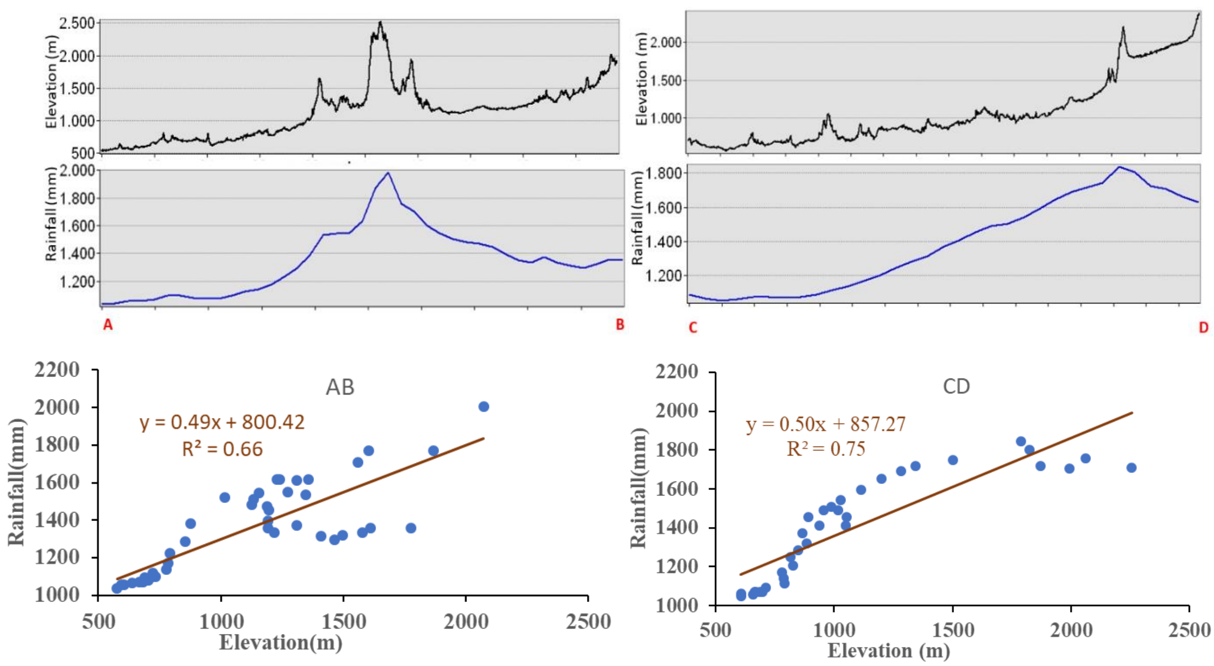

Figure 2 *Long-term mean monthly rainfall versus elevation along transect lines (fig. 1) from A to B (left) and from C to D (right) and a scatterplot of rainfall with elevation for each transect line AB and CD.*

Reference

Belay, A.S., Tilahun S.A., Moges, M. , Dessie, M., Adgo, E., Nyssen, J., Chen, M., Walraevens, K., 2019. Assessment of spatio-temporal variability of rainfall using validated multi-source satellite rainfall product(CHIRPS) in poorly gauged Beles Basin, Ethiopia. (In preparation)

Chapter 11: Dormancy, flower bud and fruit quality under conditions of insufficient chilling in apple (*Malus domestica*)

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Although, apple (*Malus* x *domestica*, Borkh.) is a temperate fruit species that has got a lot of interest in Ethiopia, due to its economic importance. Its production in Ethiopia has a major problem due to insufficient chilling that affects the period of endo-dormancy. This is manifested by irregular bud break, flower bud development, flowering, fruit set, fruit development and fruit quality. This doctoral study is therefore designed to get a better insight into 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 focus on finding insights on the expression of the genes regulating the process of endo-dormancy. Ten candidate genes including *DAM, DHNs, HTAs* and *NAC* and 6 other candidate genes which are involved in dormancy process will be used for our study.

Preliminary results from available RNA samples at FTC indicated that the 4 already identified genes are good candidate genes to describe the evolution of the dormancy process in a greenhouse (simulation of insufficient chilling) and outside (figure 1).

So far, RNA extraction protocol development that has resulted in good quality RNA. By following a modified RNA extraction protocol of the FTC lab, RNA was extracted from flower bud samples collected during the onset of dormancy to deep dormancy stages (four time points), gel electrophoresis and Nano-drop measurements were done. Even though, the samples have very good concentrations with Nano-drop readings (Table 1) the gel pictures showed degradation in most of the samples (Figure 2). By testing different protocols we were able to identify source of degradation, which happen to be method of crushing and finally by modifying the crushing protocol (crushing of tissue in liquid nitrogen using a screw driver), good quality RNA samples from flower buds were achieved (Figure 2).

The expression of the ten Candidate Genes will be assessed by RT- qPCR of the optimized RNA samples (Qiagen method). Flower bud samples will be collected from Golden Delicious and Gala cultivars grown under different chilling conditions: experimental orchards in Ethiopia (Zufil) and Belgium (Rillaar). Establishment in 2017-2018 and maintenance of the apple orchard in Debre Tabor (Ethiopia) since 2018 has been done (Figure 3). Sample collection for differential gene expression as well as validation experiments has started from beginning of October 2018 and will be undertaken until fruit set (May, 2019).We will sample flower buds at fifteen time points to compare differential gene expression as the dormancy stage progresses towards active growth. The time points will include developmental stages before the onset of dormancy until early fruit development. Following differential expression a dormancy index will be formulated and applied on Golden Delicious and Gala plants and the validation will be undertaken on four additional cultivars, two cultivars in Ethiopia (Jonagold and Granny Smith) and two more cultivars in Belgium (Jonagold and Elstar).
The morphological observations planned include flower bud quality parameters like size and number of flowers, bud break percentage, number of anthers, ovule longevity, and pollen germination will also be studied under the two chilling conditions. We will also evaluate fruit quality by parameters such as fruit weight and shape, firmness, soluble solid contents and acidity. We aim to correlate flower bud parameters and fruit quality with dormancy-related gene expression.

In addition, rest breaking treatments like defoliation, water stress, and a chemical application will be investigated at a later phase to introduce effective rest breaking treatments suitable for Ethiopian climate.

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 groundwork for understanding the genetic control of insufficient chilling during endo-dormancy and its effect on fruit set and fruit quality.

Keywords; Insufficient chilling, endo-dormancy, gene expression, RNA, qPCR

Table 1. RNA samples with good Nano-drop readings and concentrations

Cultivar	Concentration	260/280	260/230
Br2	104.9	1.99	1.65
Br3	111.6	2.06	2.2
Br4	113	2.09	2.27
Br5	136.3	2.08	2.06
Br6	139.1	1.99	1.76
Br7	123.1	2.04	1.89
Br8	136.8	2.03	1.79
Ga 1	133.9	2.01	1.73
Ga 2	164.1	2.13	2.33
Ga 3	171	2.05	2.02
Ga 4	180.2	2.01	2.17
Ga 5	103.4	2.34	2.14
Ga 6	208.9	2.13	2.29
Ga 7	163.6	2.0	1.78
Ga 8	94.2	1.92	1.44

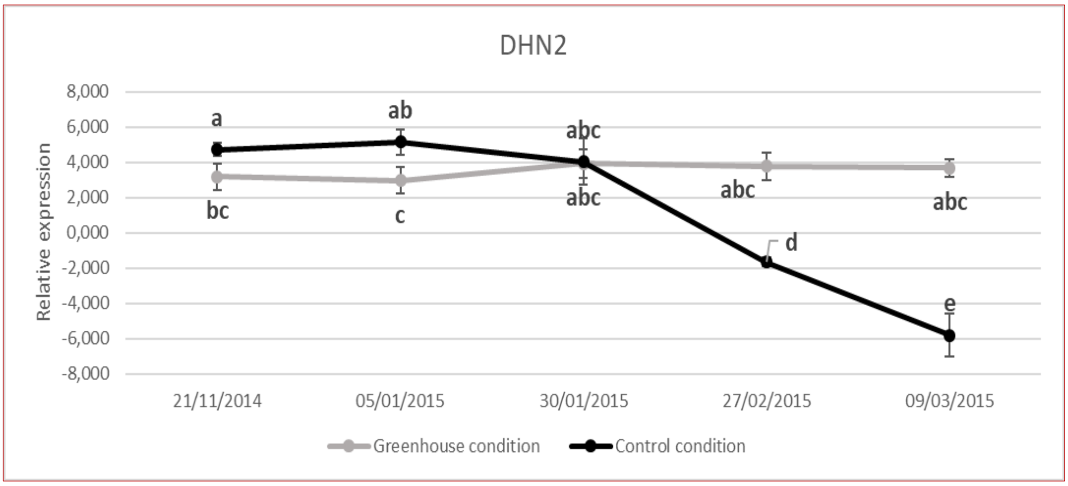

Figure 1: Gene expression of the *DHN2* gene (production of dehydrines, involved in cold adaptation) under greenhouse and field conditions. At the end of the endodormant period (30/01) gene expression starts to decrease under field conditions (sufficient chilling), but this is not the case under greenhouse conditions (insufficient chilling), hampering further flower-bud development in the greenhouse.

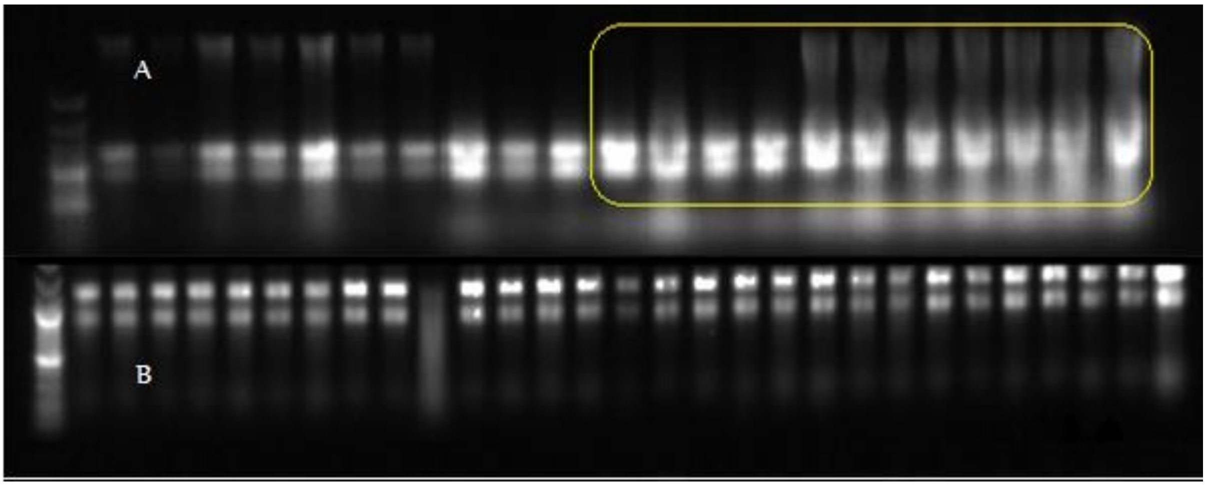

Figure 2. Gel picture showing poor quality RNA samples (A, circled in yellow) and good quality RNA samples produced with the new protocol (B, top)

Figure 3. Experimental orchard at Debre Tabor, Ethiopia, 23-01-2019

Chapter 12: Tomato chilling to reduce postharvest losses in Ethiopia

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Tomato (*Lycopersicon esculentum* Mill.) is a cash crop and contains major health promoting substances such as carotenoids (especially lycopene), phenolics, and ascorbic acid [1]. Tomato is a climacteric fruit and its ripening is initiated by a surge of autocatalytic ethylene production [2,3]. At the end of the ripening process the senescence phase starts, leading to rapid deterioration [2,3,4]. Ripening and senescence can be delayed by refrigerated storage, but because of lack of cold storage facilities in sub Saharan African countries including in Ethiopia the major proportion of tomatoes produced by the farmers is lost due to postharvest losses [4,5]. In Ethiopia, about 85 % of the farmers are small-holders and live in rural areas, where the national electricity grid is not yet connected. Postharvest losses of tomato in Ethiopia are estimated from 30 to 50 % [4,6]. Lack of cold storage facilities and physical injuries are mentioned as the most important factors of the accounted losses [4,6]. Cold storage of tomato is known to reduce the rate of physiological changes such as respiration, softening and weight loss, but below 10 to 13 °C, depending on the cultivar, chilling injury may occur as tomato is a tropical fruit [5,7]. Establishing of cooling facilities in rural areas requires alternative energy sources. The solar irradiation potential in Ethiopia is 1753-2483 kWh m^{-2} y^{-1} which is about two times that of Belgium (1000-1100 kWh m^{-2} y^{-1}) [8]. Therefore, utilization of available solar energy for cold production is a viable option. This study mainly focuses on the development of an absorption cooling system by using solar thermal energy for activation. First the effects of storage temperature (5, 10, and 15°C) on the changes of Ethiopian tomato cultivars *Melka salsa and Melka shola* will be assessed by conventional refrigeration at the green, turning and pink harvesting stage. Then, a small-scale solar absorption chiller will be designed and developed for tomato storage. The design process includes cooling load estimation for 50 kg of tomatoes, sizing of components, and construction and testing of the system. In addition, modifications will be performed as required. Finally, a large-scale solar absorption system will be modelled based on the data obtained from the small-scale absorption chiller.

Key words: postharvest loss, cold storage, solar energy, tomato, physiological change

Figure 1. Illustration of tomato harvesting, sorting and grading, cold storage, firmness *(TA.XTplus Texture analyzer, Stable Micro Systems Ltd., Godalming, Surrey, UK)*

determination, and labelled tomatoes for color change monitoring by *spectrophotometer CM-600D*

References

1. Javanmardi, J., & Kubota, C. (2006). Variation of lycopene, antioxidant activity, total soluble solids and weight loss of tomato during postharvest storage. *Postharvest biology and technology*, *41*(2), 151-155.
2. Van de Poel, B. (2013). Ethylene biosynthesis during climacteric ripening of tomato. *A systems biology approach.*
3. Giovannoni, J. J. (2004). Genetic regulation of fruit development and ripening. *The plant cell*, *16*(suppl 1), S170-S180.
4. Getinet, H., Seyoum, T., & Woldetsadik, K. (2008). The effect of cultivar, maturity stage and storage environment on quality of tomatoes. *Journal of Food Engineering*, *87*(4), 467-478.
5. Riudavets, J., Alonso, M., Gabarra, R., Arnó, J., Jaques, J. A., & Palou, L. (2016). The effects of postharvest carbon dioxide and a cold storage treatment on Tuta absoluta mortality and tomato fruit quality. *Postharvest Biology and Technology*, *120, 213-221.*
6. Emana, B., Afari-Sefa, V., Nenguwo, N., Ayana, A., Kebede, D., & Mohammed, H. (2017). Characterization of pre-and postharvest losses of tomato supply chain in Ethiopia. *Agriculture & Food Security*, *6*(1), 3.
7. McDonald, R. E., McCollum, T. G., & Baldwin, E. A. (1999). Temperature of water heat treatments influences tomato fruit quality following low-temperature storage. *Postharvest Biology and Technology*, *16*(2), 147-155.
8. http://www.worldbank.org/energy

Chapter 13: Understanding the interrelation between landscape structure on church forests' resilience, bird ecology and agricultural production in the Eastern Lake Tana basin

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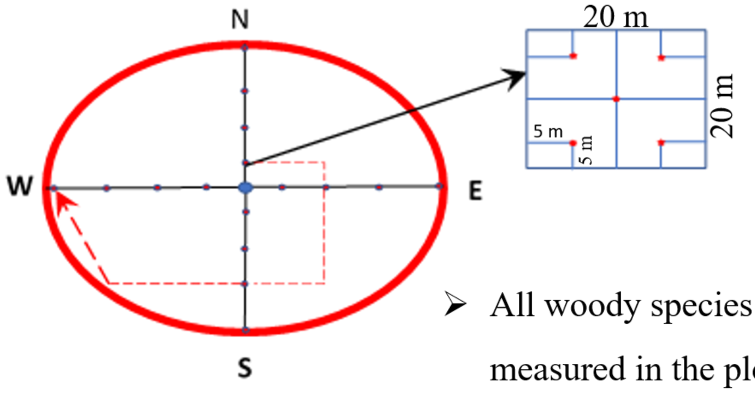
In the northwest of Ethiopia, understanding the effects of landscape structure on plant and bird community and ecosystem services (ES) remain at a very early stage. Despite the fact that the interrelation between church forests and birds may have a significant role to enhance crop production via physical (a buffer against wind and floods) and biological (sources of pollinators and pest regulators), little is known about the ES of birds and church forests. In order to effectively enhance ecological restoration and sustainable supplies of ES now and in the future, an understanding of how landscape structure affects bird species composition and ES is urgently required. Therefore, the study aims at understanding, the ecological value of church forests as safeguards for avian biodiversity and associated ecosystem services such as pollination, seed dispersal, and pest control and the ecological importance of connectivity of the landscape matrix in which these forests are embedded. This will be done in four major phases, focusing on the vegetation characteristics of the church forests themselves, the connectivity of the surrounding landscape matrix, the composition of church forest bird communities and finally on the ecosystems services the birds provide. Currently, assessment on church forest vegetation and bird species surveys are completed and the sampling procedure is visible in figure 1 and 2, respectively. Data analyses for the church forest inventory are being undertaken at Gent University. In the forest inventory, a total of 114 woody species representing 53 families were recorded. Of these, 62.3% of the species were trees, 28.9% were shrubs, and 7.9% were lianas. Species composition differed between forests with the range of 16 to 38 species. Species composition of church forests will be further related to landscape characteristics of the agricultural matrix and with management pressures within the forest fragment. Assessing seed dispersal and pest control ecosystem services will be prospects for the next phase.

Key words: Bird, church forests, ecosystem services, landscape structure, Lake Tana



- All woody species were identified, counted & measured in the plot (20m * 20m)
- Seedlings were scored in the sub plots (5m * 5m)
- Canopy measured at five points within the main plot (red stars on the center and corner of the 5 m x 5 m)

Figure 1. Sampling plot selection and data collection procedures

a)

A total of 64 audiomonts were installed within the range of 2 to 5 audiomonts per site		
1. The devices were installed at the 2nd & 4th plots, when they are two.	2. When the number of devices are 3, they were installed at the 2nd, 3rd & 4th plots.	3. When the number of devices are 4, they were installed at all plots, but when they are 5, one additional device was installed at one of the four plots.
4. The bird sound was recorded for a total of two weeks (i.e. seven hours per day, 5:30 am to 10:30 am and 4:30 pm to 6:30 pm) 5. See Figure 1 for plots location		

b)

Figure 2. Installation of the audiomonts for bird sound recording (a) and sample design of the audiomonts (b).

Results for Gebesiwit Mariyam site

Vegetation results

- 21 woody species representing 11 families were recorded in Gebesiwit Mariyam church forest.

- Of these, 66.7% species were trees, 28.57% were shrubs and 4.76% were liana species

- Fabaceae is the dominant family represented by 3 species followed by Moraceae

Bird results

- Two audiomonts were installed in the east and west direction which is the 2nd and 4th plot locations for vegetation sampling

- 18 bird species bird recording (this is just skimming, not by sound recorder but through visual observation)

Chapter 14: Floodplain sediment storage quantification: the case of upper reaches of the Gumara river

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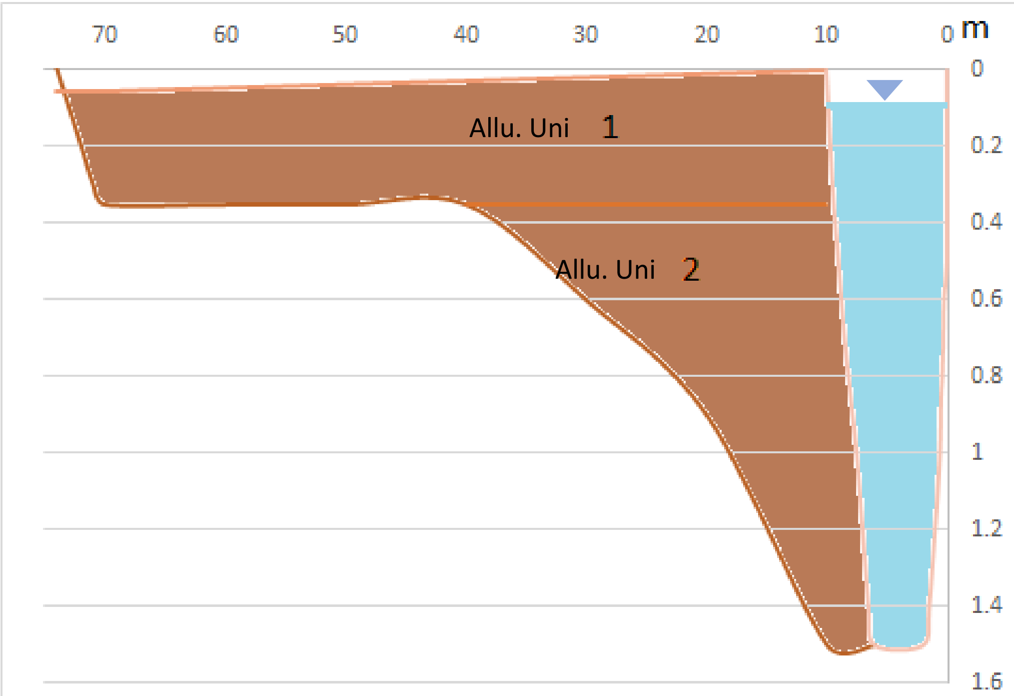
Whilst much research in the Ethiopian Highlands has been directed towards soil erosion, river sediment, and nutrient fluxes, and reservoir sedimentation, one major aspect of the sediment budget of a river catchment, floodplain deposition, has been neglected. Indeed, whilst Highland rivers receive substantial quantities of detached sediment particles from their uphill catchments, these rivers continuously deposit and rework the sediment in their often extensive floodplains rather than merely transporting the sediment load towards the outlet. This is the case for the rivers draining to Lake Tana, such as the River Gumara that originate at the foot of Mount Guna (4120 m a.s.l.) and drain westwards to Lake Tana, and which will form the focus of this study. This study is aimed at quantifying the amount of sediment stored in the alluvial plains of the upper reaches of the Gumara.

Floodplain sediment storage was estimated by combining information on floodplain spatial extent obtained through field-based and remote sensing based approaches, with information on sediment thickness obtained through sediment coring and the analysis of cut-banks. Feeling method and the Munsell color chart were used to determine the textural class and the color of the core, respectively. As we learned from the study and according to Nanson and Croke (1992) floodplain classifications confined vertical accretion sandy floodplains (A2), wandering gravel-bed river floodplains (B2), meandering river, lateral migration floodplains (B3, of suborder, non-scrolled B3a and scrolled B3b), and overbank vertical accretion (B5) is the observed ones in the area. Besides, so far the study showed that 13.39 Mm^3 of sediment is deposited in the studied reach of the Gumara River (1027.85 km^2; 176 km river length). The texture varies from clay to sandy clay loam; sandy clay, silty clay and clay being the major texture classes observed. Comparing this with floodplain sediment storage in similar-sized European catchments that are characterized by long-term human impact (Hoffmann et al. 2013) shows that floodplain sediment storage in the Gumara catchment is up 10 times lower. The topography and climatic difference between the two regions could be the potential factors for such floodplain sediment storage variations. Finally, not only the lower reaches but also the upper reaches of the Gumara river also play an important role in storing sediment of different textural classes.

Key words: floodplain, sediment storage, Gumara river, coring



Legend:

Color: Dark reddish brown (5YR ¾)   Allu. Uni 1: Alluvial unit 1 - Sandy clay

Fogeda River   Allu. Uni 2: Alluvial unit 2 - Silty clay

Figure 1: Typical floodplain cross-section around Arib Gebeya (700 m downstream of the Fogeda bridge): learns us change in thickness and texture of sediment storage along the width and depth of the floodplain

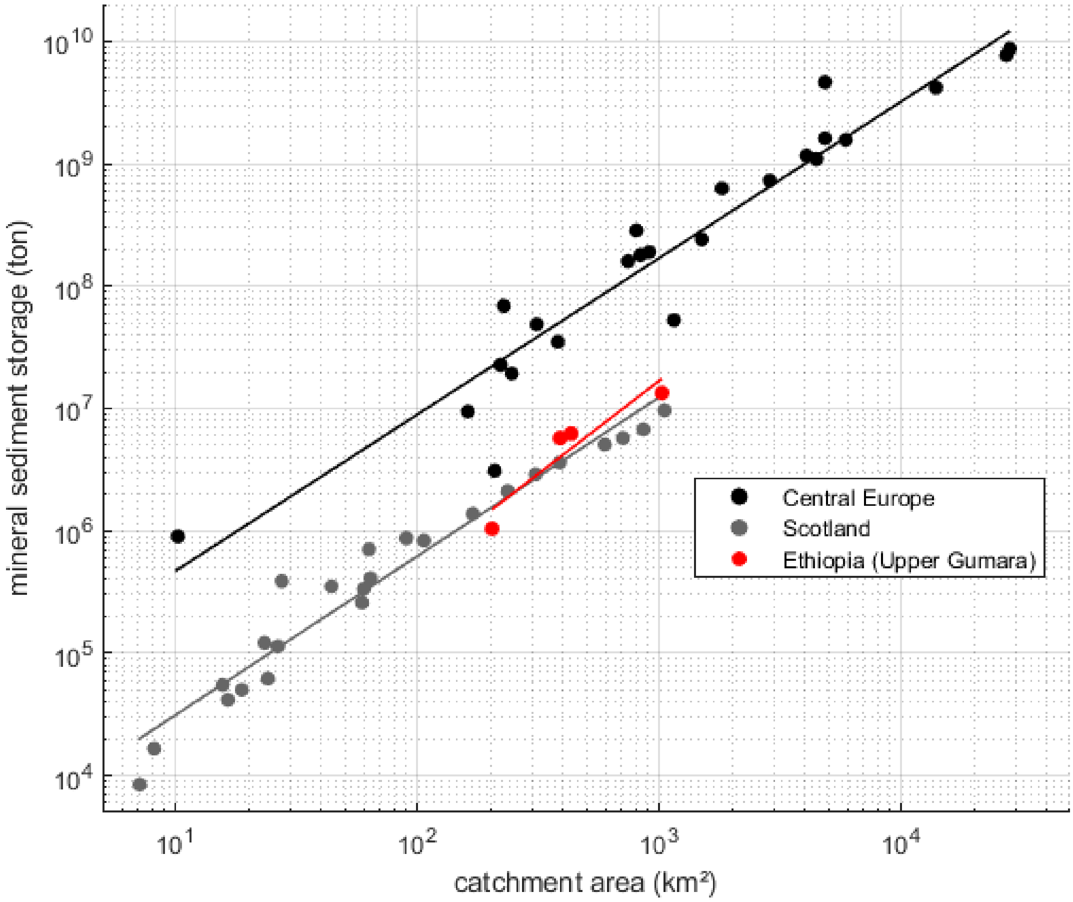


Figure 2: Mineral sediment storage vs area; the graph shows the relationship between sediment storage and catchment area for floodplains located in ca. 3 different topographical settings. The storage for the upper Gumara lies above Scotland (much upland setting) and below the central Europe (flattest setting)

References:

Nanson, G. C., & Croke, J. C. (1992). A genetic classification of floodplains. *Geomorphology*, *4*(6), 459-486.

Hoffmann, T., Schlummer, M., Notebaert, B., Verstraeten, G., & Korup, O. (2013). Carbon burial in soil sediments from Holocene agricultural erosion, Central Europe. Global Biogeochemical Cycles, 27(3), 828-835.

Chapter 15: Quantifying and understanding land degradation process in relationship to landscape connectivity in the Lake Tana basin

Habtamu Assaye[1,2], Samuel Bodé[3], Derege Tsegaye[2], Alemayehu Wassie[2], Enyew Adgo[2], Jean Poesen[4], Jan Nyssen[1], Pascal Boeckx[3], Amaury Frankl[1,5]

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Land degradation is a major environmental problem in the Lake Tana basin. In this research, we aim at quantifying and understanding the processes of land degradation by water erosion in the basin. The Enkulal catchment (ca. 10.4 km^2) was selected to represent the upland areas of the Gumara catchment. Within this catchment, six sub-catchments were selected with variable land use and cover, topography and management. Five tipping-bucket rain gauges were installed. Fourteen micro-catchments (ranging in area from 324 to 1715 m^2) were selected from five land uses. Weirs were established at the outlet of each sub-catchment and micro-catchment to measure runoff and sediment yield (Fig 1.). Divers were installed at outlets of each sub-catchment. Philips tubes were used to take time-integrated sediment samples for sediment source fingerprinting. Runoff measurement and sampling were done during runoff events for both the sub-catchments and micro-catchments. In addition, daily runoff samples were taken at sub-catchments. Spatial and temporal dynamics of gullies are being monitored by tape meter measurements and 3D photo-modeling; Structure from Motion-Multi View Stereo (SfM-MVS) technique using Photo Scan software and a unmanned aerial vehicle (UAV) [2]. In addition, the Compound Specific Stable Isotope (CSSI) finger printing technique is used to apportion sediment sources using $\delta^{13}C$ of plant derived fatty acids ($\delta^{13}C$–FAs). Results so far revealed that the runoff coefficient (RC) of the sub-catchments ranges from 24% to 55% [4]. Runoff coefficient declines as the forest cover increases, and increases with gully density. The RC from micro-catchments ranged from 5% from forests to 69% in badlands. Area-specific gully length ranges from 15 - 46 m ha^{-1}, gully area 94 - 405 m^2 ha^{-1} and gully volume 89 - 893 m^3 ha^{-1}. Average suspended sediment concentration (SSC) was higher in badland (6.6 ± 4.9 g L^{-1}) and lower in protected grassland (0.33±0.2 g L^{-1}). In addition, land use change analysis revealed that recent significant changes happened from agriculture to eucalyptus plantation, which expanded more than twice since 2007 [1]. The nutrient balance in the area [5], and impact of land fragmentation on land management and productivity [3] are also being studied.

Key words: Land degradation, discharge, 3D modeling, fingerprinting, catchment

Fig 1. Discharge measurement at sub-catchment 1 (SC1)

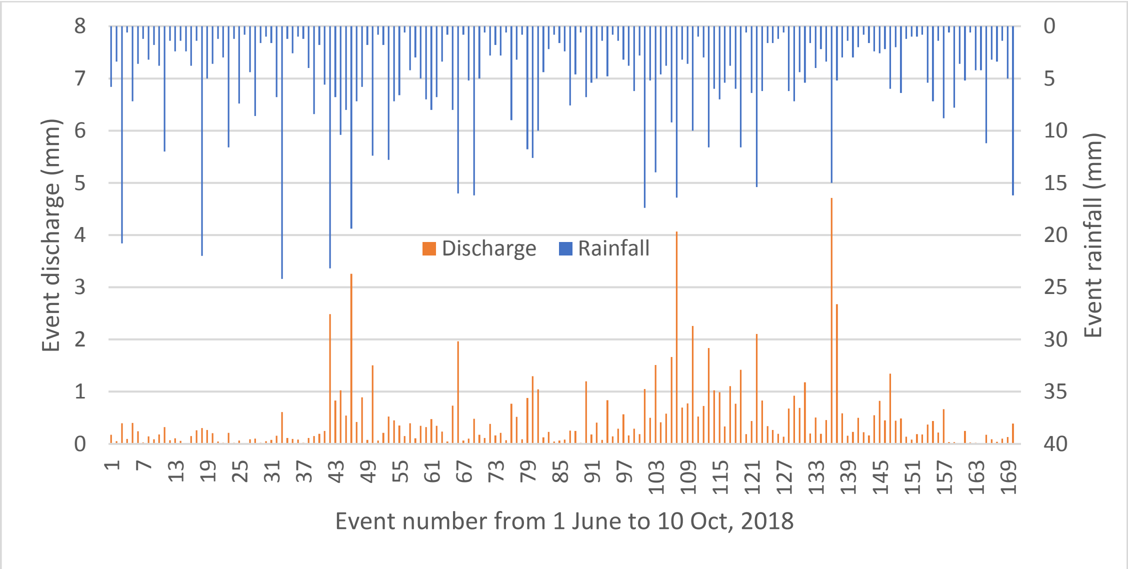

Fig 2. Event rainfall-discharge relationship at SC1

References

[1] Alelign Garedew. Effect of land use change on soil properties in the Lake Tana basin, North West Ethiopia. (MSc thesis, ongoing)

[2] Frankl, A., Stal, C., Abraha, A., Nyssen, J., Rieke-Zapp, D., De Wulf, A., Poesen, J., 2015. Detailed recording of gully morphology in 3D through image-based modelling. Catena 127, 92-101.

[3] Gebre-Egziabher Fentahun. Level of land fragmentation and its implication to productivity, conservation and management in the Lake Tana Basin, Ethiopia. (MSc thesis, ongoing)
[4] Habtamu Assaye. Effect of catchment properties on event-based rainfall-runoff response in the Lake Tana basin, northwestern Ethiopia (in preparation)
[5] Melese Geze. Analysis of nutrient balance in the agricultural landscape of the upland sediment source area of the Lake Tana basin, the case of Dera District, South Gondar Zone, Ethiopia (MSc thesis, ongoing)

Chapter 16: Effect of curing temperature and relative humidity on storability of onion

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Onion is an indispensable part of the daily Ethiopian dish and it is, thus, one of the most economically important vegetable crops in Ethiopia [2]. However, postharvest losses are extremely high mainly due to poor postharvest handling including inappropriate curing practices as well as lack of cold storage facilities [2,3]. Curing is the most common postharvest treatment employed by farmers to extend the storage life of onion in the country [1,4,5]. In Ethiopia, where the time of harvesting coincides with the dry season, farmers cure onion bulbs naturally in the production field using sunlight. Curing of onion can be also done artificially in dryers through blowing hot dry air. Onion bulbs cured naturally in the field generally have a lower shelf life compared to those cured artificially [4]. 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 to develop alternative and affordable technology for increasing the storage life of onion bulbs. For that purpose, first, a study has been conducted to investigate the effect of curing conditions and storage time on storage life of onion bulbs. The 'Bombay Red' cultivar of onion was used as test crop which has been harvested when about 0-10 % of leaves of the plant have been collapsed (topped-down). Foliages were removed by cutting the neck at the distance of one 2.5 cm from the bulbs before curing. Bulbs were artificially cured at three different temperatures (30, 40 and 50 °C) and relative humidity levels (30, 50 and 70 %) for a duration of 48 hour. Thereafter, onion bulbs were kept at ambient conditions (average temperature of 23 ºC and relative humidity of 66 %) for 90 days. Weight loss, total losses, sprouted and rotted bulbs and percentage of marketable bulbs were measured at an interval of 10 days throughout storage. The results showed that the highest weight loss (20%) was recorded when the onion bulbs were cured at 50 °C and relative humidity (RH) of 30%, followed by uncured onion bulbs (17%); the lowest weight losses (11%) were recorded for onion bulbs cured at 30 °C and 70% RH. A significant reduction in the percentage of sprouted and rotted bulbs was observed when the curing temperature was ≤ 40 °C.

The weight loss, percentage of sprouted and rotted bulbs increased with in storage time. The least total losses (51%) and highest percentage of marketable bulbs (49%) were recorded for onion bulbs cured at 40 °C and 50% RH. On the other hand, the highest total losses (93%) and lowest marketable bulbs (7%) were recorded for uncured onion bulbs. Based on the results of the present study, it can be concluded that curing at a temperatures lower than 40 °C helps to prolong the storability of onion bulbs. Despite curing improves storability of onion bulbs, the total losses are still huge. This could be mainly due to the fact that onions used for this study were immature. Thus, there is an ongoing experiment that studies the effect of curing condition and stage of maturity on storability of onions.

Keywords: Onion, curing, sprouting bulbs, marketable bulbs, weight loss

Illustration

Small scale a solar tunnel dryer was design and constructed as an alternative technology for onion curing. As shown in the figure below, air is drawn through the dryer by axial fan (C). It is heated as it passes through flat plate solar collector (A) and then partially cooled as it removes moisture from the onion bulbs which are placed in the drying chamber (B). A solar panel (D) generate all necessary electric power for the fan, the control system (F) and charging a solar battery (E) during the day.

Figure 1. A solar tunnel dryer setup constructed for onion curing: (A) solar collector; (B) drying chamber; (C) axial fan; (D) solar panel; (E) solar battery and (F) solar charge controller.

References

1. Nega, G., Mohammed, A.A., & Menamo, T. (2015). Effect of curing and top removal time on quality and shelf Life of onions (*Allium cepa* L.). Global Journal of Science Frontier Research: D Agriculture and Veterinary. 2249-4626 & Print ISSN: 0975-5896
2. Abdissa Y, Tekalig T, Pant L. (2011). Growth, bulb yield and quality of onion (*Allium cepa* L.) as influenced by nitrogen and phosphorus fertilization on vertisol I. growth attributes, biomass production and bulb yield. Afr. J. Agric. 6(14): 3253-58.
3. Biswas SK. (2010). Yield and shelf life of onion (*Allium cepa* L) as affected by varying levels of irrigation. Bangladesh J. Agril. 35(2): 247-255.
4. Gubb, I., MacTavish, H., (2002). Onion pre-and postharvest considerations. In: Rabinowitch,H.D., Currah, L. (Eds.), Allium Crop Science: Recent Advances. CABI Publishing, Wallingford, pp. 233–265.
5. Downes, K., Chope, G.A., Terry, L.A., (2009). Effect of curing at different temperatures on biochemical composition of onion (*Allium cepa* L.) skin from three freshly cured and cold stored UK-grown onion cultivars. Postharvest Biol. Technol. 54, 80–86.

Chapter 17: Habitat characterization of young-of-the-year *Labeobarbus* species

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Introduction

The Lake Tana ecosystem, home for 15 commercially important endemic *Labeobarbus* species (Nagelkerke & Sibbing, 2000) is a hotspot for biodiversity. Majority of the *Labeobarbus* species of Lake Tana are reported as migratory species to tributary rivers (Anteneh *et al*., 2013; Fedor *et al*., 2017). Gumara river is one of the most important breeding grounds for those migratory *Labeobarbus* species. After hatching in the spawning place young-of-the-year (YOY) *Labeobarbus* species are present in different habitats along the river. The lake and its tributary rivers are suffering from major changes in climate and anthropogenic factors and the impact on reproduction of the species is of overall importance for conservation and management of the stock. Owing to their important contribution to the success of the entire stock, giving credit for YOY fishes is indispensable. Then again knowledge of the requirements of the breeding and nursery habitat of *Labeobarbus* species is a pillar for conservation and management of these ecological and economical important fish species. However, the microhabitats used by the young-of-the-year (YOY) *Labeobarbus* species are not yet known. Therefore, this part of PhD work is focused on habitat characterization and survival of YOY *Labeobarbus* species in Gumara river system.

Methods

This work has been conducted in the streach of Gumara River from its mouth to upstream habitats at Wanzayie village. Along the stretches of the river, sites were selected such as a fast smooth current (run), a swift current breaking over submerged gravel or rock that produces surface agitation (riffle) and relatively deep slow water (pool). Depending on the area available for sampling 72 sampling points were chosen from 6 different sites along the stretch of the river. Fish sampls have been collected from lower to upper direction of each sampling reach using point abundance electro-fishing technique (Figure 1). Measurements of physical and chemical characteristics of the YOY fish habitats such as depth, speed of river water, substrate type, temperature, dissolved oxygen, specific conductivity and pH have measured in-situ. To estimate the food or energy sources and contribution of various components of fish diet for the survival of YOY fishes, fish specimens and other functional groups have been collected for stable isotope measurement.

Figure 1. a) Specimen collection using electrofishing b) measurements of YOY *Labeobarbus* sp.

Preliminary results

Barbus humilis, *B. pleurogramma*, *Garra spp*. and *Varichorinus beso* from the family 'Cyprinidae' and rarely *Clarias garipinus* and *Oreochromis niloticus* were caught in some sampling points during this survey. *Barbus humilis* was the most abundant species in the majority of sampling points but *Garra spp.* are dominant in speedy water or riffles. YOY *Labeobarbus* species were found in both runs and pool microhabitats including the lake shore points. They were absent in the deep pools but usually found along the vegetated shore and sheltered areas. Similarly, they are absent in fast running water or riffles with a velocity > 0.5m/s. In general, though the sampling is not yet completed, preliminary results show that habitat preference of YOY *Labeobarbus* species is strongly associated with depth and velocity of water.

Key words: microhabitat, *Labeobarbus*, electro-fishing, Gumara River,

References

Anteneh W., Getahun A. and Dejen E. (2013). Spawning migrations of Lake Tana Labeobarbus spp. (Teleostei: Cyprinidae) in the Ribb River, Ethiopia. *African Journal of Aquatic Science* 38(2):1– 8.

Nagelkerke, L. A. J. and Sibbing, F. A. (2000). The large barbs (Barbus spp., Cyprinidae, Teleostei) of Lake Tana (Ethiopia), with a description of a new species, Barbus osseeinsis. Netherlands Journal of Zoology 50, 179–214.

Shkil, F.N., Dzerzhinskii, K.F., Belay Abdissa, Borisov, V.B., Wondie Zelalem, Kapitanova, D.V, Mesfin Tsegaw and Smirnov, S.V. (2017). Notes on the breeding of large lake Tana barbs (Labeobarbus spp.) in nature and laboratory. *Ethiop. J. Biol. Sci*. 16(Suppl.): 149–170.