Groundwater in Ethiopia
Occurrence, drought proofing and technology options

Over the last two decades, groundwater development has become a new ‘phenomenon’ in developing nations. There is a rapid evolution of paradigms from scientific mapping of hydrogeology of an area for specific development projects to value chaining existing hydrogeological knowledge to help policy and decision-making knowledge to help policy and decision-making knowledge and devise appropriate technology for managed groundwater development, and to devise appropriate climate change adaptation strategies. The second paradigm shift around groundwater resources is the fact that groundwater has now become a strategic resource for economic growth, poverty reduction, environmental sustainability, and for climate change adaptation by rural livelihoods.

The three maps provided here attempt to value chain the existing hydrogeological knowledge of Ethiopia and help decision making processes. The first map shows the depth to water table in different sectors of Ethiopia, the nature of the aquifers and the possibility of using groundwater for irrigation at different scales. Depth to water table is an important indicator of groundwater usability by rural livelihoods. Extensive shallow and very shallow volcanic aquifers and loose sediments cover the vast plains of Gambela lowlands, the lake Tana area, the Shilile plain, the several vast areas in the rift valley, and grabens filled with alluvial sediments at the foothills of the rift bounding escarpments. Though the storage is as high as in the proceeding cases, shallow to very shallow aquifers made up of weathering products of metamorphic rocks are known to exist in western and southern Ethiopia. Yield of the metamorphic rocks depends on the degree of weathering. In areas marked by LSI in the first map large-scale groundwater irrigation is the very while in SSI marked areas small-scale irrigation is feasible. The very shallow to very shallow aquifers, the alluvial aquifers elsewhere in Ethiopian highlands and the regolith mantles of western Ethiopia provide a good opportunity for household water supply for domestic water use and small-scale irrigation.

Annual groundwater recharge from five of twelve drainage basins stands at 18 billion meter cubes and the total annual recharge rate can be double of this and stands at 36 billion meter cube per years. The vulnerability of aquifers to change largely depend on aquifer storage. Estimates of groundwater storage in Shilile and Alwero sandstones and associated sediments in Gambela alone show a value of 400 billion meter cube of storage.

Groundwater resources as climate change adaptation tools and as leverages of rural poverty reduction depends on the capacity of the groundwater aquifers to buffer the external climate changes (e.g., seasonality, increase or decrease in rainfall intensity, drought and flooding etc.) and local forcings (water abstraction rates). While total groundwater storage and total annual groundwater recharge are indicators of the potential of groundwater, two hydrologic properties are the determinants of the capacity of aquifers to buffer climate change: aquifer storage and recharge mechanism.

Loose sediments have the highest storage capacities while fractured volcanic rocks, fissured and karstified sedimentary rocks, indurated sedimentary rocks and basement rocks have lower storage properties in that order. Figure 2 shows potential groundwater availability and vulnerabilities during drought. The loose sedimentary aquifers of the rift valley and rift bounding grabens, the shallow volcanic aquifers surrounding lake Tana and the Alwero sandstone and associated sediments in Gambela show the lowest vulnerability to drought. The most vulnerable aquifers to climate change are the basement aquifers covering northern Ethiopia, Borena, and the Western Lowlands. Because of thicker regoliths the basalt aquifers of western Ethiopia are placed as the least vulnerable compared to basement aquifers in northern and southern Ethiopia to short-term climate variations and rainfall variability.

Recharge mechanism refers to the way rainfall water gets to the aquifers. Principally five different ways can be recognized for Ethiopia. Volcanic basement aquifers of western Ethiopia and Central Eastern highlands which are overlain by thick and well-developed soils and regolith gets there recharge directly from rainfall via diffused sources once the soil zones exceed their moisture holding capacity. However vast volcanic highlands and areas covered by basement rocks with thin regoliths develop aquifers of Ethiopia gets their recharge from fast and selective recharge from only heavy rainfalls (light rainfalls evaporate back to the atmosphere in these regions) and discharge takes place mostly to springs and streams. Aquifers in the rift valley and rift bounding grabens, in grabens as well as hill of the rift bounding faults get a significant portion of their recharge from lateral groundwater inflows from the mountains. In the Gambela lowlands and several other small places not indicated in the map aquifers get their recharge from flood water when the flood stage is higher. In this case the flood waters originate from the very basin where recharge is taking place. In arid marginal lowlands of Ethiopia recharge to groundwater comes from local wadi floods and groundwater storage is also in the wadi beds. In Ethiopia total wadi bed length exceeds 30000 km and water storage in wadi beds can potentially reach 3 billion meter cube. Volcanic and sediment aquifers of the vast Afar plain get their recharge mostly from flood waters originating from the highlands in the west and east and from Awash River in the center of the rift. The recharge mechanism map of Ethiopia has several implication in climate change adaptation. In future drought events characterized by short duration intensive rainfalls for example recharge is expected to increase in Afar, the area which gets its recharge from floodwaters originating from the highlands. Recharge would decrease in areas that get their recharge from diffuse sources. As the extensive areas in the marginal lowlands of Ethiopia get their recharge from wadi bed floods and storage in wadi bed floods, the most appropriate technology for development of groundwater appears to be subsurface dams and sand dams. In areas characterized by low flow groundwater, in future drought events characterized by short duration intensive rainfalls for example recharge is expected to increase in Afar, the area which gets its recharge from floodwaters originating from the highlands. Recharge would decrease in areas that get their recharge from diffuse sources. As the extensive areas in the marginal lowlands of Ethiopia get their recharge from wadi bed floods and storage in wadi bed floods, the most appropriate technology for development of groundwater appears to be subsurface dams and sand dams. In areas characterized by low flow groundwater, in future drought events characterized by short duration intensive rainfalls for example recharge is expected to increase in Afar, the area which gets its recharge from floodwaters originating from the highlands. Recharge would decrease in areas that get their recharge from diffuse sources. As the extensive areas in the marginal lowlands of Ethiopia get their recharge from wadi bed floods and storage in wadi bed floods, the most appropriate technology for development of groundwater appears to be subsurface dams and sand dams. In areas characterized by low flow groundwater, in future drought events characterized by short duration intensive rainfalls for example recharge is expected to increase in Afar, the area which gets its recharge from floodwaters originating from the highlands. Recharge would decrease in areas that get their recharge from diffuse sources. As the extensive areas in the marginal lowlands of Ethiopia get their recharge from wadi bed floods and storage in wadi bed floods, the most appropriate technology for development of groundwater appears to be subsurface dams and sand dams. In areas characterized by low flow groundwater. In future drought events characterized by short duration intensive rainfalls for example recharge is expected to increase in Afar, the area which gets its recharge from floodwaters originating from the highlands. Recharge would decrease in areas that get their recharge from diffuse sources. As the extensive areas in the marginal lowlands of Ethiopia get their recharge from wadi bed floods and storage in wadi bed floods, the most appropriate technology for development of groundwater appears to be subsurface dams and sand dams. In areas characterized by low flow groundwater.

Recharge Mechanism Map of Ethiopian Aquifers

Vulnerability of Aquifers to Changes in Recharge

Groundwater Occurrence in Ethiopia

Groundwater Use Options
LSI — Large scale irrigation
SSI — Small scale irrigation
Groundwater occurrence
FSI+ — secondary priority
SED — primary priority

Seifu Kebede (Addis Ababa University Department of Earth Sciences, PO Box 1176), 2010