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REVIEW ON THE ROLE OF FOREST IN RECHARGING GROUND WATER IN ETHIOPIA.

[1] **Saudi Bahmud,** [2] **Abdulkadir Mohammed**,
[1]Environmental science & Management (MSc, [2]Biodiversity conservation and Management (Msc),
[1] **Department of Forestry,**
[2] Eco tourism and Biodiversity conservation
[1] **Mattu University, Bedele, Ethiopia**

Abstract: Forests play a key role in replenishing groundwater through various processes including capture, infiltration, and storage. The purpose of this literature review is to analyze existing research on this topic and gain insights into the mechanisms and impacts of forests on groundwater recharge in Ethiopia. Forests have a dense canopy that absorbs precipitation, reducing the amount of precipitation that reaches the ground directly. This collection process extends the time the water is in contact with vegetation, allowing for evaporation and transpiration. Research studies confirm the relationship between forest cover and groundwater recharge rates and highlight the importance of forest protection and reforestation programs to ensure water security in Ethiopia. To ensure sustainable groundwater recharge in Ethiopia, forest conservation efforts and reforestation programs should be a priority.

Keywords: ***Forest, Ground Water, recharge, reforestation***

1. INTRODUCTION

In Africa, approximately 340 million people no longer have access to sufficient and hygienic water sources, such as groundwater (World Water Assessment Program, 2009). Ethiopia is the water tower of Africa with 12 river basins with an annual discharge volume of 122 billion m3 of water and an estimated volume of 2.6 to 6.5 billion m3 of groundwater potential (Varady et al. 2023). Groundwater is fresh water that flows in aquifers below the water table, is less susceptible to pollution than surface water, and is often used for public water supplies (Suciu et al. 2020; Tamiru and Wagari 2022; W.Zhu et al. 2022).In Ethiopia, forests play a key role in ensuring food security and sustainable livelihoods for millions of families. Forest biodiversity provides ecosystem services and contributes an estimated 4% to GDP through the production of honey, forest coffee, natural rubber, and timber (Desalegn and Tadesse 2004).

Forests have often been described as “sponges” that store rainwater and release it slowly to maintain aquifers and streams during periods of drought (Hamilton and King, 1983, Sandström, 1998, Calder,2004). Historically, sponge theory and related ideas have motivated policy actions to protect and restore forests. Kaimowitz, D., 2004; Jackson, R., 2005; Calder, me.2007) According to FAOSAT, Ethiopia's forest cover will be nearly 16.7 million hectares of land in 2020, accounting for 15.11% of the country's total area. Deforestation and forest degradation are among the country's greatest environmental challenges.

Groundwater is a vital natural resource that supports ecosystems and provides much of the world's drinking water. Forests play a key role in replenishing groundwater through various processes including capture, infiltration, and storage. In the context of water resources management, considerable attention has been paid to the relationship between forests and aquifer recharge. In Ethiopia, where forests cover much of the country, understanding the role of forests in groundwater recharge is critical to sustainable water supplies. The purpose of this literature review is to analyze existing research on this topic and gain insights into the mechanisms and impacts of forests on groundwater recharge in Ethiopia.

2. Forestry and the water cycle

2.1. The influence of forests on the amount of water:

The water cycle is a dynamic system that involves the movement of water through various phases such as evaporation, condensation, precipitation, and runoff. Forests play a key role in regulating the water cycle by influencing the availability, distribution, and quality of water (Pagano and Sorooshian., 2002).

Many studies have examined the role of forests in water conservation. Forests act as natural sponges, absorbing rainfall and promoting infiltration, which helps replenish groundwater resources (Meynell and Soulsby, 2008). A study by Bruijnzeel (2004) showed that forests can significantly increase river flow during periods of heavy rainfall, thereby mitigating flooding in downstream areas.Forests also control water runoff, preventing excessive surface runoff and erosion. Their forest cover intercepts precipitation, limits the amount of precipitation reaching the forest floor, and allows water to slowly penetrate the soil (Bosch and Hewlett, 1982). This gradual release of water helps regulate river flow, maintain base flows during periods of drought, and maintain water availability for ecosystems and human needs (Brown et al., 2005).

2.2. Impact of forests on water quality:

Forests play a key role in maintaining water quality by acting as natural filters. Forest vegetation, soil, and leaf litter trap sediments, nutrients, and pollutants, preventing them from entering waterways (Tallis et al., 2010). This filtering effect helps improve the quality of surface and groundwater resources.

Research has shown that forests can reduce the amount of nutrients such as nitrogen and phosphorus entering water bodies, thereby minimizing the risk of eutrophication (Cirmo and McDonnell, 1997). Forests also play a key role in cleaning up pollution and improving water clarity, which benefits aquatic ecosystems and water resources for humans (Vidon et al., 2010).

3. Forest Cover and Water Availability in Ethiopia:

3.1. Watershed ecosystem services and forest cover changes in Ethiopia

Forests play a key role in conserving water resources by regulating water flow, improving water quality, and reducing the risk of water scarcity (Neary, D. et al., 2009).

Tadesse et al.(2018) examined the impacts of changing forest cover on ecosystem services in watersheds of the Tana Lake basin in Ethiopia. The study highlights the important role of forests in regulating river flow, reducing soil erosion, and improving water quality. The results highlight the importance of protecting and restoring forest ecosystems to ensure sustainable water resources.

3.2. Forest protection and water cycles in Ethiopia

Bekele et al.(2017) investigated the interactions between forest conservation and water cycles in the Bale Mountains, Ethiopia. The study found that intact forests contribute significantly to groundwater recharge and river flow, thereby increasing the availability of water for human and ecological needs. The need for effective forest management practices to conserve water resources in the region was highlighted.

3.3. Forest cover as a resilience strategy to water scarcity in Ethiopia

Lemme et al.(2019) examined the role of forest cover as a resilience strategy to water scarcity in Jeldu district, Ethiopia. The study found that the presence of forests in the river basin increases the recharge of aquifers and ensures constant water availability during drought periods. The potential of forest restoration initiatives to secure water resources for local communities was highlighted.

3.4. Dynamics of forest cover and water resources of the Ethiopian plateau

Tesfaye et al.(2016) studied the effects of forest cover dynamics on water resources in the Gilgel Abay watershed on the Ethiopian Plateau. The study showed how deforestation and forest degradation have disrupted the balance of water resources, leading to increased flood risk and reduced water flows. The need to adopt sustainable land management practices to protect water resources was highlighted.

3.5. Forest restoration and water exploitation in Ethiopia

Guzman et al.(2020) examined the impacts of forest restoration on water productivity in the Upper Blue Nile Basin in Ethiopia. The study found that reforestation had a positive impact on water productivity, especially during the dry season. The results support the implementation of large-scale forest restoration initiatives to improve water availability in the region.

4. Mechanisms of Ground Water recharge in Forests

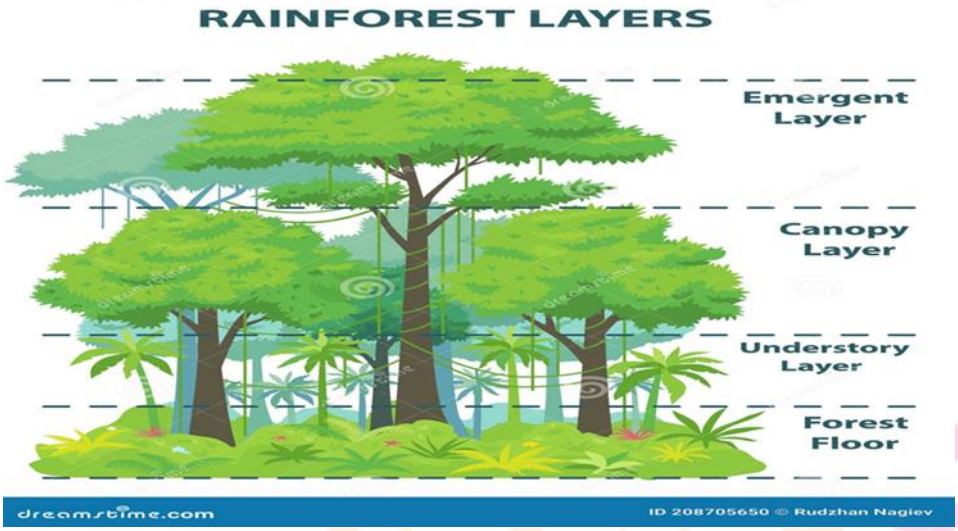
4.1. Interactions between vegetation and soil:

Forests contribute to groundwater recharge through complex interactions between vegetation and soil. Trees collect water from underground sources through their roots, which are then released into the atmosphere through their leaves. This process, known as evapotranspiration, increases soil moisture, improving

groundwater infiltration and recharge. Consequently, forests act as important regulators of hydrological processes and facilitate the replenishment of water resources (Bekele et al., 2014).

Forests have a dense canopy that absorbs precipitation, reducing the amount of precipitation that reaches the ground directly. This collection process extends the time the water is in contact with vegetation, allowing for evaporation and transpiration. Through evapotranspiration, forests contribute to humidity and the overall water cycle, minimizing land runoff (image 1)

Image1: an image illustrating forest canopy

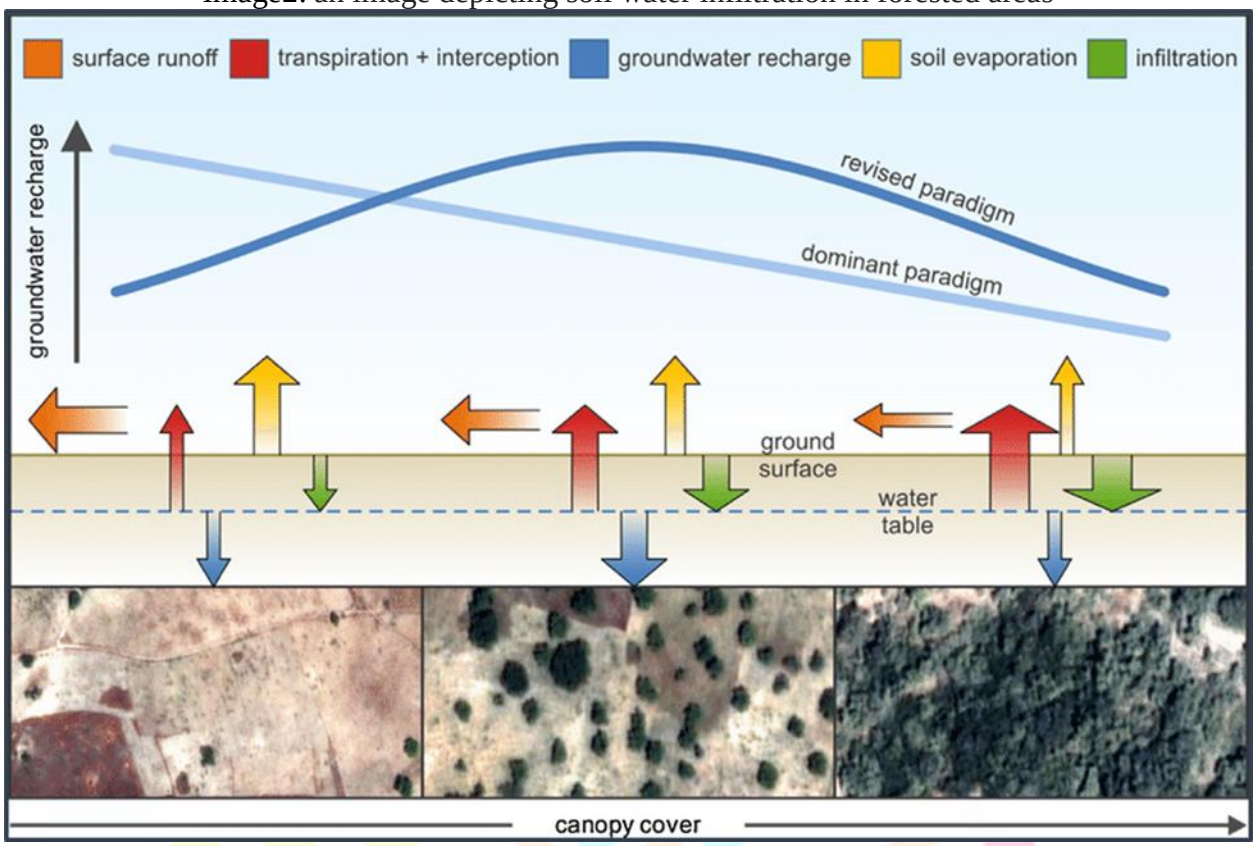


Source: Adapted from https://www.dreamstime.com

4.2. Water infiltration and storage rate:

Numerous studies have highlighted the influence of forests on seepage rates and water storage capacity. The forest cover absorbs precipitation and thus limits its direct influence on the ground surface. The research by Moges et al. (2011) found that forested areas in Ethiopia have higher infiltration rates than non-forested areas due to lower surface runoff.Tree cover and forest litter also play a key role in preventing soil compaction and promoting water infiltration through hydraulic conductivity, thereby contributing to the recharge of aquifers(Image2).

Image2: an image depicting soil water infiltration in forested areas



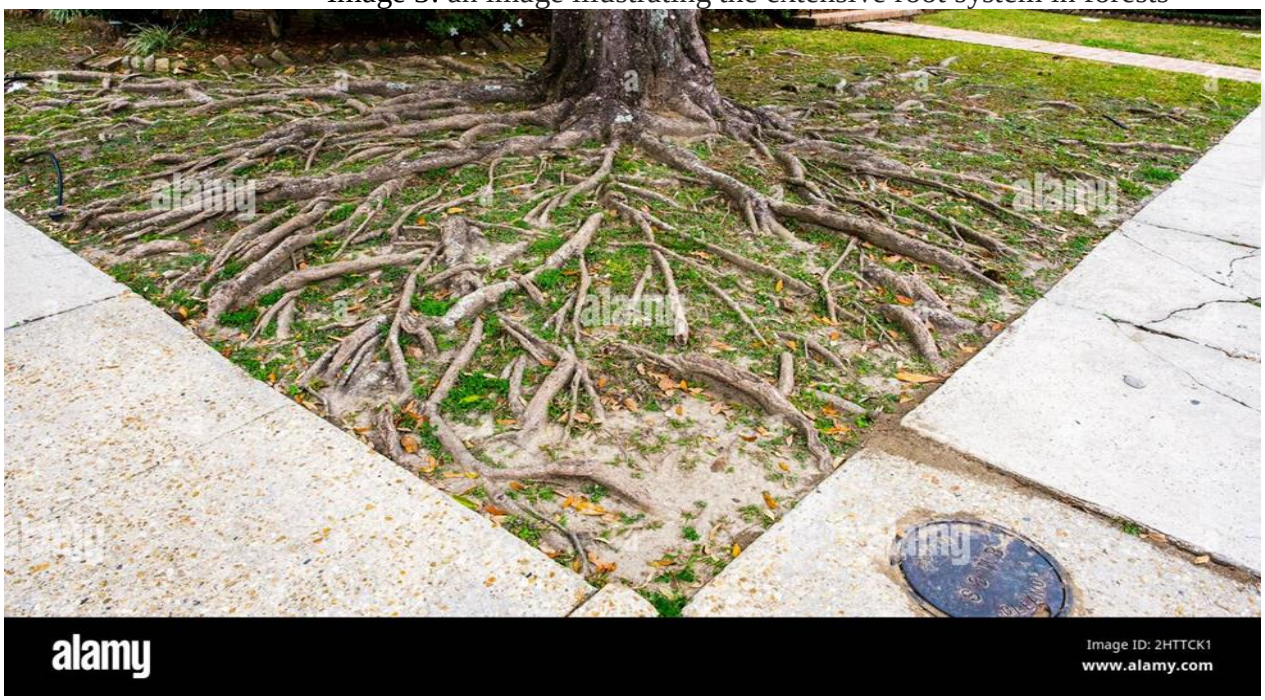
Source: adapted from (Ilstedt et al., 2016).

Forest soils enriched with decomposed waste and organic matter have a higher infiltration rate than bare soils. Forest cover and forest litter layers promote water infiltration, thereby reducing soil erosion and increasing water storage capacity. This process increases the quantity and quality of water entering underground aquifers, helping to replenish them.

4.3. Prevention of Soil Erosion:

Forests act as a natural shield against soil erosion, preserving the integrity of infiltration routes and soil structure. Trees' extensive root systems help hold soil particles together, reducing the risk of erosion from surface runoff. A study by Yitaferu et al. (2009) in the Didessa River basin in Ethiopia showed that forests have a positive effect on preventing soil erosion and thus ensuring groundwater recharge(image3)

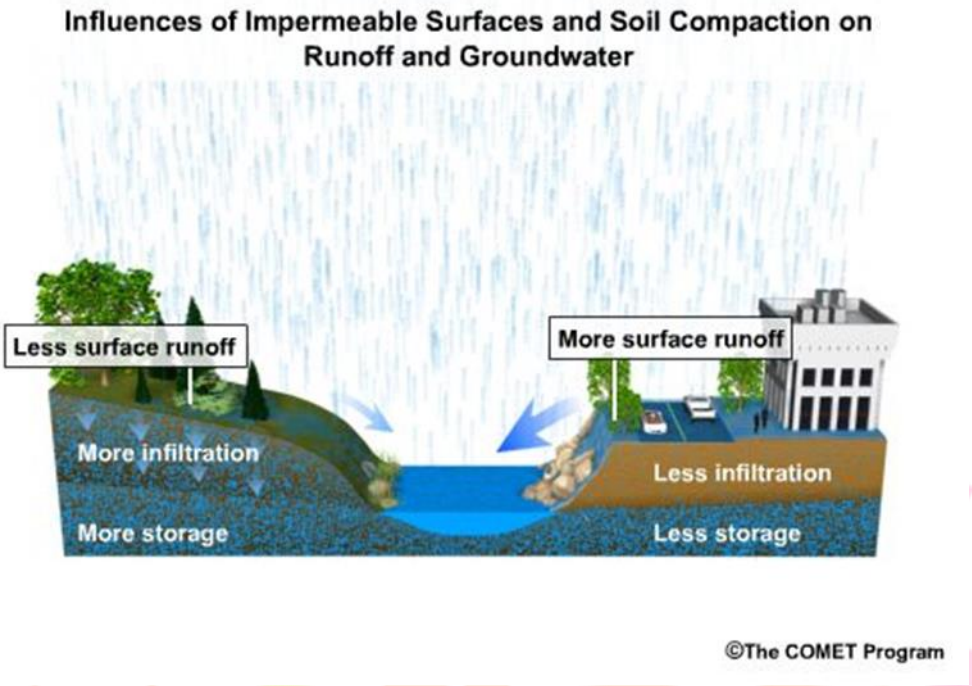
Image 3: an image illustrating the extensive root system in forests



Source: Adapted from https://www.alamy.com

Forests act as natural barriers, preventing excessive surface runoff by absorbing rainfall and reducing soil erosion. Deforestation disrupts this protective function, resulting in reduced groundwater recharge due to increased surface flow and lower infiltration rates. The protection of forests is essential for maintaining their hydrological functions and for conserving groundwater resources (image 4).

Image 4: an image contrasting water runoff in deforested and forested landscapes



Source :Adapted from https://download.comet.ucar.edu

5. Forest conservation and Ground Water recharge

5.1. Forest protection and reforestation programs:

The importance of forest protection and reforestation programs for maintaining groundwater recharge should not be underestimated. The research by Gebrehiwot et al. (2017) highlighted the positive relationship between forest cover and groundwater recharge in the upper Blue Nile basin in Ethiopia. The study highlights the importance of sustainable forest management practices and reforestation initiatives to improve groundwater recharge.

5.2. Wooded riparian areas that enable groundwater recharge:

Dahm et al. (2015) focused on the role of forested riparian areas in groundwater recharge. The study showed how riparian forests act as filters, removing sediment and pollutants and allowing water to seep beneath the surface and recharge aquifers. The importance of protecting and restoring riparian forests to ensure sustainable groundwater resources was highlighted.

5.3. Modeling forest hydrology and groundwater recharge:

Kumar et al. (2020) examined various forest hydrological models that are used to understand and simulate groundwater recharge processes. The study discusses the integration of meteorological, hydrological, and soil data to quantify the renewal potential of forest areas. The importance of accurate modeling to assess the impact of forest cover on groundwater resources was highlighted.

6. Research and Evidence:

Several studies have been conducted across Ethiopia to analyze the impact of forests on groundwater recharge. A study by Yitaferu et al. (2009) in the Didessa River basin showed that in forested areas the rate of groundwater recharge is much higher than in non-forested areas. The study found a positive relationship between forest cover and groundwater recharge and highlights the need for forest protection and reforestation programs.

Similarly, the study by Kebede (2014) conducted in the Rift Valley region of Ethiopia highlighted the essential role of forests in groundwater recharge. The study found that forests help maintain soil moisture levels, leading to higher groundwater recharge in forested areas compared to open landscapes.

7. Policy implications and Recommendation

7.1. Policy implications

Water policy must take into account the direct connection between forests and groundwater resources. Forests play an important role in regulating the water cycle, contributing to the recharge of aquifers, and mitigating climate change. Therefore, measures to combat climate change should focus on preserving and increasing forest area. Local communities play an important role in protecting forests. Policies that support community engagement and benefit-sharing mechanisms can make a significant contribution to protecting forests and therefore groundwater resources. Policies that promote cooperation between sectors (forestry, water, agriculture and urban development) can lead to more sustainable management of forest and water resources and ensure their use for future generations. Greater importance should be given to research and development to increase our knowledge of the interactions between forests and groundwater recharge.

7.2. Policy recommendations:

Develop and implement integrated water management plans that take forest protection into account.

Facilitate intersectoral collaboration to create a unified strategy for the sustainable management of forest and water resources.

Invest in research and development to collect more data on the key relationships between forests and groundwater to inform the future development of resource management policies and strategies.

8. CONCLUSION

From the literature reviewed, it can be concluded that forests play an important role in groundwater recharge in Ethiopia. Through their influence on soil moisture content, infiltration rates, and erosion control, forests contribute significantly to the replenishment of water resources. To ensure sustainable groundwater recharge in Ethiopia, forest conservation efforts and reforestation programs should be a priority. Groundwater is an essential natural resource that supports ecosystems and provides much of the world's drinking water. Forests play a key role in replenishing groundwater through various processes including capture, infiltration, and storage. Research studies confirm the relationship between forest cover and groundwater recharge rates and highlight the importance of forest protection and reforestation programs to ensure water security in Ethiopia.

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