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Institutional and Policy Barriers to the Adoption of Urine Recycling as a Sustainable Solution for Nutrient Management and Agricultural Productivity in Ethiopia

Chikeluba Arthur Umeh
Global Development Studies

Declaration

I, Chikeluba Arthur Umeh, declare that this thesis results from my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for the award of any type of academic degree.

Signature……

Date……

Abstract

This study explores the potential of urine recycling as a sustainable solution for addressing sanitation challenges, nutrient management, and enhancing agricultural productivity in Ethiopia. Through a document analysis, it examines the existing policy landscape and institutional frameworks influencing the development, promotion, and adoption of urine recycling technologies and practices. The findings reveal that Ethiopia's current policies do not explicitly address urine recycling or the use of urine-based fertilizers (UBFs), although certain environmental and agricultural policies provide a foundation for promoting sustainable practices and resource recovery. The development, promotion, and adoption of urine recycling would require a multi-pronged approach involving regulatory reforms, institutional capacity building, public-private partnerships, community engagement, and awareness campaigns. The study recommends key measures such as developing specific regulations and guidelines for UBF production, labeling, and use covering quality standards, safety protocols, and environmental concerns; strengthening relevant institutions' capacities; fostering inter-institutional collaboration; investing in research; and conducting educational and awareness programs. Facilitating public-private partnerships through incentives for sanitation-related businesses, encouraging collaboration between private enterprises and municipalities, and engaging the private sector in developing sanitation equipment could enhance accessibility and scalability. Involving local communities from the outset, conducting awareness campaigns highlighting the benefits of urine recycling and UBFs, and leveraging agricultural extension services would ensure cultural acceptance and facilitate knowledge transfer.

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Abbreviations

AISE - Agricultural Input Supply Enterprise

AISCO - Agricultural Input Supply Corporation

ATA - Agricultural Transformation Agency

ATVET - Agricultural Technical and Vocational Education Training

BoARD - Bureau of Agriculture and Rural Development

ECOSAN - Ecological Sanitation

EIA – Environmental Impact Assessment

EDHS - Ethiopian Demographic and Health Survey

EU - European Union

FTC - Farmers Training Colleges

GDP - Gross Domestic Product

GoE - Government of Ethiopia

IFPRI - International Food Policy Research Institute

JMP - Joint Monitoring Programme

MoA - Ministry of Agriculture

MoARD - Ministry of Agriculture and Rural Development

MoEFCC - Ministry of Environment, Forest, and Climate Change

MoH - Ministry of Health

MoWIE - Ministry of Water, Irrigation, and Energy

MUDH - Ministry of Urban Development and Housing

NFIA - National Fertilizer Industry Agency

NGO - Non-Governmental Organization

SDGs - Sustainable Development Goals

SNNPR - Southern Nations, Nationalities, and Peoples' Region

UDT - Urine Diversion Toilet

UDDT - Urine Diversion Dry Toilet

UBFs – Urine-Based Fertilizers

UN - United Nations

UNICEF - United Nations Children's Fund

UR – Urine Recycling

WSSU - Water Supply and Sewerage Utilities

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1. Introduction

Ethiopia is confronted with significant challenges in sanitation and hygiene, with communicable diseases, stemming from unsafe water supply and unsanitary waste disposal, accounting for 60% to 80% of health issues (UNICEF, 2023). Nutrient recycling, such as using human urine as fertilizer, presents an opportunity to address sanitation and hygiene challenges while offering solutions to food insecurity (Häfner et al., 2023).

In the face of global challenges such as population growth, rising commodity prices, and the widespread impacts of climate change, ensuring food security has become a top concern for policymakers in developing countries (IFPRI, 2012). Central to this concern is the need to increase agricultural productivity to meet the growing global demand for food, feed, and fiber. However, a slowdown in agricultural productivity growth has been observed in many developing nations in recent decades (IFPRI, 2012).

Human urine, an ancient yet valuable source of nutrients, has historically been utilized to bolster plant growth, particularly of leafy vegetables. Its nutrient-rich composition, containing essential elements like nitrogen and phosphorus crucial for plant development (Simha et al., 2018), underscores its potential as a locally available and cost-effective nutrient source. Urine recycling, the process of collecting and treating urine to extract its nutrients for reuse as fertilizer in agriculture, represents a sustainable solution (Simha et al., 2020).

The origins of urine recycling trace back to the early 1990s, with simultaneous initiatives in Sweden and Switzerland emerging in response to mounting concerns over environmental sustainability (Jönsson et al., 1997; Larsen & Gujer, 1996; Simha, 2021). These efforts championed the concept of source separation of wastewater, advocating for the separate collection of various wastewater fractions at the source, including urine, feces, bath water, and grey water, which are already mixed before treatment (Friedler et al., 2013; Vinnerås et al., 2006; Simha, 2021). This approach, rooted in the principle of tailored treatment methods for different fractions, laid the groundwork for resource recovery and recycling, with human urine garnering particular attention due to its high concentrations of nitrogen and phosphorus (accounting for 80% of nitrogen and 50% of phosphorus in domestic wastewater) relative to its volume (merely 1% of domestic wastewater) (Vinnerås et al., 2006).

Over the past three decades (1990-2020), significant progress has been made in urine recycling research, driven by collaborative efforts such as EcoSanRes (Esrey et al., 1998) and Novaquatis (Larsen & Lienert, 2007). These initiatives spurred the development of innovative technologies like urine-diverting toilets and established protocols for urine collection, storage, and purification. As a result, urine recycling has been implemented in various settings including eco-villages, summerhouses, and municipalities such as Tanum in Sweden and Durban in South Africa (Jönsson et al., 2004; Kvarnström et al., 2006; McConville et al., 2017; Mkhize et al., 2017). Advancements in on-site urine treatment technologies have further enhanced the viability of urine recycling. Methods such as urine-diverting toilets allow for separate urine collection and subsequent treatment to eliminate odors and concentrate nutrients into a dry powder fertilizer suitable for agricultural purposes (Simha, 2021; Simha et al., 2020).

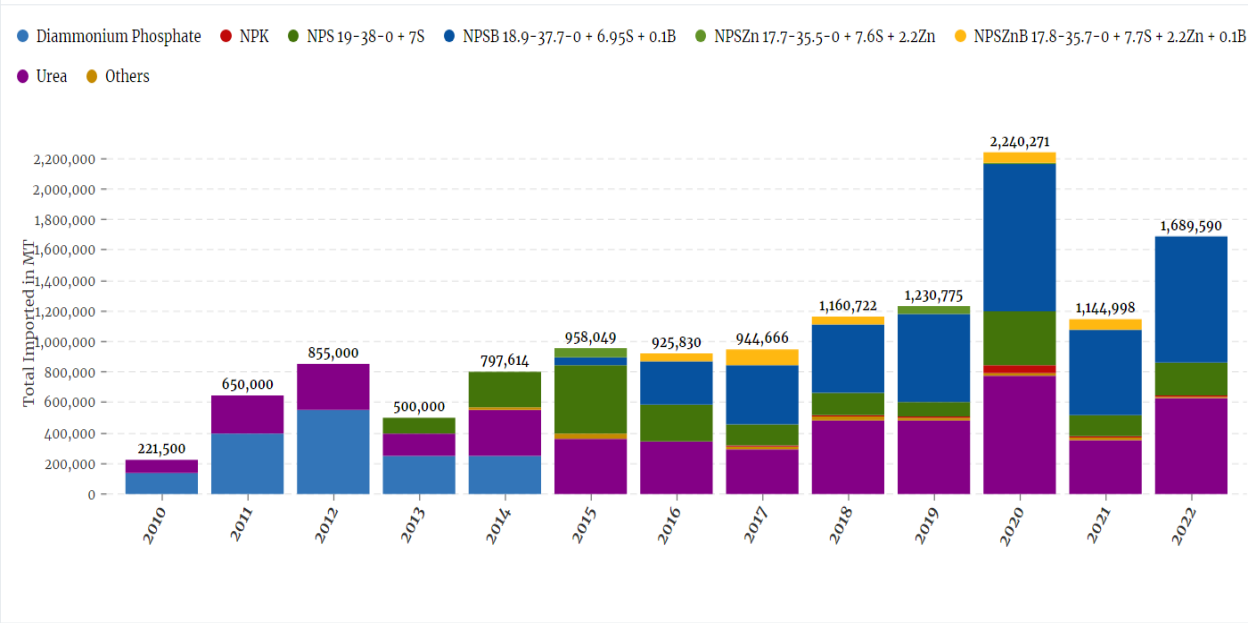
In Eastern and Southern Africa, where the economy is heavily dependent on agriculture, more than 70% of the population is engaged in the sector, predominantly smallholders cultivating less than two hectares (Simtowe, 2015). Despite contributing about 35% to GDP and employing 65% of the population, the contribution of the agricultural sector to overall economic growth has been relatively subdued compared to other sectors. This highlights the critical need to enhance agricultural productivity for the future economic development of the region (Simtowe, 2015).

Ethiopia, which exemplifies this context, has placed agricultural productivity growth at the center of its developmental strategies since the launch of the Agricultural Development Led Industrialization program in the early 1990s (Dorosh & Rashid, 2013). With sustained commitment, the country has consistently allocated more than 10% of public expenditure to agriculture over the past two decades, invested significantly in rural infrastructure, and intensified agricultural development efforts, with a particular focus on promoting extension services and fertilizer use (Dorosh & Rashid, 2013).

The effectiveness of Ethiopia's agricultural policies is evident in the remarkable growth of fertilizer use, which jumped from 3,500 tons in the early 1970s to about 34,000 tons in 1985 and reaching approximately 650,000 tons and 1,689,000 tons in 2012 and 2022 (see figure 1) respectively (AfricaFertilizer, 2024; Rashid et al., 2013). This growth was catalyzed by the market liberalization programs in the 1990s. Since that time, the promotion of fertilizers has undergone various policy shifts, spanning from liberalization, which involved participation from both the public and private

sectors to government monopolization of imports and exclusive marketing through farmers' cooperatives in 2008. (Rashid et al., 2013).

Figure 1: Fertilizer imports by product (2010-2022)



Source: Ethiopian Agricultural Business Corporation (EABC) analyzed by AfricaFertilizer.org

This was followed by the implementation of ambitious policies aimed at increasing agricultural productivity, such as the Agricultural Growth Program, Growth and Transformation Program, and the Agricultural Transformation Agency. Notably, the Growth and Transformation Program played a key role in boosting fertilizer distribution and improving seed availability. Despite a surge in fertilizer imports, the country faced a problem of excessive fertilizer availability, resulting in substantial carry-over stocks of nearly half a million tons in 2012, valued at approximately US$350 million, lying dormant in cooperative warehouses nationwide (Rashid et al., 2013).

However, the situation arises from the low use of fertilizers in the country. Only 30–40% of Ethiopian smallholder farmers use fertilizers, applying on average only 37–40 kilograms per hectare, significantly below recommended rates (Spielman et al., 2013). This low adoption rate is due to various constraints, including a sparse network of agro-dealers, inadequate technical knowledge on appropriate fertilizers, limited access to finance along the value chain that discourages bulk purchases, and exorbitant transport costs due to inadequate port, rail, and road

networks (Simtowe, 2015). The prevailing scenario of excess carry-over stocks and underutilization of fertilizers highlights a glaring incongruity between government's targets and effective demand for fertilizers. This mismatch is exacerbated by existing policies, infrastructure constraints, and institutional limitations (Rashid et al., 2013), which make fertilizers financially inaccessible to most farmers.

The low adoption rate raises a critical question: why is fertilizer usage by smallholder farmers in Ethiopia (about 37-40kg/ha) still significantly low (Spielman et al., 2013) compared to their Asian counterparts who consume an average of 209kg/ha (Simtowe, 2015), about five times what Ethiopian smallholders consume? Consequently, this low adoption results in severe soil nutrient depletion exceeding 60kg/ha (Simtowe, 2015). Reasons for this low adoption include the high cost of fertilizer triggered by multiple factors in the fertilizer value chain, as noted by Simtowe (2015), government policies, infrastructure constraints, and institutional limitations, as highlighted by Rashid et al. (2013).

Addressing these challenges requires exploring alternative options for making fertilizers available to smallholders at lower costs and in a more sustainable way. One such option under consideration is the use of urine-based fertilizers (UBFs) within the framework of resource-oriented sanitation or sustainable sanitation (Simha et al., 2017). To align with sustainable development goals (SDGs) and ensure food and fertilizer security, a shift towards circularity, resource recovery, and socioeconomic benefits in sanitation systems is imperative (Guest et al., 2009; McConville et al., 2017; Oberg et al., 2020). Source separation and urine diversion offer a viable solution, promoting nutrient recovery, mitigating emissions, reducing energy and financial costs, and potentially diminishing reliance on synthetic fertilizers (Igos et al., 2017; Brinkerhoff, 2023). Furthermore, urine recycling can address social inequities in sanitation access, particularly in underserved regions, contributing to the broader goal of universal sanitation access (Larsen et al., 2021; Aliahmad et al., 2023).

In Ethiopia, where a considerable portion of the population lacks access to basic sanitation services (JMP, 2015; UNICEF, 2023), the adoption of urine recycling presents a potential solution to the sanitation challenge. This approach can offer improved, safely managed sanitation systems, enhance agricultural productivity, and contribute to creating a safe and sustainable living environment. According to the United Nations, access to safe water, sanitation, and hygiene is

essential for human health and well-being (United Nations, 2010), and efforts to enhance accessibility to these necessities align with and support the attainment of the United Nations' Sustainable Development Goals, particularly SDG 6 (United Nations, 2015).

Despite the promising potential, widespread adoption of urine recycling technologies remains limited, primarily due to institutional barriers and the need for comprehensive regulatory frameworks (Aliahmad et al., 2022). Achieving large-scale implementation necessitates considerations beyond technical aspects, encompassing user practices, industrial networks, regulatory environments, and cultural norms (Andersson et al., 2016; Larsen et al., 2009; Zhuang et al., 2021). For instance, clarity in regulatory guidelines is crucial to fostering farmer acceptance of urine-based fertilizers in Switzerland and Germany (Aliahmad et al., 2023).

While recent research has predominantly focused on technical and environmental facets of urine recycling (Aliahmad et al., 2023), cultural barriers to the use of UDTs ((Khalid, 2018; Mugivhisa & Olowoyo, 2015), users' attitudes and perceptions of urine as fertilizers (Simha et al., 2017), and factors influencing the adoption of UDTs (M. Andersson & Minoia, 2017; Banamwana et al., 2022; Lamichhane & Babcock, 2013; Uddin et al., 2014), addressing institutional barriers is equally critical. Understanding and navigating these complexities is essential for realizing the full potential of urine recycling in advancing sustainable sanitation systems. This study investigates regulatory loopholes and institutional barriers regarding urine recycling technology adoption. Institutions in this context are various stakeholders in the sanitation and fertilizer sectors encompassing both public and private entities, including government agencies, businesses, non-profit organizations, households, educational establishments, and research bodies. By identifying areas requiring corrective adjustments, it aims to increase adoption rates of urine recycling technologies and pinpoint effective incentives and policies to encourage the utilization and management of urine-diverting toilets (UDTs) for urine collection. The findings will offer insights into regulatory frameworks and institutional mechanisms, contributing to the existing literature on urine recycling and informing policymakers, stakeholders, and researchers.

This study is relevant for addressing challenges surrounding sanitation practices and policies in Ethiopia, particularly regarding urine recycling for sustainable nutrient management and agricultural productivity. It assesses the feasibility of urine recycling as a solution and examines the influence of institutional frameworks and policy environments on its development and

adoption. Additionally, it identifies policies and practices to enhance the scalability and sustainability of urine recycling for agricultural use, considering socio-economic and environmental factors. Through structured policy interventions, the research supports the integration of urine recycling into Ethiopia's agricultural practices and sanitation systems, contributing to sustainable development and improved agricultural productivity.

1.2 Research Questions

i) How do current sanitation practices and policies in Ethiopia influence the potential for urine recycling as a sustainable solution for nutrient management and agricultural productivity?

ii) How do institutional frameworks in Ethiopia affect the development, promotion, and adoption of urine recycling technologies and practices?

iii) What business strategies can be developed to enhance the scalability and sustainability of urine recycling for agricultural use in Ethiopia?

iv) How can policy interventions be structured to support the integration of urine recycling and UBFs into Ethiopia’s agricultural practices and sanitation systems?

1.3 Hypothesis

H1: The establishment of a supportive enabling environment, characterized by comprehensive policies, regulatory frameworks, and institutional support, is crucial for the widespread adoption and effective implementation of urine recycling technologies in Ethiopia.

2. Background

2.1 Ethiopia's Sanitation and Hygiene Overview

Between 2000 and 2020, Ethiopia experienced a remarkable global achievement, witnessing a substantial decrease in open defecation rates from 79% to 17%. This notable progress was primarily attributed to the collaborative efforts outlined in the national sanitation strategy, implemented through the widespread health extension program across the country (Novotný & Mamo, 2022).

However, the reduction in open defecation mainly focused on ensuring access to sanitation facilities, often falling short of meeting basic hygienic standards, with only 7% meeting the criteria for safe management in 2020 (Novotný & Mamo, 2022). Despite these advancements, Ethiopia's sanitation situation is confronted with various challenges. The 2011 Ethiopia Demographic and Health Survey (EDHS) revealed that 82% of households use unimproved toilet facilities, while only 8% have access to privately improved sanitation services (Yimam et al., 2014; Chare Koyra et al., 2017)). Additionally, 9% rely on shared toilet facilities (Azage et al., 2020). Notably, there are persistent disparities between rural and urban areas, with 43% of people in rural regions practicing open defecation compared to 8% in urban areas (Jones, 2015). This inequality is particularly pronounced among the bottom poverty quintiles, where over three-quarters engage in open defecation, in stark contrast to the 12% among the wealthiest (Jones, 2015).

The consequences of inadequate access to improved sanitation and widespread open defecation practices go beyond immediate health concerns. Societal and economic repercussions affect households lacking proper sanitation and communities with low access levels. Although latrine coverage has increased, the continued prevalence of unhygienic latrines and open defecation contributes to an ongoing disease burden (JMP, 2014; Jones, 2015).

Ethiopia's sanitation challenges are closely linked with agricultural productivity and environmental sustainability. Inadequate sanitation contributes to environmental pollution, as untreated human waste contaminates soil and water sources, impacting agricultural yields and exacerbating health risks. Additionally, the absence of proper sanitation facilities can lead to the spread of diseases such as diarrhea, cholera, and typhoid fever, disproportionately affecting vulnerable populations, including children and the elderly, who are often involved in agricultural activities (UNICEF, 2023).

Ethiopia's agriculture heavily relies on water availability but faces challenges due to water scarcity. Inadequate waste disposal methods and poor sanitation practices significantly add to the pollution of the already scarce clean water resources used for both agricultural and domestic purposes. This further exacerbates access to clean water which hampers crop irrigation and livestock management. Furthermore, sanitation practices directly influence soil health, as improper waste disposal can contaminate soil, hindering crop growth and overall agricultural productivity (Jumber et al., 2020). Conversely, implementing proper sanitation systems can generate organic nutrients, such as compost, and urine-based fertilizers that enhance soil fertility and crop yields.

Despite these challenges, there is a positive shift towards adopting fixed-place defecation (Jones, 2015), suggesting a gradual improvement in sanitation practices. Cities like Addis Ababa and Gondar boast conventional sewerage systems, but these only cover a limited segment of the population. Challenges such as water scarcity and logistical constraints make the construction or expansion of conventional sewerage systems in Ethiopian urban areas seemingly infeasible (GoE, 2015).

In Bahir Dar, the coverage of greywater soak pits stands at 57.4%, underscoring the imperative for enhanced wastewater management strategies (Jumber et al., 2020). Bahir Dar serves as an intriguing case study due to its representative portrayal of growing urbanization in Ethiopia, coupled with diverse economic activities. The city heavily relies on natural resources such as the Abay River and Lake Tana, which serve multifarious purposes including irrigation for agriculture, hydroelectricity generation, transportation, and recreation (MoWIE, 2018).

The adequacy of fecal sludge management in the city is alarmingly low, standing at a mere 27%. This figure denotes the proportion of fecal sludge adequately contained within pit toilets, situated at a safe distance from water sources like hand-dug wells, and securely covered when full to prevent surface overflow and drainage contamination (see Figure 1). A substantial portion, accounting for 46%, remains inadequately contained within pit latrines, with no provisions for timely emptying, resulting in environmental discharge. Additionally, 15% of fecal sludge is contained and emptied but not transported to treatment facilities; instead, it is discharged into the city’s drainage channels and water bodies, while open defecation accounts for the remaining 12% (Jumber et al., 2020; MoWIE, 2018).

The ramifications extend to the contamination of vital water sources such as the Abay River and Lake Tana, rendering them unsuitable for irrigation and unsafe for household utilization. Consequently, this jeopardizes the health, livelihoods, and overall well-being of the local populace (Jumber et al., 2020).

Figure 2: Sanitation situation in Bahir Dar

Source: (Jumber et al., 2020)

Addis Ababa, Ethiopia's capital, employs a diverse range of wastewater management systems, including sewer, non-sewer, and decentralized approaches (McFarland et al., 2022). While 6% of the population has access to the sewer system, the majority relies on pit latrines, toilets connected to septic tanks, on-site decentralized treatment, or unfortunately, 14% of the city lacks access to toilets altogether (McFarland et al., 2022). The stormwater system, intended for draining stormwater away, faces contamination challenges due to routine waste discharge, impacting the rivers it drains into (McFarland et al., 2022).

Municipalities in Ethiopia, tasked with managing solid waste services, grapple with significant limitations in financial, technical, and human resources (GoE, 2015). Many lack formal waste management systems, leading to the discharge of liquid waste into open spaces. The absence of proper fecal sludge management, deficiencies in construction, and limited public control

compound the challenges in urban areas (GoE, 2015). While Ethiopia has made substantial strides in reducing open defecation, numerous challenges persist in achieving comprehensive and hygienic sanitation coverage. The need for targeted interventions, improved infrastructure, and heightened awareness remains critical to addressing these challenges and ensuring a healthier future for the Ethiopian population.

2.2 Fertilizer Subsector in Ethiopia

Until 1992, the state-controlled parastatal known as the Agricultural Input Supply Corporation (AISCO), now renamed the Agricultural Input Supply Enterprise (AISE), held a monopoly over the fertilizer market. In line with a new economic policy, the Government introduced the New Marketing System (NMS) for fertilizer in 1992, aiming to liberalize the market and establish a multi-channel distribution system. This liberalization allowed the private sector to participate in importing and distributing fertilizer, effectively putting an end to AISCO/AISE's monopoly. AISE initiated the process by appointing its wholesalers and retailers (Demeke et al., 1998).

In 1993, Ethiopian Amalgamated Limited (EAL) was the pioneer private company to import and set up its fertilizer supply network, capturing 27.9% of the total import market share by 1996. The next company, owned by the Amhara Regional Government, began operating in 1994 under Ambassel Trading House Private Limited Company (Demeke et al., 1998). Primarily functioning as a wholesale and distribution agent for AISE, it sourced its supplies from Assab. In 1996, the government appointed Ambassel as the exclusive distributor and wholesaler of AISE in the Amhara region and allocated foreign exchange for fertilizer imports. Together, EAL and Ambassel represented 35.1% of total fertilizer imports in 1996 (Demeke et al., 1998).

Motivated by the success of Ambassel, other regional governments initiated the establishment of their enterprises. By 1998, companies from all four major grain-producing regions in the country were involved in the import and distribution of fertilizers, alongside AISE and four private companies (Rashid et al., 2013). However, the competition between government, private, and holding companies proved to be short-lived. The share of private companies in total fertilizer imports declined from 28 percent in 1996 to zero in 2002 (Rashid et al., 2013). Scholars commonly argue that the indirect support provided by the government to holding companies created

challenges for the private sector to operate profitably, as documented in various studies (DSA, 2006; Byerlee et al., 2007).

An earlier study by Demeke et al. (1998) offers specific examples of government support for holding companies. It noted that in the Amhara region, Ambassel, as the sole agent of AISE, enjoyed larger market shares due to policy privileges. Farmers receiving fertilizer credits from the government were restricted from purchasing from private companies. However, counterarguments exist. Some argue that the thin fertilizer market in Ethiopia and the potentially high opportunity costs for private-sector capital in this sector might make it more lucrative for the private sector to invest in other rapidly expanding areas of the economy instead of the challenging fertilizer market (Rashid and Ayele, 2009).

According to Simtowe (2015), the deregulated fertilizer market lacked competitiveness because of the absence of extension services and other forms of demand-boosting assistance. Consequently, most private companies withdrew from the industry. The government implemented a strategy to establish an input marketing system that involves active participation from farmers' organizations. As a result, farmers' organizations assumed the role of procuring and distributing fertilizer (Rashid et al., 2013; Simtowe, 2015). The introduction was well-received as it aligned with policy recommendations from development partners aimed at tackling issues related to limited markets and challenges in product aggregation. This proved to be a proactive approach, leading to a swift increase in market share for cooperatives, reaching nearly 75 percent of total fertilizer utilization in 2007/2008 (Rashid et al., 2013). The accelerated growth was facilitated by offering subsidized credits to cooperative unions for the importation and distribution of fertilizer. Nevertheless, the policy encountered challenges stemming from the increasing cost of fertilizer and balance of payment issues during 2007/2008 (Rashid et al., 2013). In 2008, AISCO underwent a name change to Agricultural Input Supply Enterprise (AISE) and emerged as the exclusive importer of fertilizer in Ethiopia. This resulted from an agreement among the Ethiopian government, the African Development Bank, and the World Bank to centralize all fertilizer imports through AISE. Annually, AISE determines the quantity of fertilizer to import based on the estimated demand from farmers (Rashid et al., 2013; Simtowe, 2015).

2.3 Fertilizer Value Chain

The fertilizer value chain in Ethiopia encompasses various participants engaged in three main categories of activities: import planning, import execution, and marketing and distribution (Rashid et al., 2013). The import planning process commences with a demand assessment conducted by the woreda (district) agricultural bureau. This assessment is based on primary data collected through community surveys led by extension workers, or development agents. Some primary cooperatives may also conduct their demand assessments. The estimates provided by the development agents and cooperatives are harmonized at the Woreda bureau offices and then forwarded to the zonal offices. Zonal offices aggregate the woreda-level data and transmit the estimates to the Bureau of Agriculture and Rural Development (BoARD) (Rashid et al., 2013).

Since the initiation of the Growth and Transformation Program in 2010, production targets outlined by the program over a five-year plan are also considered during the finalization of estimates at the Bureau of Agriculture offices. Ultimately, the Ministry of Agriculture and Rural Development consolidates the regional estimates to arrive at the national demand estimates. Determining the net import requirement involves subtracting the carry-over stocks from the previous year from the current year's demand (Rashid et al., 2013).

In the process of carrying out imports, the Ministry of Agriculture (MoA) prepares tender documents and invites a group of public institutions, including the Ministry of Finance and Economic Development, the National Bank of Ethiopia, the Commercial Bank of Ethiopia, and the Quality and Standard Control Office, to assess and approve the anticipated demand, required foreign exchange, and initiation of international procurement tender (Rashid et al., 2013). Since 2008, the execution of imports has been exclusively entrusted to AISE. The rationale for granting AISE a monopoly is to capitalize on economies of scale, leveraging the idea that bulk imports afford the buyer increased bargaining power for negotiating lower prices. Moreover, large-scale imports are believed to potentially reduce transaction costs and enhance the efficiency of value chain management (Rashid et al., 2013).

In 2011, certain regional cooperative unions sought to break away from AISE, expressing a desire for the Ministry of Agriculture to handle fertilizer imports by forming a regional federation of cooperatives. Nevertheless, the Ministry of Agriculture deemed that permitting three or more cooperative federations to engage in importing would be inefficient. Consequently, AISE was

reaffirmed as the exclusive importer of fertilizer on behalf of farmers' cooperative unions (Rashid et al., 2013).

Once the imported fertilizer arrives at the Djibouti port, AISE notifies the regional cooperative unions for the transportation of the shipment to central warehouses. Depending on storage capacity, the cooperative unions decide where to store the fertilizer. The primary preference is to transport the fertilizer directly from the Djibouti port to the warehouses of the cooperative unions. If the unions lack storage space or are unprepared for the shipments, AISE stores the fertilizer in its central warehouses. Subsequently, the union facilitates distribution to the primary cooperatives, granting farmers direct access to purchase. In regions without cooperative unions or those difficult to reach, AISE takes charge of the delivery, while primary cooperatives function as wholesalers (Rashid et al., 2013; Simtowe, 2015).

The BoARD actively engages in the marketing and distribution of fertilizers, participating in processes such as facilitating input credit guarantees for the Commercial Bank of Ethiopia, providing transportation as necessary, and ensuring the timely delivery of fertilizers (Rashid et al., 2013). Additionally, the BoARD is involved in determining prices and margins (Simtowe, 2015). The AISE establishes the weighted average price of fertilizer at the central warehouse level, and subsequently, the BoARD incorporates margins for unions or federations and primary cooperatives, loading and unloading costs, warehouse rent, bank interest rates, and other administrative expenses. Price determination in each region involves consultation with the unions (Rashid et al., 2013). To facilitate fertilizer imports via AISE, cooperative unions are provided credit guarantees by regional governments. AISE payments are split into two stages: when the letter of credit is initiated, and when the fertilizer reaches the Djibouti port. Primary cooperatives obtain fertilizer on credit from unions and predominantly sell it on a cash basis to smallholder farmers. Farmers in Amhara and SNNPR who live in remote and food-insecure areas have the option to obtain fertilizer by paying 50 percent of the cost upfront. They agree to pay the remaining balance after the harvest. Other available credit sources include microfinance, rotating savings, and credit unions (Rashid et al., 2013).

The transformation of waste products into valuable resources holds profound significance in fostering sustainability and addressing environmental challenges. By repurposing waste, such as urine, as a nutrient-rich fertilizer, we not only mitigate pollution but also tap into a sustainable

solution for nutrient management in agriculture (Aliahmad et al., 2023; Simha et al., 2018). The objective of this thesis is to explore the potential of urine recycling within Ethiopia's existing sanitation and agricultural policies. By integrating urine recycling into the fertilizer value chain, we can enhance resource efficiency and contribute to the resilience of agricultural systems.

3. Conceptual Framework

3.1. The Five Capitals Model

The Five Capitals Model, devised by Jonathan Porritt in 2018, aims to explain sustainability through the lens of wealth creation or 'capital' (Edwards-Jones et al., 2022). This model delineates five types of capital that serve as the foundation for generating goods and services essential for enhancing our quality of life (Edwards-Jones et al., 2022). These capitals encompass natural, social, human, financial, and manufactured components (Porritt, 2020).

Natural capital, also known as environmental or ecological capital, comprises various forms of energy and matter that yield valuable resources and services (Porritt, 2020). This includes resources, some renewable like timber, grain, fish, and water, and others non-renewable like fossil fuels, as well as sinks that absorb or recycle waste, and processes such as climate regulation (Edwards-Jones et al., 2022; Porritt, 2012; Porrit, 2020). Porritt (2020) suggests strategies to maintain and enhance natural capital, including substituting scarce materials with more abundant alternatives, efficient utilization of mined materials within cyclic systems, reducing reliance on fossil fuels by transitioning to renewable resources, eliminating the accumulation of synthetic substances in nature, prioritizing waste reduction, promoting biodiversity conservation, and responsibly using renewable resources from well-managed ecosystems.

Human capital encompasses an individual's health, knowledge, skills, intellectual contributions, motivation, and capacity for interpersonal relationships (Porritt, 2020). Additionally, it encompasses emotions such as joy, passion, empathy, and spirituality, all of which are essential for productive work (Edwards-Jones et al., 2022). Human capital can also be understood as educational background and expertise, demonstrated through the ability to provide services, and produce goods beneficial to society at large (Maack & Davidsdottir, 2015). Investing in health promotion, education, and training is crucial for enhancing human capital and fostering a thriving economy (Edwards-Jones et al., 2022; Porritt, 2020).

Social capital pertains to the institutions that facilitate the maintenance and development of human capital through collaboration with others (Porritt, 2020). It encompasses any added value to the activities and economic outputs of an organization or society resulting from human relationships, partnerships, and cooperation. Examples include families, communities, businesses, trade unions,

schools, and voluntary organizations, along with social norms, values, and trust (Edwards-Jones et al., 2022; Porritt, 2020). Organizations rely on social connections and interactions to accomplish their objectives (Porritt, 2020). Internally, social capital manifests as shared values, trust, communication, and cultural norms that enable cohesive work and effective organizational functioning. Externally, social structures contribute to creating an atmosphere of consent or a license to operate, facilitating trade and broader societal functions (Porritt, 2020). Additionally, organizations depend on broader socio-political structures, such as governments, public services, legal systems, trade unions, and other organizations, to establish a stable operating environment (Porritt, 2020).

Manufactured capital encompasses tangible assets such as tools, machinery, buildings, and infrastructure that contribute to the production process without being depleted in it (Edwards-Jones et al., 2022). Its key elements include buildings, infrastructure like transportation networks and communication systems, waste management facilities, and a range of technologies spanning from basic tools to advanced IT and engineering (Edwards-Jones et al., 2022; Porritt, 2020). Enhancing manufactured capital involves utilizing infrastructure, technologies, and processes efficiently, implementing reverse logistics, re-use, and re-manufacturing systems, adopting zero-waste and zero-emission production methods, practicing industrial ecology to optimize resource utilization across organizations, improving product systems through eco-efficiency and eco-innovation, and employing sustainable construction techniques for new infrastructure or offices (Porritt, 2012, 2020).

Financial capital is a crucial component of the economy, facilitating the ownership and exchange of other forms of capital. Unlike other capitals, it lacks inherent value but represents natural, human, social, or manufactured capital (Edwards-Jones et al., 2022; Porritt, 2020). It encompasses assets in the form of currency that can be owned or traded, including shares, bonds, and banknotes. Financial capital reflects the productive potential of the other forms of capital (Porritt, 2020).

Capital refers to assets that yield future benefits in the form of service flows (Maack & Davidsdottir, 2015). The five capital theory posits that human well-being relies on service flows from five conceptualized stock categories, with financial capital serving as a liquid asset facilitating interchange between these categories (Maack & Davidsdottir, 2015). All organizations utilize these capitals to varying extents to deliver their products and services. To operate

sustainably, organizations must maintain and ideally enhance these capital assets rather than depleting or degrading them (Edwards-Jones et al., 2022).

The Five Capitals Model provides a robust conceptual framework for identifying and communicating sustainable policies, strategies, plans, programs, and interventions that promote human health benefits (Edwards-Jones et al., 2022). It offers a dynamic approach that prompts organizations to consider how to strike a balance between their environmental, social, and economic activities. This encourages reflection on maximizing the value of each capital while pursuing agreed priorities or objectives and considering the impact of activities on each capital (Edwards-Jones et al., 2022).

By deliberating on ways to optimize the value of each capital, the five capitals model aids in envisioning the sustainability of urine recycling (Porritt, 2020). It takes a holistic approach, facilitating the identification of synergies and trade-offs between different forms of capital and informing the development of targeted policies, strategies, and interventions to promote sustainable practices in urine recycling and agricultural productivity improvement while addressing sanitation challenges (Porritt, 2020).

4. Methods

4.1 Research Design

This research utilizes a document analysis approach to investigate a range of policy papers, grey literature, and research articles on sanitation, fertilizer, and urine recycling in Ethiopia. Document analysis is favored for its systematic examination of existing documents, enabling the extraction of valuable insights, themes, and patterns (Berg & Lune, 2012). This method aligns well with the study's goal of evaluating the viability of urine recycling as a solution and exploring how institutional frameworks and policy contexts impact its advancement and acceptance.

4.2 Data Collection

Purposive sampling was used to gather the data for this analysis to choose documents that accurately reflected the context of the research. The selection of documents was based on two criteria: their digital format availability and their relevance to the research topic. The academic and institutional databases JSTOR, PubMed Central, Scopus, FAOLEX, governmental websites, and other pertinent platforms were the sources of the papers. Search terms associated with the research topic were employed to find relevant documents.

4.3 Document Selection

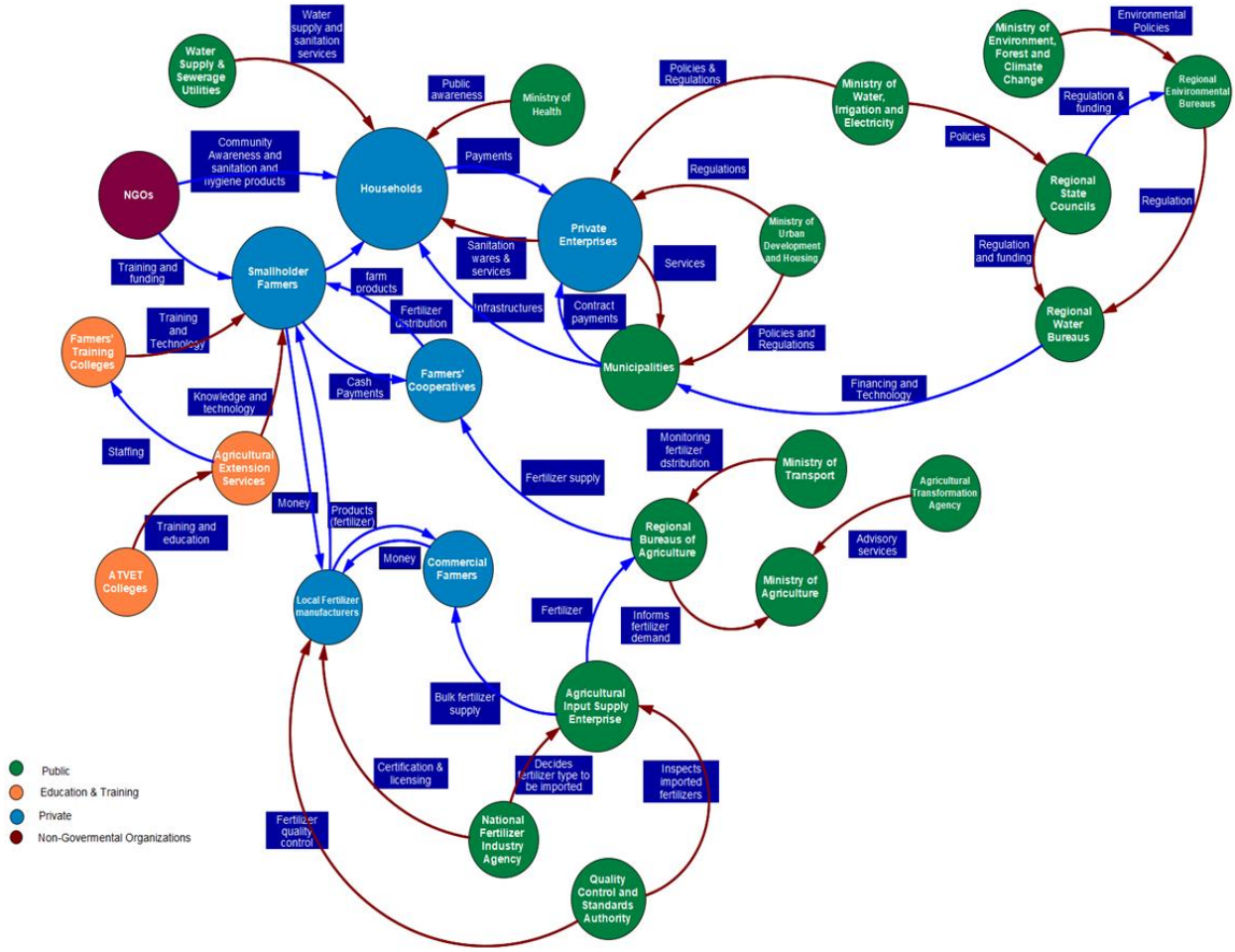
A total of 1,037 documents were initially identified through the search process. The criteria for inclusion is the relevance to key themes, which are institutional frameworks, policy environments, technology adoption, and geographic focus. After screening for relevance and eligibility based on the inclusion criteria, 35 documents were included in the final sample for analysis. The selection process aimed to ensure a comprehensive representation of the discourse surrounding the research topic while also considering the feasibility of analysis within the scope of this study.

4.4 Data Analysis

The chosen documents underwent a careful systematic examination to spot prevalent themes, patterns, and insights. Initially, a comprehensive reading of the documents was conducted to grasp their content in its entirety. Following this, a coding framework was constructed, drawing upon recurring themes, concepts, and ideas evident within the documents. This framework underwent iterative refinement throughout the analysis process, enabling a nuanced interpretation of the data (Berg & Lune, 2012; Clark et al., 2021).

The analysis reveals several institutions that are involved in the sanitation and fertilizer sectors in Ethiopia. A value network map was used to depict the relationship between these institutions to help understand how they interact (see Figure 3).

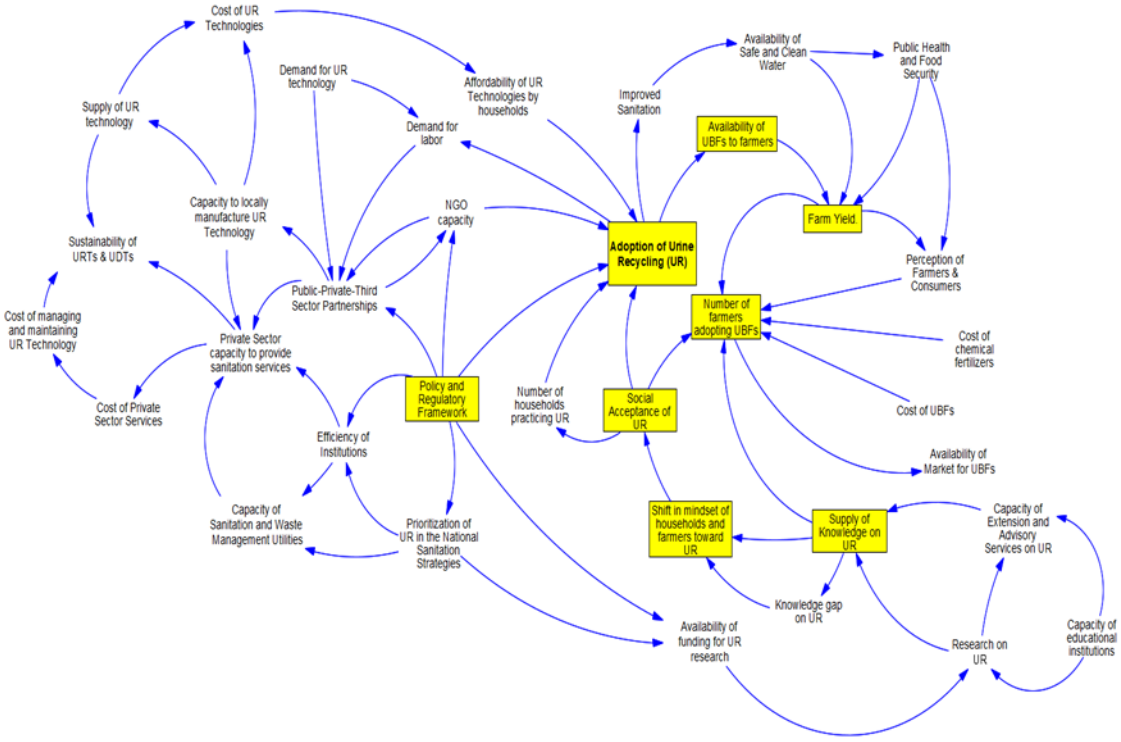
Figure 3*:* Value Network Map showing the relationship between various institutions that influence sanitation and fertilizer sectors in Ethiopia.



By graphically representing the connections between values, the Value Network Map provides a visual aid for understanding complex systems (Galle & Matti, 2022). This mapping approach makes it possible to identify significant points of intervention that help to move toward sustainability. According to Galle and Matti (2022), it promotes a common understanding of the interdependence of values in a given system, region, or industry, which enables repeated study and restructuring of the surrounding frameworks. This understanding is converted into a graphic

depiction of roles and connections, making it possible to find possibilities for intervention inside the framework of the system (Galle & Matti, 2022). To gain deeper insights into the factors influencing behavior and changes within Ethiopia's urine recycling system, a Causal Loop Diagram (see Figure 4) was utilized.

Figure 4: Causal Loop Diagram showing the factors influencing behavior and changes.



This diagram, a tool rooted in systems thinking, aids in visualizing and unraveling intricate system dynamics. It serves as a graphical depiction to explain the actions or mechanisms that drive behavior and transformation within a system (Tomoaia-Cotisel et al., 2017).

4.5 Ethical Considerations

Ethical considerations were carefully attended to during the entirety of the research endeavor. The chosen documents were sourced exclusively from publicly accessible sources, and obtained through authorized means, with no infringement upon confidential or proprietary data. Adherence to rigorous citation and attribution protocols was upheld to duly recognize the original authors and origins of the scrutinized documents (Clark et al., 2021).

4.6 Limitations

Recognizing the limitations inherent in using document analysis as a research methodology is crucial. Essentially, the strength of this study's findings relies heavily on the quality and accessibility of the papers selected. Despite careful efforts to ensure a diverse sample, there's a chance that certain viewpoints or subtle aspects relevant to this research topic might have been unintentionally left out of the analysis.

Moreover, even though the researcher has strived to maintain objectivity throughout the analysis, it's important to acknowledge how the biases and perspectives of the researcher could potentially influence the interpretation of the data. By solely relying on secondary data sources, the researcher missed out on the opportunity to collect primary data directly from key stakeholders such as farmers, households, and policymakers. Engaging with these stakeholders directly could have significantly enriched the depth and breadth of insights.

The focus on policy documents, grey literature, and research articles, while informative, may have inadvertently overlooked certain perspectives and experiences related to urine recycling in Ethiopia. It's possible that some viewpoints or contextual factors weren't adequately addressed within the scope of the research.

Despite these acknowledged limitations, our study makes a valuable contribution to the ongoing discourse surrounding the research topic. It provides insightful information that can inform future studies and policymaking efforts.

5. Results and Discussion

5.1: How current sanitation practices and policies in Ethiopia influence the potential for urine recycling as a sustainable solution for nutrient management and agricultural productivity.

In Ethiopia, a variety of sanitation practices prevail among the populace, influenced by factors such as the availability of clean and safe water, and access to improved sanitation infrastructure (MoWIE-Ethiopia, 2015). These factors shape the prevalent sanitation technologies, notably pit latrines and flush toilets. Flush toilets are usually connected to septic tanks which are periodically emptied by vacuum trucks when full, primarily in modern urban buildings mostly occupied by the rich and middle-class. Pit latrines are strategically positioned away from water sources and contain sludge until emptied by vacuum trucks or securely covered to prevent overflow. In regions lacking proper sanitation facilities, open defecation persists (Jumber et al., 2020; MoWIE-Ethiopia, 2015).

Examining these practices through the lens of a sustainable sanitation service chain—from containment to emptying and transportation to treatment and reuse—reveals that a significant portion of wastewater in Ethiopia remains untreated due to deficient conventional management systems (Jumber et al., 2020). Consequently, a combination of on-site and off-site practices is employed. On-site systems manage waste at its source, either by the safe covering of pit latrines or by localized disposal, potentially for composting (Ghangrekar, 2022). Off-site systems involve transporting wastewater to centralized treatment facilities via sewer systems or vacuum trucks. In most Ethiopian cities, vacuum trucks are instrumental in transporting sludge to treatment plants or designated disposal sites used as dry beds (Ghangrekar, 2022; Jumber et al., 2020).

Ethiopia's sanitation landscape presents an opportunity for introducing urine recycling as a sustainable solution for nutrient management, particularly in rural areas with limited sanitation infrastructure and agrarian livelihoods. Effective adoption could enhance agricultural productivity, provide alternative nutrient sources, improve sanitation facilities, reduce water contamination, and enhance public health (Jumber et al., 2020; Simha et al., 2020; UNICEF, 2023).

Yet, considering factors influencing current sanitation practices, such as water availability and infrastructure access, questions arise regarding the feasibility of urine recycling. Are the construction and management costs viable? Is the technology durable and readily available? These queries extend beyond this study's scope and merit a cost-benefit analysis.

Nonetheless, Ethiopian sanitation practices can both positively and negatively impact urine recycling's potential. On the positive side, urine-diverting toilets offer improved on-site sanitation management by reducing fecal sludge volume and odor, facilitating composting, and enhancing nutrient recovery (Simha, 2021; Simha et al., 2018, 2020), especially for a segment of the population that needs improved sanitation infrastructure, and the byproducts of urine recycling, urine-based fertilizers, and organic composts for their farms. Conversely, a segment of the populace accustomed to existing sanitation options, especially in the urban areas with improved sanitation systems and practices may resist adopting new practices especially one which makes them responsible for their sanitation. Understanding public willingness to embrace urine recycling and associated technologies is crucial in gauging their adoption potential.

5.1.1 Policy Landscape for Urine Recycling in Ethiopia

The integration of urine recycling, urine recycling technologies, and the utilization of urine-based fertilizers within agricultural systems is heavily influenced by pertinent policies governing regulatory frameworks, environmental standards, and waste management practices. This section discusses how policies directly or indirectly influence the potential for urine recycling in Ethiopia. It also compares Ethiopian policies and those of Sweden and the European Union (EU) since the Ethiopian Organic Agriculture System Proclamation No. 488/2006 makes provisions for the incorporation of internationally recognized standards for organic agriculture (Article 13.2).

Table 1: Policies that influence the adoption of urine recycling in Ethiopia.

Policy	Content
The Fertilizer Manufacturing and Trade Proclamation No. 137/1998	***Fertilizer manufacturing (Article 5)*** Any individual intending to commence a fertilizer manufacturing business must possess a competence assurance certificate, obtained by meeting the requirements stipulated by the National Fertilizer Industry Agency. The applicant must employ qualified professionals directly engaged in the manufacturing process and establish a laboratory for testing the quality and composition of the manufactured fertilizer. ***Application for Competence Assurance (Article 6)*** 1) According to Article 5 of this Proclamation, applicants seeking a competence assurance certificate must apply in the prescribed format to the Agency. 2) Additionally, the agency will document in the designated form: (a) Qualifications of professionals directly involved in manufacturing. (b) Confirmation of the establishment of a laboratory for testing the quality and composition of the manufactured fertilizer. ***Period of Validity (Article 9)*** A competence assurance certificate issued under this Proclamation remains valid for one year from the date of issuance.
Food, Medicine, and Health Care Administration and Control Proclamation 661/2009	***Article 12: Waste Handling and Disposal*** 1) Waste collection must be carried out by individuals in designated locations and in a manner that safeguards public health. 2) It is prohibited to dispose of solid, liquid, or any other waste in a manner that pollutes the environment or poses a risk to public health. ***Article 13: Availability of Toilet Facilities*** 1) Institutions or organizations offering public services are mandated to maintain clean, sufficient, and easily accessible toilet facilities for their clientele.

	2) City administrations are responsible for providing public toilets and ensuring their cleanliness.
Environmental Pollution Control, Proclamation No 300/2002	***Article 5: Management of Municipal Waste*** 1) Urban administrations are mandated to establish integrated municipal waste management systems, ensuring the collection, transportation, and where applicable, the recycling, treatment, or safe disposal of municipal waste. 2) The Authority, in partnership with relevant regional environmental agencies, shall oversee and assess the adequacy and effectiveness of municipal waste management systems. 3) Individuals responsible for premises accessible to the public must maintain adequate and suitable facilities for waste disposal, including toilets and waste containers. 4) The Authority, in collaboration with relevant regional environmental agencies and other competent bodies, will monitor waste disposal facility availability and take necessary actions to ensure satisfactory availability. ***Article 6: Environmental Standards*** 1) The Authority, in consultation with competent agencies, will develop practical environmental standards based on scientific and environmental principles.
Ethiopian Organic Agriculture System Proclamation No. 488/2006	***Article 13: Detailed Organic Agriculture Rules*** 1) Regulations to be issued under this provision shall outline procedures for organic production at the farm level, including pest management, permissible biological control methods, transportation, storage, processing, labeling, advertising, minimum inspection requirements, as well as inspection and precautionary measures. Additionally, accreditation requirements for inspection and certification bodies will be specified. 2) In cases where regulations do not specify detailed organic production rules for livestock and plant products, the Ministry is empowered

	to recognize and apply other relevant internationally accepted standards.
Urban Development Policy of Ethiopia	The policy underscores the importance of environmental protection for urban administrations, the government, and citizens to prevent ongoing suffocation and pollution resulting from urban expansion. Alongside the strict enforcement of national and regional environmental policies and regulations, urban administrations are urged to implement various environmental protection measures, including: a. Establishing appropriate rules, regulations, manpower, organizational structures, and operational systems to effectively control pollution from institutions and individual households. This involves building institutional capacity for the sustainable implementation of these measures. b. Developing systems that specify and integrate the roles of urban administrations, investors, and the public in the disposal of solid and liquid wastes, thereby guiding their implementation. c. Creating systems for waste recycling and promoting engagement in recycling activities, along with the adoption of simple recycling technologies at household, neighborhood (Kebele), urban, and institutional levels. d. Promoting cultural and attitudinal shifts among the public to prioritize environmental preservation and pollution prevention. This includes fostering continuous and sustainable public participation in environmental protection efforts.
Source: (Ethiopian Environmental Pollution Control Proclamation, 2002; Ethiopian Organic Agriculture System Proclamation, 2006; Fertilizer Manufacturing and Trade Proclamation, 1998; Food, Medicine and Health Care Administration and Control Proclamation, 2009; MoWIE-Ethiopia, 2015)	

5.1.2 Food, Medicine, and Health Care Administration and Control Proclamation 661/2009

The Food, Medicine, and Health Care Administration and Control Proclamation 661/2009 is a legislative instrument aimed at regulating waste management and sanitation practices within Ethiopia. Within its provisions, Articles 30 and 31 specifically address waste handling and disposal, and the provision of toilet facilities, respectively.

Article 30 mandates that the collection and disposal of waste, whether solid, liquid, or otherwise, must be conducted in a manner that prevents environmental contamination and adverse health effects. Furthermore, it explicitly prohibits the discharge of untreated waste from sources such as septic tanks, seepage pits, and industrial processes into the environment or water bodies. Complementarily, Article 31 stipulates that entities offering public services are obligated to ensure the provision of clean, sufficient, and accessible toilet facilities for their clientele. It further assigns responsibility to municipal and rural administrations for the provision and maintenance of public toilets, emphasizing cleanliness and accessibility.

The proclamation underscores the imperative of centralized waste collection and disposal to safeguard public health and environmental integrity. In line with this objective, urine diversion toilets and related technologies emerge as viable solutions by separating urine from other waste streams, thereby reducing contamination risks, and potentially alleviating environmental pollution. Moreover, the emphasis placed on the provision of clean and accessible sanitation facilities by institutions and local administrations aligns with the principles of sustainable sanitation. Urine diversion toilets offer a sustainable alternative in regions where conventional sewage infrastructure is lacking, thereby enhancing access to sanitation services.

By promoting sound waste management practices and ensuring adequate sanitation facilities, the proclamation *indirectly* encourages the adoption of urine recycling initiatives. Effective urine recycling not only aids in waste reduction but also facilitates improved human waste management, thereby advancing the overarching goals outlined in the legislative framework.

5.1.3 Environmental Pollution Control, Proclamation No 300/2002

The Environmental Pollution Control, Proclamation No 300/2002, represents a legislative endeavor directed at addressing the management of municipal waste and establishing

environmental standards. Its stipulations, delineated in Articles 5 and 6, respectively, prescribe directives about municipal waste management and the establishment of environmental standards.

Article 5 imposes an obligation upon urban administrations to orchestrate the collection, transportation, and judicious handling of municipal waste through the implementation of a comprehensive integrated municipal waste management system. Additionally, it assigns the responsibility of furnishing adequate and appropriate sanitation facilities for proper waste disposal to the custodian of the premises.

Conversely, Article 6, focusing on environmental standards, mandates municipal authorities, in collaboration with competent agencies, to formulate pragmatic environmental standards grounded in scientific and environmental principles. These standards encompass regulations governing the discharge of effluents into water bodies and sewage systems, delineating permissible types and quantities of substances applicable to soil or subject to disposal, as well as specifying waste management standards dictating acceptable levels and methodologies for the generation, handling, storage, treatment, transportation, and disposal of diverse waste categories.

The provisions outlined in Articles 5 and 6 present a potential framework conducive to integrating urine recycling practices within broader waste management strategies. This policy highlights the need to adopt integrated waste management systems incorporating recycling initiatives and safe disposal practices. Consequently, urine recycling technologies, if duly acknowledged and regulated, hold promise in advancing these objectives by mitigating the environmental footprint associated with human waste and facilitating the recovery of valuable resources (Aliahmad et al., 2022).

Recognition of urine recycling as a sustainable practice harboring environmental benefits could engender support within the regulatory ambit delineated by the provisions. Such endorsement would signify alignment with the overarching objectives of promoting environmentally sound waste management practices and fostering resource conservation within the purview of prevailing legislative frameworks.

5.1.4 Ethiopian Organic Agriculture System Proclamation No. 488/2006

This proclamation incorporates provisions in Article 13 that address the incorporation of internationally recognized standards in instances where detailed organic production regulations for

livestock and plant products are absent. However, the absence of specific guidelines on biofertilizers within this proclamation introduces a potential ambiguity regarding their alignment with organic agriculture principles. Consequently, this absence of clarity may impede the widespread adoption of urine-based fertilizers among farmers who prioritize adherence to established organic standards.

5.1.5 The Urban Development Policy of Ethiopia

The Urban Development Policy of Ethiopia highlights a strong commitment to environmental protection and sustainable practices in urban areas (MoWIE-Ethiopia, 2015). It emphasizes the importance of mitigating pollution and ensuring the well-being of cities through various measures.

One key aspect of the policy is the establishment of regulatory frameworks to control pollution from both institutions and individual households. This regulatory support could extend to promoting urine recycling initiatives by providing incentives or mandates for their implementation. The policy also advocates for integrated waste management systems involving urban administrations, investors, and the public. This integrated approach creates opportunities for incorporating urine recycling into overall waste management strategies, encouraging its adoption at different levels of urban development.

Furthermore, the policy encourages waste recycling and the adoption of simple technologies at various levels, including households, neighborhoods (Kebele), and institutions. This encouragement provides a conducive environment for promoting urine recycling initiatives and adopting appropriate technologies for its implementation.

Cultural and attitudinal shifts towards environmental conservation and pollution prevention are also emphasized in the policy. By fostering a culture of sustainability and environmental responsibility, there could be increased acceptance and adoption of urine recycling practices as part of broader efforts to protect the environment. Moreover, the policy highlights the importance of continuous and sustainable public participation in environmental protection efforts. Engaging the public in awareness campaigns and education programs about the benefits of urine recycling could garner support and participation, facilitating its adoption across urban communities.

Generally, the Urban Development Policy of Ethiopia provides a supportive framework for promoting urine recycling initiatives by integrating them into broader environmental protection

and sustainable development agendas. By leveraging the policy's provisions and fostering collaboration among various stakeholders, urine recycling could contribute to addressing urban pollution challenges and promoting a more sustainable urban environment in Ethiopia.

5.1.6 The Fertilizer Manufacturing and Trade Proclamation No. 137/1998

The Fertilizer Manufacturing and Trade Proclamation No. 137/1998 outlines stringent requirements for individuals seeking engagement in the fertilizer manufacturing sector. Specifically, it mandates the possession of a competence assurance certificate, which is attainable upon fulfillment of criteria established by the National Fertilizer Industry Agency. Integral to this requirement is the employment of qualified professionals directly involved in the manufacturing process and the establishment of a dedicated laboratory for assessing the quality and composition of manufactured fertilizers.

The imposition of competence assurance certificates as a prerequisite for participation in fertilizer manufacturing poses potential challenges for smaller-scale urine recycling enterprises. These entities may encounter difficulties in meeting the certification prerequisites outlined in the legislation. Nonetheless, recognizing urine recycling as a viable nutrient source for fertilizer production could catalyze the development of more formalized urine recycling ventures capable of satisfying certification standards.

It is noteworthy that while the proclamation addresses the manufacturing of conventional fertilizers, there is a clear absence of provisions on biofertilizers within its purview.

5.1.7 Contrasting Approaches: Utilizing Developed Countries as a Benchmark

Given the provisions outlined in the Ethiopian Organic Agriculture System Proclamation No. 488/2006 regarding the incorporation of internationally recognized standards for organic agriculture, this section aims to conduct a comparative analysis between Ethiopia's regulatory framework and those of Sweden and the European Union concerning organic agriculture and the use of biofertilizers. Sweden stands out as a frontrunner in urine recycling, having implemented urine recycling and Urine Diverting Toilets (UDTs) in various settings, including Sweden’s largest island of Gotland, municipalities, and summer houses in different parts of the country (Jönsson et al., 2004; Kvarnström et al., 2006; McConville et al., 2017). Given Sweden's membership in the European Union, we have also chosen to compare the EU's regulatory framework for organic agriculture with that of Ethiopia. This comparison aims to highlight potential targeted policies that

could inform Ethiopia's formulation of direct policies and guidelines specifically addressing biofertilizers, such as urine-based fertilizers.

Sweden

Sweden presents a notable contrast to the Ethiopian policy landscape, showcasing a more robust and comprehensive legal framework for environmental governance. The Environmental Code (Miljöbalken) in Sweden serves as a cornerstone, providing a structured framework for environmental protection and sustainable resource management. Within this framework, innovative waste management practices, such as urine recycling, are accommodated in alignment with overarching principles of environmental sustainability (The Swedish Environmental Code, 2000).

The National Environmental Quality Objectives (Miljömål) in Sweden establish ambitious goals for sustainable waste management, emphasizing resource efficiency and the mitigation of environmental impacts (Swedish Environmental Protection Agency, 2020). These objectives specifically advocate for using recycled nutrients, including urine, in agriculture to diminish reliance on synthetic fertilizers. Further bolstering this stance, the National Guidelines for Nutrient Recycling from Source-Separated Urine (Svenskt Vatten) provide technical directives and standards for urine recycling initiatives. These guidelines encompass various aspects, from the implementation of urine diversion toilets to the operation of urine treatment facilities, aiming to ensure the safe and hygienic utilization of urine-derived fertilizers in agricultural practices while minimizing environmental hazards (Svenskt Vatten, 2000). This progress has not only facilitated the ongoing development and promotion of urine recycling but has also fostered research collaborations among researchers, farmers, and beverage companies. An illustrative example can be found on Gotland Island, where urine-derived biofertilizer (UBF) is utilized to cultivate barley. This barley is subsequently used in beer production by Gotlands Bryggeri for experimental tasting sessions (Lindberg, 2021).

Comparison:

Scope and Specificity: Sweden's regulatory framework exhibits a higher degree of specificity and comprehensiveness concerning urine recycling and the utilization of urine-based fertilizers,

contrasting with Ethiopia's more generalized approach lacking dedicated regulations in this domain.

Integration of Sustainable Practices: Swedish policies actively endorse sustainable waste management strategies, including urine recycling, as integral components of broader environmental objectives, whereas Ethiopian policies primarily address waste collection and disposal without explicit provisions for urine recycling.

Technical Guidance: Sweden offers detailed technical guidance and standards for urine recycling projects, streamlining their implementation, and ensuring adherence to environmental and public health standards. In contrast, Ethiopia currently lacks comparable technical guidance in this regard.

Cultural and Economic Factors: The adoption of urine recycling technologies may be influenced by cultural perceptions regarding waste management and agricultural practices, as well as economic considerations such as infrastructure development and resource availability, factors that may vary between Ethiopia and Sweden.

While both Ethiopia and Sweden acknowledge the potential merits of urine recycling and urine-based fertilizers, Sweden demonstrates a more advanced regulatory landscape with established policies and guidelines, indicative of a stronger commitment to environmental sustainability and resource optimization.

European Union (EU):

The European Union (EU) adopts a robust regulatory stance, featuring well-established guidelines governing the use of biofertilizers in both organic and conventional farming practices. Notably, the EU Organic Farming Regulation delineates intricate rules for organic production, incorporating directives concerning the utilization of biofertilizers and other organic inputs. Furthermore, it mandates that biofertilizers employed in organic agriculture adhere to specific criteria about their source, composition, and production methodologies, thereby ensuring alignment with organic principles (European Commission, 2022). Concurrently, the EU Fertilizer Regulation delineates detailed criteria governing labeling and quality control, thereby safeguarding consumer and environmental interests (European Commission, 2019). These regulatory frameworks serve as a benchmark for Ethiopia as it endeavors to formulate a more comprehensive framework for urine recycling and biofertilizers.

Comparison:

• **Regulatory Framework**: The EU boasts comprehensive regulations tailored specifically to the utilization of biofertilizers in both organic and conventional agricultural contexts, whereas Ethiopia currently resorts to internationally accepted standards owing to the absence of detailed domestic regulations.

• **Specificity and Standards**: EU regulations provide precise criteria and standards governing the production and application of biofertilizers, thereby ensuring uniformity and stringent quality control. In contrast, Ethiopia may adopt standards from international sources lacking tailored criteria tailored to its unique context.

• **Consumer and Environmental Protection**: EU regulations prioritize the safeguarding of consumer and environmental interests by imposing rigorous requirements on the composition and labeling of biofertilizers. In contrast, the extent of such protective measures in Ethiopia may fluctuate depending upon the international standards embraced.

• **Market Access and Trade**: Compliance with EU regulations constitutes a prerequisite for exporting biofertilizers to EU markets, incentivizing producers to adhere to stringent standards. Conversely, Ethiopian producers may encounter fewer regulatory obstacles; however, their access to international markets may be restricted without adherence to recognized standards.

Table 2: Comparative Analysis

Policy Area	Legal framework for UR	Standards for biofertilizer	Environmental Impact Assessment (EIA)	Public health and safety regulations	Support and subsidies for sustainable practices
Ethiopia	No specific legal provisions for UR, general waste management laws apply.	No specific standards for biofertilizers, provisions made for adopting internationally recognized standards	EIA for general waste management	Generalized regulations for waste disposal	No specific support and subsidies for sustainable practices

Sweden	Comprehensive legal framework including the Environmental Code that supports recycling and sustainable waste management.	Comprehensive standards for biofertilizers	Directives for minimizing environmental hazards	Regulations for safe and hygienic utilization of UBFs, including guidelines for UR	Subsidies for sustainable agriculture, no subsidies enabling UR
EU	Extensive regulations under the EU Fertilizer Regulation covering biofertilizers.	Detailed criteria and standards for the production and application of biofertilizers	Environmental impact is prioritized, and strict quality control ensured	Rigorous requirements on the composition and labeling of biofertilizers for consumer safety	Access to the EU market as an incentive for adherence to EU standards
Gaps	Lack of specific legal provisions	Lack of specific standards for biofertilizers	Lack of comprehensive EIA of UR	Absence of direct public health and safety regulations for UR	Absence of subsidies and incentives for sustainable practices
Recommendation	Adopt specific legal standards for UR similar to EU regulations	Develop detailed standards for biofertilizer production and application using the EU and Sweden as guidelines but in an Ethiopian context	Ensure the prioritization of the environmental impact of UR and enforce strict quality control measures	Develop thorough public health and safety regulations for UR and biofertilizers	Provide subsidies and incentives to support sustainable practices

5.2: Overview of institutional roles in Ethiopia's sanitation and fertilizer sectors

In Ethiopia's fertilizer sector, various institutions play pivotal roles in ensuring the efficient functioning of the industry. The Ministry of Agriculture and Rural Development (MoARD) assumes the responsibility of setting fertilizer prices in consultation with stakeholders, aiming to maintain affordability while considering market dynamics. The Agricultural Input Supply Enterprise (AISE) holds the sole authority for importing fertilizers into Ethiopia. Meanwhile, the Ministry of Transport oversees the transportation of fertilizers across the nation, to ensure timely and secure delivery (Simtowe, 2015).

The Agricultural Transformation Agency (ATA) provides necessary advisory services on soil health and fertility to the Ministry of Agriculture, enhancing agricultural productivity. The Quality Control and Standardization Authority upholds the quality standards of imported fertilizers, ensuring they meet the required specifications. Regional Bureaus of Agriculture contribute by providing information on fertilizer demand estimates and facilitating strategic planning at the national level (Rashid et al., 2013; Simtowe, 2015).

The National Fertilizer Industry Agency (NFIA) plays a pivotal role in decision-making regarding the type of fertilizer to be imported or locally manufactured. Farmers' cooperatives collaborate closely with the Regional Bureaus of Agriculture in the distribution of fertilizers to farmers (Rashid et al., 2013; Simtowe, 2015). Agricultural Technical and Vocational Education Training (ATVET) Colleges and Farmers Training Colleges (FTCs) train Development Agents, who provide essential extension services to farmers, disseminating knowledge on new agricultural technologies and practices (Spielman et al., 2013).

Agricultural extension services, facilitated by Development Agents, play a crucial role in providing skill training, facilitating access to agricultural inputs, and collecting valuable information on farmers' needs. Non-Governmental Organizations (NGOs) collaborate with local communities, promoting initiatives and facilitating resource availability (Spielman et al., 2013).

In the sanitation sector, various institutions work collectively to address public health and environmental concerns. The Ministry of Health (MoH) spearheads public awareness campaigns on proper sanitation practices and formulates policies to safeguard public health (MoWIE, 2018). Water Supply and Sewerage Utilities (WSSU) take charge of daily operations and management of

water supply and liquid waste systems, to ensure access to clean water and proper waste management (MoWIE, 2018).

Households play a crucial role in maintaining sanitation facilities, ensuring cleanliness, and proper management. Private enterprises are actively involved in executing sanitation management initiatives, with various roles such as sludge removal, latrine construction, and maintenance of public restrooms. Non-Governmental Organizations (NGOs) collaborate with local communities, promoting initiatives and facilitating resource access, especially sanitary wares (MoWIE, 2018; MoWIE-Ethiopia, 2015). Municipalities and city administrations are responsible for providing sewerage and fecal sludge management services, ensuring compliance with regulatory standards. Regional Health Bureaus play a vital role in community awareness campaigns for reliable wastewater management. Regional Environment Bodies are tasked with environmental monitoring and impact assessment (MoWIE, 2018).

Regional Water Bureaus manage regional water resources, to ensure sustainable usage and conservation. Regional State Councils approve and finance regional sanitation projects, fostering regional development. The Ministry of Environment, Forest, and Climate Change (MoEFCC) develops environmental policies and standards, ensuring the quality of air, water, and soil. The Ministry of Urban Development and Housing (MoUDH) formulates waste management policies and oversees waste collection and disposal. The Ministry of Water, Irrigation, and Electricity (MoWIE) develops wastewater management policies and strategies, ensuring the sustainable utilization of water resources (GoE, 2015; MoWIE, 2018; MoWIE-Ethiopia, 2015).

5.2.1 Using a Value Network Map to illustrate the relationship between various institutions that influence sanitation and fertilizer sectors in Ethiopia.

The value network map (Figure 3) illustrates interactions among the institutions within Ethiopia's sanitation and fertilizer sectors discussed in the section above. Intangible flows are represented by red arrows, while tangible flows are depicted by blue arrows. Public institutions are denoted by green circles, private institutions by blue circles, and educational institutions and non-governmental organizations by orange and brown circles.

Strengths: One notable strength lies in the operational functionality of educational institutions, particularly ATVET colleges, which train agricultural extension agents deployed to farmers' training colleges to educate local farmers. Additionally, the involvement of the private sector in

the sanitation service chain, collaborating with municipalities and households to deliver sanitation products and services, is a noteworthy strength. NGOs contribute significantly to the sanitation and agricultural sectors by providing sanitary wares and promoting sustainable sanitation and farming initiatives.

Weaknesses: Despite the potential for introducing urine recycling sanitation systems within the existing framework, sustainability is not guaranteed due to the lack of explicit policies promoting urine recycling or resource-oriented sanitation systems. Public institutions such as the Ministry of Health (MoH), Ministry of Water, Irrigation, and Energy (MoWIE), Ministry of Urban Development and Housing (MUDH), and Ministry of Agriculture and Rural Development (MoARD), responsible for formulating policies on health, environment, water, sanitation, and waste management, exhibit a weakness in this regard. Furthermore, the map reveals a gap in collaboration among NGOs, private enterprises, and public institutions. Additionally, it reveals the involvement of several institutions in the sectors, some of whose roles are not spelled out leading to overlaps and in some cases duplication in the responsibilities of institutions (MOWIE, 2018; Simtowe, 2015)

Opportunities: Opportunities exist for collaboration between NGOs and public institutions like MoH and municipalities to advocate for urine recycling and foster household adoption. Collaboration among NGOs, private enterprises, and the government can support businesses servicing resource-oriented sanitation systems, locally disseminate technologies, and manage urine recycling sanitation systems. Such partnerships can ensure the sustainability of sanitation systems beyond pilot projects and facilitate the availability of urine-based fertilizers for farmers at competitive prices. Leveraging existing agricultural extension service frameworks, NGO-funded initiatives could train local farmers and households on the benefits of adopting urine recycling technology. Additionally, the map identifies an opportunity to provide alternative fertilizer sources for smallholder farmers unable to afford conventional chemical fertilizers.

5.3 How institutional frameworks in Ethiopia affect the development, promotion, and adoption of urine recycling technologies and practices.

5.3.1 Government Commitment

For urine recycling to garner adequate attention and funding, it must be prioritized within national sanitation strategies. An instance of this challenge is seen in the integration of ecological sanitation (ecosan) with urban agriculture, which faces significant policy fragmentation, particularly

concerning the utilization of excreta as organic fertilizer (Ejigu & Yeshitela, 2023). Despite the emphasis on solid waste management and organic waste reuse in Ethiopian urban development policy, it does not explicitly address the potential utilization of human urine for agriculture. The Environmental Protection Agencies primarily oversee the regulatory aspects of adopting resource-oriented sanitation technology in agriculture. However, as highlighted by Ejigu & Yeshitela (2023), institutional capacity is hindered by constraints such as inadequate human resources, financial limitations, organizational structure deficiencies, lack of environmental standard formulation, compliance monitoring, and insufficient facilities like laboratories to regulate health and environmental impacts.

A robust commitment from the government to resource-oriented sanitation is necessary for scaling up efforts, particularly in urban areas where the legal regulatory framework significantly influences the construction of sanitary systems (Esrey et al., 1998). While community-based initiatives play a pivotal role in the effective introduction and utilization of urine recycling systems, the involvement of central and local government is essential for their expansion and sustainability. Esrey et al. (1998) argue that sustainability and replicability prospects are enhanced in community-based waste management programs with strong political will and supportive government regulation.

5.3.2 Resource Availability and Sustainability

Urine recycling technology adoption in Ethiopia primarily relies on support from non-governmental organizations (NGOs) for initial investments (Ejigu & Yeshitela, 2023). For instance, while traditional pit latrines are less costly than ecosan urine-diverting dry toilets, the latter requires assistance from municipal governments or NGOs. The entire cost of constructing ecosan urine-diverting dry toilets is mainly covered by NGOs as a demonstration to influence the attitudes of households, institutions, and the private sector (Ejigu & Yeshitela, 2023). However, the NGOs will not continue to bear the cost if urine recycling is to be sustainable. What happens when the pilot projects are over? Who bears the costs for the maintenance and expansion of the initiative?

It is important to have a commercialized system in place to ensure the sustainability of all resource-oriented sanitation technologies. Under this system, households opting for the technology would be required to pay a service fee for the collection of urine and feces. The collected excreta would

then be treated and sold as fertilizers to farmers. However, there are significant challenges associated with willingness-to-pay and behavioral factors, particularly concerning affordability and maintenance costs (Banamwana et al., 2022). Users are reluctant to spend on service charges for urine-diverting toilets (Ejigu & Yeshitela, 2023). Additionally, Kassa, (2009) highlights challenges in residents' willingness to pay for managing dry feces, exchanging urine tanks, and contributing financially or through labor for waste transportation.

Consequently, the financial sustainability of resource-oriented sanitation heavily relies on NGO project funding. The government's role lies in supporting the system by providing workspace, technical assistance, and networking opportunities for businesses, both within and outside the government framework. However, no government institution directly oversees the integration, leading to financial constraints when projects are completed (Ejigu & Yeshitela, 2023).

A strong government commitment, coupled with financial backing, can drive research, pilot projects, and scale-up urine recycling initiatives. Public awareness campaigns can further promote acceptance.

5.3.3 Research and Education

Inadequate research and awareness surrounding urine recycling may impede its adoption. The lack of understanding regarding the benefits and challenges of urine recycling technology among policymakers, practitioners, farmers, and the public has proven to be a significant barrier, as observed in the case of the acceptance of ecological sanitation (ecosan) toilets in Ethiopia (Ejigu & Yeshitela, 2023). Ejigu & Yeshitela (2023) report that some farmers have a strong demand for organic compost made from excreta because organic compost offers similar benefits to commercial chemical fertilizers at a lower cost. However, elements like user awareness have an impact on the adoption of urine recycling technology, which makes this organic fertilizer more readily available (Lamichhane and Babcock, 2013). Urine-diverting toilet demand in households is still in its infancy, even though farms are placing a greater emphasis on organic fertilizer. Urine-diverting toilets are reluctant to be used because users believe they require more work than traditional pit latrines, which makes them abandon the technology (Ejigu & Yeshitela, 2023).

Educational and promotional initiatives that highlight the advantages of urine reuse in agricultural techniques can help facilitate the successful adoption of urine-diverting toilets and the use of their byproducts in agriculture (Roma et al., 2013). Thus, funding for education, research, and capacity-

building initiatives can increase knowledge and proficiency. Evidence-based approaches can be promoted through partnerships with academic institutions, research facilities, and agricultural and health extension agencies.

5.3.4 Monitoring and Evaluation

Urine recycling efforts are hard to evaluate when there aren't strong monitoring and evaluation systems in place. In their exploration of the advantages and disadvantages of resource extraction from waste streams, Ekane et al., (2016) emphasize the need for robust monitoring systems to address both perceived and real risks. Urine-diverting toilets and the use of organic compost are not regularly evaluated and monitored in Ethiopia (Ejigu & Yeshitela, 2023).

Proclamation No. 295/2002 (Articles 15/1 and 2) of the Federal Democratic Republic of Ethiopia (FDRE) states that the regional environmental agencies oversee monitoring and assessing the environmental impacts of both public and private development projects that have an impact on the sustainability of the environment and public health in the area. However, by using raw organic compost for agriculture, the Regional Environmental Agencies fail to appropriately supervise and evaluate organic compost manufacturers, whose products may negatively affect the environment and public health (Ejigu & Yeshitela, 2023). Moreover, quality assurance of organic compost is only carried out occasionally, even though the Regional Environmental Agencies must set up a system (Ejigu & Yeshitela, 2023).

Furthermore, neither government nor private organizations provide certification services for the quality of organic compost or agricultural goods that use it as fertilizer (Ejigu & Yeshitela, 2023). Adoption can be facilitated by putting in place monitoring frameworks to keep tabs on developments, evaluate results, and modify plans in light of new information.

5.4: Business strategies that can be developed to enhance the scalability and sustainability of urine recycling for agricultural use in Ethiopia

The successful implementation of resource-oriented sanitation systems hinges on collaboration, effective policies, and stakeholder engagement (van Leeuwen et al., 2018). Moreover, societal acceptance plays a pivotal role, influenced by factors such as awareness levels, religious beliefs, socioeconomic status, and environmental perceptions (Gwara et al., 2022). Illustrated in the causal loop diagram (see Figure 4), the significance of an enabling policy and regulatory framework for the scalability and sustainability of urine recycling becomes evident. Enabling policies can

enhance institutional efficiency, prioritize urine recycling in national sanitation strategies, foster public-private partnerships, and bolster the capacity of NGOs, often the primary drivers of urine recycling projects. Additionally, the presence of enabling policies may facilitate funding for research on urine recycling, thereby advancing knowledge dissemination, raising awareness, and ultimately shifting societal mindsets toward greater acceptance of urine recycling. This increased social acceptance encourages more households to adopt urine recycling practices, contributing to its widespread adoption. Consequently, the adoption of urine recycling translates to greater availability of urine-based fertilizers for farmers, leading to improved farm yields and promoting better sanitation practices. This, in turn, reduces environmental pollution and enhances public health and food security by safeguarding water sources.

Additionally, the impact of policies on public-private sector partnerships can shape private-sector engagement in urine recycling, potentially spawning new businesses offering sanitation products and services. This, in turn, can affect the accessibility and pricing of these products and services for households adopting urine recycling practices. Below, we plunge into several business strategies aimed at boosting the scalability and sustainability of urine recycling for agricultural purposes.

a. Ethiopia needs to develop and implement targeted policies to support and advance resource-oriented sanitation practices, such as urine recycling while establishing clear regulatory frameworks for the production and utilization of Urine-Based Fertilizers (UBFs) and other biofertilizers.

b. By forming partnerships with financial institutions, the government can facilitate tailored loans for businesses engaged in sanitation-related activities, encouraging local production of sanitary equipment like Urine Diverting Toilets (UDTs), urine drying technologies, and storage facilities. Additionally, fostering the growth of enterprises offering sanitation services such as waste collection, transportation, treatment, and biofertilizer production. This initiative aims to incentivize private investment in urine recycling and enhance the accessibility of cost-effective sanitation products and services.

c. Provided that accessible loans are made available, private enterprises currently collaborating with municipalities in sludge management services can expand their

operations to include urine collection and treatment. Alternatively, they can partner with other businesses specializing in urine treatment and biofertilizer production, leveraging existing infrastructure and expertise to promote urine recycling initiatives further.

5.5 Discussion

Improving sanitation isn't just about building better facilities—it's about changing mindsets and behaviors at the individual, group, and community levels (Esrey et al., 1998). For urine recycling systems to be truly sustainable, a bunch of factors need to be considered. These include things like how the local climate and seasons might affect the system, the potential impact on water resources, and the risk of pollution. It is also important to understand the cultural and behavioral aspects of the community where the system will operate, as well as the practical aspects of how the system will work and be maintained. In a nutshell, we need to think about everything from the environment to people's habits to the nuts and bolts of the system itself if we want it to succeed in the long run (Esrey et al., 1998).

A strong government commitment to urine recycling is indispensable, particularly for scaling efforts, especially in urban areas where legal regulations significantly impact sanitary system construction. NGOs and civil society organizations can assist governments in formulating favorable policy frameworks (Esrey et al., 1998). Frameworks from countries such as Sweden and Switzerland where urine recycling enjoys great support can guide countries like Ethiopia in developing frameworks that enable adopting and sustaining resource-oriented sanitation. Effective implementation and utilization of urine recycling systems rely heavily on community-based initiatives. Both central and local government participation is essential to ensure their expansion and sustainability. Additionally, collaboration with private enterprises is crucial for the long-term viability of these systems. Sole reliance on NGOs for urine recycling initiatives may result in failure after the initial pilot phase. Conversely, government efforts alone may not guarantee a sustainable solution. Thus, a public-private partnership is indispensable for ensuring longevity and sustainability. The government plays a key role in creating an enabling environment for private sector involvement. This includes establishing effective policy and regulatory frameworks to foster strong institutions that can support and guide various stakeholders. Furthermore, local manufacturers should engage in producing sanitary wares tailored to meet local needs and

conditions. Promoting innovative business models focused on sanitation services, such as collecting, transporting, and treating urine and feces for use as fertilizers, is crucial (Ejigu & Yeshitela, 2023).

Compared to most traditional sanitation systems, urine recycling systems are more complicated and typically impose more of the burden for proper operation on individual families and local communities. Users need to understand that, even with possible health advantages, inappropriate toilet usage can become a nuisance and endanger public health (Esrey et al., 1998). It is preferable to adopt the right behaviors early on to prevent these issues. Furthermore, extra caution is needed to fully utilize the recycled plant nutrients' substantial resource potential. Families and people need to know how the UDT system operates, and what may go wrong and have the dedication and know-how to properly manage it at the home level.

Studies carried out in Kenya highlight how crucial it is to take into account regional customs and preferences when making decisions about sanitation (Andersson and Minoia, 2017). Farmers in southern India have varying opinions about using urine and feces as fertilizer; positive opinions are influenced by things like improved soil conditions and possible cost savings (Simha et al., 2017). In Hawaii, awareness of and concerns about legal regulations impact people's willingness to pay for urine-diverting dry toilets (UDDT) (Lamichhane and Babcock, 2013). High building costs and little government backing are obstacles to UDDT implementation in rural Bangladesh (Uddin et al., 2014).

Sanitation initiatives ought to align with the expressed needs of communities and households, rather than imposing predetermined solutions from external sources. Projects often falter when potential users neither recognize the necessity for alternative sanitation nor possess an adequate understanding of construction and maintenance procedures (Esrey et al., 1998). Regardless of the apparent effectiveness of resource-oriented sanitation systems, their sustained success hinges on garnering trust and acceptance among potential users. To assimilate into local culture, these systems must demonstrate efficacy and gain endorsement from influential local figures (Esrey et al., 1998). According to Simha et al. (2017), programs designed to recycle nutrients must have the active participation and trust of stakeholders. They emphasize how crucial it is to start conversations early and keep in constant communication with users. Ddiba et al.(2020) stress that for projects aiming at resource recovery to be successful, stakeholders from a variety of sectors

must work together. In governance and resource recovery, Rodríguez et al. (2020) emphasize the value of involving pertinent stakeholders and developing cooperative partnerships, stressing their significance at every level, from early planning to final execution. This highlights how different players must work together to successfully execute and advance resource recovery initiatives.

Additionally, it is critical to include local users in the trial phase. During this stage, the new system can be tested and adjusted to fit the environmental and cultural norms of the area. The program's longevity and long-term performance will be greatly impacted by this stage's efficacy. Initial subsidies should align with long-term pricing structures to prevent reliance solely on free offerings, which may lead to abandonment. Users' willingness to contribute their resources, rather than depending exclusively on external financing, is a key indicator of acceptance and enduring success (Esrey et al., 1998).

Identified households can serve as pivotal agents for introducing urine recycling concepts within a community. Positive experiences shared by these households tend to propagate swiftly. Encouraging collaboration among these households facilitates mutual learning and support, mitigating initial skepticism and rejection from other community members (Esrey et al., 1998). The inclusion of women from the outset is paramount, as they bear primary responsibility for household water supply, sanitation, hygiene, and food preparation. Their perspectives and concerns must be solicited and incorporated into both program design and detailed decision-making processes (Esrey et al., 1998).

6. Policy Recommendations

To address the lack of clear policies and unlock the potential of urine recycling and biofertilizers in Ethiopia, several solutions can be explored:

1. **Develop Specific Regulations:** Creating regulations tailored to the production, labeling, and use of biofertilizers is crucial. These regulations should address quality standards, safety requirements, and environmental considerations to ensure biofertilizers' sustainable and responsible use in Ethiopian agriculture. Establishing monitoring and evaluation mechanisms to track the implementation and impact of urine recycling and UBF policies is also important. This includes assessing adoption rates, environmental impacts, and socio-economic benefits to inform future policy adjustments and improvements. Action steps include reviewing successful legal frameworks from Sweden and adapting elements applicable to the Ethiopian context.

2. **Stakeholder Engagement:** Effective policy development necessitates collaboration. Engaging with relevant stakeholders, including farmers, agricultural researchers, industry representatives, NGOs, and policymakers, is vital to gather input and develop practical and effective policies that address the needs and concerns of all involved (Drechsel & Karg, 2018; Simha et al., 2017).

3. **Capacity Building:** Equipping stakeholders with the necessary knowledge and skills is essential. Providing training and technical assistance to farmers, households, extension workers, and producers on urine recycling and UBFs can significantly enhance their understanding and facilitate their adoption and integration into sanitation and agricultural practices. This can be achieved through extension services, demonstration plots, and knowledge-sharing platforms that highlight the benefits of biofertilizers in improving soil fertility, enhancing crop productivity, and reducing reliance on chemical fertilizers. (Esrey et al., 1998).

4. **Research and Development:** Investing in research on biofertilizer technologies suitable for Ethiopian conditions is important. Investment in research and development to improve urine treatment technologies and develop low-cost, decentralized urine recycling systems

suitable for Ethiopian conditions is essential. This can involve partnerships with universities, research institutions, and private-sector stakeholders.

5. **Detailed Standards for Biofertilizers:** Detailed standards for biofertilizer production and application should be created and strict quality control measures followed. Standards from the EU and Sweden can guide this process as it is applicable in the Ethiopian context. This will promote the adoption of best practices for biofertilizer production and its use.

6. **Cross-Sectoral Coordination**: Coordination and collaboration between relevant government agencies responsible for agriculture, sanitation, water resources, and environmental protection should be encouraged. This will ensure coherence in policy implementation and maximize synergies between different sectors (Ddiba et al., 2022; Ejigu & Yeshitela, 2023).

7. **Incentive Mechanisms:** Introducing incentive mechanisms such as subsidies, loans, or certification schemes can significantly stimulate urine recycling adoption. These incentives can help offset initial costs associated with UBF production and encourage investment in sustainable agricultural practices. Action steps include facilitating tailored loans for businesses engaged in sanitation-related activities, to encourage local production of sanitary equipment like Urine Diverting Toilets (UDTs), urine drying technologies, and storage facilities thereby fostering the growth of enterprises offering sanitation services to incentivize private investment in urine recycling and enhance the accessibility of cost-effective sanitation products and services.

8. **Policy Integration:** Integrating urine recycling objectives and biofertilizer policies with existing national sanitation strategy, agricultural, environmental, waste management, and urban and rural development policies can ensure coherence and alignment with broader development objectives. This strategy can facilitate the large-scale adoption of urine recycling and mainstreaming of biofertilizers into agricultural systems promoting their sustainable use and management.

By implementing these solutions, Ethiopia can overcome the lack of clear policies on urine recycling and the use of biofertilizers and create an enabling environment for their adoption.

7. Conclusion

This study has explored the potential of urine recycling as a sustainable solution for nutrient management and agricultural productivity in Ethiopia. By examining the existing policy landscape and institutional frameworks, several key insights have emerged.

The analysis reveals that Ethiopia's current policies and regulations do not explicitly address urine recycling or the use of urine-based fertilizers (UBFs) and other biofertilizers. However, certain policies, such as the Environmental Pollution Control Proclamation and the Ethiopian Organic Agriculture System Proclamation, provide a foundation for promoting sustainable practices and resource recovery. Capitalizing on these existing policies and amending them to incorporate specific provisions for urine recycling could pave the way for its adoption and integration into the agricultural sector. Also, developing specific regulations and guidelines for the production, labeling, and use of biofertilizers like urine-based fertilizers (UBFs) is crucial. These regulations should cover quality standards, safety protocols, and environmental concerns to ensure responsible and sustainable use. Additionally, it is essential to establish clear monitoring and evaluation mechanisms to track the implementation and impact of urine recycling and UBF policies for effective oversight and continuous improvement.

The institutional landscape in Ethiopia demonstrates a complex interplay between various stakeholders, including government ministries, research institutions, non-governmental organizations, and private sector entities. Effective coordination and collaboration among these institutions are crucial for the successful development, promotion, and adoption of urine recycling technologies and practices. Strengthening the institutional capacity of relevant ministries (e.g., Ministry of Health, Ministry of Water, Irrigation, and Energy, Ministry of Urban Development and Housing, Ministry of Agriculture and Rural Development) is necessary to effectively formulate, implement, and enforce policies related to urine recycling and UBF use. Fostering collaboration and coordination among these ministries, as well as with research institutions, NGOs, and the private sector, is crucial for aligning efforts and leveraging collective expertise. Investing in research and knowledge dissemination on urine recycling technologies, best practices, and the benefits of UBFs would support evidence-based policymaking and raise awareness among stakeholders.

From a business perspective, several strategies can be employed to enhance the scalability and sustainability of urine recycling for agricultural use in Ethiopia. These include developing decentralized urine collection and treatment systems, promoting public-private partnerships, and exploring innovative financing mechanisms. Facilitating public-private partnerships by providing incentives, such as tailored loans or subsidies, for businesses engaged in sanitation-related activities like urine collection, treatment, and UBF production would encourage private investment and enhance the accessibility of these services. Encouraging collaboration between private enterprises and municipalities in waste management services to expand their operations to include urine recycling initiatives could leverage existing infrastructure and expertise. Engaging the private sector in the development and local production of sanitation equipment like urine-diverting toilets and urine-treatment technologies would improve the availability and affordability of these products for households.

Additionally, involving local communities, particularly women, in designing and implementing urine recycling programs is essential for ensuring cultural acceptance and addressing specific needs and concerns. Conducting awareness campaigns and educational programs to highlight the benefits of urine recycling and UBFs for farmers, households, and the environment would help shift societal mindsets and promote adoption. Leveraging existing agricultural extension services and NGO-funded initiatives to train local farmers and households on urine recycling practices and the use of UBFs would facilitate knowledge transfer and skill development.

In conclusion, this study underscores the need for a comprehensive and integrated approach to promote urine recycling in Ethiopia. By leveraging existing policies, strengthening institutional frameworks, and fostering collaboration among stakeholders, Ethiopia can unlock the potential of this sustainable solution to address the intertwined challenges of sanitation, nutrient management, and agricultural productivity. Embracing urine recycling contributes to environmental sustainability and aligns with Ethiopia's broader goals of achieving food security, improving public health, and promoting sustainable development.

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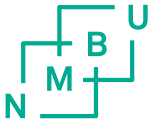

Norges miljø- og biovitenskapelige universitet
Noregs miljø- og biovitskapelege universitet
Norwegian University of Life Sciences

Postboks 5003
NO-1432 Ås
Norway