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Integrating resource oriented sanitation technologies with urban agriculture in developing countries: measuring the governance capacity of Arba Minch City, Ethiopia

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This research study aims to assess the capacity of Arba Minch City to adopt resource-oriented sanitation technology and integrate it with urban agriculture. The overarching goal is to promote sustainable urban development by not only using resources efficiently but also recovering resources from urban waste streams. To measure the city's governance capacity, the study employs a Governance Capability Framework (GCF), which identifies nine conditions and three indicators for each condition across three dimensions: knowing, wanting, and enabling. The framework helps assess the city's capacity for governance throughout the integration of urban agriculture with ecological sanitation (ecosan) technology. The research employs a triangle strategy, which consists of desk research, gray and scientific literature review, and a semi-structured interview with 27 indicators. By employing these strategies, the research evaluates Arba Minch's governance capacity to implement ecological sanitation integration with urban agriculture. The findings of the study show that Arba Minch City's governance capacity to integrate ecosan with urban farming is affected by several factors. These factors include a lack of systematic monitoring and evaluation of previous projects, fragmentation of policy tools to govern the integration of the system, and a lack of adequate public sector participation. Additionally, there is no government body responsible for integrating the system, and various non-governmental organizations play a significant role in financing, organizing, and implementing the system. On the user side, the study reveals a behavioral gap in adapting to resource-oriented sanitation technology and recovered organic fertilizer. The findings suggest that long-term system management requires a strong, active, and well-trained community group capable of taking on the role and responsibility of running similar projects. Furthermore, to mitigate the policy fragmentation challenge, policy harmonization and integration among actors to negotiate, deliberate, and agree on measures to be taken are critical. In conclusion, the study suggests that similar project developers should investigate the factors that motivate users of new technology and influence their behavioral changes. Ultimately, the study recommends a more comprehensive approach to resource-oriented sanitation technology and urban agriculture integration that takes into account governance capacity and community engagement.

KEYWORDS

ecological sanitation, governance capacity, governance capacity framework, organic fertilizer, resource-oriented sanitation technology, urban agriculture

1. Introduction

1.1. Global sanitation systems and organic waste streams

In 2008, the urban population exceeded the rural population for the first time in human history (Collender, 2011). Despite rapid urbanization in developing countries, Africa remains primarily rural (Chunga et al., 2016). The rapid growth of cities puts a strain on natural resources such as water and food and generates solid and liquid waste, leading to environmental degradation (Drechsel and Karg, 2018). Moreover, the continuous growth of the world population and finite non-renewable resources have created an imbalance between production and consumption, leading to extensive resource exploitation and significant waste generation. In urban areas, where resources are extracted, consumed, and discarded without treatment, creating a linear metabolism that poses two main challenges (Wielemaker et al., 2018). The continuous use of resources, such as phosphorus and fossil fuels, puts pressure on critical resources, and waste disposal after consumption pollutes the natural environment through water, air, and land pollution, biodiversity loss, and resource contamination. Considering an average excreta generation rate of 1.5 liters per day per person and omitting the water consumed for excreta transit in sewer systems, it has been determined that urban areas produce more than six billion liters of excreta every day (Rose et al., 2015).

The conventional sewage management approach follows a "flush-and-discharge" model that separates people from waste. This approach is characterized by a linear take-make-dispose model, encompassing the stages of production, consumption, and waste disposal (Spuhler and Lüthi, 2020; Ahmed et al., 2022). It is the predominate sanitation system characterized by a top-down, technology-focused approach, which has often proven insufficient in addressing the current urban sanitation challenges (Simha and Ganesapillai, 2017). However, this method has proven to be effective only for those who have access to the necessary infrastructure for flush toilets (Esrey et al., 2001). The conventional sewage management philosophy considers urine and feces as waste that must be treated and removed from the urban fabric (Simha and Ganesapillai, 2017). This particular sanitation system functions within a linear economy framework, which leads to environmental pollution, significant waste production, and inefficient use of resources (Ahmed et al., 2022). According to Spuhler et al. (2021), it has been observed that the top-down and technology-centered approach to urban sanitation frequently falls short in addressing the present-day challenges. As a result, this approach incurs significant environmental external costs (Langergraber and Muellegger, 2005). In contrast, developing countries frequently adopt the "drop-and-store" approach, driven by limited space, which brings forth notable challenges and problems for the agricultural and water sectors. These challenges encompass unpleasant odors, the attraction of disease-carrying organisms, and the contamination of soil and groundwater by pathogens (Werkneh and Gebru, 2022). Additionally, in most Sub-Saharan African nations, both centralized and decentralized wastewater treatment facilities are lacking, further worsening the issue of insufficient coverage for the continuously growing population in the region (Ijoma et al., 2022).

A circular or "closed-loop" approach that treats nutrients and organic matter derived from urine and feces as valuable resources provides an alternative to the conventional waste disposal methods. Ecosan is a common closed-loop approach that suggests using excreta as fertilizer in agricultural activities (Chunga et al., 2016). This approach has several benefits, including the provision of safe, clean, and high-quality sanitation and hygiene services by limiting excreta disposal into the environment. The approach is independent in terms of sewers, water, and energy, making it particularly suitable for urban areas in developing regions (Spuhler et al., 2021). Moreover, this system generates organic nutrient resources that contribute to sustainable agriculture, improving soil fertility, soil pH, soil organic carbon, soil aggregation, food security, and water conservation (Haq and Cambridge, 2012; Sukitprapanon et al., 2020; Ryals et al., 2021).

Organic waste refers to various waste streams, including human excreta, food waste, agricultural waste, and other organic materials. These waste streams contain valuable resources such as water, nutrients, energy, and other material components (Ddiba et al., 2022). Managing organic waste has substantial impacts on sustainability, specifically in the agricultural sector and managing nutrients. In order to ease the negative impacts of organic waste, an innovative method in the whole food system is required (Springmann et al., 2018). Source-separating sanitation systems, in particular, have emerged as a viable paradigm for wastewater management that enables the recycling of nutrients from organic waste, such as human excreta, as agricultural fertilizers (Harder et al., 2019). Agriculture's effects on the world's nutrient sources, sinks, and cycles can be mitigated, as can the accompanying environmental consequences (Ddiba et al., 2022).

With the nitrogen (N) and phosphorus (P) cycles being of special importance, the global food system, which is predominantly driven by agriculture, is a significant contribution to the violation of planetary boundaries (Gladek et al., 2017). There is a risk of functional collapse due to the excessive human intervention in these nutrient cycles, which has gone beyond the safe boundaries (Rockström et al., 2009). The global N and P cycles depend heavily on agriculture, yet conventional methods have depleted non-renewable resources and had a severe impact on human and environmental health (Campbell et al., 2017). Given the rising worldwide population and per capita food consumption, these issues pose a threat to the long-term viability of the global food production system (Béné et al., 2019).

Various organic waste streams, including human excreta, food waste, agricultural waste, manure, and slaughterhouse waste, are available for circular treatment in urban environments. These waste streams include a wealth of embedded resources that can be recovered by circularity techniques, including water, nutrients, energy, and other materials (Ddiba et al., 2022). Circularity holds potential for lowering the requirement for natural resource extraction and minimizing waste generation through resource recovery from organic waste (Ddiba et al., 2022). For example, organic waste such as livestock manure and compost contains valuable nutrients like nitrogen (N), phosphorus (P), potassium (K), sulfur (S), and trace minerals that support crop growth (Rahman et al., 2014). Moreover, organic matter derived from organic waste improves soil fertility, enhances microbial activity, and promotes plant growth, contributing to sustainable soil-plant systems (Bhattacharyya et al., 2005; Chauhan et al., 2012).

1.2. Resource oriented sanitation systems

Resource-oriented sanitation systems, such as ecological sanitation (ecosan), aim to treat human excreta as a valuable resource rather than waste, challenging the conventional perception of excreta (Langergraber and Muellegger, 2005; Simha and Ganesapillai, 2017). These systems involve on-site processing and off-site treatment of excreta, with the goal of recycling the nutrients for agricultural use (Langergraber and Muellegger, 2005). By integrating ecosan with urban agriculture, opportunities arise for organic waste recycling, improved soil fertility, reduced waste management costs, and enhanced food security, all while considering public health concerns (Schipanski et al., 2016).

Ecosan technologies encompass various options, including compost toilets, decentralized wastewater treatment systems, and urine diversion systems (Langergraber and Muellegger, 2005). Urine diversion plays a critical role in ecosan systems, separating and concentrating nutrients while mitigating pathogens and micro pollutants (Simha and Ganesapillai, 2017). The shift toward resource recovery from human urine highlights the need for integrated technological pathways that ensure safe and efficient nutrient recovery and pathogen inactivation (Simha and Ganesapillai, 2017).

The core principles of ecosan revolve around minimizing hygienic risks, protecting the environment, returning nutrients to the soil, conserving water resources, and ensuring affordability, acceptability, and cultural compatibility (Langergraber and Muellegger, 2005). To successfully integrate resource-oriented sanitation systems with urban agriculture, collaborative efforts, effective policies, and stakeholder cooperation are essential (van Leeuwen et al., 2018). Social acceptance also plays a crucial role, influenced by factors such as awareness, religiosity, income, and environmental dispositions (Gwara et al., 2022). Continued research and knowledge sharing are vital for optimizing nutrient recovery, developing sustainable management strategies, and promoting successful implementation of resource-oriented sanitation systems (Harder et al., 2019; Ryals et al., 2021). While resource-oriented sanitation systems present opportunities for improved resource efficiency, reduced reliance on chemical fertilizers, enhanced water conservation, and decentralized approaches, challenges persist (Schipanski et al., 2016). These challenges include social acceptance, awareness, proper management, maintenance, and addressing technical issues (Kumwenda et al., 2016; Gwara et al., 2022).

The perception and attitude toward adopting ecosan toilet and using excreta fertilizer for urban agriculture in developing countries remains a challenge (Akpan et al., 2020). In Ghana, for instance, there exists negative perception toward fresh excreta, despite recognition of its potential as fertilizer (Mariwah and Drangert, 2011). Research in Kenya underscore the significance of taking into account local cultures and preferences when making decisions related to sanitation (Andersson and Minoia, 2017). In southern India, farmer attitudes toward the reuse of urine and feces as fertilizers exhibit variations, with factors such as the enhancement of soil quality and potential cost savings influencing positive attitudes (Simha et al., 2017). In Hawaii, willingness to pay for urine diverted dry toilet (UDDT) is influenced by awareness and concerns about legal provisions (Lamichhane and Babcock, 2013). Challenges in implementing UDDT in rural Bangladesh include high construction costs and limited government support (Uddin et al., 2014). Psychological factors, such as risk and benefit judgments, influence the acceptance of excreta as fertilizer in Rwanda and Uganda (Ekane et al., 2016).

1.3. Urban agriculture

Due to changing societal values and the need to balance resource use and security in cities, urban agriculture has become more popular in the 21st century (Dobele and Zvirbule, 2020). "Urban agriculture" is the most often used and fundamental phrase, although it covers other ideas as well, including urban farming, urban gardening, and urban horticulture (Schram-Bijerk et al., 2018). Aware of the potential for sustainable development, the Food and Agriculture Organization of the United Nations (FAO) coined the term "urban agriculture" to describe agricultural methods carried out in urban settings (FAO, 1996). Defining urban agriculture precisely is crucial for guiding development initiatives and understanding its role, although variations in definitions across case studies and contexts pose challenges for global data quantification and comparison (Thebo et al., 2014; Sanyé-Mengual et al., 2016). The FAO's broad definition includes the cultivation of crops, plants, and livestock in urban and peri-urban areas, utilizing small urban spaces such as gardens, open areas, balconies, and containers (Poulsen et al., 2015). Some definitions expand the scope to encompass indoor cultivation as well (Azunre et al., 2019).

Urban agriculture is a multifaceted practice occurring within or on the fringes of urban areas, involving the cultivation, processing, and distribution of various food and non-food products using predominantly urban resources and services (Mougeot, 2000). It also serves as a livelihood means for income generation and sources of food, creating income for urban farmers, and has a significant contribution to socio-economic and environmental aspects (Smit et al., 1996; Yuan et al., 2022). Urban agriculture functions within the socio-economic and cultural dynamism of urban centers, integrating into the spatial structure of the city and involving a range of stakeholders that include communities, the public sector, the private sector, and NGOs (Vejre et al., 2016).

The contribution of urban agriculture in developing countries is mainly to solve food insecurity, create income for urban farmers, satisfy urban farmers food demands, and minimize dependence on external sources (Smit et al., 1996; Mekuria and Messay, 2018). Urban agriculture also facilitates the efficient and effective utilization of urban resources, such as organic waste, and enhances the aesthetic quality of cities (Mekuria and Messay, 2018). In developed countries, urban agriculture takes on a different character, emphasizing recreational, social, and environmental aspects, fostering community engagement, and promoting localized food systems (Smit et al., 1996; Wadumestrige

Dona et al., 2021). Both developing and developed countries utilize organic waste to enhance soil fertility, nutrient cycling, and waste management in urban agriculture (Drechsel et al., 2015; Rose et al., 2015). By converting organic waste into compost or utilizing treated wastewater and biosolids, urban agriculture reduces waste accumulation and minimizes the need for synthetic fertilizers (Waqas et al., 2023). However, proper treatment processes and regulations are necessary to ensure the safe and controlled use of organic waste, minimizing health risks and protecting public health and the environment (Strauss et al., 2017).

1.4. Governance capacity framework

The Governance Capacity Framework (GCF) has evolved as a response to the challenges faced in urban water management. Water governance requires consideration of multiple aspects, interests, and actors (Koop et al., 2017). According to the Global Water Partnership, GCF involves instruments, processes, and institutions that permit actors from several sectors to contribute ideas, decide on their priorities, apply their rights, realize their respective obligations, and compromise differences based on their capacities. A study by the Organization for Economic Cooperation and Development (OECD, 2011) on the governance of water depicts that due to institutional fragmentation, unclear legislation, inadequate capacity, poor financial management, blurred roles and responsibilities, and insufficient harmonization of goals, water governance has become a huge issue. These drawbacks call for an effective and efficient governance system that is able to address water-related issues such as water supply, wastewater management, and organic waste management.

The City Blueprint Approach (CBA) was developed to improve the transition of urban centers into water-wise cities so as to alleviate the challenges of water, waste, and climate change (Koop and van Leeuwen, 2015). The CBA comprises three related frameworks, which include the Trends and Pressures Framework (TPF), the City Blueprint Framework (CBF), and the Governance Capacity Framework (GCF) (Koop and van Leeuwen, 2015). The role of TPF is to evaluate the critical problems that the city faces related to water, waste, and climate change. The CBF, on the other hand, assesses how urban management manages its water cycle. Finally, GCF determines the major opportunities and constraints in city water governance (Koop et al., 2017). Integrating those three frameworks can benefit resource managers and decision-makers through comprehensive identifications of water-related challenges and capacities so as to address the challenges and maximize the opportunities.

Governance is at the heart of developing the GCF with wide research and practical application, with particular emphasis on water governance as a major universal challenge (Koop and van Leeuwen, 2015). The GCF is made up of three interconnected components: enabling game rules, convergent discourses, and facilitating resources (Dang et al., 2016). The GCF identifies the critical role of effective governance in dealing with difficult problems and focuses on governments' capability to mobilize resources, engage a range of actors, and implement policies (Dang et al., 2016). Therefore, under the umbrella of GCF, governance refers to rules, institutions, discourses, and resources forming the basis for effective governance processes (Witjes et al., 2019).

The assessment of governance capability includes evaluating the capacity of societal groups to cooperate and solve common challenges, considering factors such as institutional capacity, social interactions, information sharing, and collaboration among various stakeholders (Driessen et al., 2012). The assessment of governance capacity is important to understand the quality of governance and its implications for the socio-economic and political development of the city's ability to implement various programs (Fuchs and Lorek, 2005). Although the discussion on the definition and comprehensive assessment of governance capacity continued (Fuchs and Lorek, 2005), various literature identifies governance capacity as an important precondition for meeting sustainable development goals and focuses on the demand for accurate frameworks to effectively assess and improve it (Kaufman et al., 2002).

The applicability of the GCF extends beyond developed countries to also encompass developing countries. In developed countries, the framework aids in assessing governance structures' effectiveness and provides insights into addressing urban challenges related to water, waste, and climate change (Koop et al., 2017). Decision-makers can utilize the GCF to gain a deeper understanding of governance dynamics and find solutions to these challenges. In developing countries, the GCF offers guidance for strengthening governance capacity amid resource constraints and institutional challenges (Ddiba et al., 2020). It enables the examination of governance challenges associated with implementing circular economy initiatives, particularly in low- and middle-income country contexts (Ddiba et al., 2020). This broader perspective of governance capacity facilitates exploring stakeholder interactions, identifying prerequisites for resource-oriented urban sanitation and waste management systems, and understanding decision-making processes in urban governance.

The literature on governance capacity encompasses diverse dimensions and approaches. For example, Dang et al. (2016) utilized the GCF to evaluate governance capacity in the policy of forest land allocation in Vietnam, revealing the intricate links between institutional capacity, governance performance, and socioeconomic contexts. Witjes et al. (2019) applied the GCF to analyze the effectiveness of Digital Social Platforms (DSPs) in enhancing governance capacity through collaborative learning in Key Demonstration Cities, focusing on enabling conditions, collaborative learning, and the influence of socio-economic, political, cultural, and technological factors in addressing urban water challenges. These studies highlight the practical application of the GCF and its potential to advance governance capacity assessment in various contexts.

Governance capacity is of paramount importance in managing the integration of ecosan toilet output with urban agriculture. The traditional government structure is ineffective in managing integration because the issue transcends existing administrative boundaries, necessitating thinking outside of the official government structure (Ddiba et al., 2020). Moreover, the existing government system has fragmented scopes, philosophies, and responsibilities, making it necessary to resolve impending governance issues when integrating ecosan and urban agriculture (Koop et al., 2017). Most studies in the literature on nutrient recycling from organic waste focus on one sector, while the issue requires comprehensive research in multi-sectoral contexts (Ddiba et al., 2020; Rodríguez et al., 2020). Although the themes of public administration, development, capacity building, and environmental governance have adequately addressed the governance issue, there has been little work to date to address the circular economy issue (Dang et al., 2016). Moreover, further investigation is necessary to identify the factors that enable engagement in closing the nutrient loop in the context of developing countries' urban centers.

1.5. Integrating resource oriented sanitation systems, urban agriculture, and governance capacity framework

The integration of resource-oriented sanitation systems and urban agriculture requires effective governance to ensure the safe and efficient utilization of organic waste and the promotion of sustainable practices (Rose et al., 2015). The GCF provides a comprehensive approach to assess and strengthen governance processes, emphasizing the capacity of governments to mobilize resources, engage stakeholders, and implement policies (Dang et al., 2016). By using GCF, various stakeholders, especially decision-makers, can determine governance-related gaps, enhance institutional frameworks, and improve cooperation to support the integration of resource-oriented sanitation systems and urban agriculture initiatives (Dang et al., 2016). Integrating resource-oriented sanitation systems with urban farming supports the strengthening of governance capability by enhancing devolved decision-making, stakeholder engagement, and efficient utilization of resources (Smit et al., 1996; Langergraber and Muellegger, 2005). Moreover, through community engagement, cooperation of stakeholders, and institutionalization of these practices into the planning of cities, governance capacity can be improved, resulting in more resilient, and sustainable cities (Witjes et al., 2019).

According to Koop et al. (2017) and Ddiba et al. (2020), the effective integration of urban agriculture with resource-oriented sanitation systems requires combined efforts, the participation of stakeholders, and implementable institutional frameworks. By utilizing the GCF, decision-makers can gain insights into governance dynamics, identify governance challenges, and find solutions to address urban challenges related to water, waste, and climate change (Koop and van Leeuwen, 2015; Witjes et al., 2019). The application of the GCF in both developed and developing countries offers guidance for strengthening governance capacity in the face of resource constraints and institutional challenges, facilitating the exploration of interactions between stakeholders and understanding decision-making processes in urban governance (Graham and Fortier, 2006).

There has been limited research on the governance capability of organic waste resource recovery for use in urban agriculture, both in developed and developing countries. Koop et al. (2017) built on their groundbreaking work by assessing governance capacity in the water area. Using an integrated and empirical approach, the study aimed to better understand the key conditions that either hinder or improve urban water governance in Amsterdam, the Netherlands. Koop and van Leeuwen (2017) investigated the limiting factors of sustainability from the perspective of water resources in 45 cities worldwide, mostly in Europe. The findings revealed that European cities are resource-efficient; however, cities in Eastern Europe, Latin America, Asia, and Africa lack basic services and thus need to enhance governance capacity to transition into water-wise cities.

The aim of the study is to pinpoint the elements that either strengthen or weaken a city's ability to manage the recovery of nutrients from organic waste for urban agriculture. The study was conducted in Arba Minch City, Ethiopia, and used the governance capacity framework developed by Koop et al. (2017) to examine how various stakeholders involved in the resource recovery process are governed. The study is divided into six sections. Section 2 describes Arba Minch City, Ethiopia, as a case study, giving priority to previous efforts to recover resources from organic waste for urban agriculture. Section 3 describes the research method, while Section 4 discusses the outcomes of governance capacity in Arba Minch City for managing the integration of organic waste for urban agriculture. Section 5 discusses the results of Section 4 using the framework of governance capacity, and Section 6 outlines the study's key findings. Finally, Section 7 concludes the major findings.

2. Case study city (Arba Minch, Ethiopia)

Arba Minch City in southern Ethiopia is experiencing rapid urbanization, covering an estimated 18,757 hectares (see Figure 1). The city benefits from favorable climatic conditions with an annual rainfall of 1,200 mm to 1,320 mm and an average temperature of 23 degrees Celsius. Situated at an elevation ranging from 1,200 m.a.s.l. to 1,320 m.a.s.l., it offers a conducive environment for urban development. The population has seen substantial growth, starting from 74,879 in 2007, projected to reach 105,000 by 2015 and surpassing 120,000 by 2019 (African Water Facility, 2015). Projections indicate an upward trend, with an estimated population of 190,000 by 2030 (African Water Facility, 2015). Recent data from the 2023 Structure Plan paints a more dramatic picture, with the city's population already at 232,811 in 2022 and further surging to 246,453 by 2023 (Arba Minch City Administration, 2022).

According to Kassa and Behalilu (2012), approximately 10% of the population in Arba Minch City lacks access to sanitation and resorts to open defecation in fields, bushes, or gorges. In addition, most people in the city use unimproved pit latrines, which are unhealthy and serve as breeding grounds for insects, flies, mice, and other vectors. The majority of pit sludge is manually removed from the old pit and thrown into the new one, or if there is room, the old pit is refilled and new pits are dug. The fecal sludge is released into open ground on the edges of the city when trucks are used to empty pits (Kassa and Behalilu, 2012). Furthermore, the city's solid waste coverage was approximately 34% in 2012 and improved to 65% in 2015, despite very limited waste segregation and reuse efforts (African Water Facility, 2015).

Urban agriculture in Arba Minch City covers a significant portion of the town's land, occupying approximately 3,246.304 hectares or 17.31% of the total land area of 18,757 hectares. The majority of urban agricultural activities are concentrated in the

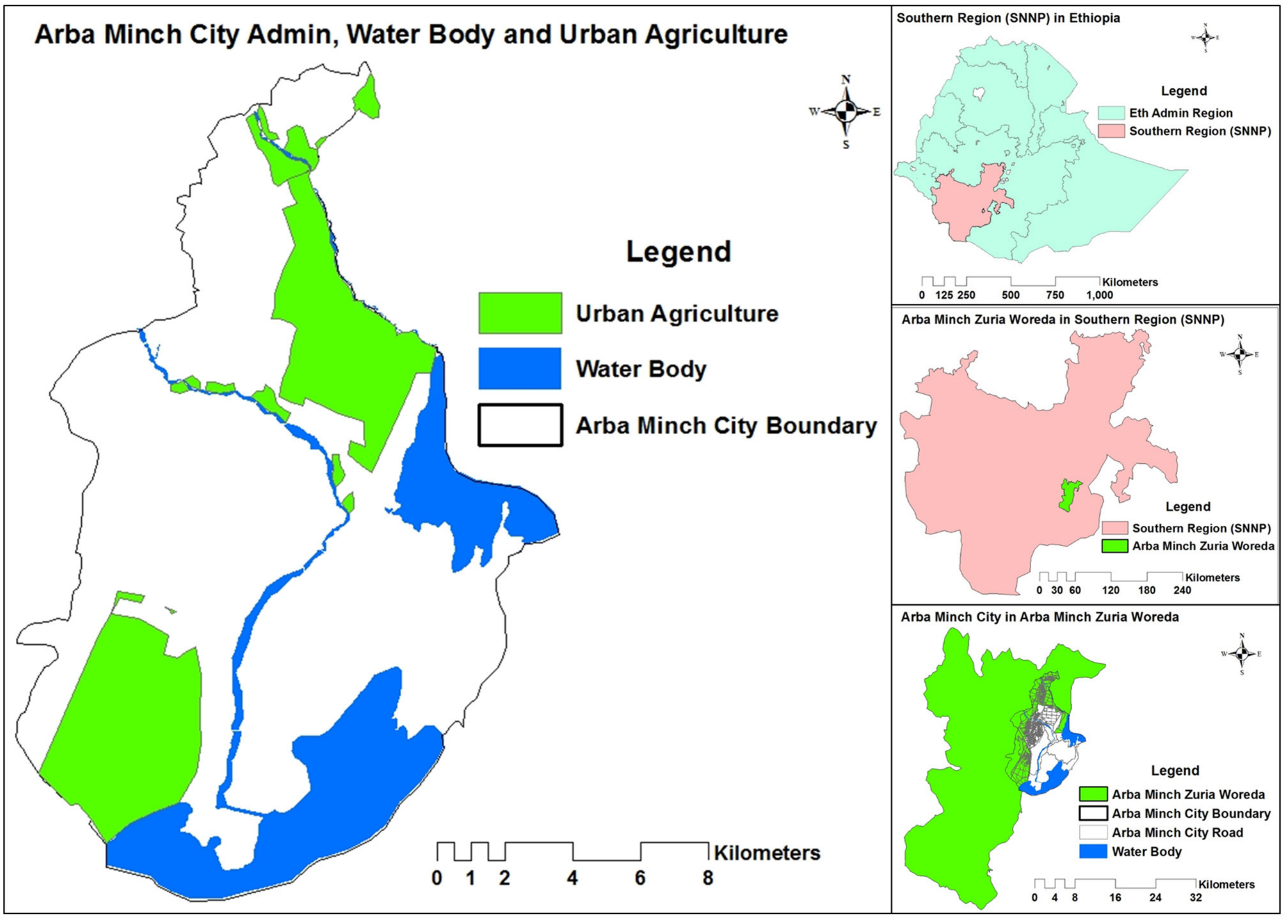

FIGURE 1
Study area.

northern and southern parts of the city, particularly in "Shara Kebele," "Kanchama," and "Gamo" Development Association. These areas provide suitable topography and convenient accessibility for day-to-day farming operations. Furthermore, there are smaller plots of land dedicated to urban agriculture along the Kulufo River, predominantly utilized by private individuals and small-scale enterprises. The agricultural practices in Arba Minch City primarily focus on the cultivation of vegetables and fruits, with a specific emphasis on the unique production of bananas. Urban agriculture along the "Kulfo" river allows farming activities to take advantage of nearby water resources. These local agricultural endeavors significantly contribute to the city's food production and support the livelihoods of its residents, bridging the gap between urban and rural environments. The availability of fertile land and suitable topography in these areas further facilitates the growth and sustainability of urban agriculture in Arba Minch City (Arba Minch City Administration, 2022).

The selection of Arba Minch City as the study site for researching the integration of resource-oriented sanitation systems with urban agriculture is justified by its active engagement in numerous relevant projects. The city serves as a hub of activity in Ethiopia, generating valuable knowledge and experiences that can be explored further in the study. With nearly two decades of sustained efforts in integrating resource-oriented sanitation systems with urban agriculture, Arba Minch offers an ideal setting for comprehensive research. The existing projects and ongoing initiatives in the city also present opportunities for collaboration, access to valuable data, and potential partnerships with local organizations and institutions.

To tackle the sanitation crisis in Arba Minch City, stakeholders have adopted new sanitation technologies. The Resource-Oriented Sanitation Concepts for Peri-urban Areas in Africa (ROSA), sponsored by the European Union, was the first to implement the resource-oriented sanitation concept in the city, aiming to achieve sustainable sanitation. During the project's lifespan (2006–2010), three ecosan toilets were created, including 16 UDDTs, 9 Arborloos, and 30 Fossa Alternas. Initially, ROSA covered the full cost of constructing a few ecosan toilets for demonstration purposes, but later users paid 75% of the cost, with the project contributing the remaining 25%. Along with the development of ecosan toilets, ROSA, in collaboration with the Arba Minch City Administration, established Micro and Small Scale Enterprises (MSSEs), specifically "Egnan Newu Mayet," a composting association, to collect organic waste from solid waste and excreta received from ecosan toilets and supply it to urban farmers producing bananas and vegetables in the city's peri-urban area.

The Sanitation for Peri-urban Areas in Africa (SPA) project, sponsored by the Dutch, began toward the final phase of the ROSA project and ran from 2009 to 2014. Its primary goal was to enhance ecosan toilets in Arba Minch by constructing 1,000 UDDTs, 2,200 Fossa Alternas, and 1,000 Arborlosses. The Arba Minch City Administration oversaw the project, while the Omo Micro Finance Institution provided loans to households using ecosan toilets at lower interest rates than the formal market rate. The SPA consortium also contributed seed funding to establish a revolving sanitation financing vehicle to fund various sanitation services in the municipality. Omo Micro Finance Institution managed loan disbursements and repayments from households (FDRE, 2015).

The Capacity-Linked Water and Sanitation for Africa's Peri-urban and Rural Areas (CLARA) project was established parallel to SPA to reinforce local capacities in water resource supply and sanitation sectors. During CLARA's duration, two small and micro enterprises that provided sanitation supply chain services, namely the "Wubet le Arba Minch" Solid Waste Collectors Association and the "Engan Newu Mayet" Compost Production Youth Association, received financial support and their performance was monitored. The CLARA project aided the Arba Minch municipality in developing a sustainable collection and treatment system for urine and feces (FDRE, 2015).

Recently, a project called "The Rural-Urban Nexus: Establishing a Nutrient Loop to Improve City Region Food System Resilience" (RUNRES) was launched to continue a similar initiative in the city. The project, which will run for 4 years, with an option for an additional 4 years, aims to establish safe, efficient, and socially acceptable innovations to close the nutrient loop and implement a circular economy to enhance people's resilience in the food systems of the Arba Minch Town, according to Arba Minch University (2019). Three MSSEs were established in Arba Minch City to close the nutrient loop: Egnanew Mayet Composting Association (ENMCPA), which recycles 1,100 tons of organic compost per year from municipal organic solid waste; Anjonus Fruit and Vegetable Processing Enterprise (AFVPE), an MSSE agro-processing enterprise that adds value to the banana value chain in Arba Minch and throughout Ethiopia, receiving raw bananas from smallholder farmers who use ENMCPA compost to facilitate the city's closed-loop nutrient cycle; and the MASSP Urine Recycling Enterprise, which has set itself up in congested areas such as bus public parks, stations, and market places to recycle urine into struvite fertilizer to close the nutrient loop.

In summary, since the launch of the first ecosan project in Arba Mnch city in 2006 by ROSA, more than 136 UDDT, 442 Fossa Alterna, and 9 Arbarloos have been constructed. NGOs have worked with the city administration, Arba Minch University, MSSEs, and other relevant actors to implement the integration of ecosan and organic solid waste with urban agriculture systems. While NGOs played a crucial role in the system's implementation since 2006, the Arba Minch City Administration has taken the lead in its development and management since 2015. Several success stories have been documented in the system. However, according to the Arba Minch City Administration, existing users of ecosan toilets and the peri-urban farming community have been poorly governed, and little is known about resident interest in replacing conventional systems with the new and innovative sanitation and organic compost system.

TABLE 1 The governance capacity framework.

Dimensions	Conditions	Indicators
Knowing	1. Awareness	1.1. Community knowledge
		1.2. Local sense of urgency
		1.3. Behavioral internalization
	2. Useful knowledge	2.1. Information availability
		2.2. Information transparency
		2.3. Knowledge cohesion
	3. Continuous learning Wanting	3.1. Smart monitoring
		3.2. Evaluation
		3.3. Cross-stakeholder learning
Wanting	4. Stakeholder engagement process	4.1. Stakeholder inclusiveness
		4.2. Protection of core values
		4.3. Progress and variety of options
	5. Management ambition	5.1. Ambitious and realistic management
		5.2. Discourse embedding
		5.3. Management cohesion
	6. Agents of change Enabling	6.1. Entrepreneurial agents
		6.2. Collaborative agents
		6.3. Visionary agents
Enabling	7. Multi-level network potential	7.1. Room to maneuver
		7.2. Clear division of responsibilities
		7.3. Authority
	8. Financial viability	8.1. Affordability
		8.2. Consumer willingness-to-pay
		8.3. Financial continuation
	9. Implementing capacity	9.1. Policy instruments
		9.2. Statutory compliance
		9.3. Preparedness

The framework consists of 27 indicators, nine conditions and three dimensions (Koop et al., 2017).

3. Methodology

The methodology used in this study is an adaptation of the Governance Capacity Framework (GCF) developed by Koop et al. (2017) as part of S.H.A. Koop (2019) doctoral dissertation. Initially, the GCF was created to identify the key factors influencing water governance capacity for five governance challenges, including solid waste management and liquid waste treatment (Koop et al., 2017). The GCF identifies nine conditions, each of which is assessed by three indicators, and the conditions are classified into three categories: knowing, wanting, and enabling (Koop et al., 2017). The "knowing" dimension refers to fully understanding, comprehending, and learning the risks and consequences of actions, policies, and strategic decisions. The "wanting" dimension, on the contrary, refers to the actor's willingness to collaborate, express, and act on ambitions, as well as apply their skills to find solutions. The "enabling" dimension was developed to assess actors' willingness to have the resources, network, and tools to carry out their goals (Koop et al., 2017).

For this study, the GCF was used by developing questions for all 27 indicators that are tailored to the study area context (Table 1). While the methodology in this study generally adheres to the GCF developed by Koop et al. (2017), special attention was given to the multi-sectoral context of integrating ecosan with urban agriculture. The study also employed the triangular approach used by Koop et al. (2017), where a desk review of policy papers, and gray and academic literature associated with organic waste use for urban agriculture in Arba Minch was carried out. The desk study provided the research with an initial score on the indicators and a primary result of governance capacity in Arba Minch City. The desk study also aided in identifying key stakeholders for interviews during field data collection.

The researcher also carried out a focus group discussion (FGD) with key stakeholders such as non-governmental organization officials, government officials, and experts from various government offices before the selection of actual interviewees so as to determine potential participants of the interview. The FGD was strengthened by site visits with key stakeholders in essential locations like the ENMCPA composting place, the MASSP Urine Recycling Enterprise site, including the enterprise's temporary UDDT toilet in a congested area of the city, the excreta dry bed owned and managed by Arba Minch City Municipality, and a range of urban farming sites located at the city periphery. The field visit enables us to decide on the scope of the study, and the literature review helps the study in two ways: first, it gives a general framework of sanitation systems at different levels and their implementation in nutrient recovery for urban farming. Secondly, the literature review offered an initial assessment of the governance capacity of Arba Minch City, which was further integrated with the interview results to measure the governance capacity in managing nutrient recovery for urban agriculture in the city. A significant number of journal articles were accessed from internet sources, providing valuable frameworks and evaluation tools for the study (see Figure 2).

To determine interviewees, the Arba Minch City Administration Sanitation Project Coordinator collaborated with senior urban planners to identify potential interviewees for the study. Major stakeholders who participated in the interview included the Arba Minch Municipality Greenery and Beautification Department, the city Urban Agriculture Department, Omo Micro-Finance Institution, the city Environmental Protection Authority, the RUNRACE Arba Minch Project Office, "Egan Newu Mayet" and MAASP Recycling Enterprises, the Arba Minch City Water and Sanitation Office, and the city urban planning department. There were a total of 24 individuals representing private and government institutions, as well as individual respondents, participate in interview session during the desk review.

The participants for the study were chosen by referring to a compiled list of potential interviewees identified with the assistance of Arba Minch City's urban planning department and the former head of Arba Minch City's Sanitation Project Coordinator, in addition to the desk study. After obtaining the interviewees' permission, a tape recorder was used during the interview sessions, with one person typically scheduled for each session, although sometimes multiple people participated. The semi-structured questions that guided the interviews were followed by related questions mainly within the scope of GCF indicators. To save time during the interview, some respondents received the questions beforehand. As the interviewees represented a variety of organizations, their responses primarily focused on indicators relevant to their experience and expertise.

After data collection, the researchers summarized each respondent interview and provided feedback for review to identify any additional information on the indicators. While most interviewees did not provide feedback, a few respondents forwarded their feedback and further discussed newly emerged comments. Insights gained from the interviews, combined with evidence gathered during the desk study, were used to assign a final score to each indicator. The results from the interviews were manually transcribed and coded for anonymity, with a range from AM001 to AM016. Additionally, a summary of the results for the 27 indicators was completed. The outcome of each of the 27 interviews was measured using a Likert-style rating method, which ranged from highly favorable (++) to highly unfavorable (−−), with (+), (0), and (−) scores in between based on the summarized findings of each indicator.

4. Result

The assessment of Arba Minch City's governance capacity for organic waste use in urban agriculture is structured into nine sections, each corresponding to one of the nine conditions identified in the GCF. The results of each section are cross-referenced with the GCF indicators, which are shown in parenthesis for easy reference.

4.1. Awareness

There appears to be a low level of awareness among Arba Minch City households, urban farmers, government institutions, and NGOs about the benefits and challenges of adopting ecosan toilets (Indicator 1.1). According to interview findings, some farmers have a high demand for organic compost recovered from excreta. They prefer compost made from solid waste and human excreta due to the inflated cost of commercial fertilizer and the equivalent or greater benefits they receive from organic compost. This finding is consistent with a study carried out in Uganda, where farmers demonstrated a positive perception of ecosan toilets due to their affordability, reduced risk, and potential to enhance crop yield (Andersson, 2014). However, the acceptance of these toilets is influenced by various factors, including user awareness (Lamichhane and Babcock, 2013). Although banana farmers have increased their demand for organic compost, household demand

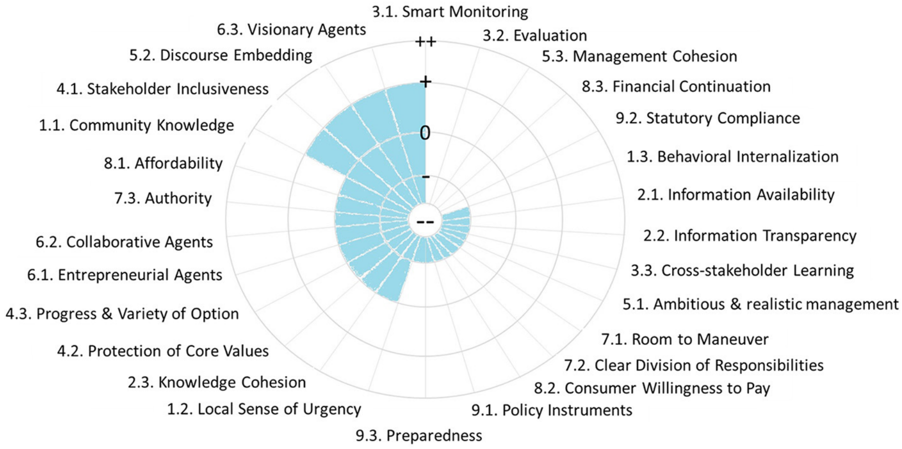

FIGURE 2
GCF results of Arba Minch City.

for ecosan toilets remains at an infancy level. Users believe the ecosan toilet to be too involving compared to the conventional pit latrine, leading to abandonment (Indicator 1.3). MSSE involved in organic compost preparation has deeper insight into the benefits and risks associated with organic fertilizer and attempts to raise awareness among urban farmers, municipal officials, and government institutions such as the city urban agriculture department and the sanitation and beautification office (Indicators 1, 2, and 3).

4.2. Useful knowledge

According to Roma et al. (2013), the adaptation of ecosan toilets and the utilization of their outputs in agriculture are more successful when educational and promotional activities are conducted to elucidate the benefits of reusing urine and excreta in agricultural practices. However, stakeholders in Arba Minch have recently had limited access to such information (Indicator 2.1). The ROSA project, 15 years ago, generated significant knowledge about ecosan and its application to urban agriculture among stakeholders in Arba Minch. For example, the project funded the cost of ecosan toilet construction for various users and involved them in the construction process to facilitate knowledge transfer and information dissemination (Indicators 2.1, 2.2, and 2.3). Nevertheless, most UDDT toilets are manufactured in factories inaccessible to the majority of users due to their specific interests (Indicator 2.3).

4.3. Continuous learning

Resource recovery from waste streams carries risks and benefits, as stated by Ekane et al. (2016). Strong monitoring systems are crucial to address perceived and real risks, especially in the presence of a low sense of urgency among stakeholders. In Arba Minch City, there is limited continuous evaluation and monitoring of ecosan toilets and organic compost use (Indicators 3.1 and 3.2). According to Federal Democratic Republic of Ethiopia (FDRE) Proclamation No. 295/2002 (Article 15/1 and 2), the regional environmental agency is responsible for monitoring and reviewing the environmental performance of public and private development initiatives that affect the health and environmental sustainability of the area (Indicators 3.1 and 3.2). However, the Environmental Protection Office of Arba Minch City weakly monitors and evaluates organic compost producers who have the potential to impact health and the environment through the use of raw organic compost for urban agriculture (Indicators 3.1 and 3.2) (FDRE, 2002). Moreover, the Environmental Protection Office in Arba Minch City and the South Nation Nationality People Regional State Environmental Protection Bureau have the responsibility of establishing a quality assurance system in the city. However, quality assurance of organic compost is only done on an *ad hoc* basis by the Addis Ababa Agricultural Research Center, and no certification service is provided by private or government organs for the quality of organic compost and agricultural products using organic compost as fertilizer (Indicators 3.1, 3.2, and 3.3).

4.4. Stakeholder engagement process

Stakeholder involvement in using organic compost and adopting an ecosan toilet has produced mixed results based on the interview outcomes. The ROSA project strives to engage relevant stakeholders during the design, monitoring, and implementation phases of organic compost use and ecosan toilet adaptation (Indicator 4.1). For instance, during the ecosan toilet design, households express interest in choosing from various ecosan toilet options (Indicator 4.3). Moreover, the recent collaboration between the Arba Minch office of the RUNRES project, private enterprises such as "Egnanew Mayet" Composting Enterprise, Anjonus Fruit and Vegetable Processing Enterprise, and MASSP Urine Recycling Enterprise, a women's association that supplies organic waste to "Egnanew Mayet" Composting Enterprise, Arba Minch City

Administration, and Arba Minch University, yields numerous benefits (Indicator 4.1).

A study by Simha et al. (2017) confirm Trust and stakeholder involvement are essential for successful nutrient recycling programs, emphasizing the need for early dialogue and continuous interaction with users. Ddiba et al. (2020) stress the significance of stakeholder collaboration in multi-sectoral contexts for successful resource recovery initiatives. Rodríguez et al. (2020) highlight the importance of engaging relevant parties and fostering collaborative relationships in governance and resource recovery, underscoring their significance at every stage, spanning from initial planning to final implementation. This underscores the need to foster collaborative efforts among diverse actors to effectively implement and advance resource recovery initiatives. However, key actors like urban farmers are hardly participating, and their views on organic waste use in farming remain unheard (Indicator 4.2). Arba Minch City's urban farmers utilize different organic wastes, including compost from municipal solid waste, untreated and treated excrement from various sources, and animal manure from poultry farms (Indicator 4.3). Nevertheless, they receive little assistance in choosing better organic fertilizers that are environmentally friendly and have minimal human health effects (Indicator 4.3).

4.5. Management ambition

Ethiopia's Climate Resilient Green Economy Strategy (CRGE) published in 2011 specifies the use of organic compost for urban agriculture (Indicator 5.2). It contains a clear strategy that defines a detailed action plan, indicators, and assigns the Ministry of Agriculture as the responsible government organ. However, the strategy only focuses on rural areas, and minimal effort is made at the national level to promote the use of organic compost. The government still subsidizes commercial fertilizer imported with significant foreign currency (Indicator 5.1). The escalating fertilizer prices at the international market, coupled with the currency depreciation of Ethiopia, have made the cost of fertilizers soar, making farmers search for alternatives. Consequently, farmers in and around Arba Minch are turning to organic compost and abandoning artificial fertilizer, creating employment opportunities for various businesses in the city and closing the nutrient circle.

Despite farmers start to use organic fertilizer, the policy, regulatory, and strategic documents concerning the nutrient cycle lack coherence, focus, explicit actions, indicators, and resources in Ethiopia. According to Ddiba et al. (2020), local-level strategic support and visionary policies are vital for driving resource recovery initiatives. The Environmental Protection Office, Arba Minch City Sanitation and Beautification Office, and the City's Sanitation and Water Supply Office all play critical roles in integrating ecosan with urban agriculture (Indicator 5.3). However, they do not have a formal communication system, such as a forum or regular contact with each other. Furthermore, private businesses, urban farmers, and individuals who use ecosan toilets receive intermittent support from government agencies. Notably, no government office in the city is openly responsible for managing non-sewer wastewater sources. The Sanitation and Water Supply office primarily deals with wastewater treatment and waterborne decentralized sanitation system, excluding waterless decentralized sanitation system. As a result, obtaining government funding, technical assistance, and materials for the major organic compost toilet has proven challenging (Indicator 5.3). Additionally, the urban development policy of Ethiopia gives little attention to liquid waste management compared to solid waste. The policy also disregards extracting nutrient from organic waste generated by toilets and instead recognizes organic compost from solid waste.

4.6. Agent of change

Arba Minch City is renowned for its support of resource-oriented sanitation systems integrated with urban agriculture. Since 2006, the ROSA, CLARA, SPA, and RUNRES projects have collaborated to achieve this objective (Indicator 6.1). As a result, several resource-oriented sanitation schemes have been engaged in Arba Minch City for use in urban agriculture. For example, a Strategic Sanitation and Waste Plan (SSWP) for the entire city was developed, and the project conducted numerous studies in conjunction with Arba Minch University on topics such as the health risks of using raw excreta for urban agriculture, implementation of ecosan technologies, and community-based approach and management strategies for these systems (Indicator 6.2). Some of the project's successes in the city include private financing institutions providing sanitation loans to households, strengthening local capacity in resource-oriented sanitation technologies, and the construction of sewage dry beds.

The leadership displayed in Arba Minch regarding the adoption of ecosan technology has been exemplary, showcasing a high standard of excellence (Indicator 6.3). As it confirmed by Gutberlet (2015), local public authorities play vital roles in both promoting and implementing resource recovery initiatives. The majority of municipal officials and management support the system by providing direct financing, workspace, materials, and technical assistance to enterprises working in resource-oriented sanitation technology. For instance, the municipality is a significant purchaser of organic compost for urban greenery, providing workspace for two businesses to assist in the preparation of organic compost and establishing a network with Hawassa City to supply organic waste for urban greenery (Indicators 6.2 and 6.3). However, the frequent turnover of municipal employees, particularly the mayor and city manager, poses a limitation to the success of these efforts (Indicator 6.3).

4.7. Multi-level network potential

The Ethiopian government has a clear strategy for organic waste extraction to recover nutrients and utilizing them for agricultural activities in conjunction with commercial fertilizer use. However, while the primary focus of the government is on rural areas, there is no government organ solely responsible for managing organic compost use for urban agriculture in urban and peri-urban areas (Indicator 7.1). To fill this void, NGOs play a crucial part in assisting enterprises working in the system and establishing a project dedicated solely to managing the closing of the nutrient loop in various cities (Indicator 7.1). One of the most critical issues in this regard is the overall system, which became complicated when NGO support was phased out. The successful implementation of organic waste resource recovery relies heavily on the clear identification and clarification of roles and responsibilities among local public authorities operating within the sanitation and waste management chain, with a particular focus on those actively involved in resource recovery. This is underscored by Drechsel and Karg (2018), emphasizing the importance of establishing accountability and clearly assigning responsibilities to ensure effective resource recovery outcomes.

For the past 18 years, more than five NGOs have been working in Arba Minch to adapt resource-oriented sanitation technologies; however, the overall activities will come to an end when those projects phase out (Indicator 7.2). The adoption of resource-oriented sanitation technology and its application in urban agriculture has received consistent support from government officials and experts in Arba Minch, although this support stems primarily from decision-makers' understanding of the benefits, which indirectly helps them achieve their goals. For example, the Arba Minch municipality and the city sanitation and water supply office support the system because it helps them achieve their primary goals, which are to manage solid and liquid wastes through the reuse of organic wastes (Indicators 7.2 and 7.3).

4.8. Financial viability

Resource-oriented sanitation technology adaptation and integration into urban agriculture are mainly supported by NGOs in Arba Minch City. In terms of initial investment, the traditional pit latrine is less expensive than the ecosan toilet, which requires assistance from the city government or NGOs (Indicator 8.1). The ROSA project covers up to 100% of ecosan toilet construction as a demonstration and for creating knowledge and influence on the attitudes of households, institutions, and the private sector. The SPA project provides seed money for Omo Micro Finance to loan for sanitation, the CLARA project builds local capacity in closing the nutrient loop, and the Africa Development Bank finances the construction of an excreta dry bed that facilitates co-composting in the city (Indicator 8.3). All resource-oriented sanitation technology adaptation and application to urban agriculture projects make various attempts to commercialize the system to make it sustainable. Households that adopt the technology will be charged a service fee for the collection of urine and feces from their toilets, and the enterprise that collects the excreta will sell it to urban farmers in the city (Indicators 8.1, 8.2, and 8.3).

The challenges of adopting ecosan technology from a willingness to pay perspective and behavioral factors are significant, particularly in terms of affordability and maintenance costs (Banamwana et al., 2022). In Arba Minch there is a problem with users' willingness to spend on service charges (Indicator 8.2). MAASP, for instance, charges 2 Birr (0.04 USD) per visit to a urine-diversion mobile toilet in the city's busiest area; however, most users refuse to pay the fee, so the enterprise decides to provide the service for free (Indicator 8.2). According to Kassa (2009), there is a notable challenge when it comes to the willingness of residents in Arba Minch City to pay for managing dry feces, exchanging urine tanks, and contributing financially or through labor for waste transportation. In general, the financial viability of integrating resource-oriented sanitation and urban agriculture is heavily reliant on NGO project funding (Indicator 8.3). The government's role is to support the system by providing working space, technical support, and networking opportunities for businesses located within or outside of the government system. However, no government institution is directly accountable for creating the integration by allocating human resources and budgeting funds to run the system. This creates a financial constraint when the projects are completed.

4.9. Implementation capacity

The integration of ecosan with urban agriculture faces significant fragmentation in policy support, particularly regarding the use of excreta as organic fertilizer. Despite the emphasis on solid waste management and organic waste reuse in the Ethiopian urban development policy, it does not explicitly address the potential utilization of excreta for urban agriculture (Indicator 9.1). The Environmental Protection Agency is mainly responsible for the regulatory aspects of integrating resource-oriented sanitation technology with urban agriculture, but the institutional capacity to do so is limited. This includes a lack of human resources, finance, structure, environmental standard formulation, compliance monitoring, and relevant facilities such as laboratories to regulate the health and environmental impacts of integration (Indicators 9.2 and 9.3). Despite Arba Minch University's efforts to support the project through various research studies, uncertainty regarding the environmental and health consequences of using excreta in urban agriculture remains an issue. WHO standards for the adoption of excreta in urban farming are not regularly checked, and the Addis Ababa Agricultural Research Center provides intermittent quality assurance for excreta use (Indicator 9.2).

Figure 3 summarizes Arba Minch City's governance capability to handle the integration of resource-oriented sanitation with urban agriculture. Each of the 27 indicators scores one of five Likert-type scales ranging from the most limiting governance capacity score (−−) to the most enabling indicator score (++) based on the summary of results organized into nine conditions, having three indicators for each conditions. The scores are organized in a spider web drawn clockwise, beginning with the most limiting indicator and progressing to the most enabling indicator. Table 2 clarifies the meaning of each Likert-type score in the 27 indicators to assist readers.

5. Discussion

Arba Minch City's governance capacity for integrating resource-oriented sanitation technology with urban agriculture is low. None of the 27 indicators score a very good enabler for the synchronization of ecosan with urban agriculture. Only four indicators are enablers, while the remaining 23 are either neutral, limiting, or very limiting factors, posing a significant challenge in

FIGURE 3
GCF methodology process of Arba Minch City, Ethiopia.

TABLE 2 Scoring scale of GCF in Arba Minch City.

Score	Description of the score
−−	The indicator is a very limiting factor in the integration of resource oriented sanitation technology adaption for the use of urban agriculture in Arba Minch.
-	The indicator performs a limiting role in the integration of resource oriented sanitation technology adaption for the use of urban agriculture in Arba Minch.
0	The indicator has a neutral role in the integration of resource oriented sanitation technology adaption for the use of urban agriculture in Arba Minch.
+	The indicator is an enabler factor in the integration of resource oriented sanitation technology adaption for the use of urban agriculture in Arba Minch.
++	The indicate is a very good factor in the integration of resource oriented sanitation technology adaption for the use of urban agriculture in Arba Minch.

the integration of ecosan with urban agriculture (see Figure 3). Major limiting factors that affect integration in Arba Minch include monitoring and evaluation of the project, management cohesion, financial sustainability, and statutory compliance with adapting resource-oriented sanitation technology.

Continual evaluation and monitoring are paramount in assessing the impacts of specific development initiatives (Tengan et al., 2021). A project's sustainability hinges on the formulation of sustainability strategies from the design phase and its effective management, monitoring, and evaluation (Mlage, 2014). These monitoring and evaluation efforts also play a crucial role in guiding future projects by providing insights into the strengths and weaknesses of past endeavors (Tengan et al., 2021). In the context of Arba Minch, inadequate monitoring and evaluation practices have hindered the governance capacity to successfully integrate ecosan with urban agriculture, leading to project failures and an inability to identify limiting factors affecting performance. Such shortcomings conceal alarming situations within projects and impede the ability to predict potential future developments (Koop et al., 2017). Considering concerns regarding potential recycling of contaminants from organic waste streams (Johansson and Forsgren, 2020), the implementation of integrated monitoring and evaluation systems becomes imperative to identify problematic incidents and foster continuous learning from experiences. Similar experiences in Chía, Colombia, have shown that systematic monitoring of sanitation and waste management systems and data sharing among stakeholders are lacking, resulting in fragmentation (Ddiba et al., 2022).

These lessons from Chía, Colombia underscore the necessity of integrating monitoring and evaluation systems and promoting information and data sharing among relevant stakeholders (Ddiba et al., 2022). By doing so, decision-makers can enhance governance capability, improve project sustainability, and ensure the success of resource-oriented sanitation systems with urban agriculture initiatives while safeguarding against potential challenges (Tengan et al., 2021). The establishment of robust monitoring and evaluation mechanisms enables a more comprehensive understanding of project outcomes and provides valuable insights for future development efforts (Mlage, 2014). By adopting these practices, Arba Minch City can make informed decisions, optimize resource recovery from organic waste, and advance toward sustainable and resilient urban environments.

The adoption of new technology in resource-oriented sanitation often poses a significant financial burden on low-income households. However, to promote financial sustainability, the projects in Arba Minch City have taken proactive steps by offering various financial options and support to those adopting the system and the businesses involved. Community ownership and operation of the projects are critical factors that can ensure the long-term financial viability of donor-funded initiatives. As such, fostering strong, active, and well-trained community groups is essential in assuming responsibility for running the projects sustainably. Donor-supported projects must prioritize sustainability as a core development value, shifting their focus toward community-based and accepted initiatives to avoid non-operational outcomes once donor support ends. Emphasizing community-centered approaches and empowering local actors can foster financial sustainability and effective resource management in Arba Minch City (Jhuthi, 2015; Miriti, 2016).

Moreover, in the pursuit of sustainable waste and resource management, an emerging approach involves adapting business models with a focus on publicly financed solutions. Public-private partnerships (PPP) present promising opportunities to enhance financial sustainability and ease the burden on government organs. Encouraging collaboration between the public and private sectors can lead to innovative solutions for waste recycling and resource recovery. For instance, in India, the encouragement of co-selling organic waste compost by the chemical fertilizer sector, and in Ghana, the establishment of a commercial co-composting plant through a PPP based on research-based piloting, exemplify successful approaches to integrated resource management. Adopting such novel approaches can help Arba Minch City develop a more resilient and sustainable urban development model by fostering the integration of resource-oriented sanitation systems with urban agriculture (Drechsel and Karg, 2018).

The integration of resource-focused sanitation systems with urban agriculture encounters several policy harmonization challenges, hindering its efficient implementation. It is essential to examine the idea of governance capacity, especially institutional capacity and governance performance, in order to address these issues. To reconcile composite policy aims and coordinate the relevant policy players, institutions must have the formal and informal rules, norms, procedures, values, beliefs, knowledge, and skills (Meijers and Stead, 2004). In the case of Arba Minch, institutional capacity gaps result from the absence of a specific government agency in charge of overseeing the use of organic compost for urban agriculture in urban and peri-urban regions. This leads to fragmentation in policy support and a lack of clear responsibilities among stakeholders, hindering effective resource recovery outcomes.

Policy integration, which involves cross-sectoral policymaking transcending the institutional responsibilities of individual departments, is another essential aspect. For successful integration, policies must act in mutually reinforcing fashion, avoiding conflicts that can arise from fragmentation in policy components (May et al., 2005). However, in Arba Minch City, the absence of a formal communication system between key stakeholders, including the Environmental Protection Office, City Sanitation and Beautification Office, and Sanitation and Water Supply Office, results in a lack of coordinated and consistent policies. The fragmentation and sub-optimal policy outcomes in integrated policies (Rayner and Howlett, 2009) suggest the need for a holistic and comprehensive approach. Policymakers should define an integrated strategy involving multiple policy domains to ensure coherence in policy ideas and goals.

Policy coordination plays a crucial role in resolving conflicts and reconciling conflicting ideas to achieve collective action outcomes (Peters, 2018). The successful implementation of resource-oriented sanitation systems with urban agriculture relies on a clear set of policies, priorities, and strategies agreed upon by relevant stakeholders. However, the phasing out of NGO support in Arba Minch City creates challenges in coordinating and aligning the efforts of different actors involved in resource recovery. To accomplish more comprehensive composite policy goals, it is necessary to create specialized coordinating structures and processes that go beyond the institutional responsibilities of particular departments. Collaborative efforts involving the government, NGOs, private enterprises, and local public authorities are essential to ensure coherent policy outcomes and the closing of the nutrient loop.

Changes in policy concepts, programs, and instruments are needed, as well as institutional modifications, to move from sectoral to integrated designs (Hall, 1993). These changes can be complex and asymmetrical, affecting not only the order of the structural elements but also cultural and cognitive aspects like beliefs and trust (Peters, 2015). In the context of Arba Minch City, the study highlights the lack of explicit actions, indicators, and resources in policy, regulatory, and strategic documents concerning the nutrient cycle. Such limitations indicate the need for comprehensive institutional transformations and the purposeful alignment of units and tasks to promote resource recovery initiatives.

The integration of resource-oriented sanitation systems with urban agriculture in Arba Minch involves a complex network of stakeholders and actors, each playing a critical role in the success and sustainability of the project. Governance, as a process of interaction and decision-making among these actors, becomes crucial in fostering cooperation and achieving collective goals (Hufty, 2011). Traditionally, governance has been expert-led and sectorally fragmented, leading to limited understanding of complex challenges in sustainability (Koop, 2019). However, the shift toward multi-level and polycentric governance approaches recognizes that the state alone cannot address societal challenges effectively, necessitating the involvement of diverse actors across different decision-making centers (Ekane et al., 2016).

In the context of resource-oriented sanitation and urban agriculture in Arba Minch, active participation and engagement of local stakeholders are vital. Community groups, households, urban farmers, government entities, NGOs, private enterprises, and researchers all have distinct roles in the integration process. Financial sustainability, a critical aspect of donor-funded projects, requires the ownership and operation of projects by various actors, particularly community groups (Miriti, 2016). Their commitment and capacity to manage and co-manage resource recovery initiatives determine the long-term success of the project (Drechsel and Karg, 2018). However, challenges arise as some households may be hesitant to adopt the new technology without NGO support (Miriti, 2016). To ensure comprehensive problem-solving and innovative solutions, participation of diverse stakeholders is crucial to access different forms of knowledge (Berkes and Folke, 2002). Collaboration among stakeholders with varying values and interests is necessary to collectively identify and solve problems related to organic waste use in urban agriculture (Koop et al., 2017).

As the integration progresses, it is essential to foster inter-sectoral management and facilitate communication among stakeholders across supply chains and reverse supply chains (Ddiba et al., 2022). Emphasizing multi-stakeholder engagement and dialogue can lead to informed decision-making and better policy formulation (Drechsel and Karg, 2018). An example of this approach is the multi-stakeholder policy formulation and action planning (MPAP) approach in Accra, which involved diverse stakeholders across agricultural and sanitation sectors, fostering collaboration and understanding of urban agriculture's role in supporting policy objectives (Drechsel and Karg, 2018).

The decision of individuals to adapt or not adapt to ecosan toilets and organic compost recovered from excreta is determined by their internalized behavior. While the use of urine and feces for agriculture is common in most countries, the adaptation of new sanitation technology and the application of organic compost recovered from excreta are new technologies for households and farmers in Arba Minch City. Therefore, local communities and farmers must change their behavior to implement these new technologies. For this reason, it is crucial to understand households' and farmers' needs and ability and willingness to bear the cost for new sanitation technology and organic compost (Cairncross, 2004). Unfortunately, resource-oriented sanitation technology adaptation has largely failed to achieve its goal because decision makers ignored user motivation and factors influencing behavioral changes (Anjum Altaf and Hughes, 1994).

According to Davis et al. (2015), interventions in sanitation technology adaptation that require behavioral change must understand the theories of behavioral change. The purpose of studying these theories is to understand why, when, and how behavioral changes occur and to provide insight into why previous efforts have either succeeded or failed (Michie and Johnston, 2012). The theories of the diffusion of innovation identify five characteristics of an individual's demand to adapt to new technology: relative advantage, complexity, compatibility, observability, and trialability (Rogers, 1995). On the contrary, the technology acceptance model depicts an individual's intention to use a new technology based on perceived usefulness and perceived ease of use (Davis, 1989). Both theories consider resource-oriented sanitation and organic compost adaptation as new technologies, and understanding the theories' characteristics is critical to influencing their behavior. Furthermore, these theories provide stakeholders with a useful framework for understanding the reasons that influence the adoption of new technologies (Chunga, 2016).

6. Contributions and future research directions

This study makes a significant contribution to urban development by thoroughly examining the governance capacity in integrating urban agriculture and resource-oriented sanitation technologies (ecosan) in Arba Minch City, Ethiopia. It effectively addresses critical challenges related to governance, which hinder the smooth integration of urban agriculture and sanitation systems. Through a comprehensive empirical approach, the study provides valuable insights and comparisons with other urban areas in Ethiopia, offering a distinct viewpoint with a focus on governance aspects, distinguishing it from previous technical-oriented studies. The study also identifies key limitations and challenges, guiding efforts to enhance local governance capacity. It sheds light on the complexities involved in the integration process and aids policymakers in developing targeted strategies to foster coordination among stakeholders. Employing qualitative and quantitative methods, the study ensures a robust and practical assessment applicable to real-world scenarios, with the potential for knowledge sharing and future measurements, enhancing its relevance in shaping sustainable urban development strategies. The effective application of the Governance Capacity Framework (GCF) bridges governance gaps, barriers, and capacities, empowering decision-makers to integrate ecosan with urban agriculture in Arba Minch City and similar urban settings across Ethiopia. Overall, the study's comprehensive approach, combined with its governance focus, enriches our understanding of urban development challenges, fostering resilience and sustainable growth in urban environments.

In light of the study's limitations, several crucial areas for future research in Arba Minch City can be proposed. Firstly, to address the challenge of stakeholder identification, incorporating Social Network Analysis (SNA) offers a promising solution. By employing SNA, researchers can systematically map and analyze the relationships and interactions among various stakeholders involved in urban agriculture and resource-oriented sanitation integration. This approach will not only facilitate a more comprehensive understanding of the stakeholders' roles and perspectives but also lead to more effective collaboration and decision-making processes. Secondly, as the study primarily focuses on a specific case within Arba Minch City, future research should encompass comparative studies across different Ethiopian cities and towns. By examining governance capacity for urban agriculture integration in diverse contexts, researchers can identify common challenges, successful strategies, and context-specific factors. This comparative approach will contribute to the development of more generalized best practices and guidelines applicable to a broader range of urban settings. Moreover, the adaptation and standardization of the Governance Capacity Framework (GCF) to suit urban agriculture integration represent a crucial area for future investigation. Given that the GCF was initially designed for the water sector, its application to urban agriculture necessitates modifications to align with the unique characteristics of the field. Developing clear guidelines and standardized indicators will enhance the accuracy and reliability of governance capacity assessments for urban agriculture integration.

7. Conclusion

Adapting resource-efficient sanitation technologies and integrating them with urban agriculture offer several advantages in developing countries. Unlike developed-country wastewater management systems, which are centralized and transport wastewater through sewer lines, developing-country systems are mostly decentralized. Modern wastewater management systems require significant investments during the investment, operation, and maintenance phases, which are often unaffordable for developing countries. Furthermore, traditional toilet technology, which is prevalent in most developing countries, is relatively easy to adapt to resource-oriented sanitation technology. Therefore, this research helps identify critical governance-related factors that influence the adoption of resource-oriented sanitation technology and the use of organic fertilizer recovered from excreta.

The study's findings suggest that general governance capability to manage the integration of ecosan and urban agriculture is low. A gap in previous project evaluation and monitoring limits the upcoming project's knowledge of what made previous projects successful or ineffective. The financial sustainability of adapting new sanitation technology and substituting inorganic fertilizer with organic fertilizer recovered from excreta was hampered when NGOs that covered a significant portion of the initial investment phased out. Therefore, a strong, active, and well-trained community group capable of taking on the role and responsibility required to sustain the project is necessary. In Ethiopia, there are policy harmonization challenges in the governance of resource-oriented sanitation technology and the application of organic fertilizer for agriculture. The relevant government offices place little emphasis on recovering nutrients from excreta, and their policies treat excreta primarily as waste that must be discarded. They also work alone, planning and implementing various related or similar projects as well as larger government projects. Therefore, consistency in policy instruments is necessary, along with increased cooperation among stakeholders and improved action across sectors.

There is a behavioral internalization gap in both the adaptation of resource-oriented sanitation technology and the adoption of organic fertilizer recovered from excreta, as revealed by existing contexts. Furthermore, previous initiatives failed to consider behavioral change theories, which are critical to adapting the new system that requires a change in behavior. These initiatives also did not give adequate consideration to existing sanitation practices that are influenced by user culture, income, available space, and the demand of an organized system capable of operating in an integrated and sustainable manner. To address these issues, government organ need to be established to manage the system by committing human, financial, and material resources. Additionally, quality assurance in the application of organic compost recovered from excreta requires improvement. There are no local-level laboratory establishments to help improve quality assurance capacity, which limits urban farmers' confidence in switching from artificial to organic fertilizers.

Understanding the context of various stakeholders, including government offices, private enterprises, NGOs, and the general public, is necessary to study governance capacity in the organization of integrating ecosan with urban agriculture. Therefore, the study's findings provide a local-level perspective on how a lack of governance capacity impedes the successful implementation of nutrient extraction from organic origins. Furthermore, the study can contribute to achieving local sustainability and self-sufficiency by closing the nutrient loop in the administration of urban areas. Finally, the study's results are crucial in managing the integration of ecosan with urban agriculture in Arba Minch City, and the approach can be replicated in other urban centers in Ethiopia and other developing countries.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

This article is one objective of a PhD degree undertaken in Addis Ababa University, Ethiopia. Hence, AE is a PhD candidate and KY is the supervisor. Taking this into consideration, AE and KY together produced this article. This includes: objective setting, determining the best methodology for measuring governance aspects in urban agriculture and resource oriented sanitation systems, preparing data collection instruments, and data analysis and conclusion of the result and discussion. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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