

## Article

# Framework Proposal for Achieving Smart and Sustainable Societies (S<sup>3</sup>)

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**Abstract:** This article introduces a Smart and Sustainable Societies (S<sup>3</sup>) framework, based on what is necessary to achieve the UN agenda by 2030. The proposed model is based on the integration of three smart strategies: (1) water provision that consists of the use of greywater and rainwater; (2) sanitation provision that comprises the nutrients recovery from excreta and organic solid waste and; (3) resource-oriented agriculture that conceives the use of the water provision system for the production of food with the use of nutrients recovered from the sanitation system. The S<sup>3</sup> framework has the potential to increase the well-being, human development, water availability, food safety, poverty alleviation, and healthy environments of societies through the provision of safely managed basic services as well as the recycling of nutrients and water to achieve sustainability at household and community levels.

**Keywords:** resource-oriented agriculture; sanitation; SDGs; sustainability; water management



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## 1. Introduction

Due to the establishment of the 17 Sustainable Development Goals (SDGs) and the necessity of achieving them or at least achieving significant advances by 2030, many initiatives have been developed, with some significant accomplishments already [1–3]. Millions of people have emerged from extreme poverty, access to education has increased, and the actual progress in technological development as well as the spread of communication have accelerated human progress [4–7]. Although, with the actual COVID-19 situation, some places have had important negative impacts and regressions in achieving their goals and others are not even close to achieving them [4,8–10]. In 2020, the most evident impact was on the economic sector, where more than 124 million people are in extreme poverty; the vulnerabilities and inadequacies of global food systems have been increased, leaving hundreds of people undernourished, while global unemployment has risen as well [11]. Additionally, one in three people lacked access to basic installations to wash their hands with water and soap, which makes them especially vulnerable to COVID-19 [4,12]. Some countries have more achievements than others. Nevertheless, economic, political, and cultural factors; the production of various frameworks with a very specific narrowed approach; the lack of focus on the preferences of users and context necessities; and the deficiency of policies and economic mechanisms oriented to design and support profitable-sustainable strategies, are some of the factors that have limited the appropriation of the solutions implemented [13–20]. This has led to the undeniable fact that the world is not on the way to achieve SDGs. The main challenges of the United Nations (UN) Agenda are to end hunger and poverty, to accomplish food security, to end all forms of malnutrition, to develop rural areas, to increase sustainable agriculture and fisheries, to achieve universal health coverage and the full human potential, to ensure access to equal healthcare, to reduce and recycle waste, and to use water and energy efficiently by 2030. It also makes clear that sustainability is not possible without full human rights access and opportunities, supporting smallholder farmers, people-centred economies, and community cohesion that

lead a collective-inclusive pursuit where all humans win; no one must be left behind, particularly the least developed countries [8,21,22]. In this regard, the UN Agenda makes clear the need and urgency to develop strategies for addressing the achievement of SDGs in a holistic manner to provide communities with tools that allow them to satisfy their needs, framed in a way to dramatically accelerate the current pace of progress and application of integral approaches [4,8]. Moreover, the Global Report 2019 emphasizes the need to adopt systemic approaches acknowledging interactions between goals due to the reality that intervention in one must affect the others (positively or negatively) [23]. Therefore, in this paper a Smart and Sustainable Societies ( $S^3$ ) framework is introduced with a systemic focus on the integration of sanitation provision, water management, and agricultural smart systems. Through the provision of safely managed sanitation services (focused on basic sanitation and organic waste management), water recovery and reuse (focused on rain and greywater treatment), and the recycling of essential nutrients (from excreta and organic waste) for agricultural use, the  $S^3$  framework intends to be an instrument that enhances the well-being of the community, human development, water availability; overcome poverty conditions, create healthy environments, achieve food security and sustainability at household and community level. A deep review and analysis of the literature was conducted to integrate the proposed framework; furthermore, analysis and discussion of the elements of the framework were completed.

## 2. Methodology

First, to structure the proposed framework, a detailed literature review and analysis was conducted among the different methods, concepts, tools, and frameworks already being applied to overcome the lack of sanitation. Second, with the information previously collected and the main focus on excreta and nutrients (nitrogen and phosphorus) recovery, an analysis and conceptual model of the current sanitation as well as the general materials and value flows were prepared. Third, based on the results of the second step, a new conceptual approach Smart and Sustainable Societies ( $S^3$ ) is proposed, aiming to be implemented in the near future as a system that somehow meets the statements or requirements to achieve sustainability. Thus, some important considerations must be kept in mind during the formulation, design, and implementation of this new approach: the framework must be developed based on social and cultural needs; in addition, safe separation, the recycling and reuse of resources, and the value system must be managed in a way that gives incentives or rewards to the user.

## 3. Results and Discussion

### 3.1. Current Approaches and Initiatives

With the establishment of the Millennium Development Goals (MDGs) in 2000 and the SDGs in 2015, sustainability challenges in societies around the world have been defined and intended to be addressed with the design of diverse approaches in different sectors under different conditions [1,15,17,19,24–32]. However, despite the efforts made, the world is far from achieving sustainability. In many countries, the provision of basic services has been as public services, so municipalities are responsible for providing drinking water, sanitation, and waste management services to the population; however, many of them lack the expertise and management capacity to provide these services adequately, which results in governmental support to manage provision systems. When being managed as public services, the budget recovery rate is not good at all; people usually decline to pay tariffs and, in some cases, there are no settled fees [13,18,19,33,34]. This approach has entailed technical problems such as insufficient treatment, resulting in the pollution of the environment and precious water and soil sources, the reliance on water to transport fecal material where water is scarce and rare, and the neglect of natural nutrient cycles where soils are depleted and in need of organic matter and nutrients; it also weakens human and political capital due to the lack of reliable governmental policies and strategies [18,29,33]. It is a fact that some countries have developed more infrastructure than others; nevertheless,

the economic, political, and cultural factors, the production of various frameworks with a very specific narrowed approach, the lack of focus on the preferences of users and context necessities, and the deficiency of policies and economic mechanisms oriented to design and support profitable-sustainable strategies, have limited their appropriation [13–20,35]. Thus, the UN Agenda emphasizes the need to develop new dynamic, sustainable, innovative, inclusive, broad, and universal approaches that recognize the interrelation between SDGs and rural-urban, smart, and sustainable societies [8,36,37].

### 3.1.1. Water and Sanitation

The establishment of SDG 6 to “Ensure availability and sustainable management of water and sanitation for all”, reflects that water and sanitation are the core of sustainable development, and the range of services they provide support poverty reduction, economic growth, and environmental sustainability [23,38]. Then, water is used for different purposes, so it is classified based on them; for instance, in developing countries tap water is used for drinking, well water for hygiene, rain and greywater for garden irrigation, and water is also supplied and distributed from different sources: through taps, standpipes, water tanks, or conveyed with buckets from a nearby river [2,33,38,39]. Water coming from surface or groundwater sources is usually untreated and considered unsafe due to the probable contamination by fecal and organic matter. Most access to water is usually not continuous, so people have to use multiple sources due to the lack of a stable water supply system. The more time people spend on water transportation from a source to a house, the less water they consume to the detriment of their physiological and hygienic needs; so, a safe and reliable supply of water is essential for individual welfare and community development [33,39–43]. Sanitation services must ensure hygienic separation of human excreta from human contact and provide privacy, ensure dignity, and maintain safety. There is a considerable amount of the population lacking access to safe and adequate sanitation, which leads to adverse health impacts such as diarrhea, the transmission of tropical and vector-borne diseases, anemia, antimicrobial resistance, childhood diseases, and poor physical and cognitive development [35,44–46]. Safe sanitation is an indispensable component of quality of care and infection prevention, particularly to protect pregnant women and newborns from infections that may lead to adverse outcomes, sepsis, and mortality. Thus, the lack of safe sanitation and quality water leads to illness and disease, which affects the entire community and pollutes the environment. It results in financial costs related to health care, lost income, forgone educational opportunities, and the results of pollution; thus, achieving universal access will be expensive but inaction brings greater costs [35,47–49]. It is important to mention that SDG 6 also includes wastewater safely, treated as an important sanitation element. Wastewater (WW) collection and treatment help to protect freshwater systems and human health, as detrimental pathogens, nutrients, and other types of pollution are prevented from entering the environment [38,50–52]. Before the implementation of Wastewater Treatment Plants (WWTPs), wastewater was discharged directly into rivers and lakes, leading to the proliferation of algae and aquatic plants, which causes eutrophication and the deterioration of water quality due to the enrichment of water bodies with nutrients such as phosphorus and nitrogen [53–55]. The construction of treatment plants has led to an important decline of nutrients in water (thus improving the quality); nevertheless, there are around 1.9 billion people using septic tanks, which are used as decentralized wastewater treatment systems that receive blackwater, and in most cases greywater, generated by households [56,57]. When well-designed and operated, septic tanks can substantially reduce the solid fraction of wastewater flows and can be considered equivalent to primary treatment. Nevertheless, in most cases the liquid fraction infiltrates the ground, while the sludge remains in the tank becoming a health and environmental problem [47,57]. Access to water and sanitation are recognized as human rights and as vital resources for human well-being, since they are used for drinking, to produce food, to clean and nurture the environment, as conveyance, and to produce energy, among other purposes. Their availability in quality and quantity is essential to create

prosperous societies. Despite that, basic sanitation and wastewater treatment have suffered from chronic under-prioritisation compared to water access and provision, they have not been recognized as manageable and renewable resources due to the lack of leadership, underinvestment and a lack of capacity, donors tend to prioritise water provision over sanitation services [39–43,49]. In fact, during 2010–2018 aids for sanitation (including water resources management) were half that those for drinking water [49]. This under-prioritisation is appreciated in the Joint Monitoring Program (JMP) reported data, where it is observed that the proportion of global population using safely managed drinking water services is 74 percent and the global sanitation coverage reaches only 53.95 percent as safely managed; while from the total wastewater generated and treated in 2015, only 32 percent was subject to some form of treatment, and an estimated 56 percent generated from households in 2020 was safely treated [4]. However, there are still 2.0 and 3.6 billion people around the globe lacking safely managed water and sanitation services, respectively [5,7]. Moreover, only 71% have handwashing facilities, which represents 2.3 billion people lacking basic hygiene services, including 670 million people with no handwashing facilities at all, making people especially vulnerable [4,6]. Additionally, the trends in septic tank and latrine coverage shows that 57.9% of sanitation facilities are latrines or septic tanks, serving around 1.9 billion people [5]. Lastly, there is a relative lack of knowledge about the volumes of wastewater generated, treated, and discharged [58]. However, from the total wastewater generated and treated in 2015, only 32 percent was subject to some form of treatment and an estimated 56 percent generated from households in 2020 was safely treated [4]. Unfortunately, the available data about wastewater generation and treatment around the world are not enough to assess the real impact [51]. Another important aspect of sanitation is the Municipal Solid Waste Management (MSWM); even though it is not included in SDG 6, it is in SDG 11 to “Make cities inclusive, safe, resilient and sustainable” by measuring the performance of the MSWM of a city; and SDG 1, “End poverty in all its forms everywhere”, which focuses on universal access to basic services. These highlight the need to acknowledge the interactions between goals, due to the fact that intervention in one must positively or negatively affect the others [23,24,58]. Then, households and businesses produce a considerable amount of solid waste that must be collected, recycled, or treated, and then disposed of regularly and properly to maintain healthy and sanitary living conditions [59,60]. Rapid urbanization, the lack of financial capacity, or low policy priority has made cities face challenges in management, since uncollected waste can cause unsanitary conditions such as blocked drainages causing flooding, open burning producing pollutants, and vector diseases, affecting the health of the population and the infrastructure of cities [59]. In 2015, at least 2 billion people lacked access to regular waste collection; in 2016 the same amount of waste was generated [60] and is expected to grow to 3.4 billion by 2050. The uncontrolled disposal of wastes is a major source of Green House Gases (GHG); for instance, organic waste coming from food is generally mixed with solid wastes (SW) and disposed of in landfills without being processed for any material or energy recovery. If the waste sector continues on its current path, food waste will represent around 9 percent of global anthropogenic GHG emission by 2025 [57,61]. The release of greenhouse gas emissions from landfills to the atmosphere and the discharge of concentrated leachate (rich in nitrogen (N), phosphorus (P), potassium (K), etc.), pollutants, and pathogens into the soil and water bodies are causing severe environmental problems, such as eutrophication of groundwater bodies and public health concerns in the world [25,50]. With the current MSWM techniques, the threat of potential global warming will be enhanced if wise and sustainable techniques are not adopted [8,25]. Therefore, the SDGs establish the need to expand capacity-building support related to water and sanitation provision, plus solid waste management including activities such as water harvesting, desalination, water efficiency, wastewater treatment, recycle, and recover and reuse technologies, as well as monitoring to establish better waste and resource management strategies and control pollution, to mention some [8,57,60]. Despite the considerable progress in global coverage in recent years, achieving access for all will require an ambitious and well-coordinated scale-up. The

current pace of progress and the implementation of integrated and holistic approaches need to be drastically accelerated, since achieving universal access requires a dramatic acceleration in the current rates of progress [49,62]. If wise and sustainable techniques are not adopted, the vision of a world free of poverty, hunger, and diseases will not be possible. However, with access to equitable and universal access to safe drinking water and sanitation, where physical, mental, and social well-being are assured, people can prosper. So, for the decentralization of water management and sanitation, monitoring, a tailor-made approach for each community, and cooperation between community and government are necessary to achieve SDGs about providing safely managed basic services [8,63].

### 3.1.2. Agriculture and Food Security

In 2019, around 690 million people were undernourished, which means 8.9% of the global population; in addition, 83 to 132 million were added to the ranks due to the COVID-19 pandemic. Food insecurity affects diet quality, increasing the risk of malnutrition for children and women; around the world, 144 million children under 5 years of age are stunted, 47 million are underfed, and 38.3 million are overweight, while at least 340 million children have micronutrient deficiencies [4,64]. Some key reasons why people are suffering from hunger are extreme climate, disruptions in food supply, and lack of income due to the loss of livelihoods, all of which increases the difficulties for the poor and vulnerable to gain access to healthy diets [8,11,64]. Indeed, agriculture is important as it provides food and for many economies it provides revenues; it also employs more than 1 billion people worldwide, so small-scale food producers constitute on average around 64% of the total world food producers [4,63,65,66]. However, agriculture can create high pressure on water resources, pollute them chemical fertilisers and cause soil erosion and loss of soil fertility due to poor farming practices. Agriculture is responsible for 80% of global deforestation, accounts for 70% of the freshwater consumption, and uses 36% of all land; plus, the food systems associated with agriculture release 29% of global greenhouse gasses (GHGs), with 137 kg of fertiliser being used per hectare of arable land [23,63,65]. Then, billions of hectares of land have been degraded, and 12 million hectares of agricultural land are expected to become unusable for food production every year. It is clear agriculture is essential for growth and well-being, but it tends to have important negative externalities; its practices can lead to eutrophication of the aquatic environment, groundwater contamination, soil acidification, soil fertility diminishing, salinization of land, and atmospheric pollution [23,63,65]. Although food security relies on agriculture, pests and crop diseases put global supplies at risk. Furthermore, managing them with an increasing use of chemical fertilisers jeopardises achieving SDGs due to GHG emissions, global agriculture could rise as much as 87% if production is just increased to meet the actual demand of the population. So, transition and improvement of actual agricultural systems is needed and requires technological innovation, strategic use of economic incentives, new forms of governance and behavioral changes, without these changes the restoration of soil health, sustainability and food security are not possible [11,25,63,64]. The world is making progress but is not on track to achieve zero hunger, under the actual business-as-usual agriculture scenarios around 637 million people will be undernourished and the environmental impacts and increasing production would reduce any chance to achieve SDGs. Nevertheless, the world can still succeed only if all people have ensured access to nutritious food that makes up a healthy diet, if small-scale food producers are supported, if policy actions are taken all along food supply chains, if food losses are reduced, and if all natural resources are sustainably managed [11,63,64].

### 3.2. Current Water Provision, Basic Sanitation, Agricultural Systems Performance, and Value Flow

Then, based on the information presented above, it is schematised how water provision, basic sanitation, and vegetable garden agriculture are currently performed at the household level. Figure 1 schematises the most common input, uses, and output flows of resources (water, excreta and solid waste); it also allows for the identification of areas



of opportunity to improve the actual provision systems. Currently, most access to water is mainly via tubed water coming from surface or groundwater sources. In the case of greywater, it usually comes from the kitchen, shower, and laundry in most cases, is not connected to the septic tank, and is used for the garden irrigation or dumped into the open ground; rainwater is sometimes used for the same purpose [42,67]. Sanitation facilities mainly consist of a toilet connected to a septic tank, flushed with water (in some cases poured with a bucket), and then the liquid fraction infiltrates into the ground while the sludge remains in the septic tank, owing to the incomplete separation of the human excreta from the human living environment [42,47,68]. In some cases, the sludge is removed to continue using the septic tank, or it is abandoned and where it is possible a new one is excavated, locking up a vast amount of nutrients, avoiding access to the financial and economic benefits from resource recovery and reuse through a viable sanitation value chain [17,69]. It can be also observed that blackwater is discharged into the soil and the organic wastes are dumped into the open ground to be burned, which directly affects the environment and leaves the nutrients without being able to be recycled. This makes clear that effective resource recycling is an inevitable issue for the sustainable future of the world, in both developed and developing countries, including resource recycling from domestic wastewater and human excreta [19].

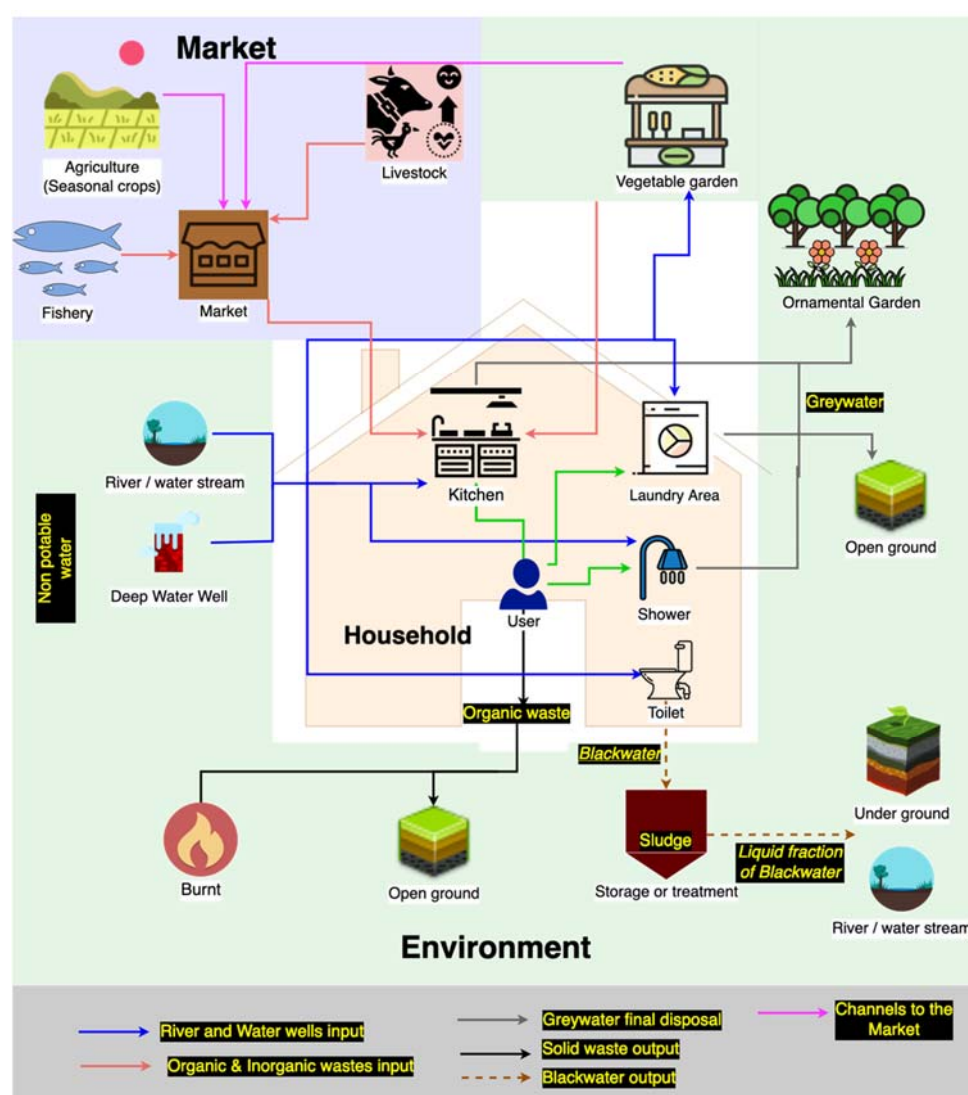
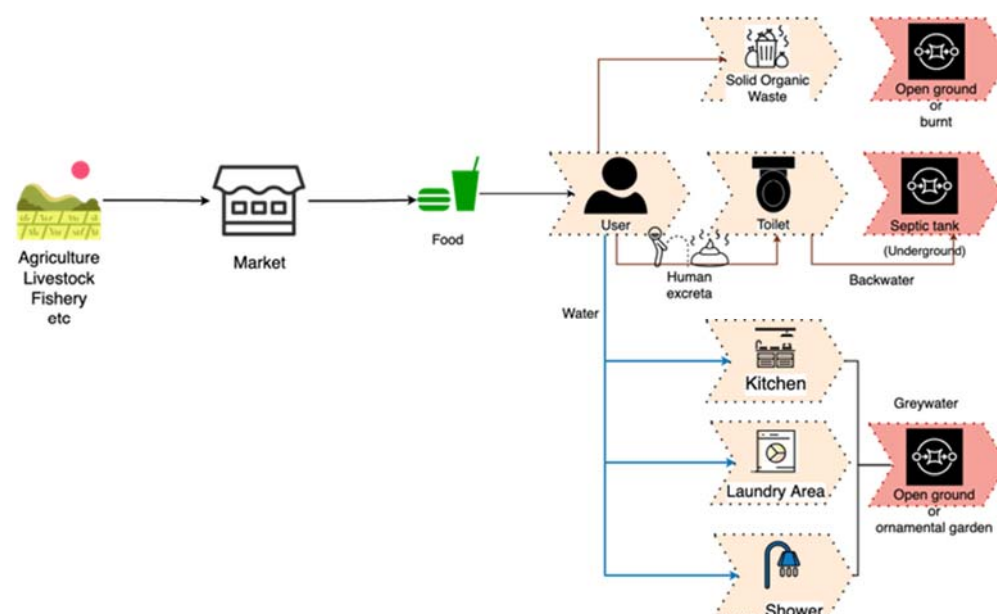


Figure 1. Current water, basic sanitation, and agricultural system performance.

The current systems described and observed in Figure 1 have their limitations: most of them are deficient, threaten public health, lock up nutrients, and use huge amounts of water, plus they are not safe, comfortable or suitable for users. In Figure 2, it can be observed that the actual resources flow in and outside the current provision systems, which are linear and do not allow for the recovery and reuse of some potential resources such as blackwater and solid waste; this means resources are not exploited to their full potential, and valuable resources are being wasted instead of being used in a profitable and smart way to sustain and develop communities. Another negative aspect is that actual systems are managed as public services, so the budget recovery rate is generally not good as people usually refuse to pay the tariffs. A well-designed public service is necessary, otherwise unfavorable waste disposal might occur due to value judgments at an individual level that are strongly influenced by the culture, habits, religion, and economic capacities of communities [31,47]. In this regard, the Mexican government through its National Water Program declared “To provide basic water and sanitation services in marginalized areas, the federation has tried to implement alternative technologies to traditional hydraulic infrastructure; however, their use and appropriation have been very limited because, in general, in the past all the interventions have not been planned with local actors” [13]. So, it appears difficult to give a sufficient incentive to invest in a treatment facility at the individual level because the return on the individual investment would not come back directly to the person who invested [70].



**Figure 2.** Current value flow of systems at the household and community level.

As mentioned in Section 3.1, it is crucial to recognize the interrelation between goals and identify its advantages. For example, recognizing treated water as a manageable and potential resource allows for it to be used in agriculture to meet irrigation demands [57,63] and to release water stress simultaneously. The problems associated with solid waste management, basic sanitation, and wastewater (such as leachates) can be reduced using compost production technology to produce organic fertiliser for use especially in low-input agriculture; this also reduces the dependence of farmers on commercial fertilisers and the related environmental impacts [25]. It helps to avoid untreated wastewater being discharged into rivers and oceans with severe consequences for both the environment and health, and to reduce water constraints that threaten food security and nutrition [40,57]. It is appreciated that there is a strong interrelation between agriculture, water needs, and organic fertilisers. So, as a result the Smart and Sustainable Societies (S<sup>3</sup>) framework is proposed and explained in the following Section 3.3.

### 3.3. The Smart and Sustainable Societies ( $S^3$ ) Framework Approach

The foundation of the  $S^3$  framework is from Ushijima et al.: 2015 Resources Oriented Agro-sanitation business and postmodern sanitation business concepts that propose adding value to human excreta through the creation of a sanitation business model based on creating incentives for users, identifying potential resources, and incorporating them to the market. So,  $S^3$  consists of the integration of the following smart strategies: (1) Water Provision that comprises the management of greywater and rainwater; (2) Sanitation Provision that conceives nutrients recovery from excreta and organic solid waste management; and (3) Resource-Oriented Agriculture (ROA) that involves the production of agricultural products through the use of organic fertiliser produced from the sanitation system and the (re)use of water from the water provision system [15,17,19,31,32]; all are supported by a value system that intends to add value to human excreta, solid waste, and recycled/reused water and agricultural products as well as to basic sanitation, water quantity and quality, and the management of organic waste. In this regard, it is important to identify (1) the potential resources and efficient ways to connect them to the next process inside the system; (2) a value system that allows for support to be given to the users; and (3) an economic compensation where the market allows, where it is essential to identify the potential channels to the market, to produce a high quality and quantity of water and fertiliser, and to avoid the contamination of products and resources in every process (especially in agriculture production).

#### 3.3.1. Smart Water, Sanitation Provision, Resource-Oriented Agricultural Systems, and Their Potential Resources

As mentioned in Section 3.1.1, water and sanitation are human rights and consequently vital for sustainable development; thus, it is even more important to ensure its provision in quantity and quality. So, for centuries people have collected and stored rainwater in buckets, tanks, ponds, and wells due to its multipurpose uses from irrigating crops to recharging groundwater, washing, flushing toilets, showering, cooking, and, in some cases, drinking [71–73]. This domestic water provision technique can be a source of water in regions where rainfall is substantial and where no other sources of water are available [43]. It consists mainly of collecting water from the rooftops through channels; later the water is stored in a deposit (i.e., cistern or tank) where it is pre-filtered for particle removal such as stones and branches, so it is clean enough to be distributed through a pumping system [72]. Similarly, greywater has the potential to become a resource rather than a waste: if treated and reused, it reduces the amount of water entering septic tanks or being discharged into the open ground, reducing contamination of fresh and groundwater resources [50,67,74–77]. Additionally, it is important to know its characteristics to set the treatment scheme as well as its possible uses, which will be determined by the amount of water produced by the number of members in a house or community. Basic greywater treatment includes particle removal and biological treatment (wetlands), plus it is suitable if human contact will be excluded; in cases where water will have direct human contact, an advanced treatment such as membrane filtration, adsorption, or disinfection must be ensured. For instance, if its use is planned for irrigation then basic treatment is sufficient [78,79]. Evidently, rain and greywater systems can be as simple or as complex as the local area requires, but in most cases they are simple, low cost, and offer many benefits; they have also proven to be highly socially appropriated and accepted because of the ease of availability and use, plus their multipurpose uses allow them to be a great solution to reduce the amount of freshwater needed to supply a household or community needing to alleviate water scarcity problems [72,80,81]. On the other hand, increasing sanitation coverage also has important benefits: it can reduce the contamination of fresh water resources and reduce the release of fecal matter and pathogens into the environment [75]. The implementation of waterless technologies that allow safe excreta separation to produce compost is proposed, since composting is well-known as a practice to recover organic matter and nutrients from fecal sludge in a safe way, especially when producers (households) are in close proximity. The



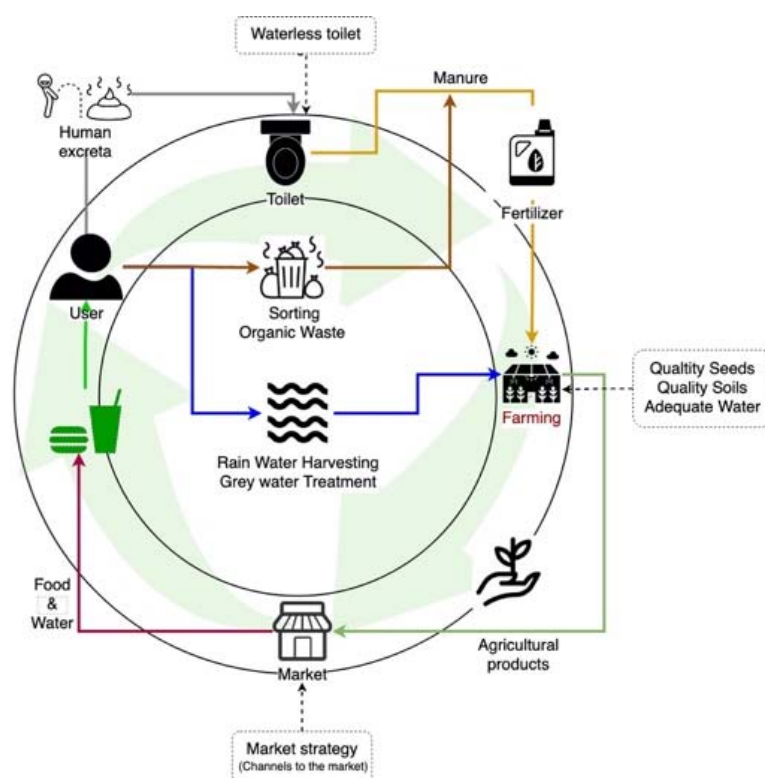
recovered nutrients can be used to substitute inorganic fertilisers for crop production, which works as a carbon source improving the organic content, structure, infiltration rate, water holding, etc., of the soil by counteracting nutrient deficiencies and improving physio-chemical soil properties: the necessary characteristics for cultivation [82,83]. Furthermore, composting does not require highly skilled labor and can be implemented in any place; the development of a composting facility can have multiple benefits such as creating jobs for local people and being a source of a significant amount of revenue generation: it could also help to solve solid waste management problems. With a sorting system at the source, organic waste can be recovered and incorporated into the composting process, which would represent an important opportunity for valuable nutrients recovery, such as nitrogen and phosphorus to produce soil ameliorants for crop production, fish feed, livestock fodder, and more [17,25]. With a sorting system, some other materials can also be recovered such as plastic, glass, cardboard, metals, and minerals that could be incorporated and reused in other value chains inside the system, even though these options are not explored in this proposal. So, the use of compost from excreta has been used in agricultural business systems implemented in Burkina Faso, Indonesia, and Peru for subsistence farming with crop rotation using urine and greywater for vegetable production [31,32,84,85]. As prescribed in SDG 17, achieving sustainability will take a combination of different tools, actors, and solutions adapted to diverse contexts to achieve sustainability; it is clear that a change in how basic services are provided is necessary, vital, and important, not only for society but also for governments. As the provision involves different actions from different perspectives, some frameworks have been designed with economic, social, environmental, technological, and political sustainable approaches; however, it is still crucial to focus part of them on understanding how communities function, in order to truly achieve sustainability [8,23].

### 3.3.2. Value System

To add value to excreta, wastewater, and solid waste, Figure 1 in Section 3.2 suggests that (1) the small current vegetable garden is a potential channel to the market; (2) the vegetable garden near the house could use fertiliser and water for irrigation; (3) human excreta and organic waste are a potential source of fertiliser; and (4) greywater and rainwater are a potential supplementary source of water for irrigation. In addition, it is essential to optimise the disinfection of sanitation products for agricultural use [15,17,19,31,32].

As result, a new value system is proposed (See Figure 3), where besides the basic services provided such as sanitation, water, and waste management, users have the possibility to increase their income through quality vegetable cultivation, by using treated grey and rainwater for irrigation as well as fertiliser produced from human excreta and organic solid waste. So, users invest in improving their sanitation and water facilities and, in return, increase their income [19,31,32]. If the value system works well, then the income increase becomes an incentive to invest in and manage the facilities.

Most of the poor in the world depend on agriculture. Ending poverty and hunger, achieving food security, improving nutrition, and ensuring the availability and sustainable management of water and sanitation, as well as sustainable economic growth, are directly linked to the production of nutritious food, increased returns from agriculture, increases in water efficiency, and the sustainable management of all natural resources. Agriculture is the most important source of food in the world, so its reform towards sustainability is crucial [25,63,64]. In addition, if some sustainable agriculture practices such as crop rotation, using organic waste and excreta as manure, and rainwater harvesting (to mention a few) are adopted and practiced in the right manner, there is the potential to promote sustainability and help achieve the SDGs [64].



**Figure 3.** Proposed value system of the S<sup>3</sup> framework.

In this sense, excreta management as well as greywater and rainwater treatment facilities function not only as the instruments for the provision of a service but also as assets of a resource-oriented agriculture business. As it is appreciated, this proposal has the intention to go further, not just reaching the production of quality fertiliser and overcoming taboos related to the use of excreta as a fertiliser, but adding value to all the products that follow the chain after fertiliser production until the sale of a final agricultural product. This proposal aims to bring together stakeholders from different sectors to improve the quality of life in villages and small cities through sustainable solutions. As stated [17,19,31,32,63], resource recovery and reuse offers value beyond environmental benefits through cost recovery, since it can be an incentive for a sustainable service system by recovering costs where revenue can feed back internally or generated revenues for reuse can fill financial gaps across the system to complement other supporting mechanisms, thus making S<sup>3</sup> more attractive.

#### 4. Conclusions

The application of the S<sup>3</sup> Framework has the potential to increase the well-being, human development, water availability, food safety, poverty alleviation, and healthy environments of societies through the provision of safely managed basic services as well as the recycling of nutrients and water to achieve sustainability at household and community levels around the world. Nevertheless, even when this research introduces a new and more comprehensive holistic approach to provide sustainable systems that may contribute to develop sustainable and smart societies; it has its limitations and the following issues must be taken into consideration, there is no one-size-fits-all solution for all the countries, so it must be designed according to local conditions, needs and preferences. Policymakers will need to assess the context-specific barriers, manage trade-offs, and maximize synergies and networks to achieve the required transformations for S<sup>3</sup> to be economically and politically viable. Moreover, it needs experts in diverse areas of knowledge such as economy, sociology, engineering, policy, business, marketing, etc., for its design, to make its implementation easier and successful. It is not a list with specific steps to follow, it is open to changes

and adaptation according to specific local conditions and resources available. Another imperative point is that implementation of technologies alone cannot achieve transition, policy, institutional and cultural changes are needed to promote smart practices, the S<sup>3</sup> framework needs to be carefully implemented, to achieve Smart Societies and enhance the involvement of communities, this being the most important challenge. Finally, it is important to mention that the S<sup>3</sup> Framework is suitable for, but not limited to, countries with high poverty levels, poor infrastructure, and severe environmental conditions, because it does not need expensive infrastructure.

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