Framework Proposal for Achieving Smart and Sustainable Societies

Subjects: Water Resources | Engineering, Environmental | Agricultural Engineering
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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 S3 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

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][2][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][5][6][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][9][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][14][15][16][17][18][19][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. 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][25][26][27][28][29][30][31][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][14][15][16][17][18][19][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. 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 [38][39]. 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 [38][40][41]. 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][42]. 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].

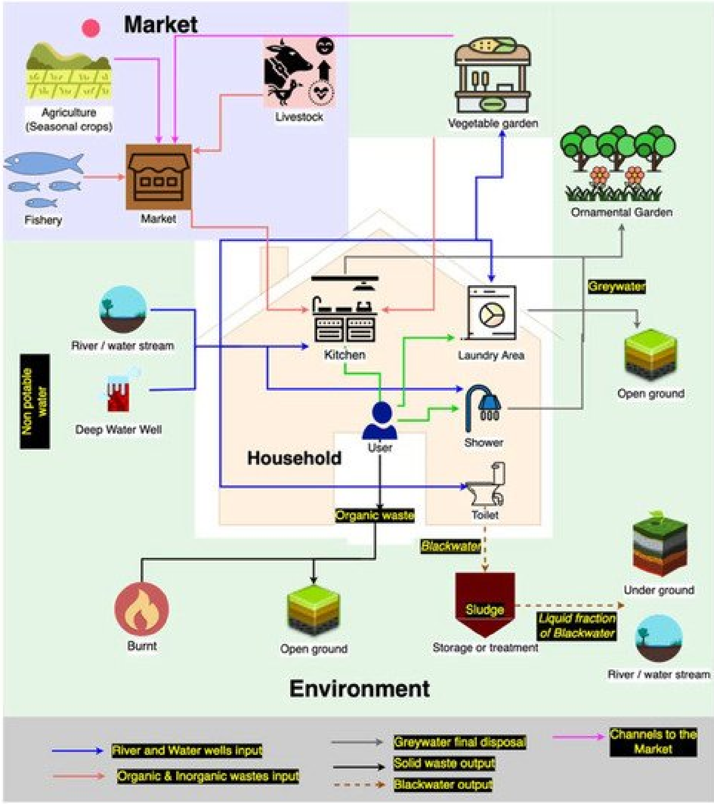

Figure 1. Current water, basic sanitation, and agricultural system performance.

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][40]. 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 [43].

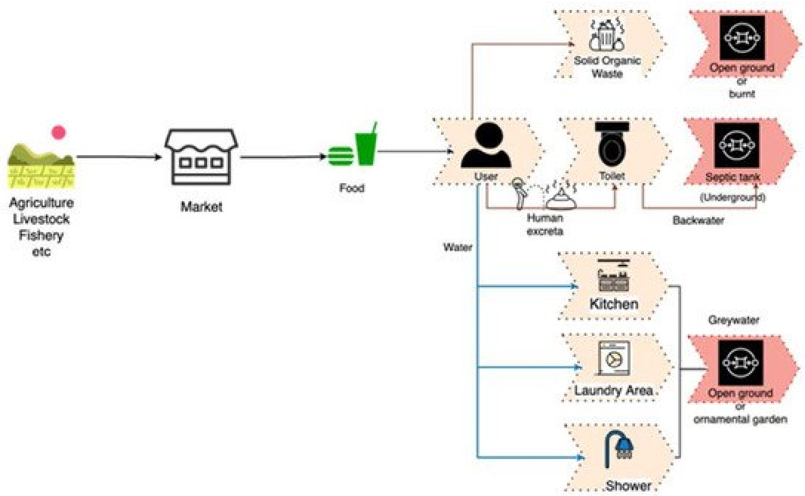

Figure 2. Current value flow of systems at the household and community level.

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 [44][45] 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 [46][44]. It is appreciated that there is a strong interrelation between agriculture, water needs, and organic fertilisers.

4. 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).

5. Conclusions

The application of the S^3 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^3 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^3 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^3 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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