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Yuck! Plural Valuation of Constructed Wetland Maintenance for Decentralized Wastewater Treatment in Rural India

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In 2012, an estimated 50% of rural households in India had a system of drainage for moving wastewater away from their homes, but 0.0% have access to safe, reuseable, treated wastewater. Constructed wetlands can provide decentralized wastewater treatment for rural villages and lead to multiple benefits, such as reusable water, reduced disease, and decreased environmental pollution. However, the maintenance of decentralized wastewater technologies is poorly understood. We used a case study design across four communities and six constructed wetlands to understand the social and cultural variables impacting the maintenance of constructed wetlands for decentralized wastewater treatment to provide agricultural irrigation water. Semi-structured interviews ($n = 39$) and focus groups ($n = 4$) were conducted with people from Telangana and Karnataka, India. Interviewees were classed into four groups: (1) Scientists, (2) Farmers, (3) Privileged Community Members, and (4) Socially Disadvantaged Community members. Inductive, constant comparison qualitative data analysis was used to develop a model for explaining the existing practice of wetland maintenance. Three themes emerged from the data: mental models of constructed wetland maintenance show plural valuation of ecosystem services, yuck as a leverage point for decreasing social cohesion in the community, and recommendations for improving maintenance through human-centered design. Based on the results, we propose a model for understanding how to incorporate the plural valuation of ecosystem services provided by constructed wetlands and human-centered design to support long-term adoption and maintenance of decentralized wastewater treatment technologies.

Keywords: water reuse, perception, agroecology, adoption, public health, WASH, irrigation, caste (untouchability)

INTRODUCTION

Over 1.3 billion individuals live in India. Wastewater (WW) from hundreds of millions of individuals goes untreated and is released back into the environment, leading to an increased incidence of disease and environmental pollution. Decentralized WW treatment (DWT) is one reasonable option for some rural communities. Yet, there is no widespread adoption despite many different available technologies and a significant amount of capital devoted to providing a solution.

Without proper water, sanitation, and hygiene (WASH), developing countries face limited growth in their Gross Domestic Product, high child mortality, limited life spans, and stunting in children (LoPalo et al., 2019). Historically, WASH programs focused on water supply and behavioral sanitation practices, and little research looked at how communities manage downstream WASH infrastructure. Wastewater treatment is an essential component of WASH for minimizing exposure to pathogens.

Constructed wetlands (CWs) are a proposed technology for water treatment and are widely used for primary and secondary WW treatment (Vymazal, 2011; Starkl et al., 2015). CWs are often regarded as a green solution for WW treatment for their relative simplicity, reliance on natural systems, green space, habitat for wildlife, limited energy requirement, and low level of technical skills needed for maintenance (Kumar and Dutta, 2019). Constructed wetlands require regular and reactionary maintenance to ensure that the physical, chemical, and biological treatment mechanisms continue to function effectively for delivering high-quality treated outflow (Werellagama and Karunaratne, 2011). The maintenance activities depend upon the plants' growing conditions inside of the CWs, the water quality of the inflow, WASH conditions of the community, and storm water related reactionary maintenance. Little is known about the process and impacting variables that affect long-term adoption and maintenance of CWs in rural communities.

This research answers the call by Desai et al. (2015) to provide in-depth case studies of the maintenance of infrastructure in India and of Schouten and Moriarty (2003) to provide a critical evaluation of existing community water management programs and insight into improving maintenance and community management of water systems in developing countries. This research also helps better understand the impacts of power and plural valuation, divergent perceptions of how nature benefits human well-being, and ecosystem services within community development (Jacobs et al., 2020). The perception differences of how the various stakeholders perceive the ecosystem services of CWs for WW treatment have not been explored to date. The studies herein examine the challenges for long-term maintenance of six CWs in South Central, India. This research explores the nexus of the existing theories and knowledge of agricultural WW reuse, maintenance of decentralized WW systems, and community-based water management.

Friedrichsen et al. (2020) describe the gaps in communication related to ecological knowledge, maintenance, and monitoring of constructed wastewater wetlands, but does not address the socio/cultural barriers to the maintenance of constructed wetlands. The objectives of this study are, therefore, to investigate what factors limit community maintenance and how these interrelate. The yuck factor and other plural values of CWs need to be incorporated into the design and implementation process of CWs to facilitate sustained maintenance. The findings enabled us to suggest recommendations for the design and dissemination process of CWs as community development projects for enhancing community WW treatment. Three key research questions are addressed in this investigation: (1) How does the plural valuation of ecosystem services impact maintenance of CWs for DWT? (2) How does the yuck factor influence social cohesion and plural valuation of ecosystem services of CWs? (3) How can the design of CWs be human-centered to account for the plural valuation of ecosystems?

While some studies have explored engineering and water quality aspects of CWs and DWT, few develop a social understanding of perspectives and maintenance of DWT. Due to the degree of personal contact and maintenance required, the adoption of decentralized units differs significantly from centralized units due to the yuck factor (Mankad and Tapsuwan, 2011). However, it is not clear how these differences extend to the adoption of DWT for agricultural irrigation or how they affect maintenance behavior of predictive maintenance models (Devitt et al., 2016). The psychological socio-cultural response to WW has often been characterized in the literature as the yuck factor (Mankad and Tapsuwan, 2011) or attributed to religious contextual differences (Saad et al., 2017). The yuck factor is the immediate emotional disgust or repugnance that causes aversion. The yuck factor is culturally taught (Schmidt, 2008) and disgust can be caused by several factors, such as violation of morality including ideas of holiness and purity, aversion of pathogens, or sexual defilement (Rozin et al., 1999; Rozin, 2015).

Case studies across the globe provide insight into barriers to maintenance and why CWs may fail. Across four CWs in India, barriers to maintenance included lack of perceived ownership, lack of effective institutional structure to raise maintenance funds, lack of equitable access to valued output (e.g., harvested, composted aquatic vegetation), and lack of finances (Kumar et al., 2016). In Thailand, the lack of a key person to take responsibility for maintenance, lack of skill in maintaining effective community engagement and participation, ineffective regulation of the CW, high rate of construction error, and lack of perceived value of the generated services (i.e., wastewater treatment, composted sludge, etc.) provided by the CW all limited maintenance (Laugesen et al., 2010a; Brix et al., 2011). In Latin America, Gauss (2008) observed the maintenance of 10 CWs, identifying lack of access to consistent influent water flow, ownership, community organization, equipment, community involvement in planning, appropriate skill level, accounting for maintenance in the planning process, and limited financial resources as barriers to maintenance of CWs (Gauss, 2008). In a meta-analysis of sanitation infrastructural project case studies across India, Mexico, and South Africa, the lack of appropriate, effective, long-term engagement of the community from the initial planning through maintenance was identified as the mechanism leading to failure of the systems (Starkl et al., 2013b).

However, little research has examined how the yuck factor has impacted maintenance.

The governance of natural resources reflects the most powerful stakeholders' values and their cultural worldview (Colvin et al., 2015; Suhardiman et al., 2019). All people value fairness and purity and seek to avoid harm, but how those values are applied by different groups result in priority differences (Haidt, 2007). This can impact behavior and lead stakeholders to support different environmental governance policies (Stern, 2000). Several lines of research explore this work, including the plural valuation of ecosystem services (Arias-Arévalo et al., 2018; Jacobs et al., 2020), nature's contribution to people (NCP) (Díaz et al., 2018), and critical theory of environmental social justice. Values are important determinants of behavior, and other theories explain how values impact the way individuals make decisions about environmental behaviors (Stern et al., 1999), how values impact the governance of landscapes (Schulz et al., 2018, 2019), and how to account for trade-offs across the relational, intrinsic, and instrumental values in ecosystem management policy (Ellis et al., 2019).

However, it is particularly difficult to articulate the values of an ecosystem service and incorporate them into policymaking, especially when their derived value can attenuate the social division of socially disadvantaged communities from those in power, influencing intrinsic and intangible dimensions of well-being (Wegner and Pascual, 2011). There is a substantial impact on group identity and political power that influences how various stakeholders support particular environmental policies (Kahan, 2010). Decisions in the political sphere may be based on moral foundations that appeal to the most dominant group (Haidt, 2007).

Plural valuation of ecosystem services recognizes that different stakeholders perceive varying values, connect ecosystem services to well-being, and recognize power dynamics between stakeholders perpetuate inequality and conflict related to environmental management (Arias-Arévalo et al., 2018; Jacobs et al., 2020; Zafra-Calvo et al., 2020). If not accounted for in environmental management, plural valuation of ecosystem services may contribute to social division eroding a community's social cohesion (Berbés-Blázquez et al., 2016). For example, in the United States, a wastewater reuse project was plagued by power dynamics and discrimination (Lejano and Leong, 2012). Social cohesion is the "nature and extent of social and economic divisions within society" (Easterly et al., 2006). Social cohesion is strongest when there are limited leverage points where divisions and inequality can be aggravated, but instead, the community embraces and is empowered by its diversity to improve wellbeing (Easterly et al., 2006). Without social cohesion, there is limited capacity for the community to have effective communication channels for providing feedback for maintenance. If the ecosystem is ignored, community development programs may not function as intended and may even negatively impact environmental management (Zafra-Calvo et al., 2020).

The caste system was a type of social order in India before British colonization and was exacerbated by colonial policy. It has led to widespread discrimination and marginalization, reducing social cohesion. The concepts of purity and pollution imply that garbage, human feces, and wastewater are polluting elements, and individuals who work with those resources are thusly polluted (Gupta et al., 2016; Doron, 2018). Some socially disadvantaged individuals and groups seeking to improve their social hierarchy do not want to be associated with their historical occupation and do not want employment in these sectors. Socially disadvantaged community members may include scheduled castes, scheduled tribes, and other backward castes (Gupta, 2005). Additionally, individuals of higher castes still do not want to be associated with polluting objects and occupations (Desai and Dubey, 2012). This has minimized the number of individuals motivated to manage waste in India. India's government has done very little to motivate or increase the capacity of individuals to enter into jobs associated with waste management (Doron, 2018).

MATERIALS AND METHODS

This study is an iterative, inductive, constructivist qualitative (Charmaz, 2014) case study examining the maintenance process of CWs for DWT that provides agricultural irrigation water. Mental models were indirectly elicited through semi-structured interviews (Jones et al., 2014). The first author relied on the constant comparison process (Charmaz, 2014) between each of the constructed wetlands, communities, and stakeholder groups to understand the dimensionality of the process of maintaining the CWs.

Theory: Mental Models and Plural Valuation

How to best elicit, share, and examine the plural valuation of ecosystem services in community development to limit the effects of power between stakeholders has not been thoroughly explored (Arias-Arévalo et al., 2018; Jacobs et al., 2020) but has been widely seen as problematic (Zafra-Calvo et al., 2020). Mental models may provide a method for eliciting stakeholders' plural valuation of the CWs. It allows multiple perspectives to be collected in a way to develop an understanding of how communication and power are dealt with across gaps and overlaps between stakeholder groups (Friedrichsen et al., 2019).

Mental models are cognitive structures of how the world works. Mental models are built through experiences and cultural norms. Individuals from the same sub-cultural background will hold a collective cultural model of how the world works. Individuals use their mental models to filter incoming information and predict the future outcomes of decisions (D'Andrade, 2005; Quinn, 2005; Jones et al., 2011). Individuals may have multiple partial or whole cultural models depending upon their group memberships (Quinn and Holland, 1987).

Comparing and contrasting stakeholder mental models to identify gaps and overlaps can provide insight into how natural resources are managed and used to facilitate community development (Jones et al., 2014; Friedrichsen et al., 2018, 2019). The study of mental models can be elicited individually or in group settings, depending upon stakeholder preference, power structure, and how stakeholders prefer to express their values.

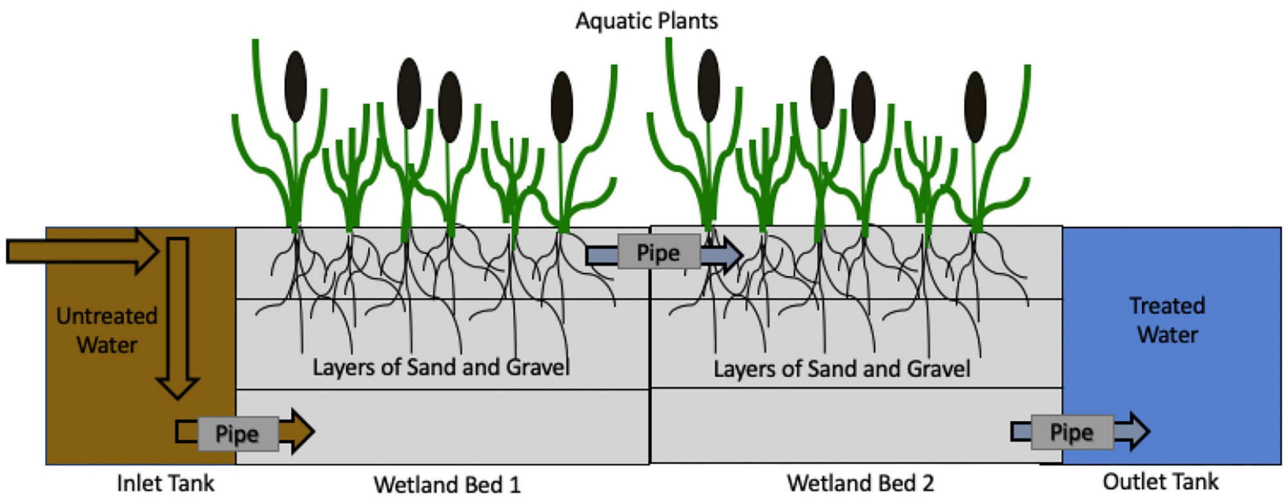

FIGURE 1 | Basic design of horizontal flow CW implemented in the communities.

Study Design and Sampling

This study was designed to examine the maintenance of CWs within established research and extension programs. The International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), as part of their Integrated Farmer Participatory Watershed Management Model (IFPWM), built ∼30 CWs for communities across south India that had limited access to water for crop production and existing concrete drainage systems that collect mostly gray WW. ICRISAT aimed on increasing agricultural irrigation water quality and improving the food safety of crops grown with WW through disseminating CWs (Datta et al., 2016, 2018). The horizontal flow, gravity-based CWs mimic and recreate natural wetlands' ecosystem services by delivering clean water via supporting processes of filtration and sedimentation of particles, uptake of extra nutrients in wastewater, and reducing microbial loads in outflow (**Figure 1**). The CWs were in various degrees of surface and subsurface flow at the time of observation. Of the six CWs observed, two CWs had primary treatment (gravel tanks or sedimentation pond). CWs often lack primary treatment in developing countries (Denny, 1997).

The designed capacity of the CWs ranged from 20 to 56 (m^3/d), serving between 70 and 500 households. The primary maintenance activities recommended by ICRISAT for CWs include harvesting of aquatic vegetation and backwashing every several months. ICRISAT recommended the cleaning of the gravel and sand in the wetland beds approximately every 5 years. Other major, routine, and non-routine maintenance activities were identified by stakeholders, including replacing gravel and sand in wetland beds, mosquito management, and leveling of the wetland bed material to prevent stagnation (Friedrichsen et al., 2020).

IFPWM is based on a participatory development model where a watershed committee is formed that consists of various stakeholders who represent a wide range of religions, gender, and castes. IFPWM is mainly funded by social-responsibility corporations. The watershed committee then chooses what innovations to adopt in the community from a suite of innovations, the innovations' placements, identifies willing farmers, and communicates between the community and ICRISAT. (Wani and Ramakrishna, 2005; Wani, 2008; Wani and Sidhu, 2009; Datta et al., 2018). ICRISAT aims to foster ownership of the CWs by farmers who use the outflow through either monetary contribution to the construction or donated labor. ICRISAT fostered ownership by the community through celebrations centered around the beginning and end of the construction of the CW and handing over responsibility. For the CWs, watershed committee members along with the farmers using the outflow approved the construction, identified the location of the constructed wetland, and oversaw construction and maintenance of the CWs during the IFPWM project duration. Scientists and extension agents provided reactionary advice to the CW's functionality during the IFPWM project duration and collected water samples to monitor water quality. The IFPWM project durations varied per community, depending upon funding available with a minimum of 4 years.

This cross-sectional design compares the mental models of scientists, farmers, privileged, and socially disadvantaged community members, allowing for the examination of how plural valuation of ecosystem services of CWs impacts the dissemination, adoption, and maintenances in the community. Six CWs in four communities were selected to be part of this research study. Selection criteria for their inclusion included: (1) proximity to ICRISAT to ensure that there was communication and knowledge exchange between ICRISAT researchers and the participants, (2) CWs were past their adoption phase by the community and within their maintenance period, and (3) outflow water of the CW was being used for agricultural crop production. The study aimed to include constructed wetlands that were constructed 6 months to 5 years prior and were at the time in a

TABLE 1 | Participants by stakeholder group.

Participant	Number
Farmers using WW	9
Farmer using harvested biomass from CW	1
Watershed Committee members	6
Community WASH maintenance representative	4
Extension Agents	11
Sarpanch (Village president)	3
Scientists	5
Neighbors living near CW (Focus group of 3–6 individuals)	4

period of needing maintenance. Data saturation was determined when no new concepts arose from interviews with two additional extension agents in a seventh constructed wetland in a fifth community (Bernard, 2011). Each community was visited at least twice with at least a month between the initial and final visits. The first author was a research fellow within the CW project at ICRISAT and had prolonged engagement (4 months) with the scientists and extension agents during the entire data collection period.

Sampling purposefully selected individuals who represented all of the various dimensions of maintaining the CWs (**Table 1**) (Bernard, 2011). Interview participants ($n = 39$) were identified and approached by their local extension agents to initiate the conversation with a trusted individual (Warren and Tracy, 2015). Focus groups were conducted with neighbors living near the constructed wetlands ($n = 4$), with each focus group having 3–6 participants. The categories of participants used for the sampling frame in **Table 1** were then grouped into how they perceived the CW valuation: Scientist, Farmers, Privileged, and Socially Disadvantaged community members (**Table 2**). Extension agents had mental models that included segments of various other stakeholder groups' mental models. In general, watershed committee members and the *Sarpunch*es (village president) had values aligned with the category of privileged community members. In contrast, neighbors and community WASH representatives held values that aligned with socially disadvantaged community members. The research was reviewed and approved by the University of Florida Institutional Review Board. The participants provided their oral informed consent to participate in this study.

Data Collection

Data were collected through semi-structured interviews (Laukkanen and Wang, 2015), observations, and tours of the CWs and surrounding communities (Abel et al., 1998). The first author conducted all interviews ($n = 43$) in the spring of 2018 as a research scholar at ICRISAT. All participants gave informed consent. The interviews were conducted in the participants' offices, houses, on roads next to the CWs, or in nearby community areas to improve reliability and validity of their responses (Jones et al., 2014). The interview guide was developed and pilot-tested with extension agents (Zahnd and Willis, 2007). The interview guide was developed during data collection as preliminary data analysis occurred throughout the data collection process to include emerging themes (Charmaz, 2014). The objective of the interviews was to elicit the stakeholders' mental models of the maintenance of the CWs. Interview topics included the CW planning process, perceptions of water quality of effluent, CW functionality and maintenance, responsibility for CW maintenance, implementation process, barriers to implementation, design suggestions, explanations of design modifications over time, and challenges and benefits of the CW. Most participants were eager to participate in the research, especially the farmers and watershed committee members. They gave tours of the CWs and the farmland where the irrigation water was used. Local politicians and some scientists were less eager to participate, although they did consent and find time to contribute. Socially disadvantaged community members were meager but appreciated the opportunity to share their perspectives. Interviews lasted from 15 min to 2 h. Interviews with CW neighbors were shorter and interviews with scientists, extension agents, and farmers using the wastewater were longer. Interviews with scientists and extension agents were conducted in English. Interviews with other participants were conducted in their first language, either Kannada or Telugu, using three translators. A subsample of the Telugu interviews was spot translated by the second translator to ensure accuracy. Field notes were taken after community visits.

All interviews were audio-recorded and then transcribed by the first author. Participants were asked to draw the constructed wetland during the interview, which added to understanding their perceptions of the unit (Literat, 2013). Interviews lasted from 15 min up to 2 h, depending on the individual's level of interaction with the CW.

Data Analysis

A constant comparative method was used for data analysis (Glaser and Strauss, 1967). The first author, who used peer debriefing during the initial data analysis, coded all the interviews in NVivo (version 12). There were 166 emergent themes, grouped into 15 categories (Bernard and Ryan, 2010). **Table 3** presents the codebook with all categories, and **Table 4** gives an example of emergent themes from one code category with representative quotes. The 3CM card sorting technique (Kearney, 2015), coupled with debriefing conservations, was used with three participants to provide feedback on the findings of the emerging categories during data collection and analysis as a form of member checking (Birt et al., 2016). Memos were written during data collection, analysis, and diagramming (Charmaz, 2014) to understand the differences between varying CWs and communities (Glaser and Strauss, 1967). Mental models were created and represented with influence diagrams for each stakeholder group (Jones et al., 2014; Friedrichsen et al., 2018). A process model (Morgan, 2018) was created to explain the maintenance of the constructed wetlands. It was developed through iterative diagramming during the data collection, data analysis, and peer debriefing (Charmaz, 2014). Peer debriefing was used throughout the data analysis process (Saldana, 2015). The model builds upon the work in Friedrichsen et al. (2020) of the importance of ecological knowledge on monitoring the CW

TABLE 2 | Stakeholder groups, cultural models and mental models of CW maintenance.

Cultural mental model	Stakeholders with part or whole mental model alignment	Mental model
Expert	Scientists, Extension agents	Instrumental ecosystem service value of CW greater than cost of maintenance
Beneficiary	Farmers using WW, farmer using harvested biomass from CW, Extension agents	CW has agricultural value with or without maintenance
Socially disadvantaged community member	Community WASH maintenance representative, neighbors living near CW, Extension agents,	Yuck devaluation is greater than the value of maintenance
Privileged community member	Watershed committee members, *Sarpanch,* Extension agents	Yuck! CW maintenance is not my responsibility

TABLE 3 | Code book for data analysis.

Categories
Suggestions for design
Responsibility for CW maintenance
Challenges caused by the CW and barriers to maintenance
Knowledge of CW maintenance
Perceived benefits of CW
Monitoring of CW
Mechanization of CW maintenance
Composting of aquatic vegetation biomass
Indicators of CW functionality
CW labor and maintenance
Gender and CW
Farmer characteristics as related to CW outflow use
Location of CW
Payment for CW maintenance and CW income generation
Maintenance activities

performance within stakeholder communication and perceived utility of maintenance for water quality.

RESULTS

The development of the maintenance process of the CWs within the communities followed a linear process that led to the current state of plural valuation, governance, and maintenance (**Figure 2**). The results are divided into three sections that address each of the research questions. The first section compares and contrasts the mental models of experts, beneficiaries, privileged, and socially disadvantaged community members related to the plural valuation of ecosystems of CWs. The second section examines how the yuck factor impacted CW maintenance related to being a leverage point for social division and decreasing the dignity of the maintainers. The third section gives suggestions to improve the human-centered design of the CW to overcome the plural valuation of the ecosystem services perceived by stakeholders to address the yuck factor. Minimizing the yuck factor promotes maintenance and increases the perceived benefit for maintenance and, consequently, motivates maintenance.

TABLE 4 | Codebook example of themes grouped under the category of CW labor and maintenance.

Theme	Representative quote
Village servants do the maintenance	Interviewer: Whose responsibility is it to clean out those drains? Farmer 32: Gran panchyt. There is a person called village servant who is appointed by the *sarpunch* who needs to take care of it. Interviewer: Why is he not taking care of this? Farmer 32: [The location of work is] Alternating, the village servant will change the location of cleaning so by the time he cleans this location it blocks there
Pay more to clean out	Maintenance 11: More money because this is dirty, difficult work
Labor comes from another village	Maintenance 49: We are from a different village, we came here only for today.
No labor	Extension 37: Responsibility, sincerely they (the community) have to do the harvesting. Some villages you will not get the labor. They, the *panchyt* or farmers, have to bring the labor from outside. So it will be cost more.
Caste and labor	Extension 46: There is a probable with it being viewed as dirty work. And there are cultural taboos associated with dirty work.
Protective gear	Scientist 26: There is a fear to go inside and to do the cleaning. That is why we suggest people who are cleaning the wetland that they should have protective gear. In the watershed we have given the protective gear also. But to implement it properly is difficult. I have personally seen some people who enjoy playing with snakes even if you give them the protective gear they will say I don't need. So it is kind of, snakes prevents a lot of workers to come for the work. Then also we are required to give them googles, gum shoes when they are going inside.

Plural Valuation of Ecosystem Services

The mental models of CW ecosystem services held by experts, beneficiaries, privileged, and socially disadvantaged community members were strikingly different (**Figure 3**). Scientists perceived

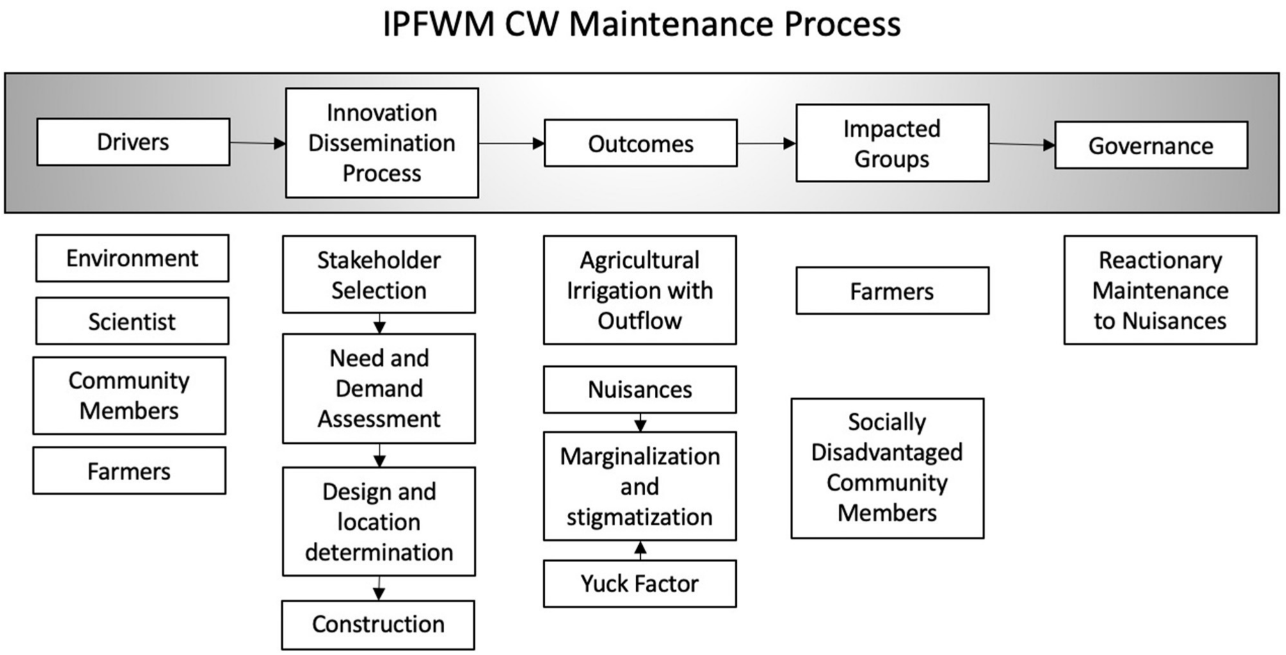

FIGURE 2 | IPFWM CW implementation and maintenance process.

the CWs provided a valuable ecosystem service of treating WW in the community while providing irrigation water for nearby crops. Of non-scientists, only beneficiaries perceived a direct benefit of the CW's ecosystem services, which was the value of improving their occupational health. The community did not perceive the CW provided any ecosystem services to them. They only saw the CW as providing an ecosystem service to the farmer and socially disadvantaged community. Perceived misconceptions by the community related to WW reuse and food safety may have limited perceived value and ecosystem services, influencing their motivation to contribute to maintaining the CW.

Plural Valuation of CW Maintenance Among Stakeholders

Stakeholders had contrasting and divergent mental models of ecosystem services provided by the CW. Privileged community members and socially disadvantaged community members did not perceive any ecosystem services (**Figure 3**). Experts perceived that the CW would be maintained by the community because of the multiple ecosystem services the CW provided the beneficiaries, privileged, and socially disadvantaged community. Scientist 51 said, "They are facing water scarcity. If we build a wastewater treatment it means it will be helpful to them… We can help the farmer, villagers, to give the technology [and] to give the technological support but maintenance they have to take care." Experts perceived the communities would perceive value from the multiple ecosystem services provided by the CWs.

However, there was little perceived ecosystem service value by the community to maintain the CWs for the sake of improving public health. No privileged nor any socially disadvantaged community members mentioned a public health benefit from the CWs or maintaining the CWs. Instead, sanitary worker 12 said, "Farmers are ready to pay [for the maintenance]. They are getting a benefit; they are getting water." When asked what would happen after ICRISAT officially ended their IPFWM and left the CW maintenance to the communities, extension agent 46 said, "This project will end because no one will spend the money to maintain it." The extension agent went on to explain that only once the community understood and valued the benefit of the CW to improving their environmental and health conditions would they spend money to maintain the CW.

Most farmers using the CW outflow had used WW previously, so they did not perceive changes in their water supply. However, several noted that the CW infrastructure (drains and outflow holding tank) did improve their ability to collect WW for irrigation. Several farmers did perceive health benefits:

> *I am not getting any types of health problems. That time [before the constructed wetland], I also have some health problems. Allergies. That time. This time [with the constructed wetland], I am not getting any type of health problem—allergies. (Farmer 4)*

In addition to saying the water quality had improved since CW installation, Farmer 4 also asked that the CW be expanded to improve the quality of the outflow. Farmer 5 noted reduced skin allergies from using the outflow of the CW in addition to improved crop yields. Farmer 5 said, "[Now,] I am getting good water, good yields, good crops. No problem for this crop. Before, [when] I was using the [untreated] wastewater. The crop was somewhat affected." Also, several farmers said that wastewater is better than groundwater because it provides nutrients to the crop.

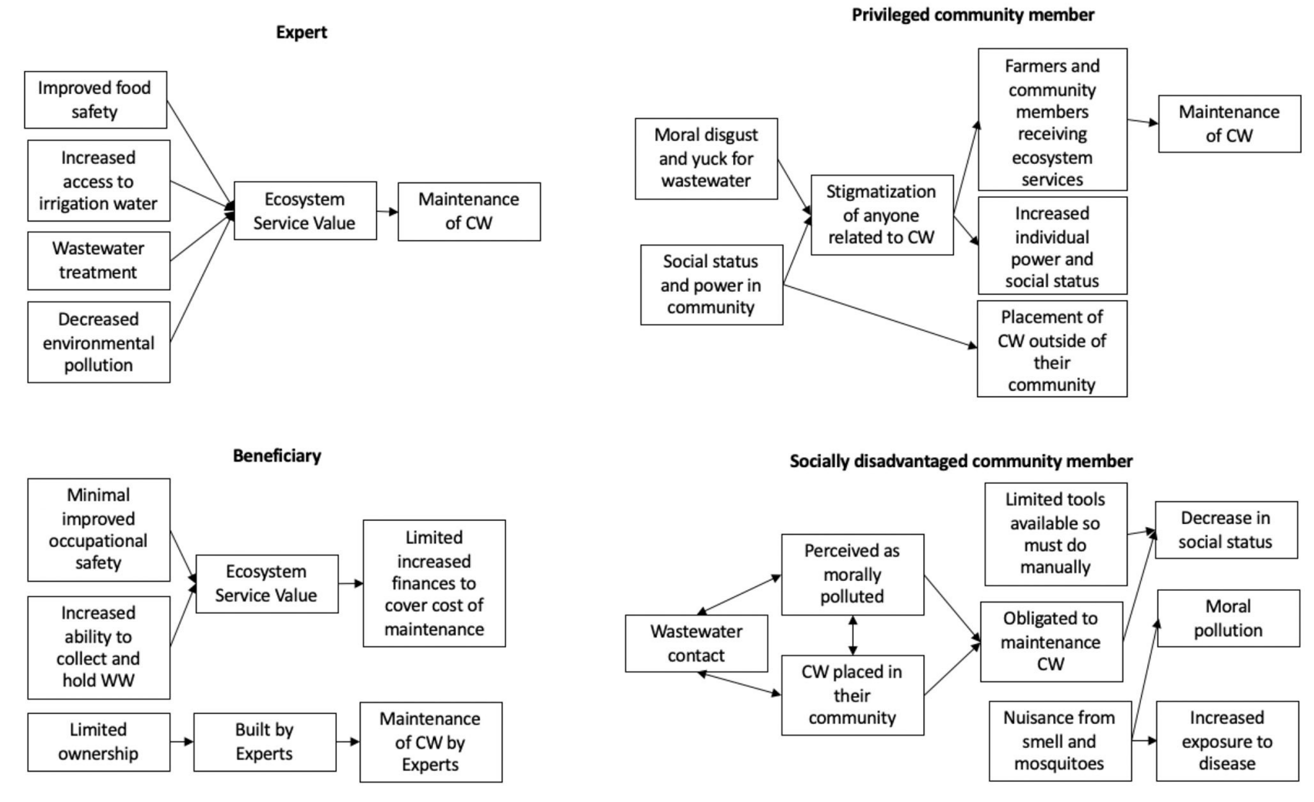

FIGURE 3 | Mental models of plural valuation of ecosystem services by stakeholders.

Food Safety

There was a limited perception of an improved food safety benefit by the privileged and socially disadvantaged community, or farmers. Several misconceptions and hesitations impacted the use of the outflow of the CW, likely further increased social stigmatization of the CW, limiting the perceived food safety benefit. When probed about the safety of using WW for crop production, Farmer 18 replied:

> *They are growing and eating spinach, eggplant, leafy vegetables. There is no effect [on our health]. [However, vegetables are grown] inside [the soil], potato, carrot, these types of crops no need to grow using treated wastewater… When the root vegetable is growing inside in the ground. The wastewater is going inside, and the vegetable will absorb any chemicals. Leafy vegetables are grown above the ground [and will not be exposed to the wastewater]. (Farmer 18)*

This belief was also echoed by Farmer 31, who was using the outflow from a CW to grow only above-ground vegetables (eggplants and tomatoes) instead of below ground vegetables (onions). The various levels of understanding and misconceptions related to public health and WW in agricultural irrigation are also noted by scientists working on the project.

> *Food contamination is very important. Actually, farmers or villagers are not that aware of food contamination, so this is an aspect that is important from the policy side. What I see is local people irrigating salad crops directly with raw wastewater. I don't think they really understand the relation with wastewater and their health and well-being. I don't think that awareness is there. (Scientist 26)*

The misconceptions and lack of knowledge of food safety related to WW for fresh vegetable production may perpetuate negative opinions within the community related to reusing WW. This may have impacted both acceptance and perceived benefit of maintaining the CWs for improving public health. The lack of an assigned value of the ecosystem services provided by the CW resulted in both the privileged and socially disadvantaged community members and farmers performing limited maintenance on the CWs.

Since the communities do not perceive or value the experts' expected ecosystem services from the CW, the privileged and socially disadvantaged community members are not willing to place a monetary value on its maintenance.

> *What I feel the end user [the consumer], I don't think he will worry very much about the maintenance of the wetland. That is what I feel. If there is a farmer who has the experience, like directly seeing a difference, like how his skin is being impacted, he will definitely fight for the wetland, for the maintenance. (Extension Agent 25)*

Farmers, privileged, and socially disadvantaged community members did not perceive value from the treated WW. They, therefore, were unwilling to spend time or money on the maintenance of the CW.

Cultural Beliefs: Morality and Yuck

This section explores the moral dimensions of the plural devaluation of the ecosystem services through the yuck factor. More specifically, the perceived devaluation of the ecosystem services provided by the CW and WW treatment contributes to social division and discrimination within the community. Experts perceived a value in the ecosystem services provided by the CW, however, the community saw the CW as morally degrading. The contrasting mental models of ecosystem services valuation and their relationship to the CW maintenance led to limited maintenance by stakeholders. Instead, it fostered social tension, stigmatization, and marginalization (**Figure 3**).

Location

ICRISAT devotes a considerable effort to identifying and working with a diverse group of individuals on the watershed committee board that represent multiple genders, castes, and religions. These watershed committee boards are charged with participatory planning and selecting the location of the constructed wetland.

> *The upper castes don't want to strongly relate themselves to wastewater. That you might have seen. So a lot of the time, locations of the wetlands are all towards a certain area, which is in proximity to the lower caste community… The location is always closest to the least favored community. (Scientist 25)*

However, the participatory planning escalated social inequality within the community, exposing the socially disadvantaged community members to moral pollution and violating their purity by locating the CWs within their neighborhoods.

Due to the topography, WW flow may influence where one community (with greater or lesser social hierarchy) lives in the village. This can lead to individuals perceiving an unequal distribution of the polluting nature and nuisances of the CW.

> *The plants in the constructed wetland are dropping their leaves right now and blocking the constructed wetland… Because of the dropping leaves, there are mosquitos, children are falling sick, and the odor is like hell in the night times. Whenever we tell the sarpanch [village president], field officers, watershed committee they are not taking care of it… they said that we need to clean it on our own. How can we do it? It is complete village. (Socially Disadvantaged community member, CW Neighbor 15)*

The local officials are privatizing the CW nuisances, placing the responsibility to maintain the CWs on the socially disadvantaged neighbors. The local officials do not see maintenance as a larger community public health effort and the CW as a public resource. At the time of data collection, the CW next to neighbor 15 had been modified to reduce the nuisances that the lack of maintenance had caused—the cement drainage system in front of the inlet tanks was broken and the inflow was being directed around the CW and across neighboring fields.

> *The water got blocked there. We diverted the canal. There is a jam. There is a small stone, we took out the small stone, so now it goes out the other canal and not going into the constructed wetland. We did not do that. The municipal person that came, we told him the problem, we just complained about the problems, mosquitos, pigs, garbage, he diverted that canal.… Whenever people like you come, they come and look at the conditions, they talk about the constructed wetland, other than that no one is going to talk about the constructed wetland except you guys. The maintenance is not good. … We told 3-4 times, we told the committee members, but they did not respond. (Socially Disadvantaged community member, CW Neighbor 15)*

Socially disadvantaged community members may lack the necessary social capital, power, or empowerment to provide feedback essential for timely and effective maintenance. Without effective maintenance, the CW becomes a devaluing ecosystem service and is a source of moral impurity, which negatively compounds socially disadvantaged community members' social standings and mitigates the value that the CW brings to the community. The net result is a degeneration of social cohesion in the community.

Social Division

When promoting a CW's maintenance, the yuck factor can exacerbate divisions within the community, bringing out prejudices between the individuals with power and socially disadvantaged community members. One stakeholder perceived difficulty in communicating with the community to stop putting garbage inside of the CW. Watershed committee member 18 said, "They are not learning. They did not hear. So once again they put inside… The community people are *Dalit*, low caste, so they are not understanding those words. They are aggressive people like that." The prejudice by the watershed committee member responsible for maintaining the CW and securing resources from ICRISAT has limited the community's ability to act cohesively and tackle the CW's poor maintenance issue.

Dignity and Labor

Finding labor to maintain the CWs was difficult. It often required hiring daily labor from other villages, costing 1.5-2 times the local daily wage, because there was no perceived value in the CWs. A community sanitary manager 11 said, "I am doing technical work, not hard work. I'm not doing the work. I am advising laborers. Not doing the work. Members are there [from] *panchayt* [local village administrative units] office, 20 members. These people only doing this work, otherwise they will get from outside laborers." The community sanitary manager 11 is not a socially disadvantaged community member, consequently, he did not work inside the CW. Instead, he contracted individuals to do manual labor of maintaining the CW, which is considered polluting.

In some of the communities, it was perceived that only socially disadvantaged community members could do the maintenance since the CW was associated with WW. Scientist 52 explains,

> *Cleaning and other things certain caste people might not like to get their hands dirt. But when there is some economic benefit coming out of it. The farmer who is enjoying the benefit might put his own money to get that cleared—if he really wants. He might hire people and get it cleared, [and] get it maintained because it needs certain cleaning periodically. (Scientist 52)*

Even when the CW work could be mechanized, communities preferred to hire socially disadvantaged community members to do maintenance. Watershed Committee Member 18 said, "Actually, weed whacker is difficult. Manual work is good... Need to do work with manpower only. Laborers also getting some work. They are getting some job, some money; the work is only doing *Dalit*s." In contrast, one farmer requested a weed whacker during the interview, and one extension agent mentioned their utility when labor is unavailable. Maintenance of the CW degrades individuals' purity by doing the maintenance and contributes to poor social cohesion in the community. Thus, only individuals who are already perceived by the community as having degraded sanctity will do the manual work within the CWs, and they will then seek machinery to avoid physical contact with the WW.

Compounding Social Stigma

Without proper tools to do the CW maintenance, there is increased social stigma associated with maintaining the CWs. Instead of appearing as a dignified job, maintenance becomes associated with manual scavenging. Jumping into the WW inflow, Farmer 42 removed sludge and garbage with his hands while standing mid-thigh deep in the untreated WW. Farmer 42 had no tools or safety protection to do this work. In addition, another farmer and one maintenance individual requested protective safety clothing from ICRISAT to maintain the CW during the first author's visits to the CWs. Not having the correct tools to maintain the CW reinforces the perception of categorizing the maintenance of the CW with manual scavenging.

The cost of maintenance of the CW caused further burden social stigma to the socially disadvantaged farmers using the WW outflow. The farmers who accepted the CWs frequently had already been using untreated WW. In attempt to improve their social status and purity, they accepted the adoption of the CW. However, these already impoverished farmers unexpectantly became saddled with the burden of maintenance because the community perceived they were receiving the benefit. The focus group of neighbors in community 23 responded to the question of who should pay for the maintenance by saying, "Farmers of [village] only. Why? Because they are getting benefit from it. The reason they have to maintain these wastewater treatment plants." The limited profit the farmers were receiving from irrigating an acre or two would be considerably less than the cost of maintenance. The yuck factor of WW leads to the degradation of the sanctity and dignity of the individual maintaining the CW. The maintainers' dignity is further compromised by their lack of available appropriate tools and the financial burden of maintenance. Without proper maintenance, tools, and available capital for maintaining the CWs, then the CW nuisances are compounded. For example, in extreme weather events and flash flooding, "If rain comes, water stagnation will be here. And usually because of the stagnation of this water bad smell mosquitos, malaria and typhoid," said Participant 43.

However, with the installation of the CW, one farmer perceived an increase in the social acceptability of his practice of using WW, leading to an increase in social standing and dignity within the community. This was because the farmer gained attention from the national level news and foreign visitors to his farm. That attention improved the farmer's social status.

The yuck factor impacts the location of the CWs, the communication feedback loops about the necessary maintenance, and who will do the maintenance work in the CW (**Figure 3**). The yuck factor is currently augmented by the limited availability of tools and inadequate financial capacity for the maintenance work. All of which further degrades the maintainers' dignity. The CW maintenance work is perceived to be so yucky or polluting that individuals who are already spiritually impure are the only ones that can do the work, which decreases social cohesion in the communities. Without proper maintenance, the nuisances foster a perceived severe public health situation.

Human-Centered Design to Promote Maintenance

The participants were excited to share suggestions for improving the CWs. Many of the suggestions provide important insight into how to design and disseminate the CWs for overcoming the yuck factor and giving value to the maintenance of CWs to promote ecosystem services. Improving the functionality of CWs and preventing the cascading nuisances that create negative social stigma in the community are essential design considerations for accommodating the stark differences in the plural valuation of the CWs' ecosystem services.

Design of the CW

Participants stated that an appropriate design would shift the maintenance work from manual to mechanized. Manual work with human feces, "manual scavenging" is illegal in India and is considered spiritually polluting (Permutt, 2011). The participants perceived that the maintenance of a CW was, to a degree, "manual scavenging." Designing CWs so that the maintenance work can be done with machines will enable maintenance work to be less degrading and spiritually polluting. For example, creating a design that allows for the use of "*honey suckers*," tankers designed to empty septic tanks, to remove the built-up sludge would eliminate the need for manual work inside the inflow tanks of CWs. Farmer 13 said "Cleaning you are asking? Manpower is not workings inside, machinery is better, easier to work."

The participants had many additional suggestions for improving the CW's design for overcoming the yuck factor. Their suggestions included: improving the adaptability to the local context, aesthetics, ease of maintenance, and reducing clogging (**Table 5**).

An advantage of DWT in India is that it can be designed to accommodate local conditions associated with purity and

TABLE 5 | Design suggestions for improving the maintenance and acceptability of the CW within the community.

Adaptability to Local Context
- Constructed out of flexible and easily modifiable structure materials (not concrete)
- Installation of a primary treatment system before CW
- Outflow management (allow groundwater infiltration from outlet tank vs increase storage capacity of outlet tank)

Aesthetics
- Build solid fence around so community cannot see, and animals cannot fall in
- Use plants in CW that repel snakes and mosquitos
- Park like atmosphere for public use
- Covered inlet and outlet tanks to reduce nuisances
- Move CW away from village
- Move CW away from village's drinking water source
- Functioning subsurface flow design
- Increase velocity of water moving through CW

Ease of Maintenance
- Walkways in unit, so it is easier to remove plant biomass without falling into filtration tanks
- Physical barriers to prevent garbage from entering (mesh and fences)
- Designed so honey sucker can remove sludge
- Designed so all maintenance activities are mechanized
- Better designed so that outflow can effectively remove clogging
- Improved designed so plant biomass can be removed from structure easier

Improved Functionality
- Install a settling tank before CW
- Designed to better handle storm water and all the silt and garbage that comes with it
- Fence or mesh to prevent garbage from entering CW
- Remove internal walls within CW so that there is one single gravel filtration tank
- Larger gravel to reduce clogging

social stigma. However, local and climate constraints are not known until the CW is installed and begins to function. Even if communities are involved with the CW's design and placement, they may have varying valuations of the CW, and often have no realistic understanding of the system. The community members are not prepared for the social stigmas that might arise or barriers to efficient maintenance. They do not have an existing mental model that could help them understand what the CW does or its maintenance requirements. A CW design needs to be easily modifiable with little expense to the community as they learn about its functionality, social implications, and maintenance needs to ensure successful long-term implementation. The design of CWs need to account for and limit maintenance situations that contribute to social stigmatization and instead provide opportunities for social advancement through maintenance. These design parameters may help improve the perceived value of CWs' ecosystem.

The aesthetics of a CW is essential for building an additional ecosystem service for the community to value while preventing social stigmatization. Scientist 52 said, "This water should be used and then create a green patch out of know where, someone sees a green patch it becomes really spectacular people will come and look at it. [And the community will ask] When everything else is gray, how is this green?" Scientists often complained that the participants were spreading rumors that the CWs were breeding locations for mosquitoes. Designing CWs to promote positive attitudes and values toward their aesthetics may prevent rejection of the CWs by the greater communities after installation. Suggestions include developing a park or planting flowers within or nearby the CW.

Reducing Maintenance Frequency

Watershed committee member 33 suggested creating a second set of "four tubs" or siltation tanks to serve as a second inlet. The community could divert the inflow into the second set of tanks when the first four siltation tanks are clogged with sludge. This would improve the functionality of the CW and ease maintenance. "When the sludge is silted in that particular place... We have suggested, one more four tubs besides that. First three months this one, second three months this one." This would allow the community time to clean or replace the gravel in the siltation tanks every three months, diverting the water to another set of siltation tanks instead of around the CW. This would improve functionality and prevent public nuisances of the CW associated with the clogged inlet tanks, such as smell, stagnant water, and mosquitos.

Associated Community Infrastructure

Without proper community infrastructure and public programs, the CW becomes the defacto stigmatized infrastructure dealing with everything impure (garbage, feces, and use of the site as an open defecation location), increasing the community's perception of purity. Accompanying the dissemination of the CWs with solid waste management and open defecation awareness programs helped prevent the cascading impacts of insufficient WASH infrastructure. In two communities, ICRSAT and the local government worked together to find land and establish a solid waste collection service to diminish the amount of solid waste that would flow into the CW from stormwater and individuals disposing of garbage.

The CWs are stigmatized as being polluting in nature due to their association with open defecation. In one community, the *sarpanch*, the *panchayat* president, discussed the extensive and effective anti-open defecation behavior modification program she had created to change her community members' behavior to improve public health. She emphasized her program of finding individuals and posting murals across the community to change the social norm of the acceptability of open defecation. Reduction of open defecation decreased CW's use as an open defecation site.

The yuck factor associated with CWs may be diminished and the perception of instrumental ecosystem valuation improved with the human-centered design of the CWs. Additionally, the establishment of an associated WASH community infrastructure and programs to limit open defecation and promote solid waste management will improve the inflow to CWs and associated perceptions.

DISCUSSION

In this case study, we examined the yuck factor's moral dimensions as related to WW and strategies for overcoming the yuck factor to promote the maintenance of decentralized WW treatment. The foundational moral value of purity or sanctity was not appropriately and effectively included in the planning, design, implementation, adoption, or maintenance of CW. We showed that the yuck factor might become a leverage point for social division and inequality in the community if there is not strong enough social cohesion. ICRISAT has done a considerable amount of work to identify ways to address these variables, however, without also addressing plural valuation of WW, yuck factor, social cohesion, social stigma, and perceived benefit of untreated WW, it may be difficult to move forward. This case study provides an essential comparative piece for examining plural valuations of ecosystem services of a constructed environment and the role of the value of sanctity, as well as its relationship to adoption, maintenance, and long-term implementation of an innovation. Based on this case study, we propose a preliminary innovation process model that integrates a plural valuation framework (PVF) and human-centered design to facilitate CW maintenance by communities. This proposed model overcomes the challenges of contrasting plural valuation, yuck, and power differentials within communities and may facilitate long-term maintenance of CWs (**Figure 4**).

Plural Valuation Framework

In reference to community water management, Schouten and Moriarty (2003) stated, "At its worst, community management is nothing more than the dumping of what used to be government's responsibility on to the community." The management and maintenance of decentralized WW treatment technologies is a dynamic and difficult behavior for ensuring voluntary continuity within communities. Other variables identified in DWT literature include accountability, willingness to pay, ability to pay, enforcement of rules, sense of community ownership, social cohesion, the existence of appropriate governance rules and regulations, and leadership. They all contribute to reinforcing or undermining social cohesion (Schouten and Moriarty, 2003; Saravanan et al., 2009). Inappropriately assuming that communities have created an equitable cooperative agreement during participatory planning and adoption may be at the core of why community-based watershed management has not succeeded (Saravanan et al., 2009; Starkl et al., 2013b).

PVF, a natural resource management planning process developed around the concept of plural valuation, recognizes power dynamics impacts certain cultural groups' values of nature, intentionally or unintentionally, excluded from ecosystem service valuation (Arias-Arévalo et al., 2017). Therefore, using PVF as a template for a CW implementation's planning and innovation process may prove beneficial to addressing these variables. People tend to value and prefer opportunities to demonstrate competence (Deci and Ryan, 2012), protect community status, and environmental quality (Haidt, 2007). How they choose to do this, however, is a function of culture and opportunity. The PVF focuses on providing an equitable space for social learning to solve these challenges. The first step is eliciting the plural valuation of the CW (e.g., mental models) and understanding the community's cultural landscape in a manner that is comfortable to all community members. Then, PVF suggests managing power dynamics through creating a third place, a place removed of pre-existing historical power dynamic struggles, that is comfortable for everyone, providing a place of social learning through the implementation process of the CW (Jacobs et al., 2020).

Human-Centered Design of CW

To facilitate long-term adoption and maintenance, the CW design must be perceived to be appropriate for and straightforward to the community members. To accomplish this, CWs need to be redesigned (Denny, 1997; Laugesen et al., 2010a; Møller et al., 2012). Human-centered design is an iterative, participatory design process that focuses on emphasizing and understanding the users' experience, needs, and cultural context, and then refining the design based on a formative evaluation. Human-centered design relies on a participatory methodology to understand the community's needs, including the cultural meaning they create from interacting with the CW (Giacomin, 2014).

This case study suggests that CWs could be made more appropriate if their designs would limit human contact with WW, consequently facilitating and enhancing dignity, even improving social cohesion within the community. To minimize human contact with WW, CWs need to be designed with human-centered design standards that focus on the how the CW is maintained, its ergonomics, and its yuck factor, while being considerate of the users' meaning of the maintenance. Additionally, the CW should be designed to adapt with accompanying capable governance systems responsible for maintenance, including modifying the system based upon feedback from the community.

Proposing a human-centered design approach is a paradigm change in the innovation process of how CWs are designed from a science-based, reductionistic approach to designing a system for achieving specified environmental quality thresholds that include the cultural contexts of the use and meaning of the CWs (Gauss, 2008; Laugesen et al., 2010a).

CW implementation planning should incorporate every stage of the WW system from collecting wastewater, treating wastewater, managing and creating valued outputs (e.g., treated WW and composted sludge), providing energy or renewable energy for the system, integrating the CW with the local situation making a park or providing wildlife habitat as appropriate to needs of community, creating an institutional structure that supports management and finances for supporting maintenance (Laugesen et al., 2010a), and implementation with the associated missing WASH infrastructure (e.g. solid waste management) (Gauss, 2008).

We would like to acknowledge that this process model was developed from only one case study and that once the plural valuation of ecosystem services, yuck factor and social cohesion, and human-centered design are addressed by technology transferring institutions, new variables may arise that impact maintenance.

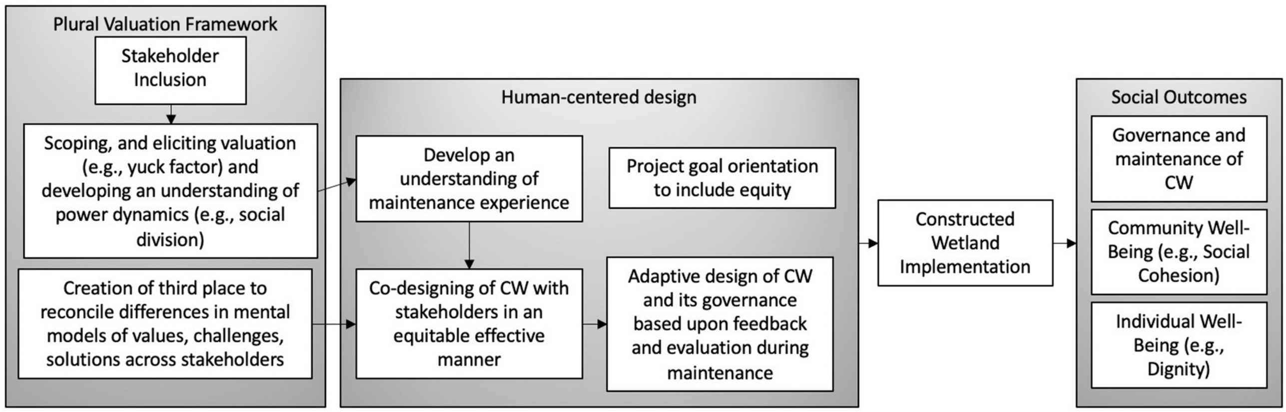

FIGURE 4 | Plural valuation and human-centered design for CW innovation.

Limitations

Because there was limited maintenance by the community at the time of data collection, this case study does not include a thorough understanding of governance and agency within the community as related to maintenance of the CW.

The author is a white female from the United States, who was a research scholar at ICRISAT during data collection. ICRISAT provided the translators and drivers. The participants may have perceived the author as a member of ICRISAT. Individuals who were interviewed may have altered their responses depending on their alignment with ICRISAT and IFPWM. To mitigate this limitation, the sample of individuals came from street intercepted neighbors living next to the CWs. The sample of participants was not limited by ICRISAT's contacts. Scientists were not present nor involved during participant identification or data collection. Data collection and participant selection only occurred with the translator. During data collection, ICRISAT was writing grant proposals to renew Water4Crops.

The case study within this research is only one example, and the explanations cannot be generalized to other DWT units' maintenance. We would like to encourage future research into the maintenance of DWT units, so a general theory could be developed over time and improve DWT outreach globally.

Recommendations

Key insights from the literature on the dissemination of the CWs and to facilitate participatory development and long-term maintenance include:

1. Human-centered design is adaptable, modifiable, and durable, facilitating adoption and maintenance in the face of change with limited non-routine maintenance requirements (Laugesen et al., 2010b). The design must support maintenance that does not cause anyone to compromise their physical or social-religious concerns about purity.
2. Low-cost design and maintenance of CWs (Laugesen et al., 2010b). Access to tools and finances to appropriately and effectively maintain the CW without social stigma or financial burden.
3. Dissemination and participatory planning which does not aggravate existing or create new social divisions within the community (Arias-Arévalo et al., 2018; Jacobs et al., 2020; Zafra-Calvo et al., 2020).
4. Appropriate institutions to support regulation, fundraising for maintenance, generate public support for the project and take responsibility for maintenance (Brix et al., 2011; Møller et al., 2012; Starkl et al., 2013b). For example, technical assistance for communities could be provided at a clustering of DWT scale (Gauss, 2008; Starkl et al., 2013a).
5. Long-term maintenance planning with local community commitment and buy-in (Laugesen et al., 2010b; Rashid and Pandit, 2019).

CONCLUSIONS

Constructed wetlands in rural India have the potential to provide important ecosystem services of DWT. Currently, most of the WW in India from 1.3 billion people goes untreated and is released into the environment or reused without treatment in agricultural irrigation (National Sample Survey Office, Ministry of Statistics and Programme Implementation, 2016). DWT provided by CWs offers the potential to reduce disease and environmental degradation in rural communities. However, widespread adoption and maintenance of DWT units has not occurred despite technological innovation and capital investment. This case study provides a preliminary understanding of how plural valuation of ecosystem services, yuck, and moral disgust impact maintenance of DWT units. This case study is critical because few other community-based examples of plural valuation of ecosystem services related to WW treatment have been explored. This research is intended to provide a first example of examining the process of maintaining constructed wetlands. Additional case studies need to examine these dimensions across different contexts to build long-term adoption of DWT units, which could result in the construction of a theoretical model of a DWT innovation process managed by communities.

Decentralized WW treatment must anticipate plural valuation and devaluation of ecosystem services by not requiring anyone to compromise their physical health and social concerns about purity. Addressing the improved human-centered design of CWs, plural valuation of WW, power dynamics of community members, the current social stigma associated with the maintenance of CWs, the yuck factor, perceived benefit, increasing community WASH infrastructure and programs, and limiting antagonization of social divisions within rural communities are essential first steps before implementing any innovation or technology that treats WW for agricultural irrigation that also requires maintenance.

DATA AVAILABILITY STATEMENT

Data is not available due to ethical restrictions. Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Florida Institutional Review Board. The ethics committee waived the requirement of written informed consent for participation.

AUTHOR CONTRIBUTIONS

This research was completed as part of a doctoral degree program for CF. CF designed, collected, analyzed and wrote the manuscript. MM, SD, and SW all provided mentorship during research design, collection, analysis, and revised the final draft of the article. All authors contributed to the article and approved the submitted version.

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