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Is Agricultural Intensification a Growing Health Concern? Perceptions from Waste Management Stakeholders in Vietnam

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Abstract: This article characterizes the health risk perceptions toward excreta and wastewater management practices among waste management stakeholders in Vietnam and explores the implications of such perceptions on hygiene behaviors and preventative actions. Key informant interviews (n = 19; 12 women and 7 men) were conducted with farmers, community leaders, researchers, and government representatives in Hanoi and Ha Nam Province. Interviews were audio-recorded with permission, transcribed, and analyzed using a constant comparative method and qualitative thematic analysis. Researchers and government representatives perceived that the lack of knowledge of safe waste management practices among farmers was responsible for the use of "outdated" and often "unsafe" waste management practices. However, many farmers were aware of the health risks and safe hygienic practices but felt that safety measures were impractical and viewed susceptibility to diseases as low risk. Farmers also identified unfavorable climate and working conditions, limited financial capacity, and limited farm space as barriers to adopting safe management practices. At the broader level, inadequate communication between ministries often led to the creation of inconsistent waste management regulations. These barriers create constraints on efforts to improve sustainable waste management practices. Promoting collaboration between sectors, encouraging farmer-to-farmer knowledge sharing, and designing and implementing risk communication strategies that account for risk perceptions of stakeholders are recommended.

Keywords: risk perceptions; wastewater; health risks; waste management; agricultural intensification; Vietnam; excreta

1. Introduction

Global food demand and associated intensification of agriculture are increasing rapidly, especially in regions facing high economic and population growth, such as Southeast Asia [1]. Livestock is one of the fastest growing agricultural subsectors in this region [2]. In Vietnam, livestock operations contribute to 16.1% of total agricultural output, most of which are produced by smallholder farmers [3]. Furthermore, although its share has decreased over time, crops still account for the majority of

agricultural output in Vietnam (56.2%). Crop and livestock operations generate substantial amounts of waste, with livestock alone generating approximately 85 million tons of waste per year [4]. Waste and waste by-products, such as excreta and wastewater, are commonly used in northern and central Vietnam as cost-effective fertilizers for agriculture and aquaculture [5]. While intensification of agriculture can improve food security, support livelihoods of smallholder farmers, and provide sustainable fertilizers [6], it can also lead to excessive quantities of waste being generated in constrained areas.

Excessive waste, combined with inappropriate waste management approaches, can pose health risks to smallholder farmers, to the general public who live close to farms, and to consumers of wastewater-irrigated crops [7–9]. Vietnam is a relatively heavy user of pesticides, which present possible health risks to farmers and community members drawing water from streams and rivers where pesticide run-off is more pronounced [3,10]. In a rural agricultural community in Ha Nam Province, where wastewater and excreta are commonly used in agriculture, a cross-sectional survey of 1425 people showed that 47% were infected with at least one of three soil-transmitted helminth (STH) species. In the same community, it was estimated that farmers ingested around 91 mg of excreta per year from agricultural excreta handling practices, a risk factor for STH infections [11]. Rural farmers who reused fresh excreta were also 1.24 times more likely to be infected with any STHs than those who did not handle excreta [12]. For farmers that use biogas wastewater for irrigation purposes, the annual diarrhea risk was estimated to range from 17.4 to 21.1% (from *Escherichia coli*) [13]. Urban farmers are also at a high risk of diarrheal disease; a quantitative microbial risk assessment estimated a disease burden of 0.011 disability-adjusted life years per person per year in urban farmers in Hanoi. Finally, high levels of microbial contamination have been reported in wastewater-irrigated vegetables, presenting potential diarrheal disease risks to consumers [14,15].

Whether or not a farmer develops an agriculture-related illness depends on a variety of environmental, agent, and host factors. An important host factor is the perception of risks among farmers, which influences how they manage these risks [16]. While a number of studies have described waste management practices of farmers in Vietnam [5,17–20], few have analyzed their perceptions of health risks associated with waste management practices [5,19,21]. Furthermore, despite the role researchers and policymakers play in shaping waste management regulations for farmers [19,21], even fewer studies have considered researchers' and policy makers' perceptions of why farmers decide to adopt safe or unsafe excreta and waste management practices. As such, it is difficult to assess waste management health risks and develop successful public health interventions because understanding hygiene behavior is an essential component of risk assessments and interventions [21].

Given the rapidly growing waste quantities in Vietnam in recent years, the increasing pressures on existing waste treatment systems, and the health risks associated with agricultural practices, there is a need to understand the risk perceptions of waste management stakeholders. The aim of this study is to characterize the perceived health risks associated with human, animal, and wastewater management practices among farmers as well as community leaders, researchers, and policymakers who have an interest in waste management. Understanding such risk perceptions of waste management stakeholders may provide important insights for developing sustainable waste resource use while protecting human and environmental health in Vietnam and globally.

2. Methods

2.1. Study Areas

Hanoi (capital city) and Hoang Tay commune of Ha Nam Province (situated about 60 km south of Hanoi) were selected as study sites (Figure 1). Since many national research institutes and ministries are located in Hanoi, the researcher and policymaker interviewees were recruited from Hanoi. Community leader and farmer interviewees were recruited from Hoang Tay commune because of the common use of wastewater and excreta in agriculture, similar to many other areas in central

and northern Vietnam [19,21]. Around 5761 people live in Hoang Tay, and 37% of households apply human excreta to fertilize crops [22]. Furthermore, many households rely on rudimentary forms of on-site sanitation facilities; for example, there are approximately 222 septic tanks, 469 pit latrines, and 250 biogas units in the community.

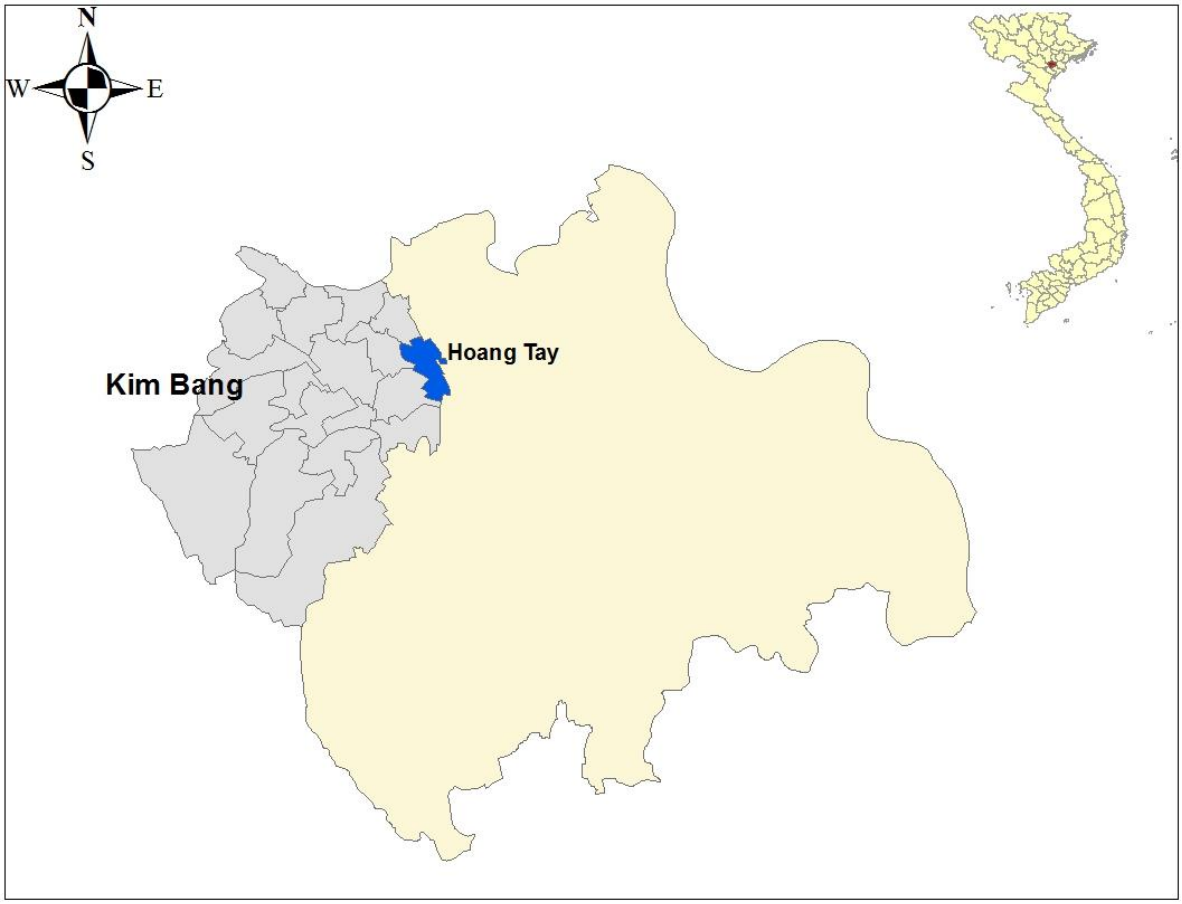

Figure 1. This map depicts the location of one of the two study sites: Hoang Tay commune in Kim Bang district of Ha Nam Province in northern Vietnam.

2.2. Conceptual Framework

Risk perception involves an individual's beliefs, attitudes, judgments, and feelings, which are determined by a range of factors at both the individual and environmental levels. To better understand these factors among waste management stakeholders in Vietnam, we used a risk perception framework developed by Dobbie and Brown (2014) to conceptualize and analyze the findings from the interviews. According to this framework, the most important variables that might influence risk perceptions are knowledge, attitudes, beliefs, and values. Knowledge, interacting with attitudes of trust, sense of fairness, and perceived control, has been shown to directly influence perceived risk. Values indirectly influence perceived risk through social identity and shared values, while cultural norms can also influence risk perceptions and attitudes toward risk. The framework suggests that social identity and cultural identity drive risk perception. Moreover, the framework has also been used extensively to study risk perceptions in the context of sustainable resource management [23,24].

2.3. Data Collection

This research was supported by previously established relationships between community members and researchers at the Center for Public Health and Ecosystem Research (CENPHER), Hanoi University of Public Health [25,26]. In-depth key informant interviews [27] were conducted

in April 2015 with farmers and community leaders in Hoang Tay as well as researchers and policy makers in Hanoi. Farmers were selected from Hoang Tay using a maximum variation sampling technique, which maximized information capture across age groups, educational backgrounds, and gender [28]; community leaders, researchers and policymakers were selected based on informal social connections [29]. Community leaders included representatives from the Hoang Tay Health Station and the Hoang Tay People's Committee. Researchers and policymakers were affiliated with research institutes (National Institute for Hygiene and Epidemiology, National Institute for Occupational and Environmental Health, Soil and Fertilizer Research Institute, Vietnam National University for Agriculture, Hanoi University of Public Health) and ministries (Ministry of Health, Ministry of Agriculture and Rural Development), respectively. Theoretical saturation, a point where no new information or themes were observed after the completion of additional interviews, was achieved after 19 interviews. Interviewees included farmers (n = 8) and community leaders (n = 2) in Hoang Tay as well as researchers and policymakers in Hanoi (n = 9). Respondents were mainly women (12 women, 7 men). Interviews ranged from 30 to 45 min in duration and were conducted in the participants' home (for farmers) or office (for researchers, community leaders, and policymakers).

The interview guide was semi-structured [27,30] and included open-ended questions, which explored topics such as perceptions of health risk, wastewater and excreta management practices, health-seeking practices, and barriers and solutions to implement safe waste management practices. Farmers were asked to reflect on their own waste management practices, while community leaders, researchers, and policymakers discussed broader waste management issues and current policies. In-depth interviews were conducted in English or Vietnamese with the assistance of a female Vietnamese researcher, and they were audio-recorded with permission and transcribed verbatim [31]. On-site observations of farms and waste management practices were documented during the interview process with farmers [32]. All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the University of Guelph Research Ethics Board (#14DC004) and the Hanoi University of Public Health Ethical Review Board (#015-203/DD-YTCC).

2.4. Data Analysis

An iterative constant comparative method [33] guided the thematic analysis [34], which involved several steps. First, interview transcripts were read while listening to audio recordings and re-read to become deeply familiar with the data [34]. Next, initial codes were deductively and inductively generated systematically within and across the interview transcripts [35]. These codes were then refined, expanded, and collapsed into themes [35,36]. A formal codebook was created [36] and used to code segments of text for all interviews (Appendix A). To facilitate the code and theme development, memos and concept maps were used. Memos were used to identify and synthesize similarities, differences, and patterns within and between interviews as well as differences and similarities between male and female participants, farmers, university researchers, and policymakers [37]. A concept map was created to help visualize themes and relationships within and among codes and themes [38]. Audit trails, triangulation of data and results, and peer debriefing methods were used to increase the validity of analysis and results [39]. Dedoose qualitative analysis software (Dedoose Version 6.2.21, UCLA, Los Angeles, USA) was used to assist in data organization, coding, and data retrieval.

3. Results

3.1. Perceptions of Waste Management

A total of 19 interviews were conducted with farmers (n = 8) and community leaders in Hoang Tay (n = 2) as well as researchers and policymakers in Hanoi (n = 9). Respondents were mainly women (12 women, 7 men). Interviews ranged from 30 to 45 min in duration. Twenty-six codes emerged from the interview analysis, which were grouped into the four broader themes of agricultural

intensification, government responsibility, knowledge and communication, and hygiene behavior and waste management practices (Figure 2; Table 1).

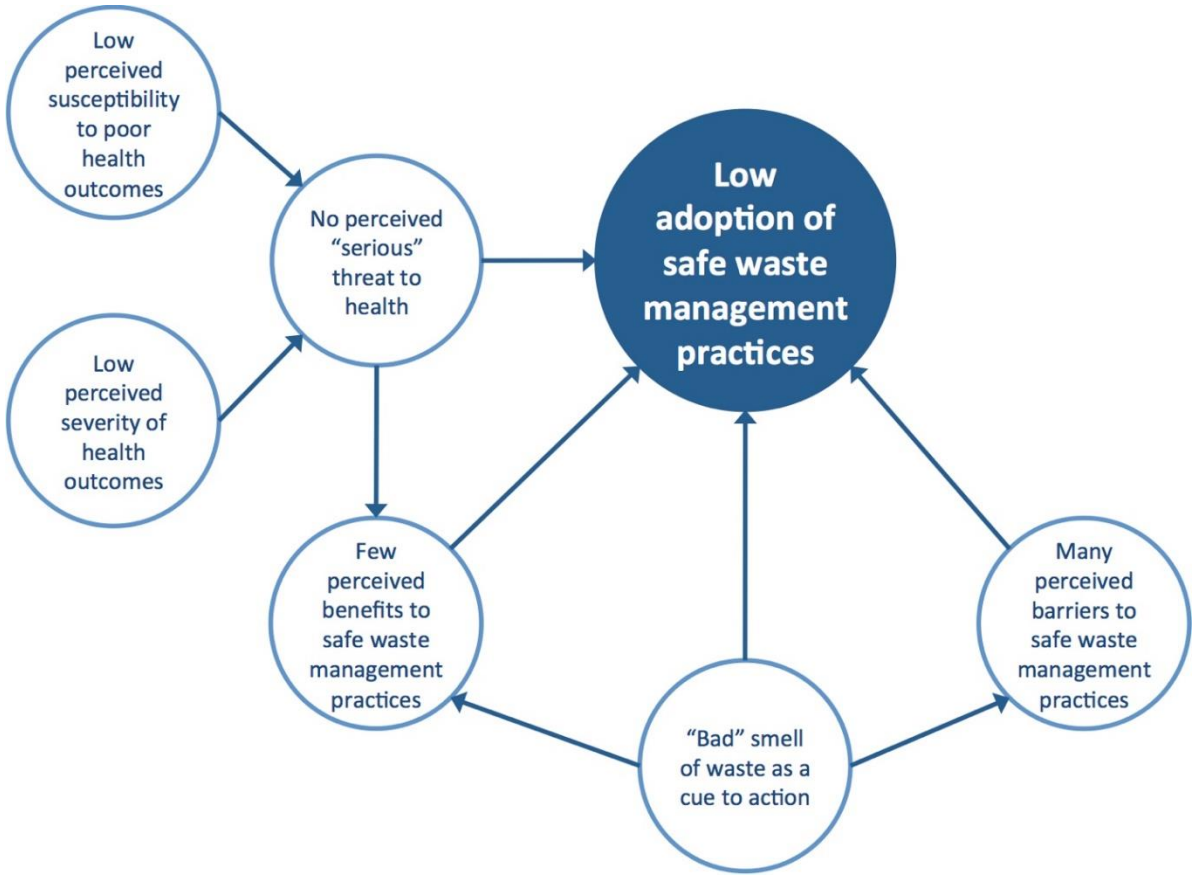

Figure 2. This concept map uses ideas expressed by farmer interviewees to illustrate why it is difficult for farmers to change waste management practices.

Table 1. Common health perceptions voiced by farmers and direct quotes that illustrate these perceptions.

Perception	Quote(s)
Waste management practices have little effect on health	"Used to practices, normal, no tiredness, feel like it is clean, don't see any problem." "farmers know the risk in sanitation, but in terms of practice, not same as they know."
Smell is synonymous with disease	"Smell . . . the local people they afraid of it. Even now if they smell, and don't see the feces, but smell, it is a problem." "Smell in the air, causing some headache." "when you see bad smell, one day-two day, cannot see any problem, but when exposed to bad smell in long-term . . . there will be some health problem but not sure what it is."
Composting guidelines are disregarded	"think [untreated waste] is safe since no smell." "How to control the smell form composting, I think big problem. Because they make composting in farm, nearby a lot of neighbors, and how to control smell to affect neighbor. I think very big problem."

Table 1. *Cont.*

Perception	Quote(s)
Protective gear is inconvenient and at times unnecessary	"[protective gear is used] mainly to protect from smell . . . but when farmers practice in the field, they never use gloves, they said that it is less practical, so they don't want to use. Farmers use bare hand directly, even don't like boots. Only wear a hat or cap."
Practices should follow neighbors' example	"Neighbors may not want to clean as often (habit), their attitude not good, the smell may come from that house. His house he cleans every day and cleans every time he sees feces." "people . . . are a bit lazy. Even if they know, they do not want to change." "when discharging [biogas and wastewater] directly, no influence on the environment since everyone is doing it."

Researchers and policymakers emphasized that although a single small-scale farm alone does not produce a lot of livestock waste, "80% of people in Vietnam farm small-scale in rural areas", and the "cumulative and increasing quantity of livestock waste" were identified as growing concerns. Increasing global human population, "especially in developing countries", was identified as a driver for increased demand for livestock and agricultural intensification, leading to "problems with animal waste management in recent years". While management practices may have been sufficient in the past, agricultural intensification brings new and emerging challenges that require new and different approaches to waste management; the adoption of these new methods by farmers was identified as a challenge by community leaders, researchers, and policymakers (Figure 2).

3.2. Changing Awareness and Perceptions of Waste-Associated Health Risks

Researchers and policymakers were worried that farmers in Vietnam were using waste management techniques that were "not good enough" and could negatively "affect human health". Indeed, all researchers, policymakers, and farmers were concerned that agricultural intensification was leading to "more close contact" with animals, creating "more health risks" for farmers. One researcher perceived that there was an increasing awareness about waste-related health risks among farmers, commenting how "in the past people did not really care" but now they are "starting to think about their health more".

All farmers identified at least one health outcome perceived to be associated with direct contact with waste, wastewater, smell, or polluted water sources. Although more aware of acute health risks (e.g., "headaches", "eye disease", "skin and nail problems", and "diarrhea"), some farmers discussed the possibility of chronic diseases from long-term exposure to waste or wastewater (e.g., "cancer"). For instance, one farmer explained that he "cannot see any health impact right now, it will be a long time until impacts are seen". Another farmer explained that "there will be some health problems" from long-term exposure to bad smelling waste, but he was "not sure" what health outcomes would be experienced.

Despite awareness of health risks from waste management among farmers, some perceived a low susceptibility to poor health outcomes related to waste management, reporting that they "feel like [their] farm is clean" and "do not see any problems". Furthermore, some farmers perceived low severity of poor health outcomes, explaining that they "do not know any serious health effects from animal waste", or that the ones that do exist are just a normal part of life that is difficult to avoid (Table 1).

3.3. Smell as a Cue to Improve Waste Management

Waste and wastewater were perceived by farmers to be dangerous to human health only if it created a "bad smell in the air" or if it "looks very dirty". For many farmers, the presence of a strong smell influenced the adoption of certain waste management practices (Figure 2). For instance, while the

use of biogas digesters was perceived by some farmers to be "hygienic", most farmers explained that "you cannot use" digested biogas sludge as a fertilizer because it "has a smell". Furthermore, farmers reported they did not want to buy fresh vegetables irrigated with "biogas water" because it was perceived to cause diarrhea, and one researcher expressed that biogas effluent still contains "a lot of *Salmonella*". Some farmers perceived that composted waste has a worse smell than biogas waste; as such, farmers considered composted waste to be a higher risk to human health than biogas waste and often did not use this waste as fertilizer. Composted waste without smell was perceived as safe, and farmers identified that composted waste was "very high in nutrition for plants and fish".

Farmers explained that there was social pressure for bad smelling farms to engage in better waste management practices, highlighting the role of smell on subjective norms for these farming communities. For instance, farmers identified that a key component of waste management concerned "how to control the smell" of the waste on their own farms so that it does not "affect the neighbors' [health]". Local stakeholders expressed how farmers commonly perceived the "smell from neighbors is dirtier than the smell from their own farms", while farmers indicated that their neighbors "do not want to clean as often" and that neighbors' "attitude [toward waste management] is not good".

3.4. Perceived Barriers to Implementing Safe Waste Management Practices Differed among Stakeholders

Farmers believed that barriers outweighed benefits to safe management practices. Researchers and policymakers perceived that the lack of knowledge of safe waste management practices among farmers was responsible for their use of "outdated" and often "unsafe" practices. However, farmers explained that they know they should wear protective gear (such as masks, gloves, and boots) when handling waste, but they saw the gear as "less practical", "not convenient", "hard to do work with", and "something that no one wears". Farmers explained that they used "bare hands directly" when handling waste that had little smell. Most farmers believed that their current practices were "safe", especially if their neighbors practiced in the "same way" and that there were no benefits of taking additional waste management safety precautions. Most farmers, however, did report that using protective gear was occasionally used to "mainly protect themselves from smell".

Fragmented jurisdiction impacted waste management regulations. Researchers and policymakers noted that, similar to other countries, Vietnamese agricultural waste management regulations were often fragmented. For instance, a Ministry of Health representative reported being "just responsible for the health" impacts of waste management. Government representatives stated that they needed to focus on priorities within their own departmental jurisdiction, and none of them suggested that waste management required the involvement of other ministries, such as coordination between the Ministry of Natural Resources and Environment and the Ministry of Agriculture and Rural Development. Many government representatives noted that the lack of communication between ministries often led to the creation of inconsistent waste management regulations. Furthermore, many farmers expressed that "villages have their own regulations" and that "the government does not pay a lot of attention to waste management", thus limiting their interest in following regulations.

Communication was seen as both a benefit and a barrier to improving agricultural waste management. Most researchers and policymakers identified communication and education at the community level as "very important" for improving waste management practices. Researchers explained how farmers often "learn from each other" and tend to make collective changes to practices as farmers "do not want to change waste management practices alone". However, community-level communication could also create a barrier to adopting safe waste management practices as researchers and policymakers emphasized the potential for farmers to follow their peers more strongly than regulations, leading to the sharing of "incorrect" waste management information between farmers. Using farmer-to-farmer communication as a platform to share "correct" information about waste management practices was stressed as a potential method to improve communication of regulations to farmers.

4. Discussion

This study found that farmers knew there were some health risks associated with waste management practices; however, they often perceived safe waste management practices (e.g., wearing protective equipment) to be inconvenient or unnecessary. For example, some Vietnamese farmers in our study perceived that excreta were free of pathogens when it no longer smelled, and farmers often handled dry excreta with fewer precautions than when handling stronger-smelling excreta; however, research indicates that both substances contain similar levels of contaminants and pathogens [40]. Smell was a major concern for farmers, and this concern is supported by other qualitative studies [21]. Our study also found that farmers often learned practices from each other and that they often had no knowledge of federal waste management regulations. This was supported by the literature, which highlights that perceptions of waste management practices among farmers more strongly influence practices than waste management regulations or guidelines [19]. Researchers and policymakers expressed that although farmers desired to improve current practices, they often incorrectly utilized biogas and chemical fertilizers. Perceptions of waste management have a large influence on which practices are utilized; therefore, this study recommends that perceptions of waste management practices should be taken into account when designing and delivering risk communication strategies or developing waste management regulations and guidelines.

All respondents stated that a lack of feasible regulations, or the lack of adherence to existing regulations, are problematic and hinder the improvement of waste management and health behaviors; this is consistent with what is found in the literature [41,42]. Furthermore, communication between levels of government appeared to be inconsistent and the viewpoints of government representatives on waste management practices and recommendations for creating regulations differed greatly between government departments. This lack of coherence supports the need for a more integrated view of human and environmental health within the government [41,43]. Both farmers and policymakers also perceived that there was a lack of connection between human, animal, and environmental health, demonstrating that neither group viewed health in a holistic matter. Many policymakers could not comment on waste management risks outside of their immediate area of expertise. Future research could evaluate regulations to identify how they can be better integrated and implemented to improve both human and environmental health. Combining health and environmental risk assessments can enable a deeper understanding of environmental hazards and disease burdens linked to poor waste management [43].

Farmer interviewees explained how existing regulations often conflicted with their own perceptions of waste management. Because the regulations were perceived as difficult to follow, farmers were more likely to follow their personal perceptions or examples of their neighbors instead of regulations. Previous studies suggest that ineffective waste management practices can be attributed to lack of farmer knowledge [17]. However, we found that waste management practices are less driven by lack of farmer knowledge but rather by the low perceived impact of health risks, low concern, and low perceived feasibility of protective measures among farmers. As such, we recommend that the Vietnamese Government should move from a top-down approach to one that favors joint problem-solving between sectors and with farmers. Moreover, increased funding for research and extension is needed to develop management practices that reduce waste, increase agricultural efficiency, and protect human health and the environment. For instance, health impact assessments with sanitation planning [44] or a One Health approach for integrated human and animal waste management [45] have potential to develop effective agricultural waste reuse and recycling efforts.

In 2015, the World Health Organization (WHO) created Sanitation Safety Planning, a step-by-step risk-based approach to assist in the implementation of the 2006 WHO guidelines for safe use of wastewater, excreta, and greywater in agriculture and aquaculture [46]. Until recently, government regulations were often rigid and unadaptable, which made them incompatible with small-scale waste management [40,47]. The measures proposed by the WHO mainly require behavioral change by farmers. Insights from this study, in particular the lack of concern from farmers and the perceived

low impact of health risks from waste, could be integrated with the WHO guidelines to provide local context and improve adaptability and uptake of the WHO guidelines.

This study intended to capture an in-depth understanding of risk perceptions of agricultural waste management of farmers, researchers, and policymakers in Vietnam, but one main limitation should be acknowledged. The case study methodology limits our ability to generalize findings to other agricultural areas within Vietnam and internationally; however, we feel that the inclusion of a wide range of stakeholders in the study strengthens the internal validity.

5. Conclusions

In this study, we analyzed the risk perceptions of wastewater and excreta management among farmers, community stakeholders, and policymakers in Vietnam. We found that farmers often developed their risk perceptions from direct experiences of managing waste, whereas researchers and policymakers drew on research and education to a larger extent. Farmers were aware of health risks, but despite this knowledge, they often viewed the application of safe waste management practices as impractical or unnecessary. Furthermore, farmers did not engage in safe waste management practices due to perceptions of negligible health risks from wastewater and excreta. In contrast, researchers and policymakers in Vietnam often attributed the lack of knowledge of safe waste management practices among farmers as the underlying reason for non-compliance with regulations and safe waste management practices. Thus, this research highlights that differences in waste management risk perceptions can exist among stakeholders, which creates a barrier to sustainable waste resource use. The design and implementation of risk communication strategies based on the risk perceptions of farmers and waste stakeholders are needed to improve waste management practices in Vietnam and more broadly. Through this, farmers can better use excreta and wastewater in agriculture in a manner that protects the health of the environment, farm workers, and public at large.

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Appendix A

Table A1. Codebook used to code the transcripts of interviews. Name of code is accompanied by the definition of the code, and a quote directly from the interviews is given as an illustrative example of how to apply the code.

Name of Code	Definition	Example Quote
Agricultural Intensification		
Small-scale farming	Small-scale farming, how small-scale practices and regulations are different from industrial.	"Small farm is much better for management because in the small farm they combine livestock and co-production."
Smell	Mentions smell as an issue, or how a waste management practice has made smell increase/decrease.	"All in the village, the smell is very heavy, odor is a very big problem."
Wastewater reuse practices	Discusses practices or methods of wastewater reuse in both agricultural and household settings.	"River is polluted, but they are still using it for agricultural activities. There is no other water source for agriculture."
Hygiene Behavior & Waste Management methods		
Protective gear	Discussion of the use of protective gear, frequency or barriers to use, and perceptions or guidelines related to protective gear.	"When [farmers] practice in the field, they never use gloves, they say that it is less practical, so they don't want to use them. [Farmers] use their bare hands directly, even don't like to wear boots. They only wear a hat or cap."
Biogas	Mentions biogas use, including benefits, challenges, costs, or common practices relating to biogas.	"Most people want to use biogas. If they do not, they just do not have enough money to buy it."
Pathogens and diseases	Mentions specific pathogens or diseases.	"In feces, so many pathogens, like bacteria, especially *Salmonella*, *E. coli*, parasite, some parasite can transfer from animal to humans."
Awareness and Communication		
Communication barriers	Identification of barriers or challenges that are making it difficult to communicate or carry out proper practices.	"There are 54 ethnic minority groups, sometimes they use different languages. This makes communication difficult."
Health risk awareness	Awareness of health implications from exposure to wastewater or excreta	"Knowledge very low, some farmers know they have to finish treatment of animal waste, but some others are not concerned about [correct treatment methods]."
Community education	Education methods that focus on the village/community level(e.g., use of community health worker or village-level interventions to improve waste management).	"Education and community very important for health and management of animal waste. They do not want to change alone...you need someone strong to help them change this."
Government		
Waste management regulations	Regulations (or proposed regulations/recommendations) that control waste management practices.	"We have regulation, but the focus on animal waste is very little."
Adherence to recommendations	How farmers have (or have not) followed existing laws or recommendations.	"From regulation, from theory to reality, there's a lot of space there."
Intragovernmental communication	Discussion of government levels and regulations in the interviews. Includes discrepancies or disagreements found when comparing interviews.	"I only know about the health issue, not the environmental issues."

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