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RESEARCH ARTICLE

Socio-economic determinants for the deployment of Climate-Smart One-Health innovations. A meta-analysis approach prioritizing Ghana and Benin

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Abstract

An ecosystem is inhabited by organisms that rely on it for their livelihoods. For an ecosystem to sustain life, its life-supporting components must be alive to be able to preserve both the ecosystem's life-supporting components like soil, vegetation, water, etc., and the living organisms inhabiting the ecosystem like humans, birds, domestic, and wild animals, termed as the One-Health concept. This is indispensable for the sustainability of life. Several factors determine the ability of the ecosystem to provide ecosystem services and support life, more so amidst climate change. Hence, climate-smart (CS) One-Health innovations are essential to maintain the integrity of the ecosystem to be able to support life. However, factors that could effectively determine the deployment of such CS One-Health innovations are not well identified. This paper, closes the knowledge gap through a systematic review of literature for a meta-analysis of the socio-economic determinants for the successful deployment of CS One-Health innovations. Using a scoping review methodology, search engines like Google Scholar, PubMed, Scopus, and AgriEcon were explored extensively for literature on CS One-Health innovations. Search results were then screened and only articles that met the inclusion criteria were considered in this study. Subsequently, appropriate articles were identified for data extraction. Results revealed that political will, community participation, knowledge of CS One-Health practices, the willingness of parties to engage in multi-disciplinary collaborative activities, and level of investment (income/funds) were enablers for the deployment of CS One-Health innovations. On the other hand, behavior incompatibility with innovations, policy failure to restrict the use of toxic substances in agriculture, poor community knowledge of CS One-Health innovations, and language barriers between communities

sources considered are thus publicly available and elaborated in the references section with their identification numbers and associated links.

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and innovators, hindered such deployment. Hence, multiple factors (fostering and hindering) must be addressed in a multi-disciplinary framework to ensure the successful deployment of CS One-Health innovations.

Author summary

The One-Health concept can be an effective way to reduce biological, climatic, and environmental hazards in a shared ecosystem to help achieve proper health for humans, animals, and birds through sustainable and climate-smart (CS) use of ecosystem resources like water, soil, and vegetation. Therefore, innovations that are CS but hinged on the One-Health concept are central to achieving the above goal. Unfortunately, most innovations have been designed considering only their geographical, biological, and physical compatibility with the players in the ecosystem. However, for humans, the largest influencing players in any ecosystem, consideration of their socio-economic interests is essential for the adoption of such CS One-Health innovations effectively and sustainably. For instance, innovations must be compatible with local culture, political systems, land tenure systems, and knowledge. These innovations must also yield net-positive benefits toward household food security or incomes. These local aspects, determine human behavior, and thus their willingness and ability to adopt CS One-Health innovations to the desired scale of deployment.

1. Introduction

The One-Health concept has emerged over the last decade as a key concept guiding international research and policy in the field of emerging infectious diseases especially zoonoses [1]. One-Health is defined as the collaboration of multiple disciplines working locally, nationally, and globally to attain optimal health for people, animals, plants, and the environment [2]. The concept focuses on the interaction between humans, livestock, and wildlife [3]. However, over time it has been expanded to incorporate food security, poverty reduction, gender equity, and health systems strengthening [4]. The One-Health concept has yielded initiatives that help in reducing diseases and managing ecosystems optimally including engaging in early and rapid detection of health threats and collecting data to promote integrated disease surveillance and prevention [2]. However, despite an increasing commitment to One-Health initiatives across the world, implementing One-Health approaches in practice still proves challenging. For instance, most countries lack formal mechanisms for coordination and integration of One-Health activities across human health, agricultural, and environmental sectors, which are traditionally based in separate government ministries or agencies, moreover with different mandates in activities and spending [5]. One-Health practices under such agencies are also threatened by challenges which include the abatement of disciplinary divides and the creation of knowledge among various stakeholders with different backgrounds and interests such as scientists, regulators, farmers, industrialists, and consumers among others [6].

Although a number of developed countries have taken reasonable strides in incorporating One-Health activities, practices, and initiatives in their governance structure, this trend is still lacking in most of the developing countries [6]. Nevertheless, progress has been registered in certain regions of Africa. For instance, in West Africa in countries like Ghana & Benin, the One-Health Initiative aims is used as a vehicle to adopt a holistic approach in responding to

possible public health events such as high-impact infectious diseases emerging at the interface between humans, animals, and the environment [7]. However, key challenges still envisage and impede the deployment and sustainability of these One-Health innovations, some of which are dominantly behavioral social economic factors [8]. Yet, a proper understanding of these social and economic factors that determine the deployment of One-Health Innovations, more so at such a time when global ecosystems are also facing climate change challenges, would be essential in changing the mindset of the population towards adopting these CS One-Health measures [9]. Unfortunately, studies on how such socio-economic factors have influenced the deployment of CS One-Health innovations are fragmented, and often focused on individual aspects of the CS One-Health practices. Subsequently, a holistic view on how socio-economic factors must interact with biological, climatic, and environmental factors to enhance the deployment of CS One-Health innovations is missing, yet essential to effectively guide policy and investment opportunities from the private sector towards the deployment CS One-Health innovations at scale [9].

Normally, the One-Health concept is conceptualized to be challenged dominantly by biological, environmental, and climate hazards that compromise the health aspects of soil, water, humans, animals, birds, and crops in the shared environment [10]. For instance, toxic pesticides affect soil, water, animal, and human consumers' health, while zoonotic diseases can affect both animals and humans, and extreme climatic events like floods and drought can affect animals, crops, humans, and ecosystem services of beneficial organisms like soil micro-organisms [10]. The conceptualized One-Health comprehensive challenge description is illustrated in Fig 1.

However, all these broader challenges (biological, environmental, and climate) are hinged on the socio-economic interests of humans acting in the context-specific ecosystem [10]. This makes it important therefore to consider socio-economic aspects while designing One-Health innovations, more especially those that are aimed to be easily adoptable in CS led agriculture innovations for specific contexts [9]. These socio-economic considerations would render the CS One-Health innovations more adaptable to challenges, with more mitigative capacity, and a higher possibility to deliver ecosystem productivity desirable to sustain animal and human life [9,10]. In Fig 2, the envisioned context-specific intervention framework that considers socio-economic aspects for CS agriculture led innovations for improved One-Health gains is illustrated. Unfortunately, in designing many CS agriculture innovations, the One-Health aspect hinged on the socio-economic behavior of adopters of these innovations, has largely been neglected, partly due to being unaware of its importance, or exactly what socio-economic aspects had to be considered for more adaptable, mitigative, and productive innovations [5,9].

Therefore, the study aids to close this knowledge gap through a meta-analysis of the mostly fragmented literature into a somewhat one piece of literature that provides a holistic view on the socio-economic determinants for deployment of CS One-Health innovations. Specifically, while mostly prioritizing Ghana and Benin, this paper focuses on four discussion areas likely to influence the deployment and implementation of One-Health initiatives: What socio-economic determinants do influence the implementation of CS One-Health Innovations?

1. What challenges are recorded during the implementation of CS One-Health Innovations?
2. What are the impacts of the implementation of CS One-Health practices?
3. What are the commonly used methods of implementation of CS One-Health innovations?

The review widens the One-Health concept and makes it fully inclusive/holistic. Initially, the concept was restricted to animal-human-environmental health (and basically zoonotic

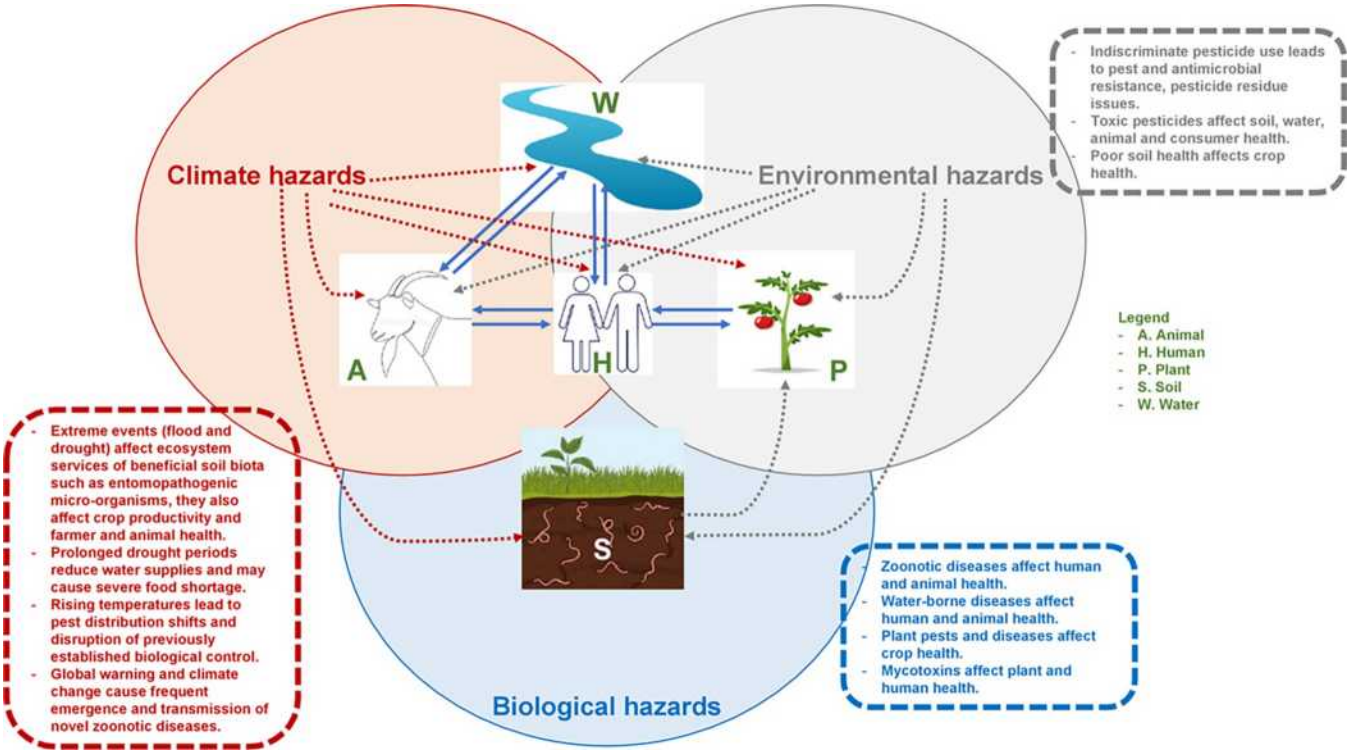

Fig 1. Comprehensive broader challenge description of the One-Health concept.

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diseases) until now when we are spelling out other obvious linkages (soil, water, plant health). For instance, the use of toxic herbicides and pesticides used in the treatment of plants and animal pests and diseases, do affect soil, water, animal, and human health if are especially used excessively [1,9]. In turn, poor soil and water health also affect the health of plants, animals, and humans [5,10]. Therefore, the study shows the valuable expansion of the One-Health concept beyond the original animal-human-environmental health (zoonoses/pandemics), to the other elements of the ecosystem (soil, water, plant health) that we emphasize in Fig 1). The study also draws the attention of One-Health experts and achieves the goal of generating deeper, wider, and more inclusive knowledge around the One-Health concept. Another strategic novelty is that the study brings to attention the role of climate and environmental hazards and shows how these interact with biological hazards to influence ecosystem health (Fig 1). Since agriculture is one sector that supports most of the human livelihoods as well as livestock, thus it could be one sector through which the benefits of the One-Health concept could be harnessed [1,10]. However, given the rapidly changing climate, the agriculture sector must be climate-smart as well to mitigate the effects of climate change, while as well consolidating the benefits of the One-Health concept. Any climate-smart agriculture interventions should serve three major objectives to adopting households including 1) increasing household productivity, 2) improving resilience/adaptation of these households to shocks, and 3) mitigating the effects of the shocks which comprises reductions in greenhouse gas (GHG) emissions, as illustrated in Fig 2 [5,10]. Thus, climate-smart One-Health interventions/practices/innovations are designed around these three objectives to significantly address One-Health challenges (basically climate and environmental hazards and their negative impacts on soil, water, plant, animal, and human health), as illustrated in Fig 2 [1,5,10,11].

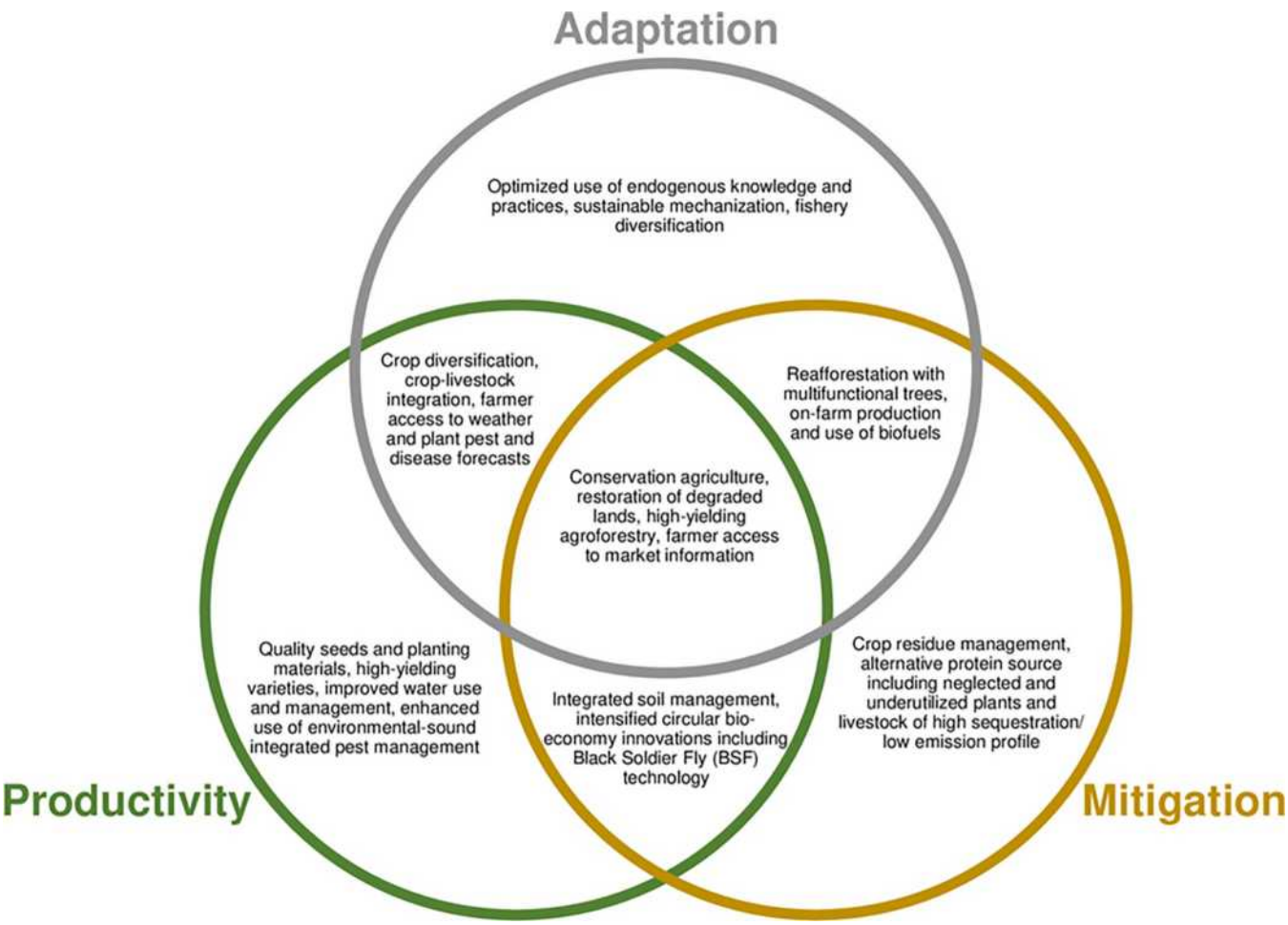

Fig 2. Envisioned context-specific intervention framework for CS agriculture led innovations for improved One-Health gains.

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2. Methodology

2.1. Literature Search

To address questions supporting this study, a search was completed for articles relevant to CS One-Health initiatives including documents that examined the CS One-Health approaches in terms of the different practices of implementation, challenges faced during implementation, impact of these One-Health practices after implementation, and determinants of the deployment of such One-Health approaches and practices (innovations) in various countries globally but with emphasis on Ghana and Benin. There is a targeted focus on Ghana and Benin as the 2 countries where the implementation of the One-Health CS innovations (Accelerating Impacts of CGIAR Climate Research for Africa-AICCRA project in Africa) is ongoing. AICCRA targets to avail CGIAR-generated science through all of Africa, funded by the World Bank until 2023 (see: https://aiccra.marlo.cgiar.org). Additionally, other documents containing relevant information on CS One-Health initiatives, approaches, practices, or innovations were also considered. The systematic review followed a predetermined protocol for conducting meta-analysis for such literature. Inclusion criteria were determined through keyword searches in Google Scholar, PubMed, Scopus, and AgriEcon. Examples of key search terms were "One-Health Innovations: "Ghana", "Benin", "Africa", "Asia", "Europe", "America", "impact", "determinants", "implementation", challenges" and "practices", among others. All searches

were carried out without filters. No restrictions were made on publications year. Cases of disagreement for some publications were resolved by mutual consent among authors. This meta-analysis prototype methodology has recently been used [12–14].

2.2. Screening and eligibility

Articles found from the search were screened for relevance to the topic using the title/abstract screening approach. Within the scope of the mini review, documents that were deemed relevant had to at least mention the keywords in their abstracts or title. Articles that passed the mini-review were further screened using the full-text screening approach. Only articles that were relevant after the full-text screening were considered for inclusion in the study as citations and references. Articles whose full-text format could not be retrieved from some databases were further searched in other databases listed above. Any article that failed to present a full-text format in any of the databases considered above was excluded from the study. The selected articles were further scanned for their publishers being scientifically indexed as credible sources of scientific literature on the One-Health initiative. Additional studies were also identified through handpicking and snowball technique from colleagues who were knowledgeable about these articles. Care was taken to ensure that all selected journal articles were ISI–listed (indexed for Impact Factor). This was done using Resurchify, a website that computes the impact factor of a journal article searched and sourced online.

2.3. Articles' inclusion criteria

Consideration of studies that explicitly attempted or explained the adoption and scaling of CS One-Health initiatives was made. More specifically, a study was included if:

- It investigated the various practices and adoption of CS One-Health innovations.
- It reported the impact of implementation CS One-Health practices.
- It explained the determinants for adoption of One-Health innovations.
- It provided vital insights on aspects of the One-Health approach.
- It could be fully retrieved for evaluation

From the above criteria, a total of 43 articles and 11 reports were identified and considered for data extraction. Selected articles were subjected to a descriptive approach for information extractions. Data extracted included information on whether the article assessed various implementation practices of CS One-Health initiatives, practices, or innovations, analyzed impacts of these practices, addressed challenges faced during implementation, and described socio-economic determinants for the deployment of these CS One-Health innovations. Data extracted were aligned in an excel template for further review and were summarized following these themes: the title, methodology used, practices implemented, and key findings regarding determinants for deployment of CS One-Health innovations, and citation. In Table 1, some of the key studies reviewed are presented.

3. Results and discussions

3.1. Socio-economic determinants for deployment of CS One-Health innovations

Age of farmers. Several studies point to the farmers' age as an important factor towards adoption of CS One-Health practices. Specifically, as farmers grow older, their interest and

Table 1. Summary of socio-economic determinants for deployment of CS One-Health innovations.

Citation	Location/ scope	Sample size	Methodology	Key Findings regarding deployment of CS One-Health innovations
Bardosh et al. [18]	Africa	Not applicable	Meta data analysis	• Existence of systemic challenges in local implementation systems • It is a tough job to try and translate what is happening in the science to policymakers and the public.
Asante et al. [28]	Africa	Not applicable	Meta data analysis	• A worrying case of misdiagnosis and subsequent inappropriate treatment exists • There is lack of diagnostic tests and clinical awareness for many zoonotic diseases in most parts of Africa • There is overuse of antibiotics (mainly as growth promoters) in animal husbandry • The close bond shared between humans and dogs can facilitate the transmission of pathogens between them.
Francoise [8]	Ghana	Not applicable	Meta data analysis	• CS One-Health innovations have improved outbreak investigations in Ghana • Challenges remain in sustainability of One-Health innovations • Challenges exist in convincing policy makers of benefits of planning and investing in One-Health innovations
Perez Arredondo et al. [23]	Ghana & India	Not applicable	Meta data analysis	• Limited technical infrastructure for culling and disposal of birds exists. • Low investment levels in the poultry sector, and several cultural aspects inhibit CS One-Health innovations. • Challenges in information exchange, training, overly high dog population inhibit implementation
Akrofi-Atitianti et al. [16]	Ghana	80 households, FGDs & expert interviews	Mixed methods	• The following factors influence the farmers capacity to practice CS Agroecology: Farmers' level of education, Farmland tenure, Age, Access to extension facilities, Location (district) of the farm, Farmers' residential status
Wilkes et al. [2]	Not applicable	Not applicable	Meta-data analysis	Advantages of CS One-Hhealth innovations implementation include: engaging in the early and rapid detection of health threats; Promoting an integrated disease surveillance, prevention, and response system; Improving education and communication among professionals focused on human, animal, plant, and environmental issues; Strengthening the economy by improving long term impacts on food safety, security, and productivity.
Okello et al. [29]	Nigeria, Tanzania, and Uganda	series of Key Informant Interviews (n = 32) with policy makers, government officials and academics	Case study	• Broad institutional changes are required for One-Health innovations to become a widespread approach to health policy. • There is no 'one size fits all' approach to achieving the intersectoral collaboration. • Improved livestock health and productivity plus a greater wildlife biodiversity are key to better One-Health innovations' successful deployment.
Gibbs [30]			Meta-data analysis	• One-Health has achieved control of infectious diseases, control of non-infectious diseases in past decade • Challenges e.g., need for One-Health supportive agenda, communicating the need of One-Health are anticipated

(*Continued*)

Table 1. (Continued)

Citation	Location/ scope	Sample size	Methodology	Key Findings regarding deployment of CS One-Health innovations
Baum et al. [31]			Meta data analysis	• A standardized framework for systematic evaluation of One-Health innovations is required to identify how much value can be gained by fusing efforts across health sectors.
Ryan et al. [32]			Meta data analysis	• Restricting access to catchment areas and water bodies for Cryptosporidium is good to avoid One-Health risks • Source water contamination can be avoided or reduced by the implementation of management strategies such as wildlife population control • Hygienic practices are essential for any prevention strategy against disease transmission.
Mazet et al. [33]	Tanzania		Cross sectional approach	• New diagnostic techniques for disease detection necessary to facilitate One-Health innovations deployment. • Training Tanzanians of all education levels about zoonotic diseases good for successful deployment. • Health and environmental policy interventions to mitigate the impacts of zoonotic diseases is necessary. • Pathogens were isolated from multiple water sources used by people and frequented by livestock and wildlife.
Munyua et al. [34]	Kenya		Meta-data analysis	• Surveillance system in domestic and wild animals that meets the needs of animal and human health is essential. • A workforce trained in the One-Health approach good for innovations' deployment • Improved outbreak investigations and a robust and productive public health scientific program including the discovery of zoonotic pathogens new to the world, essential for sustainable deployment
Tambo et al. [24]	Nigeria		Meta data analysis	• There is need for robust leadership commitment and investment in One-Health innovations
Lombardo et al. [35]	Italy		Case study approach	• Farm position and territory influence CS One-Health implementation.
Gower et al. [21]	Africa		Meta data analysis	• One-Health implementation will require political will and endorsement, across international, regional, national, and local agendas for stability and sustainability
Cunningham et al. [36]			Meta data analysis	• For public health wellbeing, human must conserve nature and preserve ecosystems, including disease regulation, that biodiversity provides while also mitigate activities which lead to disease emergence for sustainable One-Health
Ladbury et al. [25]	Northern Tanzania		Case study	• Challenges highlighted against CS One-Health deployment include ethical approval processes, consenting procedures, and field and laboratory logistics. • More efforts should be channeled to investment of time in sensitization. • Communication, and collaboration is needed to overcome interdisciplinary challenges • One-Health requires the multi collaboration of disciplines to be a success.

(*Continued*)

Table 1. (Continued)

Citation	Location/ scope	Sample size	Methodology	Key Findings regarding deployment of CS One-Health innovations
Kayunze et al. [37]	Southern Africa		Meta data analysis	• There is little collaboration between medical and veterinary services despite the shared underlying science and the increasing infectious disease threat. Poor collaboration threatens One-Health innovations deployment
Muhanga & Malungo [15]	Tanzania	1440 respondents	Cross section approach	• These factors were found to be significantly associated with deployment of One-Health innovations: Attitudes of farmers, levels of engagement in health-related discussions, level of information seeking, and Age of farmers
Horrigan et al. [20]			Meta data analysis	• Government programs, research, and other factors can influence moves toward sustainability in agriculture. • Other factors that influence adoption of sustainable CS One-Health practices are land ownership, the age of the farmer, and Land tenure
Cleaveland et al. [9]	Africa		Meta data analysis	• Data on risks involved in deployment of One-Health innovations in Africa are limited.
Allan et al. [11]	Africa		Meta data analysis.	• For a successful implementation of One-Health innovations, there is need to understand the human, animal and environment interactions or transmissions. • Large gaps persist in our knowledge of the burden and epidemiology of leptospirosis.
Gebreyes et al. [22]			Meta-data analysis.	• Science-based risk management policies that respect transboundary and international guidelines are essential for proper One-Health innovations deployment. • Capacity building of applicably and appropriately knowledgeable and skilled One-Health personnel is necessary. • Environmental and clinical diagnostic laboratories with an integrated and shared database are necessary • Improved use of existing natural resources and implementation plans based on cost-benefit analyses is key.
Sekyere & Mensah [38]			Meta-data analysis	• Effective surveillance and monitoring of antimicrobial drug usage key to successful deployment. • Licensing, banning, or restricting the prescription of reserved, expired, and substandard drugs is important. • Periodic monitoring of pharmacies and veterinary shops and antibiotic stewardship for updated drugs. • Periodic monitoring of patients on hemodialysis is crucial for successful deployment.
Lombi et al. [6]			Meta-data analysis	• Better communication, cooperation, and integration between fields of animal and environment toxicology. • Actively engaging the public and private stakeholders in research and innovation and implementation. • Challenges with abatement of disciplinary divides limits success

(*Continued*)

Table 1. (Continued)

Citation	Location/ scope	Sample size	Methodology	Key Findings regarding deployment of CS One-Health innovations
Cleaveland et al. [9]			Meta-data analysis	• Sustainability of CS One-Health innovations is dependent on changing the mindset of the population. • Household dilemma to balance potential health care cost limits deployment scale • Agro-economists working on livestock productivity and economic benefits needed to cost innovations • Lack of coordination hinders deployment of CS One-Health innovations
Amuguni et al. [39]			Meta-data analysis	• Redesign of a more integrative and dynamic educational system good for CS One-Health deployment • Mismatch between present siloed professional competencies and the requirements of an increasingly multidisciplinary complex world, fail proper deployment of CS One-Health innovations
Frankson et al. [40]			Meta-data analysis	• Lack of effort has been directed at identifying the seminal knowledge, skills, and attitudes necessary for individuals to successfully contribute to One-Health efforts, hinders deployment. • New and continuing education programs for One-Health professionals are essential for deployment
Cunningham et al. [41]	Africa		Meta-data analysis	• Land use influences kind of CS One-Health practices applicable thus deployment. • Making use of local knowledge and insights influence One-Health innovations' implementation.
Jeggo & Mackenzie [17]			Meta-data analysis	• Communication, collaboration, and trust is a key in implementation of One-Health. • There is a need to ensure community participation and an open, broad-based dialogue. • Strengthen cross-sectoral political commitment and government leadership on One-Health is key. • Increasing community awareness and participation in disease prevention and control is important
Kelly et al. [5]			Meta-data analysis	• High political will is key in One-Health innovations' implementation. • It is critical to continue to raise communal awareness of One-Health innovations for successful deployment. • There is a need to invest in training a workforce of One-Health leaders to foster deployment.
Stephanie et al. [42]	Africa		Mixed methods approach	• Successful deployment of CS One-Health innovations is dependent on stakeholders' trust, transparency, equal representation, and consensus from all relevant sectors.
Pieracci et al. [27]	Ethiopia / East Africa		Mixed methods approach	• Enhancement of public health and veterinary laboratories favors One-Health implementation • Intersectoral linkages favors One-Health innovations' implementation

(*Continued*)

Table 1. (Continued)

Citation	Location/ scope	Sample size	Methodology	Key Findings regarding deployment of CS One-Health innovations
Dickmann et al. [19]	Uganda, Burundi, Zambia, Mali, DR Congo, Kenya, Zimbabwe, Ghana, and Tanzania		Mixed methods approach	• Bottom-Up approach favors One-Health innovations' implementation • The lack of scientific understanding of diseases in the population, and poor communication between health professionals, international aid workers, and communities hinders CS One-Health innovations' implementation. • Over dependency on international aid hinders One-Health implementation.
Garcia et al. [26]			Meta-data analysis	• Adopting preslaughter interventions enhances One-Health innovations' deployment • Hand washing is important in controlling spread of zoonotic diseases • Control of zoonotic EHEC on farms should primarily target the main source, the animal reservoir. • A coordinated multidisciplinary effort toward understanding and integrating the epidemiology, and pathogenesis facilitate deployment of One-Health innovations
Zinsstag et al. [4]			Meta data analysis	• Lack of intersectoral collaboration hinders One-Health innovations' implementation. • Implementation of CS One-Health innovations reduces costs in shared infrastructure such as hosting laboratories for human and animals' highly contagious diseases under one roof.
Aguirre et al. [43]			Review of literature regarding the natural history of T. gondii (Toxoplasmac).	• Effective screening processes for consumer meats, with new standardized tests for disease monitoring and control fosters One-Health innovations • Outdoor cats restricted from community gardens as a food biosecurity issue enhances One-Health innovations • Vaccine's development enhances One-Health innovations deployment.
Lim et al. [3]			Meta data analysis	• Banning antimicrobial use in food animal as growth promoters • In health facilities, stringent infection control, deep environmental cleaning, appropriate hand hygiene and antimicrobial stewardship foster CS One-Health innovations. • High-resolution One-Health-focused surveillance against diverse human, animal, and environmental sources.
Overgaauw et al. [44]			Meta data analysis	• Cultural rigidities hinder CS One-Health innovations deployment and implementation.

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ability to adopt CS One-Health innovations increases. For example, in Ghana, practices of CS Agriculture increased with an increase in farmers' age but only up to a threshold beyond which adoption of CS agriculture declined as farmers became older than they would physically be able to execute CS One-Health practices. The reasoning behind older farmers being more likely to adopt CS One-Health innovations, is that younger farmers are less likely to have the necessary endowments in livelihood assets or capital that is needed to invest in One-Health innovations compared to older farmers. Thus, access to natural capital (farmlands), financial capital (credit, bank loans), human capital (farm experience, know-how), social capital (household control, trust) and physical capital (access to technologies) are more likely to limit

younger farmers from the deployment of CS One-Health innovations than older farmers [15,16]. This was also because as farmers grow, they tend to reduce farm investments as well as the propensity to experiment or employ new technologies as they grow older (experience farmers gain while aging in agriculture) and specialize on innovations proven to them. Nevertheless, younger farmers were observed to possess entrepreneurial abilities and being less risk averse compared to the aged ones, which could also foster deployment of CS One-Health innovations.

Community/Public participation. Most studies acknowledged the importance of considering the involvement of the public or local communities in the implementation of CS One-Health innovations. Communities have a better view and understanding the challenges they are faced with and can support interventions that help them overcome these challenges if are convinced that they would render feasible solutions [17,18]. In countries where One-Health innovations have been successful, a bottom-to-top approach which acknowledges the resourcefulness and strength of the community together with well-structured leadership systems has been deployed [19]. There is need therefore that a better mutual understanding between the implementors of CS One-Health innovations, and the local communities is secured to facilitate a faster and more effective deployment of such innovations. Communities can modify their cultural or religious practices to reduce risk and create safer environments, but these modifications must be framed in ways that take account of local reasoning and what matters for both communities' survival and for instance, infections control.

Political will. The extent of support among key decision makers including the government, policy makers among others is key in the implementation and successful deployment of CS One-Health innovations. For instance, in Ghana & Benin, policy makers were central in lobbying for the needed financial resources from government to facilitate the deployment of the One-Health innovations. Such primary capital investment is essential to later attract private sector to further investment in One-Health innovations' deployment. For instance, across sub-Saharan Africa, a recent publicly-funded aflatoxin biocontrol innovation (Aflasafe) has been scaled up via private sector involvement using an innovative process of making a commercial case for a biopesticide or biocontrol product, licensing the product to carefully selected manufacturers, and technically backstopping them for a limited period in promoting CS integrated pest management (CS-IPM) [10]. Even other government platforms, for instance planning programs, research, and others do all influence moves toward implementation and sustainability of One-Health innovations [20]. One-Health innovations' implementation requires political will and endorsement, across both the international, regional, national, and local agendas for their stability and subsequent sustainability [21]. For the countries where One-Health implementation has been successful, there exists a high political will, with oversight and support at prime minister's or presidential levels which promote country ownership, sustained attention, and collaboration across sectors [5]. In addition, policy makers, parliamentarians, and other political leaders can play a vital role of sensitizing and persuading communities to adopt One-Health measures [19], as well as the development of adequate science-based risk management policies that would cover One-Health innovations [22].

Knowledge of CS One-Health innovations among the public / level of education. For successful implementation of One-Health innovations, there was need to understand the human, animal and environmental interactions or transmissions [11]. Having Knowledge on CS One-Health innovations' benefits, how it is practiced, and the dangers that arise due to the lack of it, prompts the public into adopting these innovations. Increasing ecological knowledge among smallholder farmers was cited as a key action to catalyze uptake of nature based solutions for plant health [10]. Some of the studies bring out the level of education as a key factor for implementation, and several studies noted that practicing CS One-Health innovations was

increasing with an increasing education level of farmers [16]. Nevertheless, all this connects to farmers or communities having knowledge on One-Health. Moreover, one of the most mentioned challenges in several studies to the implementation of CS One-Health innovations is the lack of One-Health knowledge among communities/ the public [23]. Therefore, it was critical to raise awareness of One-Health innovations. Universities should progressively incorporate CS One-Health education into their curricula, including designated degree programs. These programs need to be developed around a set of core competencies with an emphasis on practical skill-building to provide students with the knowledge and experience necessary to address complex CS One-Health threats [5].

Level of investment in One-Health. Some of the CS One-Health innovations and practices require more resource commitment in terms of funding and supporting research. For instance, high investment levels are needed in building integrated and effective community One-Health surveillance systems that are comprehensive and sustainable [24]. Investment of resources in sensitization, communication, and collaboration also helps overcome interdisciplinary challenges inherent in CS One-Health innovations' research and deployment. Such investments pave the way for successful and sustainable implementation of CS One-Health projects, and subsequently CS One-Health innovations at community level [25].

Multi-disciplinary collaboration. CS One-Health innovations do require multi collaboration of disciplines for these innovations' successful and sustainable deployment, such as veterinary, medical, biological, environmental, ecological, and social scientists among others [25]. Multi-disciplinary collaboration facilitates the development of novel strategies to prevent, control, and treat for instance zoonotic infections and diseases [26]. Multi-disciplinarity also enables creation of a strong knowledge system where all broader and specific recommendations are considered during implementation [6]. Unfortunately, most of the key disciplines/ sectors such as veterinary medicine among others for instance, in Ghana are still underdeveloped, yet there is need to join forces with these and other disciplines and sectors on all levels and collaborate for the successful deployment of the CS One-Health initiatives [19]. Therefore, there is a strong need to enhance the public health and veterinary laboratories, joint outbreak, and surveillance activities, and intersectoral linkages for successful implementation of CS One-Health innovations [27].

Land tenure systems. Land tenure is critical to the adoption of CS One-Health measures and thus their successful and sustainable deployment, such as organic agriculture where synthetic chemicals are not used. It is highly unlikely that tenant farmers would invest the necessary labor and sustain the difficult conversion period without some guarantee of access to the land in later years when the benefits of organic production are attainable [20]. For the case of CS agriculture especially, farmers are more likely to invest time and resources on their own farms than on farms where ownership rights are insecure and not guaranteed [16].

Demographic location (district) of the farm / households. For example, households living in urban areas of Ghana were found to practice CS agriculture initiatives more compared to the ones in rural areas. This was attributed to the increasing rate of information flow regarding CS One-Health innovations among urban districts / households as compared to the rural districts. Subsequently, those farm households in urban areas tended to adopt CS One-Health practices more than those in rural areas [16]. Therefore, there is need to accelerate more, the CS One-Health information flow among rural areas / households given the barriers of remoteness experienced in rural areas that limit information flow, thus awareness and subsequent adoption and deployment of CS One-Health innovations.

Nature of existing health systems. To develop an effective One-Health implementation plan for strengthening capacity at national, regional, or global levels, there needs to be reexamination of how existing systems are structured, resourced, and managed. Such analyses will

enable the development and sustainability of synergies among the human health, animal health, and ecosystem sectors [22]. In most of African countries these health systems are hugely wanting, which still hinders the optimal possible deployment of CS One-Health innovations in Africa.

Participatory research. Participatory research with farmers will be essential in all steps taken to develop, improve, and implement CS-IPM strategies. Placing farmers' views and practices at the Centre of this research–as co-creators of knowledge–will hence ensure that new recommendations are suitable and can be readily adopted. Great opportunities exist to co-develop and improve technology and practical knowledge for CS-IPM. Smallholder farmers and farmer associations can assist with cross-fertilization of ideas spanning plant, animal, and human systems. Such lines of interdisciplinary thinking are critical to realizing the benefits of a CS One-Health approach [10,28–44].

Climate-informed advisory services. The decision of a farmer to adopt novel technology and pest management tactics may be driven by the perceived cost-benefit ratio of using the new versus the existing technology. Agricultural advisors will therefore have an important role to play in demonstrating the economic rationale for CS agriculture particularly in adopting CS-IPM which is complex and dependent on the combination of several different pest control tactics (that may also need to adaptively shift in response to changing conditions). Advisory services should be available to help farmers overcome the challenge of incorporating new tactics into functioning systems, and in deciding whether or not to continue using all previous tactics or abandon some in favor of novel approaches for instance [10,30–32].

3.2. Examples of One-Health innovations or programs adopted

Country wide vaccination programs have been rolled out targeting domestic animals in several countries including livestock, pets and a few wild animals that are often in contact with humans. For example, in Ghana there are localized and non-regular vaccination campaigns that are organized jointly by different non-governmental organizations, international donors and district veterinary officers [23]. These vaccination campaigns help reduce the disease burden in animals, and hence reduce environmental contamination including agricultural lands and exposure of humans to the pathogens [28].

Imposing restrictions on the use of toxic substances in agriculture has been the other One-Health innovation implemented so far. For example there are restrictions on antimicrobial use in animal food as growth promoters, yet these help reduce the spread of C. difficile (Clostridium difficile) and other antimicrobial-resistant pathogens [3]. Additionally, restricting prescription of reserved, expired, and substandard drugs has been the other innovation, alongside periodic monitoring of pharmacies and veterinary shops, and antibiotic stewardship.

Testing wildlife, livestock and water sources for zoonotic pathogens has been the other innovation. Such testing enables timely and regular monitoring of water quality and use, evaluating livestock and human diseases' impact on pastoral livelihoods, engagement of new diagnostic techniques, zoonoses training for new health and environmental policy interventions, and field epidemiology and laboratories' trainings [31]. Serological testing (the testing of blood serum to detect the presence of antibodies against a specific antigen) and the subsequent culling of seropositive animals, have also been crucial One-Health interventions, leading to adequate control of zoonoses in developing countries. These are used together with the point-of-care testing in health care centers to inform treatment and decrease the possibility of wrongful diagnosis and inappropriate treatment in patients seeking treatment at health centers [28].

Adopting preslaughter interventions such as veterinary inspection, vaccination, bacteriophages (viruses that kill bacteria), sodium chlorate and probiotics has also been another One-

Health innovation used widely. These interventions effectively reduce bacterial contamination levels from the abattoir to the table and reduce the shedding of EHEC O157 (Enterohemorrhagic Escherichia coli, a pathogen that causes a severe intestinal infection in humans) in the feces of weaned domestic ruminants [26]. However, despite such strategies, food-borne illnesses and food-related deaths still occur far too frequently [45]. Therefore, there is still even a bigger need to expand the continuum of interventions from the abattoir back to the farm, to have the greatest potential to reduce pathogenic contamination of meats and resultant human illnesses.

Another example of CS One-Health adopted innovations is the use of traditional farming techniques that support CS One-Health. For instance, (i) crop rotation that reduces the need of using fertilizers, (ii) planting of cover crops that improve the soil quality, control soil erosion as well as reducing weeds, and (iii) low tillage farming that minimizes disturbances to the soil and increase the retention of water, nutrients, and the topsoil, (iv) rotational grazing that prevents soil erosion by maintaining sufficient vegetation cover, and (v) production diversity, the growing of a variety of crops providing a buffer against both ecological and economic problems [10,46].

Intensive circular bioeconomy initiatives like production of black soldier fly (BSF) larvae from organic waste that are used as animal feed, and production of compost from organic waste are other examples of CS One-Health innovations [47]. The organic waste from agricultural production and food processing that would have been left to accumulate in the environment thereby emitting toxicity and greenhouse gasses while polluting air quality, is instead recycled into animal feeds or compost that are reused in agriculture [47]. Such innovations minimize resources usage and wastage, enhance household adaptability to limited resources, and reduce climate change through reduced GHG emissions, while ensuring better human and environmental health [46,47].

The application of CS-IPM where biological methods are deployed, and chemical pesticides (least toxic) are used only as a last resort, have been the other set of One-Health innovations used in most developing countries. These innovations generally emphasize crop rotations, intercropping, and other methods of disrupting pest cycles, and use of plant varieties that have high resistance to pests [20]. Moreover, Egan et al. [10] identify five practices that routinely underpin IPM strategies including (i)The development and use of resistant and tolerant crop varieties, (ii) The biological control of pests by their natural enemies, (iii) Habitat manipulation, such as push-pull systems for pest deterrence and weed suppression, (iv) The use of biopesticides such as plant- and microbially-derived compounds and (v) Exploitation of semiochemicals (i.e., the chemical signals used by pests) for pest monitoring and trapping. In some regions, computer applications have been used as part of the One-Health Programs to foster deployment of One-Health innovations in general. For instance, in Philippines, a mobile app called the animal front was developed for One-Health workers to collect data used to analyze community relationships with animals. The analysis would also help design, approaches used in animal husbandry, management of domestic animals, common animal illnesses, and appropriate treatments. The analysis would also help design appropriate methods of animal slaughter for food preparation and storage, identification of common One-Health challenges during animal slaughter thus fostering suggestions for interventions, and timely access to experts when suggested interventions have failed [2].

3.3. Key selected impacts of One-Health innovations' deployment

Generally, One-Health innovations have improved disease outbreak investigations in all countries where they have been deployed especially at the interfaces of key livelihood supporting sectors like agriculture including farming and livestock–domestic and wild, forestry, and

fishing. For instance, in Ghana this One-Health innovations' adapted investigations have enabled continuous monitoring and surveillance of newly emerging diseases and pandemic outbreaks for example Ebola, thus avoiding its wide spread [8]. Subsequently, such timely surveillance enables timely and effective control of infectious diseases, the non-infectious diseases, and conditions for both [30]. In the case where CS-IPM approaches are adopted, crop losses to pests are reduced because of effective and cost-efficient management of existing crop pests, increasing both food security and income for male and female farmers. It also decreases negative impacts on the broader ecosystem making farming systems more resilient to climate change and promotes a rational use of agricultural inputs thereby reducing the greenhouse gas (GHG) emissions intensity per unit of food produced [48]. More specifically, One-Health innovations have promoted early and rapid detection of health threats, collecting data to promote an integrated disease surveillance, prevention, and response system, improving education and communication among professionals focused on human, animal, plant, and environmental issues. This then allows for earlier interventions, exposure and integrating of students engaged in professional education to concepts related to One-Health that facilitates inter-professional collaboration around discovery, innovation, research, developing policy focused on upstream drivers of disease emergence including land use and landscape alterations, water access and cleanliness, migration, and climatic shifts. Subsequently, these interventions strengthen the economy by improving long term impacts on food safety, security, crop productivity, improved livestock health and productivity, plus a greater wildlife biodiversity [2,29].

3.4. Challenges to the deployment of One-Health innovations

Challenges can be viewed as those factors affecting the deployment of One-Health innovations but from the negative side. Specifically, those aspects that would slow down, inhibit, or even fail the deployment of these innovations. Hence, strategies for successful deployment of One-Health innovations need to be aware of these challenges. For instance:

Culture. Culture affects peoples' perceptions of food, health, illness and death, beliefs about causes of disease, approaches to health promotion, how illness and pain are experienced and expressed, where patients seek help, and the types of treatment patients prefer [49]. Therefore, culture has usually been a key challenge to deployment of One-Health innovations. For example, findings from a study aimed at prevention, control, and response to anthrax outbreak in Northern Tanzania, Selela Ward Monduli district using a One-Health approach indicated that eating carcasses was observed to be one of the most common practices in Selela Ward besides some of the on-going awareness campaigns and health education interventions for the prevention and control of anthrax. Some pastoralists in the Maasai community mostly considered the extent of decomposition of a dead animal which they want to consume rather than potential risks of zoonotic disease transmission. Pastoralists might be aware of the risks associated with consumption of raw milk, blood, or raw or undercooked meat, but they continue to practice these risky behaviors particularly in rural areas. For instance, the Maasai community has a belief that, drinking raw blood is important for young boys who have just been circumcised, because they believe that the raw blood replenishes nutrients lost during the circumcision procedure. In addition, from the meetings conducted with the local people, anthrax was reported as being brought by bad spirits of Maasai ancestors. Therefore, when anthrax outbreak occurred, they tended to tie a small piece of animal skin on the finger as a way of chasing out the bad spirit from the household which was perceived to protect them from acquiring anthrax [50]. Such beliefs and many more from various cultures of various communities do not only make sensitization on One-Health innovations necessary but also difficult because of

the parallelism to culture. Certainly, correcting such cultural behavior, beliefs and practices is a key determinant in the success of the One-Health initiatives particularly as regards prevention and control of zoonotic infectious diseases.

Language barrier. Furthermore, Mwakapeje et al. [50] indicated that during field exercises, the team had to use a translator to communicate with the Maasai as most of them did not speak Kiswahili which is the national language. Therefore, awareness of anthrax, health education, and other relevant outbreak information had to be translated to Maasai language. To some extent, this could not ascertain whether the right information was conveyed. This becomes a hinderance in implementing One-Health innovations because it makes sensitization difficult.

The top-down approach. Traditionally, community engagement approaches are often limited in explaining better to local people what they must do and how to better apply One-Health innovations' recommendations. This conventional top-down approach does not truly acknowledge the resourcefulness and strength of communities, and too often misses critical action-enhancing insights. This sharing and communication of knowledge that is too focused on official scientific information and official community leaders, ignoring informal communication and leadership systems of communities (e.g., 'rumors' and 'Queen Mums') inhibits effective deployment of One-Health innovations. Incidentally, the top-down approach mostly offers behavioral advice that is frequently inadequate, insensitive, and patronizing; hence adequate explanations are often missing and recommendations ignore the critical identity-building social and religious forces of societies [19]. Therefore, the community engagement approaches tend to fail to meet the purpose for which they were intended in using this approach posing more difficulties in the implementation of One-Health innovations.

Anti-biotic resistance. The overuse of antibiotics (mainly as growth promoters) in animal husbandry, coupled with the close contact of humans and farm animals, facilitates the emergence of resistant zoonotic bacterial pathogens. Studies have shown that resistance in pathogenic zoonotic bacteria and/or changes in fecal microbiota increased shortly after the introduction of antibiotics in veterinary practice [28]. Another study by Lim et al. [3] also affirmed the misuse of antimicrobials in domesticated animals for food as growth promoters and as a non-specific means of infection prevention since the 1950s and 1960s. Lim et al. [3] also noted that the use of antimicrobials, especially those with activity against commensal bowel flora, created an environment that mimics the gastrointestinal tract of infants, allowing Clostridium difficile (bacteria that can infect the bowel and cause diarrhea) to flourish. Such mimicking resulted into domesticated animals for food becoming a major reservoir and amplification host for Clostridium difficile. Major producers of food animals such as Brazil, China, Canada, India, and Australia use antimicrobials in animal feeds thus increasing the risk of transmission of Clostridium difficile to humans.

Mismatched interests. The mismatch in professional and cultural interests and values between researchers and policymakers can be a significant barrier to linking sound knowledge with effective action and salient policy. Researchers benefit the most and gain the most prestige from publishing papers presenting new knowledge and innovative concepts. Knowledge production prioritizes 'global' audiences in the most prestigious scientific journals, and downplays local information sharing and community-based activities. There are few direct incentives and reward systems to encourage engaging in the more difficult, long-term, and politically fraught translation of such knowledge into action or policy on the ground for local people. The reward systems for research, therefore, tend to marginalize the needs of the marginalized. Research is done, and the benefits accrue in the number of publications, citations and future research grants obtained [18].

Limited community knowledge and awareness. A clear elaboration of this are the findings from the HALI (Health for Animals and Livelihood Improvement) project initiated to test the feasibility of the One-Health approach in rural Tanzania by investigating the impact of zoonotic disease on the health and livelihoods of rural Tanzanians living in the water limited Ruaha ecosystem. These indicated that more than two-thirds of participating pastoral households did not believe that illness in their families can be contracted from livestock, and nearly half believed the same of wildlife. Furthermore, when the HALI project began working in the region, 75% of households did not consider sharing water sources with livestock or wildlife a health risk, illustrating the need for effective community education [33].

Over dependency on international aid. The international development and deployment model often results in cementing dependency on international aid. International aid is too often designed to please the 'senders' but does not meet the local needs. There exists a discrepancy in the priority setting of the response which focus on imposing 'evidence based' solutions that lack external validity in affected communities, i.e., they too often recommend actions that are inconsistent with, ignore, or violate traditional behavior. While there appears to be a consensus now on what needs to be done, how to achieve these goals remains a challenge [19]. Additionally, Munyua et al. [34] assert that sustainability of the current progress and efforts are not guaranteed due to the reliance on donor funding to implement the One-Health activities. This is due to the uncertainty of the receipt of the funds or delay in funding. This is a challenge that goes beyond One-Health implementation and is largely appreciated for many donor-initiated efforts.

Oversight of health threats associated with companion animals. Many One-Health initiatives focus mainly on the relationship between humans and livestock or wildlife health, because several zoonotic disease pandemics and (re)emerging infectious diseases originate from these animal species. However, the role of companion animals, particularly dogs and cats, is often underestimated in One-Health communications. Dogs, farm animals, and cats more often spend their life indoors in very close physical contact with their owners thus there are several zoonotic infectious diseases, as well as resistant bacteria, that may be transmitted directly or indirectly from these species to humans especially in young children and immunocompromised individuals. Most cases of these conditions are not serious, and deaths are very rare but some of these diseases can be life threatening, such as rabies, rat bite fever infections, and tick-borne infections, and plagues [28,44]. There exists an often-unrecognized risk from pets, that is the reverse zoonotic disease transmission, the so-called zooanthroponosis [44]. This is where animals get infected with human diseases. Microsporum species and Trichophyton species are identified as infectious agents originating from humans to animals especially in companion animals. Apart from zoonoses, other negative effects of pet ownership include dog and cat bites or scratches, fall injuries, caused by falling or tripping over dogs and cats and allergic reactions of individuals (often genetically) predisposed because of close animal contact. Dog biting and cat scratching incidents can cause physical health problems both at the time of infliction but also afterwards by triggering trauma-related secondary infections. Dog bite incidents can result in medical treatment, hospitalization and even death. Moreover, imported dogs are reintroducing diseases and parasites in countries where they were previously eliminated or had not existed before for example USA [44].

Inaccessibility to diagnostic testing in non-industrialized countries. Such inaccessibility has meant that knowledge of the epidemiology of various pathogens is scarce, and as a result, the burden of the pathogens is under-reported and underestimated, which reinforces ineffective clinical and public health management of diseases acquired from these pathogens [32]. Moreover, Asante et al. [28] documented a worrying case of misdiagnosis and subsequent inappropriate treatment where patients admitted to hospitals were given standard empirical

treatments that typically included antimalarials and penicillin antibiotics. Therefore, inaccessibility to rapid, cost- effective and reliable diagnostic tests for non-industrialized countries, hampers detection, reporting and interpretation of results on multiple infections, thus impeding deployment of One-Health innovations.

Poor intersectoral and multi-sectoral collaboration. In their socio-political context, One-Health innovations aspire to change not only ways of working but also existing governance and network relationships, hence they do influence power and politics [18]. Therefore, the operationalization of One-Health innovations is challenged by poor sectoral collaborations including lack of policies / guidelines on information and resource sharing, biased funding, and imbalanced participation across different sectors [51]. Moreover, various ministries and organizations tend to have different interests, curricula, mandates and policies hence creating a barrier to linking resources and knowledge for effective policy and action to supporting One-Health approaches [4].

Limited clinical awareness of zoonotic diseases involving companion animals and pets. For example, Bardosh et al. [18] and Overgaauw et al. [44] note that in most cases, physicians do not regularly ask about the presence of pets or pet contact, nor do they discuss the risks of zoonotic diseases with patients, regardless of the patient's immune status, which means that many cases of zoonotic diseases sometimes go undiagnosed. The public and people at high risk of pet-associated diseases are not aware of the risks associated with high-risk pet practices or recommendations to reduce them [44]. There is an ineradicable belief among a large part of the public that the licking of human wounds by dogs can disinfect them and that the saliva thereby has healing properties. In addition, it is regularly reported that a dog's tongue is believed to be sterile. This is not the case and the oral flora of a dog comprises hundreds of species (including pathogenic) bacteria, fungi, and viruses that can be harmful to humans [44]. In patients at high risk, severe wound infections, sepsis, disseminated intravascular coagulation, or death can occur. Non awareness with hazards reinforces fear, thus communication plays an important role to create awareness, hence deployment of One-Health innovations [44,52–55].

Lack of reported systematic evaluations. Lack of systematic evaluations combined with the sporadic collection and presentation of One-Health metrics limits a full understanding of outcomes. A standardized framework for systematic evaluation of One-Health innovations would be useful to identify how much value can be gained by fusing efforts across health sectors [4,52,53]. They also stress the need for standards of reporting data sources and quality so that data scientists and One-Health experts can evaluate and compare methods and findings across studies and sectors.

Poor communication for the need of One-Health. There exists a challenge in convincing policy makers about the benefits of planning and investing in One-Health innovations [8]. It is a tough job to try and translate what is happening in the science to policymakers and the public. People often think about their own health more than they really think about wildlife or conservation [4,54]. Poor communication poses a challenge when it comes to implementing the One-Health initiatives in ways that build, interest support, and investment by the various stakeholders [18,55].

4. Conclusion

From a robust meta-analysis review of credible scientific literature, the study identified several socio-economic factors that determine the deployment of CS One-Health innovations. These factors must be considered and addressed for successful deployment of these innovations. Generally, some of these factors if are in place, do foster One-Health innovations, while others

hinder it (challenges). For instance, key among fostering factors include; relatively old aged farmers with substantial farming experience to apply these innovations, secure land tenure systems that guarantees necessary financial investments, participation of communities in One-Health innovations to bring about local ownership of these innovations, communities being politically willing to support these innovations, communities being sensitized and knowledgeable about One-Health innovations so to accept and adopt them, and multi-disciplinary collaborations in the execution of One-Health innovations which is necessary to galvanize the required diversity of expertise. Among those factors that hinder One-Health innovations are; cultures whose beliefs and values are non-complimentary to One-Health innovations, language barriers between innovators and communities, a top-down approach that is usually used to implement these innovations but takes no consideration of communal compatibility, resistance to antibiotics that makes further deployment unnecessary, over dependency on foreign aid whose (aid) conditions that are sometimes incompatible with the local context, inaccessibility to proper diagnostic testing especially in developing countries that fail timely execution of One-Health activities, and finally, lack of proper systematic evaluations of One-Health innovations for proper communication of the need for innovations to the public and policy makers. Additionally, limited investment and heavy capacity-building needs with regards to education, training, and professional development, do also hinder One-Health innovations. Moreover, these capacities needs must be addressed, and built on local terms, using local assets, and made compatible to local conditions, so to reduce dependency on international support and its associated challenges. In principle, there is no 'one size fits all' approach to achieving the needed intersectoral collaboration, significant resource mobilization and political co-operation that are required to realize One-Health innovations. Therefore, individual country requirements cannot be underestimated, dismissed, nor prescribed in a top-down manner.

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