sustainability

Article

An Integrative Approach to Healthy Social-Ecological System to Support Increased Resilience of Resource Management in Food-Producing Systems

Laura Urdes [1,*], Violeta-Elena Simion [2], Laurentiu-Gabriel Talaghir [3,4] and Veronica Mindrescu [5]

[1] Faculty of Management, Economic Engineering in Agriculture and Rural Development, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Marasti Bvd. 59, 011464 Bucharest, Romania
[2] Faculty of Veterinary Medicine, University Spiru Haret Bucharest, Basarabia Bvd. 256, 030352 Bucharest, Romania
[3] Faculty of Physical Education and Sport, Dunarea de Jos University of Galati, 800008 Galati, Romania
[4] Faculty of Physical Education and Health, South Ural State University, 454080 Chelyabinsk, Russia
[5] Faculty of Physical Education and Mountain Sports, Transylvania University of Brasov, 010374 Brasov, Romania
* Correspondence: urdeslaura@gmail.com

Abstract: The study addresses health-associated risks and health indicators required for the framing of Social-Ecological System Health (SESH) in aquaculture food-producing systems. The advantages of using a healthy Social-Ecological System (SES) are highlighted, to aid in the development of a new ecological system fostering the sustainability of aquatic ecosystems. The study used statistic modelling of some human infections with *Cryptosporidium* spp. and *Cyclospora* spp., used to obtain an estimate of the costs of zoonoses to health systems, and the outcomes of an epidemiological study involving the *Eustrongylides* spp. in fish. The study indicated that parasitic zoonoses have an important economic impact on health systems, environment and society at large. Holistic approaches to health, addressing all relevant actors are required to mitigate these impacts. To address the risk of eustrongylides and other fish-, and water-borne zoonoses, the development of new social-ecological system health should be constructed. For aquaculture production, such systems must include a biosecurity plan co-developed and negotiated by all relevant stakeholders. While the system's feasibility is yet to be validated, regular revision of such systems' functioning and outputs is an important premise to make them operational.

Keywords: circular economy; One Health; Social-Ecological System Health (SESH); economic impact of zoonoses; aquatic ecosystems

check for updates

Citation: Urdes, L.; Simion, V.-E.; Talaghir, L.-G.; Mindrescu, V. An Integrative Approach to Healthy Social-Ecological System to Support Increased Resilience of Resource Management in Food-Producing Systems. *Sustainability* **2022**, *14*, 14830. https://doi.org/10.3390/su142214830

Academic Editor: Antonio Boggia

Received: 7 October 2022
Accepted: 7 November 2022
Published: 10 November 2022

1. Introduction

The theory of resilience and ecological resilience proposed by Holling, 1973 [1] have emerged as powerful tools enabling understanding of the systems linking humans with nature, thus establishing the basis of what is currently named "social-ecological systems (SES)" [2].

Social-ecological systems are complex adaptive systems composed of diverse human and non-human entities, which dynamically interact within networks, operating at a variety of spatial and temporal scales, dampening or accelerating change [3]. The individual behaviors of entities are interdependent. These entities adapt to changes in their social and ecological environment causing their social-ecological environment to change. From all these diverse elements adapting to, and interacting with each other, a new behavior of the whole social-ecological system emerges, making the entities to re-adapt to these newly emerged environments. Social-ecological systems are continuously changing, as that is what complex adaptive systems do. Currently, social-ecological systems are perceived as the most suitable integrated approaches to resilient health systems.

Health system resilience is the ability to prepare for, manage and learn from sudden and extreme changes impacting on the system. Resilience in health depends on the durability of social-ecological systems, which is further dependent on the adaptive capacity of the system's individual components, and the capability to link health and ecosystem management with the durability of SES. To allow for meaningful correlations between health and ecosystem management, ecological models are utilized, as these help explain outcomes, and identify potential prevention strategies for these outcomes.

The Centers for Disease Control and Prevention [4] uses a four-level system for ecological models of prevention, which is based on individual, relationship, community and societal influences. In Bronfenbrenner's ecological systems theory [5], each of these tiers correspond to the microsystem (the most proximal ecological level where individuals are embedded), mesosystem (involving processes that occur between the multiple microsystems of an individual), exosystem (the next outermost level including the microsystems in which individuals are involved), and macrosystem (representing society and interaction with the society views of an individual) as the constituents of an ecological system. The most effective programs are those working across these levels, including a multi-level prevention program [5].

Environmental sustainability refers to the way we use natural resources, responsibly managing the environment and preventing pollution, so that these resources are available for future generations. The concept is part of the broader sustainability goal where, additional to the environment's attributes, ecology, economy and society elements play equally important roles. Clean air, soil and water, proper management and risk reduction are key components of environmental sustainability. These components are attainable by shifting to renewable resources, protecting the health of ecosystems, avoiding excess pollution, targeting welfare and making intergenerational decisions based on long-term consequences [6]. Sustainable and environmentally friendly ecological approaches indicating key dimensions of environmental systems, and how these integrate within the One Health approach are at the core of the circular thinking model. Ecological systems explain how human development is influenced by different types of environmental systems, showing different outcomes for various groups of stakeholders [7–9]. As with other environmental risks, pollution reflects on the biology of pathogens, which reflects back on the biology and diversity of species [10,11], ultimately impacting the health and well-being of humans and thus, the One Health concept. The emergence of communicable diseases associated with human-animal interaction can have significant societal and economic impacts, also threatening biodiversity conservation [12]. COVID-19 and Avian Influenza pandemics have illustrated how devastating and persistent such outbreaks can be, calling for mitigation plans to tackle the challenges posed by human manipulations of animal species: "If no changes are made, it is inevitable that zoonotic pathogens will continue to emerge and threaten global health and economies", [13].

Although there have been proposed various approaches to connect human and animal health with ecosystem management, operational implementations of these approaches have been hampered by "the lack of a common, coherent framework and a consensus on what defines healthy social-ecological systems (SES)"), [14].

The Social-Ecological System Health (SESH) framework proposed by De Garine-Wichatitsky et al. (2021), [14] advocates for the implementation of the One Health concept in practice, by creating a framework that lays the foundations of a co-construction process based on an equitable representation of all relevant parties, while setting the boundaries of the socio-ecological system of interest.

One Health reinforces the goals set through the United Nations 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, to include health with global development. To encourage economic growth, strategies aimed at improving health and education, among other goals set in the Agenda, are required [14]. The question is how to accelerate income in the economy through sustainable, sound evidence-based developments, and building upon past lessons while compensating for weaknesses of specific programs [8,9,15,16]. An integrated economic framework for assessing zoonoses using the One Health concept, providing an understanding of the cross-sector economic impact of zoonotic diseases by a range of analytical tools, facilitates an understanding of disease costs and the costs and benefits of control measures. The framework's analysis outputs should be derived from economic impact and disease transmission models, as well as from existing options for the evaluation of risk management. These variables would allow for a better understanding of the factors dependent on the adoption of risk management strategies. Improved understanding of the costs incurred by zoonotic diseases optimizes the implementation of effective control measures, while contributing to improved health and macroeconomic growth [16,17].

Zoonoses are caused by animal disease agents transmissible to humans. Some zoonotic agents enter the human body with ingested food or water, causing what is called food/water-borne zoonosis. The severity of zoonoses can be sometimes life-threatening. The risk is present from source to consumption, requiring control throughout the food chain to reduce their economic impact. The management of parasite infestations and, especially those associated with food-borne pathogens, require due consultation among stakeholders, and this may prove particularly difficult when there are no dedicated, official institutions in place, as stakeholders may not be willing to effectively collaborate.

In this article, we are suggesting an ecologic, transdisciplinary framework, exemplified by a case study involving *Eustrongylides* spp. in fish, also a long-time neglected fish-borne zoonotic pathogen [18,19]. The aim of the study is to propose a social-ecological approach, derived from the SESH logic model developed by De Garine-Wichatitsky et al. (2021) [14], for the control of eustrongylidosis, and potentially other fish-borne diseases with importance to socio-ecological systems. We will also emphasize causal assumptions with economic and social impact to address ecosystem dynamics. The objectives of the study are: (i) to suggest a modified SESH conceptual framework to address the risk of *Eustrongylides* spp. and other fish-borne zoonotic agent, highlighting requirements for a fully operational SESH, in order to assist the long-term development of management principles by relevant stakeholders; (ii) to aid in framing a preliminary definition addressing health risks associated with fish eustrongilidosis by linking the ecosystem management with the human and animal health through SESH; (iii) to identify health indicators of SES fit for local ecosystems, that can guide collective actions to control and monitor *Eustrongylides* spp. and potentially other food-borne diseases, while meeting the need of local entities, and where there are no dedicated institutional structures in place.

Literature Review

Eustrongylides spp. (Phylum: Nemathelminthes, Class: Adenophorea, Order: Enoplida, Family: Dioctophymatidae) is a parasitic nematode with acknowledged potential to cause food-borne zoonoses via the consumption of infested or contaminated fish [19–24]. Although a total of 19 species have been described worldwide on the basis of adult and larval morphology, three species are referred to in the literature: *E. tubifex*, *E. ignotus* and *E. excisus* [25–29] and the Marine Species Register currently indicates 8 species of *Eustrongylides* spp., of which 5 species are incompletely defined taxa (*taxon inquirendum*), [30]. The larvae of the genus *Eustrongylides* have almost identical morphology, with no clear interspecific differentiation [31,32]. In most cases, the specimens found have been misreported and misclassified [33–35]. Reports from previous studies in the Danube Delta are based on the macroscopic description of the parasite down to the genus level. Epigenetic studies are required to identify the agent at a species level [36].

In a series of investigations of fish eustrongylidosis conducted in four aquatic ecosystems, in Danube Delta, the co-existence of the nematode with other parasite species within the same fish host was recorded, indicating that the nematode's specific biology may play a role in these co-infections [37]. The existence and importance of co-infection has only recently been recognized. The notion went into use in the second half of the XXth century [38–40]. Seen now as a naturally occurring phenomenon, concurrent infestations of a host with more than one parasite species seem to have always existed in animal populations. It is argued that, under natural conditions, infestations of one host with more than one species of parasites are more widespread than was believed. Some scientists indicated that co-infection is most often observed in fish where, in effect, it is ubiquitous [38].

Infestations with *Eustrongylides* spp. in fish are alleged to generate economic loss through impairment of reproduction, alteration of flesh coupled with sensorial devaluation of the meat, commercially displeasing appearance, and faster deterioration of the fish or fish products, which all lead to marketer/consumer rejections [41].

Humans become infested by the consumption of raw or under-cooked infested and contaminated fish or fish products. An increasing number of reports of eustrongylidosis in humans have been recorded in Africa, Asia, U.S. and Europe, with more frequent reporting in fish meal-based, less developed countries. Fish with eustrongylidosis are found occasionally by fishermen, who named this nemathode "the red wire worm". There are also reports of additional fish species and environments affected by *Eustrongylides* spp., worldwide [42].

The parasite is commonly found in areas of denser, polluted and eutrophicated habitats [36]. The nematode is not reportable to the OIE, but it is recognized amongst the pathogens causing food-originating, incidental gastro-intestinal disorders in humans, which, in most cases, would require medical treatment and monitoring. To our knowledge, eustrongylidosis has been underreported and misdiagnosed, as *Eustrongylides* spp. is less common than other zoonotic parasites (e.g., *Anisakis* spp.), and because both patients and doctors are often unaware of the zoonotic potential of the agent under natural conditions [43]. In the absence of adequate measures to mitigate the spread of parasites, it is expected that the number of infections to become more prevalent in the near future.

Blockchain technologies, originally designed for virtual currencies, are now available for health care sectors, mainly in the data storage and protection system. Coupled with good management and a circular thinking model, these technologies could change how we produce food [44,45].

2. Materials and Methods

To aid in framing a preliminary definition of Social-Ecological System Health (SESH) fostering the healthy development of a new ecological system in aquatic ecosystems, we used the epidemiological study of *Eustrongylides* spp. infestations in fish, and modelled statistical data we considered relevant for the identification of an economic impact of parasitic zoonoses.

2.1. The Epidemiological Study

An observational (cross-sectional) study was carried out between 2003–2008 and 2013–2014, in four out of the total of seven aquatic systems from the Danube Delta, Romania, in the Sontea–Fortuna (SF), Gorgova–Uzlina (GU), Dunavat–Dranov (DD) and Razim–Sinoie (RS) natural complexes of the Biosphere Reserve. The area of these aquatic systems varies between 9170 ha and 90,000 ha, with a small volume of water flowing through riverine lakes and water channels [46].

Eight species of fish, totalling 8215 individuals, were investigated, of which: 4652 European perches (*Perca fluviatilis*), 852 rudds (*Scardinius erythrophthalmus*), 56 Wels catfishes (*Silurus glanis*), 288 Northern pikes (*Esox lucius*), 1327 pike perches (*Stizostedion lucioperca*), 995 common daces (*Leuciscus leuciscus*), 23 pumpkinseeds (*Lepomis gibbosus*) and 22 European eels (*Anguilla anguilla*), Linnaeus, 1758. The fish samples were selected by cluster and multistage sampling as, logistically, it was not possible to study random selections of all individuals within the study population. Hence, groups of individuals were selected individually, and then all individuals within the selected groups were included in the study. Occasionally, a secondary random selection of the individuals within these clusters was made. This applied to the captures of multispecies fish, where smaller, species-based units of individuals were formed (i.e., according to the species to which they belonged). Based on the case definition, the samples were split into nematode-free/non-diseased and infested/diseased. The fish samples were selected from larger batches of fish. These batches were obtained in March, July, September and October through regular industrial fishing intended for the public market. The fish were collected from fishermen and local fisheries and processors, close to the sampling sites. This was a study of fish captures destined for commercial fishing, and the studied animals were dead when they were selected in the study, hence no ethical legal aspects were raised.

The number and size of the investigated fish species varied throughout the study with the dominant species of fish present at the time of fishing and in the sampling site, the season and climatic conditions at the site of fishing, and the fishing gear used to capture the fish. Also, during prohibition (when fishing of some species was not allowed) and outside the seasons mentioned above (i.e., during winter), the prevalence could not be recorded. The fish showing abdominal distension, cachexia, loss of condition and scales, skin and fin erosions were classified as diseased. The fish with a healthy appearance, identified as such by clinical examination and examination of the coelomic cavity, were classified as non-diseased and were excluded from further investigations. To identify the parasites and the related pathology in the fish, the samples underwent parasitological, anatomopathological and histopathological examinations. Light microscopy was used to examine native slides of the gills, skin and intestinal mucosa scrapes, and squash preparations of the tissues. Thin slices of the abdominal muscles (2–3 mm) were sampled and analyzed by transillumination, with UVP Visit-White light Analytik Jena GmbH, to aid in the identification of the encysted *Eustrongylides* spp. larvae. The macroscopic examination of the larvae was carried out on fresh and fixed samples (70–90% ethanol), with Krüss Optronic binocular glass and Panasonic Lumix DMC-LS60, 6 megapixels, 3× optical zoom. For the morphological parameters, we used the glass micrometer disk Slide and the identification guide described by Bauer (1987) [47], Moravec (1994) [29], and Anderson (2000) [26]. For the myxosporean *Myxozoa* spp. spores, malachite green staining technique was used. The slides were examined with Labophot 2–Nikon, BG-33 light filter, AFX-DX Nikon exponometer and FX-35 DX camera; LEICA DM LS2 microscope and, occasionally, a portable ML-4M microscope.

2.2. Input for Statistical Data

Two main databases were used to collect data on communicable pathogens, health conditions and costs to the health system between the years 2009 and 2019. From the World Health Organization (WHO) [48] we collected data on two foodborne parasitic diseases, reported during the time period in the United States. The database of the Centers for Disease Control and Prevention (CDC) [4] provided data on health expenditure by diseases and conditions in units of expenditures. The collected data were analyzed in order to evaluate the economic impact and costs of parasitic zoonoses to society. The main Hypothesis of the research is:

Hypothesis 1 (H1). *Parasitic zoonoses have an important economic impact to society.*

3. Results

3.1. Infections with Eustrongylides spp.

Out of the 8215 fish individuals examined in total, 5442 individuals from all fish species taken in this study presented infestations with *Eustrongylides* spp. larvae.

Silurus glanis and *Esox lucius* captured in all four study sites presented infestations with *Eustrongylides* spp. larvae. Throughout the study, *Eustrongylides* spp. larvae were found in 16 individuals of *S. glanis* (out of the total of 56 individuals of *S. glanis* captured; prevalence = 0.28%), and in 202 individuals of *E. lucius* (out of total of 288 individuals of *E. lucius* captured; prevalence = 0.70%). Occasionally, the larvae were found in *Lepomis gibbosus* captured from Gorgova–Uzlina (i.e., 11 individuals infested out of 23 *L. gibbosus* captured in total; prevalence = 0.47%), *Scardinius erythrophthalmus* (six infested out of 852 captured in total; prevalence = 0.007%), *Perca fluviatilis* (3271 infested out of 4652 captured in total; prevalence = 0.70%), *Stizosteidon lucioperca* (906 infested out of 1327 captured in total; prevalence = 0.68%), *Leuciscus leuciscus* (592 infested out of 995 captured in total; prevalence = 0.59%) and *Anguilla anguilla* (20 infested out of 22 captured *A. anguilla* in total; prevalence = 0.90%). None of these species had been found affected by the *Eustrongylides* spp. larvae before [34,49,50]. In *P. fluviatilis*, the nematode larvae were present in the muscle, intestines, gonads and peritoneum. In *S. lucioperca* the larvae were found trapped in the mesentery, liver, peritoneum, gonads and abdominal muscle. A sub-capsular leukocyte infiltrate in the liver was also present. In *L. leuciscus* the larvae were found in the body cavity. Some larvae were attached to the mesentery, somatic muscles and liver. In *S. glanis* and *E. lucius* the larvae were attached to the intestines, peritoneum, abdominal muscle, liver, gonads and mesentery, with discrete hyperemia of intestines and ascites in these species. In *A. anguilla*, the nematode was adhering to the liver, spleen, intestines, gonads and peritoneal serosa. The total prevalence of the co-infections (co-infections/total samples by species) was 10.14% in *P. fluviatilis* and 0.70% in *S. erythtrophthalmus.* In *P. fluviatilis*, mixed infestations of *Eustrongylides* spp. with *Myxobolus* spp. were recorded in the fish captured from Sontea–Fortuna (SF), Gorgova–Uzlina (GU) and Razim–Sinoie (RS), with a prevalence of 8.16%. Co-infections of *Eustrongylides* spp. with *Triaenophorus* spp. were recorded in *P. fluviatilis* captured from the Razim–Sinoie (RS), Dunavat-Dranov (DD) and Gorgova-Uzlina (GU) aquatic ecosystems, with a prevalence of 1.63%. Co-infections of *Eustrongylides* spp. with *Triaenophorus* spp. and *Piscicola* spp. were identified in *P. fluviatilis* captured from DD and RS aquatic systems, with a prevalence of 0.34%, while co-infection of the nematode with *Posthodiplostomum cuticola* were found in *S. erythrophthalmus* captured from Gorgova-Uzlina (GU) aquatic systems, with a prevalence of 0.70%. During the study, there was recorded the tendency of the nematode to infect new populations of fish, which indicate a very low species specificity, with potentially important consequences for the aquaculture and food-producing industries [17,51,52].

3.2. Economic Impact and Costs of Water-Borne Parasitic Zoonoses to Society

With the global growth of aquaculture and increasing volumes of international trade in aquatic animals and their products [53], fish-borne zoonoses require special attention. Due to better diagnostic capability, the incidence of zoonotic diseases has increased in recent years. However, the diagnosis of zoonotic agents in humans by clinicians and medical practitioners is often impeded by poor knowledge of the zoonotic potential of disease agents in aquatic species, and the associated clinical signs [43]. Over the past 25 years, fish eustrongylidosis has been increasingly reported by scientists, fisheries and fishermen, there is scientific evidence indicating an increase in the number of new animal species becoming affected by *Eustrongylides* spp., as well as an increase in the frequency of larval eustrongylidosis in wild fish populations within and outside the Danube Delta area [18,19,25,34,35,37,41,42,47,49,52]. Motile larvae often leave the fresh corpse of the host fish, suggesting that they may be able to find new hosts afterwards [25,36]. The nematode is attracted by increased environmental pollution, including heavy metal pollutants, which seem to enhance their spreading potential within and outside their host species. *Eustrongylides* spp. has been subjected to public warnings, via mass media included, on the health-associated risks should raw or poorly cooked infested fish is consumed [25,36]. There is an increased risk of the parasite to 'escape' from the natural environment through the incidental introduction of infested fish into fish farms, through the use of water or feed contaminated with parasite eggs and larvae, or through fish-eating birds [25,36].

Observations of larval eustrongylidosis in the freshwater fish caught from the Danube river are increasing, but the mitigating measures addressing the condition are still lacking, possibly impacting local socio-economic environments and threatening biodiversity conservation. Disease prevention and control, especially when these pose risks to human health and well-being, are essential conditions for the sustainable development of ecosystems.

Eustrongylidosis is not notifiable to the OIE [54], therefore, reliable data on its frequency within the susceptible animal populations, number of humans diagnosed with

Eustrongylides spp., as well as the economic costs incurred by aquaculture and selling markets caused by these infections, are missing to our knowledge. This made it impossible for the authors to study with accuracy the cost of the parasite to the economy and society. However, there are zoonotic parasites that can be used to estimate the costs of such diseases on national health systems and economies. In doing so, we used data on the impact of two more common, notifiable water-borne parasitic pathogens: *Cryptosporidium* spp. and *Cyclospora* spp.

Cryptosporidium spp. and *Cyclospora* spp. are coccidian protozoan parasites of the gastrointestinal tract of humans and animals, often causing life-threatening diarrhea in immunocompetent and immunocompromised patients. *Cyclospora* spp. is among the causes of "traveler's diarrhea", being endemic and restricted to developing countries—hence, it is less common than *Cryptosporidium* spp. [55]. Infections with *Cryptosporidium* spp. are much more frequent than those caused by the *Cyclospora* spp. protozoan. The peak infection rate was reached in the years 2017 (1843), 2016 (1838) and 2015 (1658) (Figure 1), [4]. Although more infections occurred during the years 2015–2017, in this time period the number of hospitalizations decreased, and the number of international travel-associated did not reach maximum values either. The number of Outbreak-associated cases was higher in 2015, 2018 and 2019 (Figure 2).

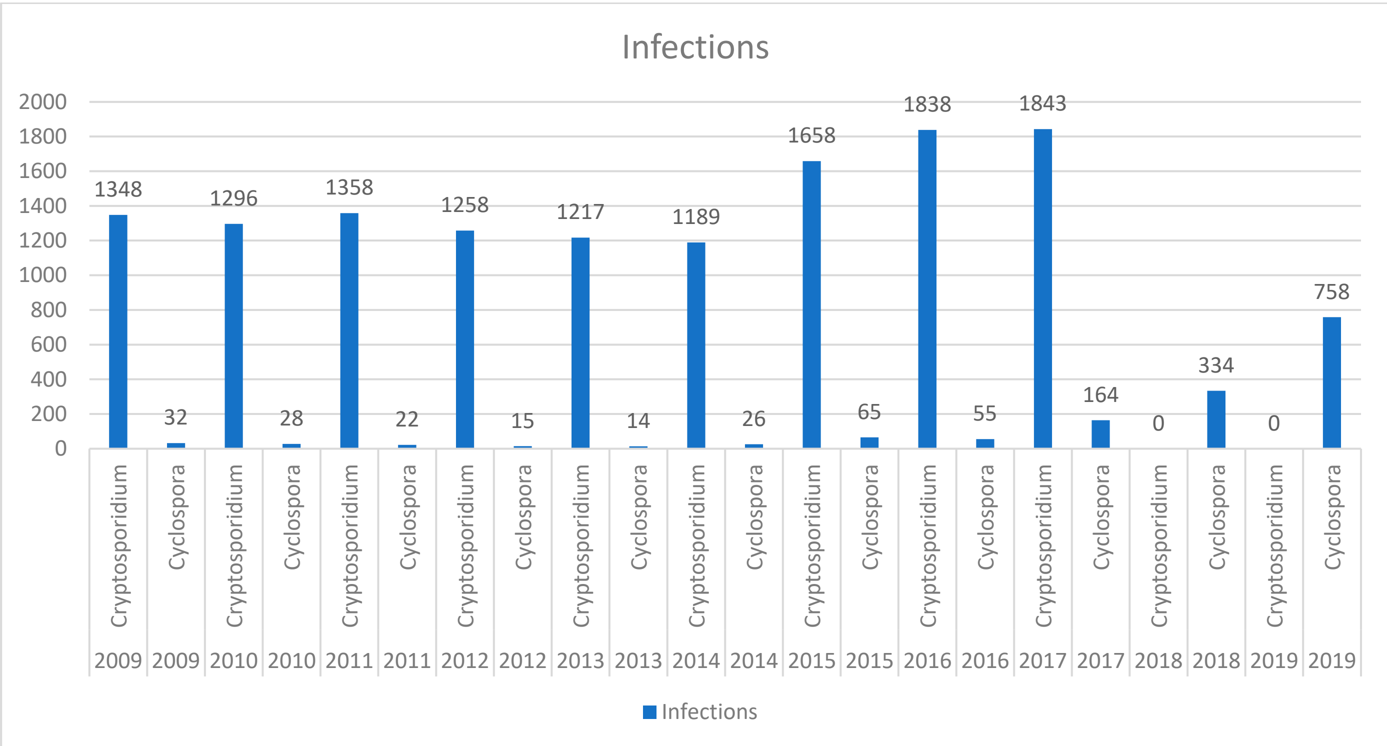

Figure 1. Number of human infections with *Cryptosporidium* spp. and *Cyclospora* spp. between the years 2009 and 2019. Data collected in Connecticut, Georgia, Maryland, Minnesota, New Mexico, Oregon, Tennessee, and selected counties in California, Colorado, and New York. † Per 100,000 persons. (FoodNet* https://wwwn.cdc.gov/, accessed on 22 September 2022).

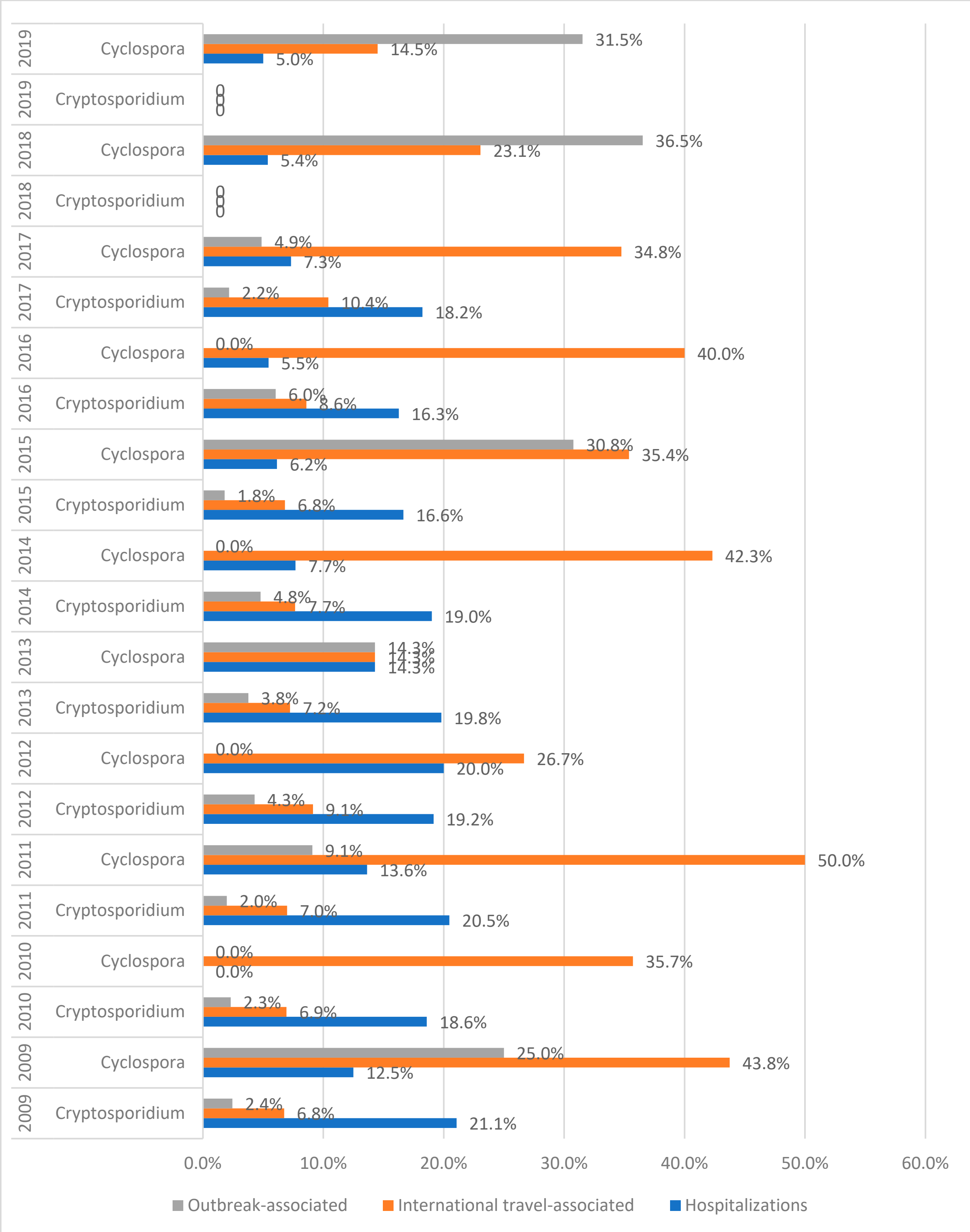

Figure 2. Pathogen case counts (%).

Observing the descriptive statistics (Table 1) with very high values of standard error, standard deviation and Variance empowers us to use a non-parametric test. The Skewness and Kurtosis value shows that the data source does not present a normal distribution. Thus, we decide to implement a SEM (Structured Equation Model) for non-parametric data using SmartPls. The data present a very high correlation between (Table 2):

Infections—Deaths (0.83)
Infections—International travel-associated (0.93)
Infections—Incidence rate † (1)
Infections—Hospitalizations (0.98)
International travel-associated—Hospitalizations (0.86)
Incidence rate †—Deaths (0.85)

Table 1. Descriptive statistics of human cryptosporidiosis and cyclosporiasis between the years 2009 and 2019.

Statistical Indices	Infections	Deaths	International Travel-Associated	Incidence Rate †	Hospitalizations	Outbreak-Associated
Mean	659.9	2.1	62.5	1.4	114.1	37.7
Standard Error	150.6	0.6	12.0	0.3	28.6	12.1
Standard Deviation	706.6	2.8	56.2	1.5	134.0	56.5
Sample Variance	499,295.7	7.6	3156.6	2.1	17,957.8	3196.3
Kurtosis	−1.6	−0.7	−0.5	−1.7	−1.8	7.3
Skewness	0.4	0.9	0.6	0.4	0.5	2.5

Table 2. Correlation Coefficient.

	Infections	Deaths	International Travel—Associated	Incidence Rate †	Hospitalizations	Outbreak-Associated
Infections	1.00					
Deaths	0.83	1.00				
International travel-associated	0.93	0.65	1.00			
Incidence rate †	1.00	0.85	0.92	1.00		
Hospitalizations	0.98	0.89	0.86	0.98	1.00	
Outbreak-associated	0.38	0.10	0.56	0.37	0.21	1.00

These high values are also associated with multicollinearity; thus, we designed a model with two zoonotic variables made of three subitems (Deaths, Pathogen and Travel) and Impact made of three subitems (Hospital and Outbreak). We eliminated from our model the variables Incidence rate† and Infections to avoid multicollinearity. Pathogen variables refer to the two parasite species, *Cryptosporidium* and *Cyclospora*.

We were able to create a structural equation model thanks to the factors we had discovered. The research evaluated the significance of the disappearing tetrads involved in the model in the PLS-SEM scenario by confirmatory tetrad analysis (CTA-PLS) and the bootstrapping technique [56]. We were able to place restrictions on the model [57] by identifying the direction of influence and correlations between the two variables (Figure 3). The direction of the influence is obscured by CFA, which is its main flaw. However, it can quantify the impacts of each component and sub-factor and show whether the model fits the data well and is reliable [58]. The model determines the loading factors for each variable. This served as the main defense for selecting the CFA over a predictive study like a regression model [56,57]. By considering a number of indices to evaluate how well the model shows the variables and supports the putative hypothesis, the SmartPLS tool helps the user analyze the model saturation [58]. The normed fit index (NFI), the standardized root mean square residual (SRMR), and correlative indices like Akaike's information criterion (AIC) and the Bayesian information criterion are examples of absolute indices. The latter two allow for inferential statistics (BIC). The software additionally establishes the significance of the latent constructs using the correlation coefficient and Cronbach's alpha (CA) test [59,60].

By using composite reliability (CR), rho A, and average variance retrieved, the model's fit and consistency were evaluated (AVE). Significant values of CA, CR, and AVE as double-weighting factors are occasionally linked to high multicollinearity between variables. The software computes the variance inflation factor (VIF) requirement to get around this issue [61,62]. We decided to use SmartPLS to conduct a confirmatory factor analysis in order to gain more knowledge about the variables affecting consumer impressions. In order to assess the validity and reliability of the model, we chose to employ the nonparametric PLS-SEM technique [63–65], which offers a number of statistics, including composite reliability (CR), Cronbach's alpha (CA), rho A, average variance extracted (AVE), and others. When more sub-items (questions) made up a variable, the CA index tended to produce larger values.

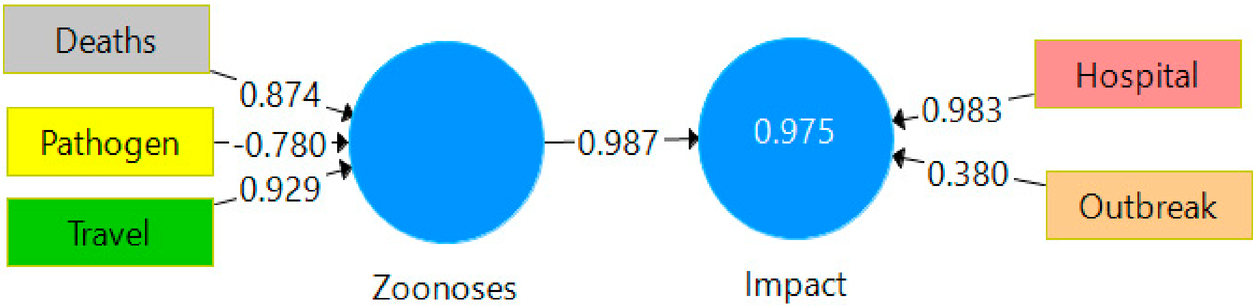

Figure 3. R Square coefficients and path analysis of SEM SmartPLS analysis. Source: SmartPLS analysis. (reprinted from a free version of SmartPLS software, version 3.3.9, created on 24 September 2022) [63].

From the model represented in Figure 3, it can be observed that the path coefficient [66] is very high for Zoonoses->Impact (0.987), indicating that Parasitic zoonoses have a significant economic impact on society.

The loading factors (LFs) to analyze latent constructs in Figure 3, aim to enhance the most important elements that influence the following:

- Zoonoses: Death (LF = 0.87), Pathogen (LF = 0.78), and Travel (LF = 0.929). These most important items were analyzed as sub-criteria for Zoonoses, and they have a high influence because have LF > 0.6.
- Impact: Hospital (LF = 0.983) and Outbreak (LF = 0.38). The main cost to the society caused by Zoonoses was determined by hospitalization. The outbreak-associated also added supplementary costs.

Constructing Reliability and Validity:

SmartPLS software offers a suite of tests to validate the statistical analysis and to ensure the correct interpretation of the research results. In the first phase, we decided to evaluate the consistency of the model designed based on the validation steps provided in Table 3. In our analysis, we have two formative variables the only statistic calculated by Smart Pls is rho A (Table 3). It can also be observed that the rho A criterion was enough. These values, the very high correlation between Zoonoses and Impact (0.987) and the very high value of R square for Impact (0.975) allow us to assume that our model is coherent and representative of the sample which was analyzed (Figure 3).

Table 3. Validation steps/tests.

	Cronbach's Alpha (CA)	rho_A	Composite Reliability (CR)	Average Variance Extracted (AVE)
Treshold	>0.7	>0.7	>0.7	>0.5
Impact		1		
Zoonoses		1		

Source: SmartPLS analysis (reprinted from a free version of SmartPLS software, version 3.3.9, created on 24 September 2022).

3.3. Collinearity Statistics VIF

SmartPls estimated the VIF of each construct to avoid the multicollinearity effect, which would artificially increase the importance of some factors. The VIF values for each component of our research are displayed in Table 4. They are all below the threshold of five, as can be seen. These numbers gave us the confidence to claim that our hypothesis H1 is accepted based on the criteria in Tables 1–4 because the VIF as a whole doesn't show any multicollinearity among the variables.

Table 4. VIF Coefficients.

Variable	VIF
Deaths	2.796
Hospital	1.045
Outbreak	1.045
Pathogen	2.407
Travel	1.777

To determine the significance of the variables, the variance inflation factor (VIF) of each construct was calculated using the SmartPLS program with 5000 samples and a reliability of 95%. The bootstrapping method evaluates the relevance of the vanishing tetrads predicted by the model in the PLS-SEM scenario [57]. The significance of each variable was assessed using the variance inflation factor (VIF) for each idea. The VIF being below the permitted limit meant that there was no collinearity between the variables. The variance inflation factor (VIF) for each construct was calculated using a total of 1000 samples, and the bootstrapping approach was 95% reliable using SmartPLS software [63–66], as shown in Table 5.

Table 5. The T-Test Statistics and *p*-Values of the Bootstrapping Analysis.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Test Statistics (∣O/STDEV∣)	*p*-Values
Zoonozes-> Impact	0.987	0.991	0.004	223.330	**0.000**

Source: SmartPLS analysis (source: reprinted from a free version of SmartPLS software, version 3.3.9, created on 24 September 2022).

Figure 4 and Table 5 provide an overview of the findings. The bootstrapping value of two-tailed t-tests is higher than 1.96. In other words, the numbers are more meaningful since they are larger at the critical level. The *p*-value is less than 0.05, indicating that our model is valid and representative. Good values were obtained for the path coefficients (223.33). Pathogen and outbreak sub-criteria has smaller values than 1.96, meaning that their influence is not decisive.

Figure 4. Bootstrapping. Source: SmartPLS analysis (source: reprinted from a free version of SmartPLS software, version 3.3.9, created on 2 April 2022).

The research emphasizes the zoonoses with their three key factors analyzed to have a significant influence on the hospitalization and outbreak. The results of the bootstrapping analysis show that our model satisfies all the criteria.

4. Discussion

4.1. Health Economics

Humans act as the main connecting interface between domestic and wild habitats, facilitating through more or less direct activities, the introduction pathogens existing in the wild, including of pathogens with zoonotic potential. Accidental or deliberate introduction of exotic species in new habitats, coupled with the lack of, or poor disease monitoring, are comporting now a greater risk of pathogen dissemination than in the past, due to the continued pressure on land for agriculture, economic rationale and urban development, which have all led to the intensification of the interactions between wild and domestic habitats. The current problem lies in the recognition and diagnosis of zoonotic diseases in humans, as there is poor knowledge of the zoonotic potential of pathogens and diseases that they cause under natural conditions [43].

"Whether in costs of prevention or in dealing with the problems of an outbreak, (direct economic loss, loss of consumer confidence or action taken by Governments) it is an inescapable fact that diseases cost money. Each business has to make a management decision, based on its appraisal of and policy towards risk, and choose where it meets those costs. The choices are to either avoid a disease or cope with its consequences. Inevitably there will be costs", [67].

Global spending on health from 2000 to 2019 more than doubled in real terms over the past two decades, reaching US$8.5 trillion in 2019, or 9.8% of global GDP. However, it was unequally distributed, with high-income countries accounting for approximately 80%. Health spending in low-income countries was financed primarily by out-of-pocket spending (OOPS; 44%) and external aid (29%), while government spending dominated in high-income countries (70%). The share of health in government spending increased over the past two decades in upper, middle and high-income countries, stagnated in lower-middle income countries and declined in low-income countries between 2000 and 2011, before partially rebounding and stabilizing in recent years. Over the past two decades, OOPS rose across all income groups on a per capita basis but fell as a share of total health spending. External aid rose considerably over the past two decades. In countries that are highly dependent on external aid, health priority in government spending fell in line with the increased aid. The share of global health aid that went to low-income countries was smaller than the share of the global extremely poor population living in those countries. In low- and middle-income countries, an average of two-thirds of external aid for health went to infectious diseases, while government health spending was evenly split between infectious and non-communicable diseases [67].

From our records of the field cases of infection with eustrongylides, coupled with the statistical analysis of human cryptosporidiosis and cyclosporiasis between the years 2009 and 2019, it follows that the frequency of parasitic disease cases is variable. There are years that the number of cases decreases, and then they increase again (Figure 1), [68]. This recurring trend shows that the current measures aimed at reducing the incidence of parasites, with all the costs incurred by monitoring and control programs in place, are not sufficiently effective, incurring direct and indirect social, economic and health costs [68,69].

While aquaculture is required to expand production to meet the increasing needs for aquatic products of a growing world population, the intensification of fish production provides an ideal environment for disease agents to flourish. This causes losses in productivity. Aquatic animals and their products are transported around the globe in less time than the incubation period of a disease. People, equipment, water, etc., are also potential routes of dissemination of disease agents. Treatment and specific profilaxy, such as vaccination, are not effective and cannot prevent losses caused by such diseases. The threat of transboundary diseases has never needed more than now-tailored biosecurity plans integrated with the management strategy, and efficient social-ecological system models to increase the marketing success of the business and prevent zoonoses transmission. Biosecurity plans ensure trading partners and consumers that aquaculture products are healthy, accounting for the welfare of animals, and guaranteeing the origin of stocks. To operate in a sustainable manner, biosecurity plans should be integrated with new environmentally and socially sound systems, such as the SESH framework proposed by De Garine-Wichatitsky et al. [14], (Figure 5).

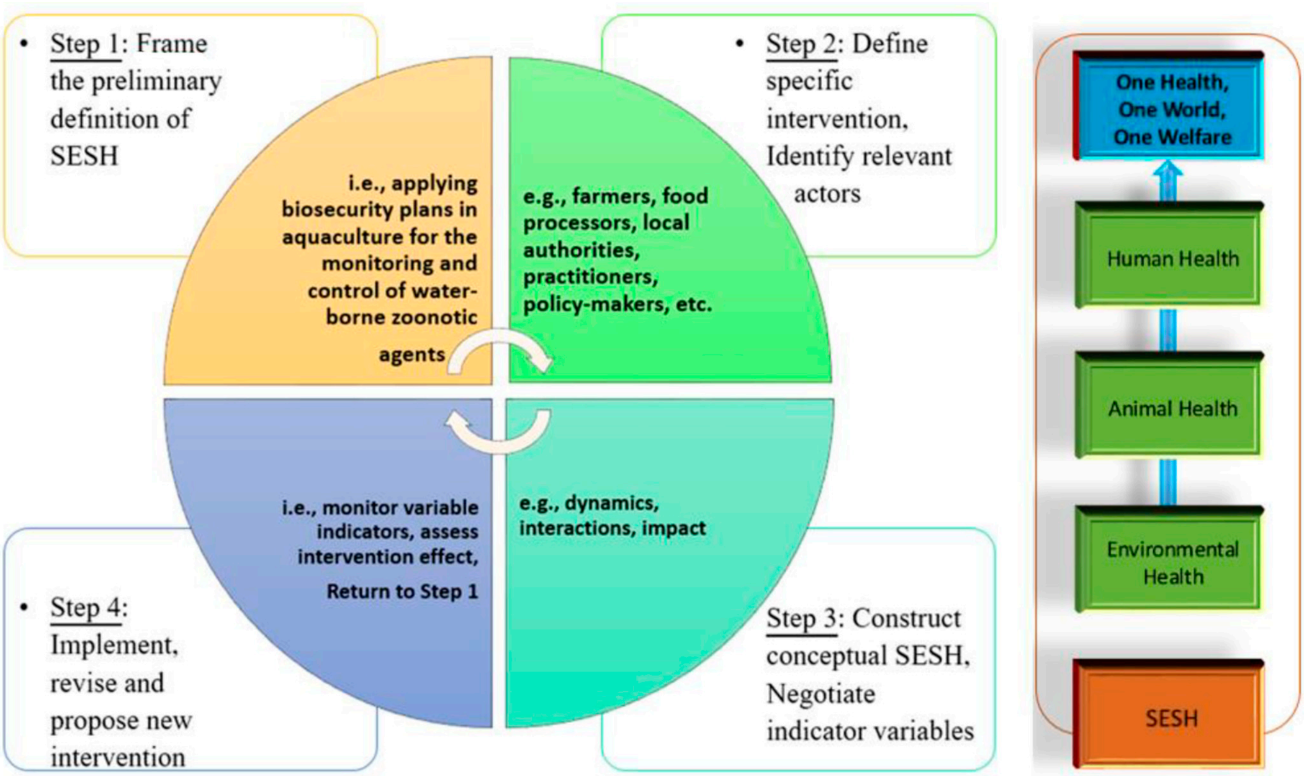

Figure 5. Developing a SESH framework to address local healthy Social-Ecological System for aquaculture production by integration of biosecurity plans focused on water-borne diseases.

4.2. Using the SESH Approach to Implement One Health

Human and animal health and well-being, biodiversity and ecosystems, are all interlinked, and they are recognized as such by the One Health, One World and One Welfare concepts (Figure 5), [70,71]. The current challenge, however, is translating these concepts into practice, recognizing that the key element of resilience in health remains an implementation-preventing barrier and, consequently, preventing macroeconomic growth [17]. De Garine-Wichatitsky et al. (2021), [14] suggested that the operationalization of an ecosystem approach to human health should be based on a social-ecological system and resilience framework which would recognize key components in the human and natural systems, with the aim of recognizing emerging health and environmental risks and promoting economic development.

Ecological approaches to health that have proved sustainable and environmentally friendly, recognizing key dimensions in environmental systems, and how these integrate within the One Health approach are at the core of the circular thinking model. The CDC's model [4] indicates that, when planning and implementing health promotion interventions, individual, interpersonal, community, organizational and societal variables should all be accounted for, because they influence choices regarding health, lifestyle and behavior. The ecological systems theory explaining how human development is influenced by different types of environmental systems is useful to indicate the different outcomes for various groups of stakeholders.

Parasites reveal environmental impact [10,11] and, this ultimately impacts the health and well-being of humans. Eustrongylidosis is an example of a disease occurring in aquatic wildlife, thriving along with human habitats, flourished by eutrophication and environmental pollution [11]. In most cases, there are no official institutional structures in place to deal with this disease and the possible risks it poses to aquaculture and natural ecosystems.

Maintaining spatial separation of individuals helps prevent the spreading of disease agents. Biosecurity is functioning well with terrestrial animal production, and, in aquatic ecosystems, it might be conceived as a modern way of dealing with activities that have gone on before. It formalizes disease control strategies and communicates these strategies to stakeholders. However, farmers tend not to be convinced by the usefulness of concepts, unless they can be shown to have a real impact on the viability and profitability of their farm. Biosecurity needs might differ from one facility to another.

The design of a SESH for aquaculture production should include a tailored biosecurity plan, which also helps frame the preliminary definition. The plan should address the health risks associated with diseases and link ecosystem management with human and animal health. Preliminary discussions should consider some general questions, such as: *Is the facility interested in implementing a biosecurity plan? What are the diseases considered as having a financial, welfare or regulatory impact? Could these diseases be controlled or prevented? If yes, how? Does the facility have the necessary resources to achieve this? Is there a clear cost benefit?* Answers to these questions can be obtained through and integrated with a SESH model similar to that proposed by De Garine-Wichatitsky et al. (2021) [14], allowing for considerations of requirements, potential costs–benefits, and likely success of the plan implementation.

The most critical element is that such planning requires good communication between stakeholders. Farmers, food processors and other food-producing actors are responsible for delivering safe and high-quality products, prepared in accordance with national and international laws and regulations. There may be unknown consequences of these interactions, and there may be both knowledge gaps and fragmented responsibilities. The need to implement unpopular measures will inevitably inconvenience staff and people. Implementation of biosecurity plans in aquaculture premises often requires the allocation of additional resources. Farmers and producers expect a return on their investment. People are not particularly good at making such decisions, placing too much weight on the recent past and overemphasizing these risks. The more staff are inconvenienced, the less likely they are to follow biosecurity policies. Good communication about responsibilities, reasons and expectations is key to understanding and commitment to the required policies being beneficial, and would serve us all well.

The Social-Ecological System Health (SESH) framework proposed by De Garine-Wichatitsky et al. (2021), [14] is used to advocate for implementation of the One Health concept in practice, by creating a framework that lay the foundations of a co-construction process based on an equitable representation of all relevant parties, while setting the boundaries of the socio-ecological system of interest. The proposed framework aids in the identification of causal relationships among health components of ecosystems, increasing production and providing more sustainability to natural aquaculture systems, in light of existing pollution and climate change threats, while ensuring human health and well-being. In their paper, De Garine-Wichatitsky et al. (2021), [14] presented a SESH hands-on, transdisciplinary approach used to develop a management program for the control of ticks and tick-borne diseases in South of France, involving researchers, private sector, local institutions and citizen. Health indicators of socio-ecological systems and collective actions aimed at mitigating the disease locally were envisaged. The SESH operational approach consisted in six operational steps. SESH was defined first, by identifying specific interventions. Secondly, limitations of the SES system in relation to the specific intervention and groups of relevant stakeholders were established. The conceptual model was then constructed with the selected stakeholder groups, negotiating indicator variables for each Health component and interaction, and considering animal. Animal, plant, environmental and human health. Acceptable ranges for each Health component were negotiated to collectively convene a shared context-based definition of SESH, respectively, an integrated management of the risks associated with the disease agent. In theory, monitoring, assessment and revision/proposition of new interventions would follow. De Garine-Wichatitsky et al. (2021), [14] indicated that negotiation and implementation of monitoring and evaluation systems are the most challenging components of the system's implementation, as these require consensus regarding acceptable ranges of values for chosen indicators. De Garine-Wichatitsky et al.'s study [14] ended the implementation of the outputs of the SESH process by using the resulting conceptual framework to classify the expression of ideas from local actors, and allow for the presentation of their needs and priorities [14].

In our view, to address local healthy Social-Ecological Systems for aquaculture production the integration of biosecurity plans, focused mainly on water-borne diseases into SESH (Figure 5), would ensure more efficient monitoring and control of water-borne disease agents in areas where there are no official institutional structures in place to prevent their systemic dissemination.

5. Conclusions

Health is an important indicator of the system's function. It is a desirable state of the social-ecological system (SES), proof of sustainability of a system, and one of the goals for sustainable economic development. This approach helps frame sustainable development programs at the level of animal, human and ecosystem health [70,71]. While a global biomonitoring program is needed to ensure the safety of fish as food sources, adopting operational frameworks based on the participatory, context-based and dynamic definition of Social-Ecological System Health facilitating the participation of all relevant stakeholders from the connecting sectors and disciplines is recommended to be able to respond to threats such as zoonotic diseases, poverty and environmental hazards.

Parasitic zoonoses have an economic impact on health systems and society at large, through their persistence and periodic recurrence within affected populations. A holistic approach supporting the mitigation of neglected, non-notifiable, fish-borne zoonotic agents is clearly needed as, apparently, this is the only way leading to sustainable ecosystem management. However, to be able to mitigate the impact of such diseases on society, stakeholders must be made aware of this fact and be willing to cooperate.

Increasing the efficiency of environmental monitoring programs should be among the key elements of the attainment of sustainable development and economic growth, and it should be accounted for whenever the health concept is being framed [42]. Blockchain technologies coupled with good management and a circular thinking model, are expected to lead to the implementation of the "zero waste" concept, as well as to change how we produce and consume as a society [44,45]. This study shows that using a social-ecological approach derived from the SESH logic model developed by De Garine-Wichatitsky et al. (2021), [14] with integrated aquaculture biosecurity plans designed for the monitoring of water-borne disease agents is the best approach. This helps address the risk of further spreading of disease agents, as in the case of *Eustrongylides* spp., *Cryptosporidium* spp. and *yclospora* spp., as well as other water-borne agents, in an integrated and environmentally sustainable manner.

The two-series follow-up study of fish eustrongylidosis described in this paper allowed for long-term observations of ecology-related characteristics of the disease, with notes on various feeding and reproduction habits, of the studied species. Such data could be used to help frame the definition of SESH in reference to a specific intervention and a specific context (area, stakeholders, etc.), based on which boundaries of the SES are of interest and relevant groups of stakeholders can be identified (Figure 5). A conceptual model of a SESH-biosecurity integrated plan should consider management priorities and concerns with short and long-term objectives.

Fully operational SESH are required to assist in the development of the management principles for the long term, especially in areas where there are no official institutional structures in place to mitigate disease-associated risks. Monitoring, assessment, and, most importantly, revision of the system's efficiency and effectiveness are of paramount importance for the success of the strategy chosen via this process.

6. Limitations and Suggestions for Future Research

Implementation of a Social-Ecological System (SES) has become a heuristic process for transdisciplinary visions of transitional agro-ecological systems. However, to enhance the parasitic control in aquaculture systems, the integration of a biosecurity plan with the system would be necessary. To our knowledge, this is the first time that biosecurity plans are suggested to be included with SESH models designed for aquaculture food-producing systems (Figure 5). The implementation of biosecurity-plan-integrated-SESHs has not been validated in practice, but authors intend to further this research in the near future.

In De Garine-Wichatitsky's study [14], the proposed SESH helped frame the definition of the system and facilitated transdisciplinary participation, but it did not reach the monitoring and revision stages. The feasibility of the system needs to be validated by the system implementation, to help monitor variable indicators, model the trajectory of the Social-Ecological System (SES), and propose new interventions following the revision of the outcomes.

Author Contributions: All authors contributed substantially to the work reported. Conceptualization, L.U.; methodology, V.-E.S. and L.U.; software, L.-G.T.; validation V.-E.S.; formal analysis, L.-G.T. and V.-E.S.; investigation, L.U., V.-E.S. and L.-G.T.; resources L.U., V.-E.S. and L.-G.T.; data curation, L.U.; writing—original draft preparation, L.U.; writing—review and editing, L.U., V.-E.S., L.-G.T. and V.M.; visualization, L.U., V.-E.S. and V.M.; supervision, V.-E.S.; project administration, L.U.; funding acquisition, L.U., V.-E.S., L.-G.T. and V.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Acknowledgments: The authors thank Marius Hangan and Cristiana Diaconescu, from the University of Agricultural Sciences and Veterinary Medicine of Bucharest, for helping with the sampling and chemistry analyses.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Holling, C.S. Engineering resilience versus ecological resilience, National Academy of Engineering. In *Engineering within Ecological Constraints*; The National Academies Press: Washington, DC, USA, 1996; pp. 31–43.
2. Berkes, F.; Folke, C. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*; Cambridge University Press: Cambridge, UK, 2000.
3. Walker, B.H.; Salt, D. *Resilience Thinking: Sustaining People and Ecosystems in a Changing World*; Island Press: Washington, DC, USA, 2006.
4. Centers for Disease Control and Prevention (CDC). Available online: https://wwwn.cdc.gov/FoodNetFast/PathogenSurveillance/AnnualSummary (accessed on 28 October 2022).
5. Ettekal, A.; Mahoney, J. Ecological Systems Theory. In *The SAGE Encyclopedia of Out-of-School Learning*; Peppler, K., Ed.; SAGE: Newbury Park, CA, USA, 2017. [CrossRef]
6. Capobianco, A. *Environmental Considerations in Competition Enforcement—Note by South Africa. OECD Unclassified DAF/COMP/WD 2021*; Directorate for Financial and Entreprise Affairs Competition Committee: Paris, France, 2021; Volume 53.
7. Krasny, M.; Lundholm, C.; Plummer, R. Resilience in social-ecological systems: The roles of learning and education. *Environ. Educ. Res.* **2010**, *16*, 6. [CrossRef]
8. Kadykalo, A.N.; Beaudoin, C.; Hackenburg, D.M.; Young, N.; Cooke, S.J. Social–ecological systems approaches are essential for understanding and responding to the complex impacts of COVID-19 on people and the environment. *PLOS Sustain. Transform.* **2022**, *1*, e0000006. [CrossRef]
9. Fabinyi, M.; Evans, L.; Foale, S.J. Social-ecological systems, social diversity, and power: Insights from anthropology and political ecology. *Ecol. Soc.* **2014**, *19*, 28. [CrossRef]
10. Blanar, C.A.; Munkittrick, K.R.; Houlahan, J.; Maclatchy, D.L.; Marcogliese, D.J. Pollution and parasitism in aquatic animals: A meta-analysis of effect size. *Aquat. Toxicol.* **2009**, *93*, 18–28. [CrossRef]
11. Khan, R.A.; Thulin, J. Influence of pollution on parasites of aquatic animals. *Adv Parasitol.* **1991**, *30*, 201–238. [CrossRef]
12. Cunningham, A.A.; Daszak, P.; Wood, J.L. One health, emerging infectious diseases and wildlife: Two decades of progress? *Philos. Trans. R. Soc. B Biol. Sci.* **2017**, *372*, 20160167. [CrossRef]

13. Waters, A. People are to blame for COVID-19. *Vet. Rec.* **2020**, *186*, 467. [CrossRef]
14. De Garine-Wichatitsky, M.; Binot, A.; Ward, J.; Caron, A.; Perrotton, A.; Ross, H.; Tran, Q.H.; Valls-Fox, H.; Gordon, I.J.; Promburom, P.; et al. "Health in" and "Health of" Social-Ecological Systems: A Practical Framework for the Management of Healthy and Resilient Agricultural and Natural Ecosystems. *Front. Public Health* **2021**, *8*, 616328. [CrossRef]
15. UN. 2015. Available online: https://sdgs.un.org/goals (accessed on 9 November 2022).
16. Dye, C. Expanded health systems for sustainable development. *Science* **2018**, *359*, 1337–1339. [CrossRef]
17. Narrod, C.; Zinsstag, J.; Tiongco, M. A one health framework for estimating the economic costs of zoonotic diseases on society. *Ecohealth* **2012**, *9*, 150–162. [CrossRef]
18. Spalding, M.A.; Bancroft, G.T.; Forrester, D.J. The Epizootiology of Eustrongylidosis in Wading Birds (Ciconiiformes) in Florida. *J. Wildl. Dis.* **1993**, *29*, 237–249. [CrossRef] [PubMed]
19. Narr, L.L.; O'Donnell, J.G.; Libster, B.; Alessi, P.; Abraham, D. Eustrongylidosis a parasitic infection acquired by eating live minnow. *J. Am. Osteopath. Assoc.* **1996**, *96*, 400–402. [PubMed]
20. Ljubojevic, D.; Novakov, N.; Djordjevic, V.; Radosavljevic, V.; Pelic, M.; Cirkovic, M. Potential Parasitic Hazards for Humans in Fish Meat. *Procedia Food Sci.* **2015**, *5*, 172–175. [CrossRef]
21. Eberhard, M.L.; Hurwitz, H.; Sun, A.M.; Coletta, D. Intestinal perforation caused by larval Eustrongylides (Nematoda: Dioctophymatoidae) in New Jersey. *Am. J. Trop. Med. Hyg.* **1989**, *40*, 648–650. [CrossRef] [PubMed]
22. Eberhard, M.L.; Ruiz-Tiben, E. Cutaneous emergence of Eustrongylides in two persons from South Sudan. *Am. J. Trop. Med. Hyg.* **2014**, *90*, 315–317. [CrossRef]
23. Shamsi, S. Seafood-Borne Parasitic Diseases: A "One-Health" Approach Is Needed. *Fishes* **2019**, *4*, 9. [CrossRef]
24. CDC MMWR. Epidemiologic Notes and Reports on Intestinal Perforation Caused by Larval Eustrongylides—Maryland. In *Morbidity and Mortality Weekly Report*; Center for Disease Control and Prevention U.S.A: Atlanta, GA, USA, 1982; Volume 31, pp. 383–384, 389. Available online: https://www.cdc.gov/mmwr/preview/mmwrhtml/00001134.htm (accessed on 9 November 2022).
25. Urdes, L.D. Fish Eustrongylidosis (Ph: Nematoda), a disease with potential socio-economic impact. In Proceedings of the "Deltas and Wetlands", the 25th Scientific Symposium, Tulcea, Romania, 18–21 May 2017.
26. Anderson, R.C. Order Strongylida (the bursate nematodes). In *Nematode Parasites of Vertebrates: Their Development and Transmission*; CABI Publishing: Wallingford, UK, 2000; pp. 41–230.
27. Carlsson, M.; Karvemo, S.; Tudor, M.; Sloboda, M.; Mihalca, A.D.; Ghira, I.; Bel, L.; Modry, D. Monitoring a large population of dice snake at lake Sinoe in Dobrogea, Romania. *Mertensiella* **2011**, *18*, 237–244.
28. Franson, J.C.; Custer, T.W. Prevalence of Eustrongylidosis in Wading Birds from Colonies in California, Texas and Rhode Island, United States of America. *Colonial Waterbirds* **1994**, *17*, 168–172. [CrossRef]
29. Moravec, F. *Parasitic Nematodes of Freshwater Fishes of Europe*; Kluwer Academic-Springer: Amsterdam, The Netherlands, 1994; pp. 374–384.
30. WoRMS 2021. Eustrongylides Jägerskiöld. 1909. Available online: https://www.marinespecies.org/aphia.php?p=taxdetails&id=22887 (accessed on 28 October 2022).
31. Hangan, M. Contributii la Studiul Epizootologic al Parazitozelor la Unele Specii de Pesti din Delta Dunarii. Ph.D. Thesis, University of Agricultural Sciences and Veterinary Medicine of Bucharest, Bucharest, Romania, 2008.
32. Guardone, L.; Ricci, E.; Susini, F.; Polsinelli, E.; Guglielmone, G.; Armani, A. First detection of *Eustrongylides excisus* (Nematoda: Dioctophymatidae) in big-scale sand smelt (*Atherina boyeri*) from the lake Massaciuccoli (Northwest Tuscany, Italy): Implications for public health and seafood quality. *Food Control* **2021**, *120*, 107517. [CrossRef]
33. Xiong, F.; Li, W.X.; Wu, S.G.; Zou, H.; Wang, G.T. Molecular Phylogeny and Host Specificity of the Larval Eustrongylides (Nematoda: Dioctophmidae) from freshwater fish in China. *J. Parasitol.* **2013**, *99*, 137–144. [CrossRef]
34. Urdes, L.D.; Hangan, M.; Petrica, V. Eustrongylides' Autumnal Distribution and its Pathogenicity in Razelm, Dranov and Murighiol Lakes' Fish. *Anim. Sci. Ser.* **2008**, *51*, 1181–1185.
35. Urdes, L.; Diaconescu, C.; Vlase, G.; Ianitchi, D.; Diaconescu, S.; Hangan, M. Research on the Interrelationship Between Some Species of Freshwater Fish and Helminthic Larvae within Aquatic Ecosystems Polluted with Heavy Metals. *Anim. Sci. Biotechnol.* **2010**, *43*, 72–75.
36. Urdes, L.D. Alcivar-Warren Acacia—A comparative study on metals and parasites in shellfish. *J. Shellfish. Res.* **2022**, *40*, 565–588. [CrossRef]
37. Urdes, L.; Diaconescu, C.; Hangan, M.; Vlase, G. Structured survey on *Eustrongylides* sp., (Ph Nematoda) within a polluted aquatic ecosystem. *Zootechny* **2010**, *53*, 449–453.
38. Olteanu, G.; Panaitescu, D.; Gherman, I.; Zgardan, E.; Apatenko, V.; Fazakas, B.; Balcescu-Codreanu, D.; Teodorescu, I.; Iacobiciu, I.; Talambuta, I.; et al. *Poliparazitismul la Om, Animale, Plante şi Mediu*; Ceres: Bucharest, Romania, 2001; pp. 41–348.
39. Vaumourin, E.; Vourch, G.; Gasqui, P.; Vayssier-Taussat, M. The importance of multiparasitism: Examining the consequences of co-infections for human and animal health. *Parasites Vectors* **2015**, *8*, 545. [CrossRef]
40. Steinmann, P.; Utzinger, J.; Du, Z.-W.; Zhou, X.-N. Multiparasitism a neglected reality on global, regional and local scale. *Adv. Parasitol.* **2010**, *73*, 21–50. [CrossRef]
41. Ibiwoye, T.I.I.; Sule, A.M.; Okomoda, J.K.; Agbontale, J.J. Investigation of nematode *Eustrongylides* larvae infections in mudfish *Clarias gariepinus* and *C. anguillaris* from Bida floodplain of Nigeria . *J. Appl. Sci. Environ. Manag.* **2005**, *8*, 520–529.

42. Williams, M.; Hernandez-Jover, M.; Shamsi, S. Parasites of zoonotic interest in selected edible freshwater fish imported to Australia. *Food Waterborne Parasitol.* **2021**, *26*, e00138. [CrossRef]
43. Adeyemo, O.K.; Foyle, L. Public Health, Zoonoses, and Seafood Safety. In *Fundamentals of Aquatic Veterinary Medicine*; Wiley-Blackwell: Hoboken, NJ, USA, 2021; pp. 181–204. ISBN 978-1-119-61270-4.
44. Franco-García, M.; Carpio Aguilar, J.-C.; Bressers, H.T. *Towards Zero Waste—Circular Economy Boost, Waste to Resources*; Springer International: London, UK, 2019.
45. Bucea-Manea-Țoniş, R.; Šević, A.; Ilić, M.P.; Bucea-Manea-Țoniş, R.; Popović Šević, N.; Mihoreanu, L. Untapped Aspects of Innovation and Competition within a European Resilient Circular Economy. A Dual Comparative Study. *Sustainability* **2021**, *13*, 8290. [CrossRef]
46. Cocioarta, A.B. Analiza Ecosistemelor Acvatice ale Principalelor Lacuri din Delta Dunării în Vederea Exploatării Pescărești. Ph.D. Thesis, University "Dunarea de Jos" of Galati, Galati, Romania, 2017.
47. Bauer, O.N. *The Key to the Parasites of Freshwater Fishes in the USSR*; Izdatelstvo Akademii Nauk SSSR: Leningrad, Russia, 1987.
48. World Health Organization (WHO). Available online: https://apps.who.int/nha/database/Select/Indicators/en (accessed on 28 October 2022).
49. Urdes, L.; Hangan, M.; Diaconescu, C.; Marin, M.; Gîdea, M. A Case Report on fish Eustrongylidosis (Ph: Nematoda) in zander (*Sander lucioperca*). *Anim. Sci. Ser. D* **2017**, *LX*, 372–374.
50. Urdes, L.D.; Diaconescu, C.; Cojocaru, C.D.; Diaconescu, S. The frequency of fish-born parasitic zoonoses within the Romanian area of the black sea. In Proceedings of the EAFP Conference on Diseases of Fish and Shellfish, Split, Croatia, 12–16 September 2011; Volume 258.
51. Forget, G.; Lebel, N. An ecosystem approach to human health. *Int. J. Occup. Environ. Health* **2001**, *7*, S1–S38.
52. Bjelic-Cabrilo, I.; Novakov, N.; Cirkovic, M.; Kostic, D.; Popovic, E.; Aleksic, N.; Lujic, J. The first determination of *Eustrongylides excisus* Jägerskiöld, 1909 larvae (Nematoda: Dioctophymatidae) in the pike-perch *Sander lucioperca* in Vojvodina (Serbia). *Helminthologia* **2013**, *50*, 291–294. [CrossRef]
53. FAO (Food and Agriculture Organization). *The State of World Fisheries and Aquaculture*; FAO: Rome, Italy, 2000.
54. Speare, D.J. Aquatic Animal Health Code, 8th ed. *Can. Vet. J.* **2017**, *47*, 1.
55. Adal, K. From Wisconsin to Nepal: Cryptosporidium, Cyclospora, and Microsporidia. *Curr. Opin. Infect. Dis.* **1994**, *7*, 609–615. [CrossRef]
56. Gudergan, S.P.; Ringle, C.M.; Wend, S.; Will, A. Confirmatory Tetrad analysis in PLS path modeling. *J. Bus. Res.* **2008**, *61*, 1238–1249. [CrossRef]
57. Vinzi, V.E.; Chin, W.W.; Henseler, J.; Wang, H. *Handbook of Partial Least Squares*; Springer: Berlin/Heidelberg, Germany, 2010.
58. Hair, J.F.; Hult, G.T.M.; Ringle, C.M.; Sarstedt, M.A. *Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, 3rd ed.; Sage: Thousand Oaks, CA, USA, 2022.
59. Stone, M. Cross-Validatory Choice and Assessment of Statistical Predictions. *J. R. Stat. Soc.* **1974**, *36*, 111–147. [CrossRef]
60. Lopez-Odar, D.; Alvarez-Risco, A.; Vara-Horna, A.; Chafloque-Cespedes, R.; Sekar, M.C. Validity and reliability of the questionnaire that evaluates factors associated with perceived environmental behavior and perceived ecological purchasing behavior in Peruvian consumers. *Soc. Responsib. J.* **2020**, *16*, 403–417. [CrossRef]
61. Kenny, D.A.; Kaniskan, B.; McCoach, D.B. The Performance of RMSEA in Models with Small Degrees of Freedom. *Sociol. Methods Res.* **2015**, *44*, 486–507. [CrossRef]
62. Henseler, J.; Dijkstra, T.K.; Sarstedt, M.; Ringle, C.M.; Diamantopoulos, A.; Straub, D.W.; Ketchen, D.J.; Hair, J.F.; Hult, G.T.M.; Calantone, R.J. Common Beliefs and Reality about Partial Least Squares: Comments on Rönkkö & Evermann. *Organ. Res. Methods* **2014**, *17*, 182–209.
63. Hooper, D.; Coughlan, J.; Mullen, M.R. Structural Equation Modelling: Guidelines for Determining Model Fit. *Electron. J. Bus. Res. Methods* **2008**, *6*, 53–60.
64. Ringle, C.M.; Wende, S.; Becker, J.-M. SmartPLS 3. Boenningstedt SmartPLS GmbH. 2015. Available online: http://www.smartpls.com (accessed on 9 November 2022).
65. Hair, J.F.; Hult, G.T.M.; Ringle, C.M.; Sarstedt, M.A. *Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, 2nd ed.; Sage: Thousand Oaks, CA, USA, 2017.
66. Sarstedt, M.; Hair, J.F.; Pick, M.; Liengaard, B.D.; Radomir, L.; Ringle, C.M. Progress in partial least squares structural equation modelling use in marketing research in the last decade. *Psychol. Mark.* **2022**, *39*, 1035–1064. [CrossRef]
67. OATA. *Biosecurity and the Ornamental Fish Industry, "Future Proofing the Industry"*; OATA Ltd.: Wiltshire, UK, 2001.
68. World Health Organization (WHO). *Global Expenditure on Health: Public Spending on the Rise?* World Health Organization: Geneva, Switzerland, 2021.
69. WHO. *Commission on Macroeconomics and Health & World Health Organization. Macroeconomics and Health: Investing in Health for Economic Development: Executive Summary/Report of the Commission on Macroeconomics and Health*; World Health Organization: Geneva, Switzerland, 2001; Available online: https://apps.who.int/iris/handle/10665/42463 (accessed on 9 November 2022).
70. Garcia Pinillos, R.; Appleby, M.C.; Manteca, X.; Scott-Park, F.; Smith, C.; Velarde, A. One Welfare—A platform for improving human and animal welfare. *Vet. Rec.* **2016**, *179*, 412–413. [CrossRef] [PubMed]
71. Lerner, H.; Berg, C. The concept of health in One Health and some practical implications for research and education: What is One Health? *Infect. Ecol. Epidemiol.* **2015**, *5*, 25300. [CrossRef] [PubMed]