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Pond water quality and its relation to fish yield and disease occurrence in small-scale aquaculture in arid areas

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ABSTRACT

The study was conducted to determine the associations between water availability and management practises with pond water parameters in small-scale aquaculture in arid areas. Further, the study determined the associations between fish yield and disease incidence with the pond water parameters. We visited 36 tilapia farmers in Dodoma, a semi-arid region in Tanzania, for interviews and measurements of pond water parameters. The interviews collected information about pond type, pond age, water sources, feed type, pond fertilisation, stocking density, and disease incidences. The sources of water for the aquaculture activities were tap water, boreholes, and shallow wells. The source of water and management practises were linked to the parameters of the pond water. On the other hand, the parameters of the pond water were associated with fish yield and the likelihood of disease occurrence. Fish yield had a non-linear relationship with DO, turbidity, salinity, and stocking density and a linear association with pH. To expand aquaculture development in arid areas, efficient use of water through integrated aquaculture is recommended. Training farmers in good management practises and integration is necessary to ensure sustainable aquaculture development in arid areas.

1. Introduction

Aquaculture has the potential to reduce hunger and poverty while improving human health and well-being [1]. Freshwater fish account for about 75% of the global edible aquaculture volume [2]. Over the last two decades, global aquaculture development has steadily increased while wild aquatic catches have stagnated [1–3], calling for increased aquaculture development in different parts of the world to cover the deficit. Aquaculture development in arid and semi-arid areas has increased rapidly in different parts of the world due to the availability of land for fish farming in these areas [4]. However, one of the most significant constraints to aquaculture development in arid and semi-arid regions is limited water supply [4]. The arid and semi-arid areas are characterised by low precipitation, a high evaporation rate, and limited sources of fresh water, making them vulnerable to the impact of climate change [5]. As a result, sustainable aquaculture development in these areas depends on careful planning and management of water resources. Technological improvements and the integration of aquaculture with other activities have, however, reduced the problem of water consumption in different arid areas of the world [4,6–8]. Aquaculture integration links various activities by using the same amount of water, reducing the use of water, and reusing the water for different activities [4]. For example, technological improvements have facilitated aquaculture expansion in arid and semi-arid areas of North Africa [9], Asia and South America [4].

Water quality is critical in aquaculture because it affects the health, survival, and growth of aquaculture species [10,11]. The

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physical, chemical, and biological properties of water play a substantial role in fish growth and health [10,11]. Thus, the water quality properties should be kept at their optimal level for a healthy pond ecosystem [12]. Chronic exposure to suboptimal concentrations of one or more water-quality variables stresses the fish, making them more vulnerable to disease [10,13]. Temperature, pH, dissolved oxygen (DO), ammonia, and water clarity are the most critical water quality parameters in the aquaculture ecosystem [14,15]. Temperature has a direct effect on fish metabolism, influencing growth and development [15,16]. Since fish are cold-blooded, their body temperature varies depending on their environment. Thus, under optimal temperature conditions, fish use the majority of their food nutrients for growth and reproduction.

Pond management practises such as daily feed input, stocking density, and fertilisation have a significant impact on water quality [11,17,18]. The use of high-quality feed in an optimal amount reduces waste load and oxygen demand [12,19]. Excessive application of fertilisers or manure in ponds increases the nutrient load that promotes phytoplankton bloom [10]. On the other hand, using untreated organic waste and raw livestock manure in fish ponds increases the risk of pathogen transfer to the fish [11,20]. Furthermore, high stocking density causes fish waste to build up [11,17]. Microbial decomposition of unutilized feed and fish faeces uses oxygen in respiration and emits carbon dioxide, ammonia, nitrogen, phosphate, and other inorganic substances into the water, which promotes plankton growth [10]. Thus, proper pond management practises are essential for promoting the healthy aquatic environment required for efficient production. However, due to a lack of technical skills, high pumping costs, and competing uses of water, the quality of water in ponds is normally not well maintained in small-scale aquaculture [21].

The purpose of this study was to determine the associations between water availability and management practises on pond water parameters and their effect on fish yield and fish health in Nile tilapia (*Oreochromis niloticus*) farming. Although tilapia species can tolerate low levels of dissolved oxygen, the preferred DO for optimum growth should be above 5 mg/L [27]. The optimum temperature and salinity for normal development, reproduction, and growth of tilapia are between 28 and 32 °C and 0–8 ppt, respectively [28,29]. The pH of the water should range between 6.5 and 9.5 [10].

The study was conducted in Dodoma, a rapidly growing semi-arid region in central Tanzania (Fig. 1The Dodoma Urban Water Supply and Sewerage Authority (DUWASA) supplies water in urban areas [26,31]. However, due to multiple uses, the water is not enough for aquaculture, calling for interventions to promote efficient water use. The government has acknowledged the importance of aquaculture expansion in the region [25], but successful interventions will depend on knowledge of the current situation. Thus, the study aims to create awareness about the water challenges faced by farmers and their influence on aquaculture productivity. The following research questions were addressed: 1. How do water availability and management practises influence pond water quality? 2. How do the physico-chemical characteristics of pond water relate to fish yield? 3. How do the physico-chemical characteristics of pond water influence fish health?

2. Materials and methods

2.1. Study area

The Dodoma region is located at latitudes of 4° to 8° south and longitudes of 35° to 37° east. The region has expanded rapidly due to the establishment of universities and the shift of government headquarters from Dar es Salaam to the region [25]. According to the 2012 national census, the region had a population of 2,492,989 [32]. The study was conducted in the Dodoma urban district (Fig. 1),

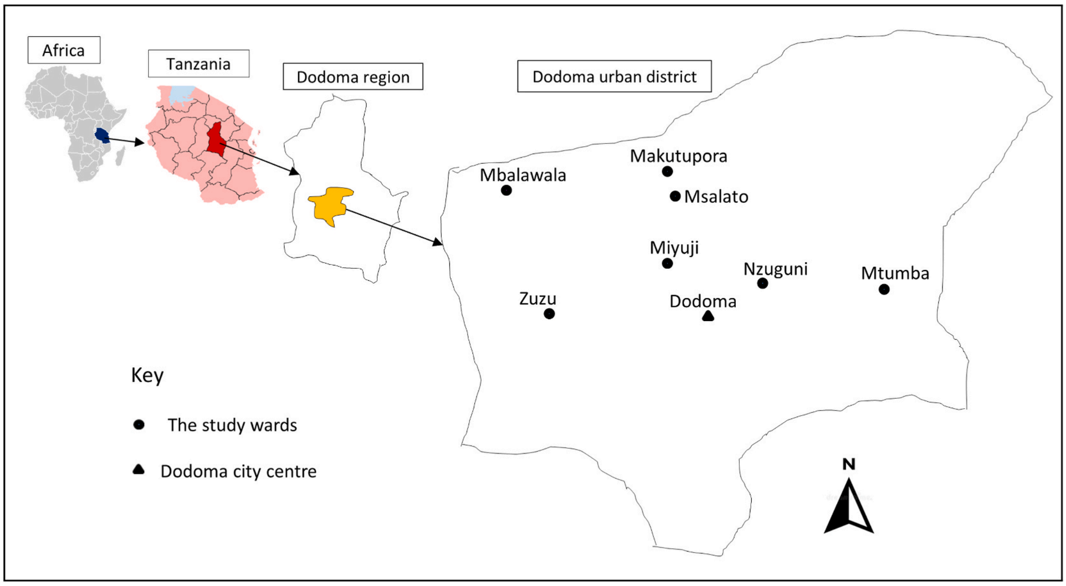

Fig. 1. A map of the Dodoma urban district showing the study wards.

which is one of the seven districts of the Dodoma region. The Dodoma urban district is the capital city of the Dodoma region and the most urbanised district in the region [26].

The climate of the Dodoma region is predominantly semi-arid, characterised by a long dry season from May to November [33,34]. Rains are unimodal, falling between November and April, averaging 550 mm per year, and experience very high evapotranspiration rates of 2000 mm [34–36]. Maximum and minimum temperatures average 31 °C and 18 °C, respectively [33]. Due to the largely seasonal rains, the Dodoma urban district has no permanent surface water bodies, so groundwater from the aquifer in the Makutupora catchment serves as the primary water supply [26].

Fishing activities in the region are minimal due to the limited permanent surface water [38,39]. The Mtera and Hombolo dams are the most popular fishing spots [38,40]. However, fish stocks in these dams have decreased dramatically due to overfishing and poor management, resulting in low catches [38,41]. As a result, aquaculture development is required to support the growing population. Fresh-water fish farming in Tanzania is largely practised in the southern and northern highlands due to the availability of water [24]. The population growth in the Dodoma region has increased opportunities for investments in food production, including aquaculture development [25]. However, competition for water from other economic activities limits aquaculture development in the semi-arid region [26].

2.2. Data collection

The data was collected from March to May 2021. With the aid of information obtained from the district fisheries officer, all tilapia fish farmers in 7 wards in the Dodoma urban district (Fig. 1) were visited for interviews and measurements of pond water parameters. The survey adhered to confidentiality and required informed consent from the participants. Structured questionnaires were used to collect data on pond type, sources of water, manure application in the ponds, water quality monitoring, and the incidence of fish diseases. Only a few farmers keep records and monitor water parameters. Thus, the farmers were visited once per week to measure water parameters during the study period. The water parameters measured were DO, pH, salinity, turbidity, and temperature. Water temperature and turbidity were evaluated directly in the ponds by using a HANNA Combo HI 98129 and a Secchi disc, respectively. Water samples for DO, pH, and salinity analysis were collected at four points in the pond and mixed to form a homogeneous representative sample. A clean collecting bottle was dipped 20 cm below the surface of the water and allowed to feel the water. The water samples were then placed in a clean cup for measuring DO, pH, and salinity. The DO was measured with a HANNA HI9142 DO metre, the pH with a HANNA Combo HI98129 multimeter, and the salinity with a hand-held salinometer. To control for weather effects such as solar radiation, temperature, and rainfall, the measurements were done on a single day from 7:30–8:30 a.m. and in the evening from 5:00–6:30 p.m. on all farms. The University of Dodoma provided ethical approval for the study, with reference number MA.84/261/02.

2.3. General information

A total of 36 tilapia farmers were visited. Aquaculture is a new endeavour in the region, with the majority of the farms established 2 years ago and the oldest farm established 9 years ago. Ponds were of three types: concrete (20), polythene-lined (9), and earthen (7). The farmers planted grasses, sweet potatoes (*Ipomoea batatas*), and vegetables in areas surrounding the ponds to prevent soil erosion during the rainy season. One farm had mosquito fern plants (*Azolla* spp.) in the pond water as a source of fish feed. Fourteen farmers used cow manure in their ponds, while twenty-two farmers did not due to a lack of manure and awareness. Eleven farms owned a borehole; 18 depended on tap water; and 7 farms owned a shallow well. The stocking density ranged from 2 to 9 fish/m^2, with an average of 5 fish/m^2 ± 1. Pond ages ranged from 0.6 to 9 years, averaging 4 years ±2.3. The mean pond size was 162 m^2 (97 SD), while the mean pond depth was 114 cm (38 SD).

2.4. Data analysis

Data visualisation was done by using diagnostic tools such as histograms, Q-Q plots, and scatter plots. The Pearson correlation was used to assess the relationships between the water parameters, pond size, pond depth, and stocking density. The relationship between fish yield and the water parameters was not linear; thus, a non-parametric regression was required. Therefore, a generalised additive model (GAM) using the *gam* package in R was used to measure the associations between fish yield (kg) and DO, pH, temperature, salinity, turbidity, and stocking density. The disease occurrence had a binary outcome (yes or no), so we used a logistic GAM to determine the associations between the disease incidences, management practises, and water parameters. GAM is a flexible non-parametric regression technique that is not restricted to linear relationships [42]. It fits response variables to explanatory variables using smooth functions for both continuous numeric and binary outcomes [43,44]. In all analyses, we ran multivariate models with all the predictor variables. The models were evaluated by using the gam.check() function to check for multicollinearity between the predictor variables and the concurvity() function to check for concurvity of the models. All the analyses were done in R version 4.2.

3. Results

3.1. Water parameters

3.1.1. DO values ranged from 3.2 to 8.2 mgL with an average of 5.4 mgL ±1.5 SD, the pH was

5.2–7.3 with an average of 6.6 ± 0.5, the salinity was 1.8–4.5 ppt with an average of 3.2 ± 0.6, the Secchi depth was 15–61 cm with an average of 39 cm ± 14.8, and the temperature was 24.3–32 °C with an average of 27.8 °C ± 1.8. Further details are shown in Table 1.

3.2. Correlations between the water parameters, stocking density, and pond features

The results show correlations between the water parameters, stocking density, pond age, pond size, and pond depth (Table 2). DO had a negative correlation with turbidity and salinity and a positive correlation with pH, temperature, pond age, and pond size. pH had a positive correlation with temperature and pond age. Further details are shown in Table 2.

3.3. Relationship between water source and management practises with dissolved oxygen and disease incidence

The level of DO was associated with the source of water, pond fertilisation, and pond type (Table 3). The level of DO was lower in farms that used water from shallow wells compared to boreholes and in polythene-lined ponds compared to concrete ponds. Likewise, ponds with manure had higher levels of DO than those without manure (Table 3). Disease incidences, on the other hand, were higher in farms that used tap water and shallow wells compared to boreholes and in ponds with manure compared to those without manure (Table 3).

3.4. Relationships between fish yield, water parameters, and stocking density

The results indicate a significant relationship between fish yield, DO, turbidity, pH, salinity, and stocking density (Table 4). There was a non-linear relationship between fish yield and DO, where fish yield increased with DO to about 6 mgL and then declined (Fig. 2a). In addition, the fish yield increased as Secchi depth (water clarity) and pH increased (Fig. 2b & c). Furthermore, fish yield increased with salinity and had a unimodal relationship with stocking density (Fig. 2d and e). Stocking density increased fish yield up to about 5 fish/m^2, then decreased (Fig. 2e).

3.5. Associations between water parameters and the likelihood of disease incidence

Sixteen farmers experienced fish diseases, while 20 farmers did not experience diseases. The majority of the diseases encountered were fungal. The pond water parameters and pond age were linked to the likelihood of disease occurrence (Table 5). The likelihood of disease incidence was low at high levels of DO and pH (Fig. 3a & b), low levels of turbidity (Fig. 3c), and in young ponds (Fig. 3d).

4. Discussion

The study determined the associations between water availability and management practises with pond water quality and the resultant effect on fish yield and health. The level of DO and fish disease incidence were associated with the source of water, pond manure, and pond type. The pond water parameters, on the other hand, were associated with fish yield and the likelihood of disease occurrence in the fish ponds.

Water quality is the most important factor that affects fish health and performance in aquaculture [10,45]. Maintenance of optimal water quality is critical in aquaculture for reducing disease occurrence and poor fish growth [10]. However, maintenance of water quality in small-scale aquaculture is a challenge because of a lack of capital, knowledge, and a limited water supply [45,46]. Managing water quality in arid areas is more challenging due to water scarcity and excessive evaporation. In this study, the level of DO and disease occurrence were associated with the source of water. The level of DO was lower when the source of water was shallow wells as compared to farmers who owned boreholes. The boreholes ensure a continuous supply of water, while water from shallow wells depends on the amount of rainfall. Underground water is a major source of water for aquaculture in arid areas [4], but bore holes have high drilling and pumping costs. Thus, improving water use efficiency through integrated aquaculture systems such as aquaponics [7] has the potential to promote aquaculture development in arid areas.

Management practises such as the use of manure and the type and amount of feed are also important as they influence water quality, which affects the health of the pond ecosystem. Optimum use of manure increases primary productivity and the release of oxygen [18]. However, manure should be used with caution as it may be a source of pathogens [11]. Feeds have been shown to be a source of pathogens in livestock [47,48]. Homemade feeds that are sometimes mixed with kitchen leftovers can reduce water quality and increase the risk of pathogens. Thus, training and improvement of extension services are important to increase farmers' knowledge

Table 1
The mean values of the water parameters measured.

Parameters	Overall mean (±SD)	Concrete pond mean (±SD)	Polythene ponds mean (±SD)	Earthen ponds mean (±SD)
DO	5.4 ± 1.5	5.7 ± 1.6	4.6 ± 1.3	4.3 ± 0.7
pH	6.6 ± 0.5	6.5 ± 0.5	6.6 ± 0.4	6.7 ± 0.2
Temperature	27.8 ± 1.8	28.1 ± 2.1	27.8 ± 1.02	27.5 ± 2.1
Salinity	3.2 ± 0.6	3.2 ± 0.7	2.9 ± 0.3	3.1 ± 0.7
Turbidity (Secchi depth)	39 ± 14.8	43.2 ± 14.4	35.2 ± 22.1	46.2 ± 17.6

Table 2
Pearson correlation coefficients showing associations between pond water parameters, stocking density, pond age, pond size, and pond depth.

Variable	DO	Turbidity	pH	Salinity	Temp.	Stocking density	Pond age	Pond size	Pond depth
DO	1.00	−0.41**	0.40**	−0.29*	0.40**	−0.15	0.68***	0.38*	0.24
Turbidity	−0.41**	1.00	−0.03	−0.06	−0.15	−0.13	−0.004	−0.39*	0.21
pH	0.40**	−0.03	1.00	0.25	0.30*	0.16	0.30*	0.24	0.12
Salinity	−0.29*	−0.06	0.25	1.00	0.20	0.19	0.34**	0.23	0.14
Temp.	0.40**	−0.15	0.30*	0.20	1.00	0.28	0.25	0.13	0.09
Stocking density	−0.15	−0.13	0.16	0.19	0.28	1.00	0.10	0.91***	−0.21
Pond age	0.68***	−0.004	0.30*	0.34**	0.25	0.10	1.00	0.51***	−0.043
Pond size	0.38*	−0.39*	0.24	0.23	0.13	0.91***	0.51***	1.00	−0.32*
Pond depth	0.24	0.21	0.12	0.14	0.09	−0.21	−0.04	−0.32*	1.00

***$p < 0.001$ **$p < 0.05$ * $p < 0.1$.

Table 3
Associations of dissolved oxygen and disease incidences with water source, pond fertilisation, and pond type.

Explanatory variables		DO			Disease incidences		
Variables	Levels	Coefficient ±SE	t-value	p-value	Coefficient ±SE	t-value	p-value
Intercept		2.076 ± 0.821	4.009	0.005	0.621 ± 0.285	2.062	0.008
Water source	borehole	0			0		
	DUWASA	0.282 ± 0.137	0.470	0.642	0.651 ± 0.129	2.028	0.032
	shallow well	−1.347 ± 0.642	−2.098	0.045	0.691 ± 0.299	1.979	0.048
Pond manure	no	0			0		
	yes	2.076 ± 0.347	5.968	<0.001	−0.314 ± 0.174	−1.995	0.032
Feed type	commercial	0			0		
	home-made	−0.708 ± 0.515	−1.374	0.081	0.077 ± 0.019	0.340	0.736
Pond type	concrete	0			0		
	earthen	−0.017 ± 0.642	−0.027	0.978	0.064 ± 0.208	0.210	0.835
	polythene	−1.996 ± 0.641	−1.847	0.046	0.339 ± 0.188	1.173	0.251
Pond size (m^2)		0.029 ± 0.001	1.893	0.069	0.008 ± 0.005	0.615	0.544
Pond depth		0.012 ± 0.003	1.314	0.200	−0.004 ± 0.002	−0.929	0.361

Table 4
A generalised additive model that predicts fish yield (kg m^{-2}) based on pond age, dissolved oxygen (mgL), turbidity (Secchi disc depth in cm), pH, salinity, stocking density, and water temperature.

Parametric coefficients					
Response variable	Predictors	Estimate	Std. error	t-value	p-value
Fish yield (kg m^{-2})	Intercept	5.940	1.015	5.849	<0.0001
	Pond age	−0.181	0.236	−0.767	0.45
Approximate significance of smooth terms					
		edf	Ref.df	F	p-value
	Dissolved oxygen	1.897	1.988	9.169	0.002
	Turbidity	1.409	1.693	9.177	0.001
	pH	1.000	1.000	8.119	0.008
	Salinity	1.613	1.957	5.470	0.017
	Stocking density	2.365	2.729	5.027	0.009
	Temperature	1.000	1.000	0.066	0.750

of the importance of proper management practises for fish health and water quality.

The levels of DO, turbidity, pH, temperature, and nitrogenous waste are the critical water quality parameters in aquaculture [10,15]. Many of these variables have cumulative and interrelated effects on fish growth and health [14,49,50]. The water quality parameters in this study had varying associations with fish yield. Aquatic animals become stressed when they are repeatedly exposed to an unideal concentration of one or more water quality variables [13,45]. Oxygen is essential to the survival of the fish and the sustainability of the healthy bacteria that decompose the waste [10]. Fish production increases at optimum levels of oxygen through increased feeding and growth rates [27,51]. Fish yield, however, had a unimodal relationship with DO in this study, probably due to the interaction with other variables such as water temperature. Because the measurements were made during the day, it is possible that aquatic plants with high levels of photosynthesis increased DO during the day and decreased it through respiration at night [52].

Low pH alters gill structure and function, impairing the ability to maintain internal ion balance [10,53]. As a result, fish spend extra metabolic energy for gill function at the expense of growth [10]. The pH values of most ponds in this study were within acceptable ranges of between 6.5 and 7.3, and the fish yield increased with the pH. This finding agrees with previous studies that have found a positive correlation between pH and fish yield [14], fish weight [45], and growth [54,55].

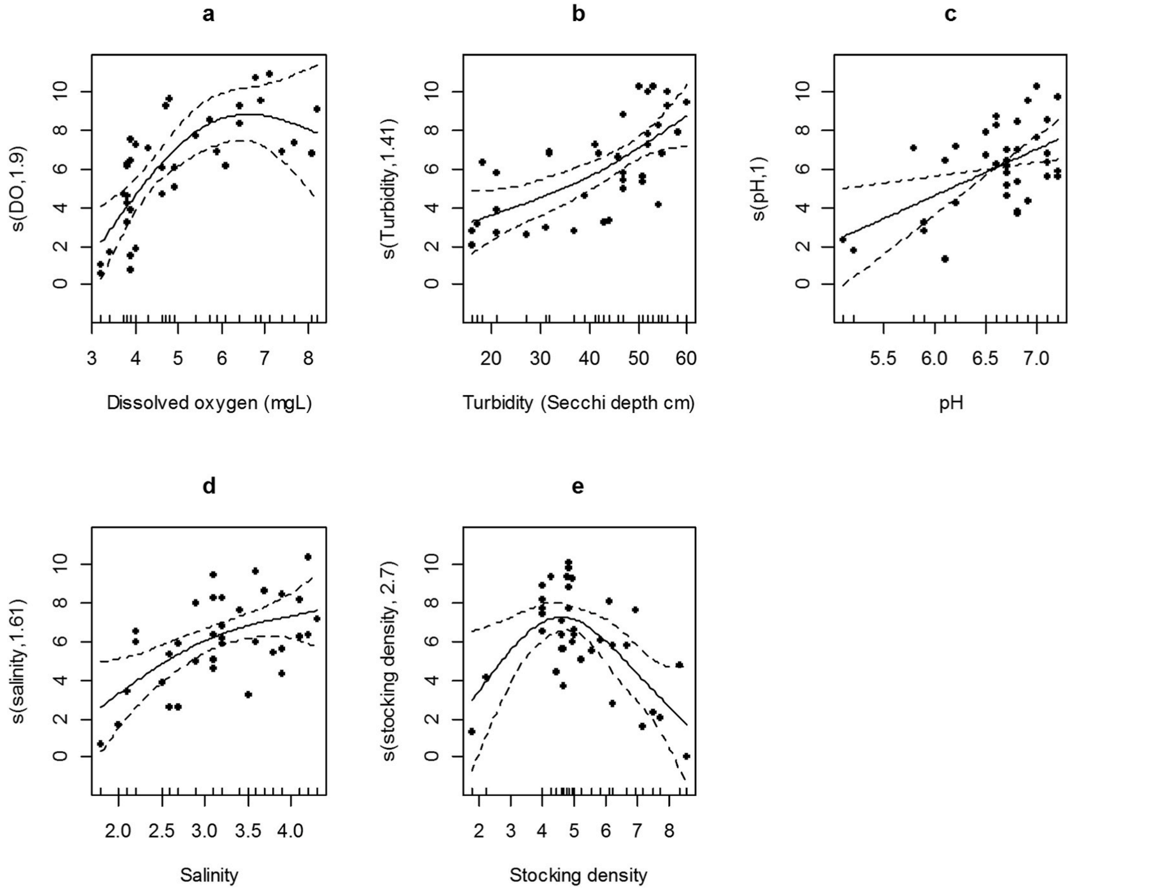

Fig. 2. GAM-predicted smooth splines of the fish yield (kg) as a function of: (a) dissolved oxygen, (b) Secchi visibility depth, (c) pH, (d) salinity, and stocking density. The degrees of freedom for non-linear fits are in parenthesis on the y-axis. The dashed curves show pointwise 2-SE limits for the fitted curves.

Table 5
Logistic generalised additive model predicting the probability of disease incidence in relation to pond water parameters, stocking density, and pond age.

Parametric coefficients					
Response variable	Predictors	Estimate	Std. error	t-value	p-value
Disease incidence (yes = 1, no = 0)	Intercept	−4.299	1.379	−3.477	0.014
	Stocking density	0.003	0.001	1.59	0.110
Approximate significance of smooth terms					
		edf	Ref.df	Chi. square	p-value
	Dissolved oxygen (mgL)	1.000	1.00	5.983	0.014
	pH	1.000	1.00	4.155	0.041
	Turbidity	1.000	1.00	4.210	0.040
	Salinity (ppt)	1.000	1.00	0.017	0.897
	Temperature	1.689	2.05	1.512	0.485
	Pond age	1.000	1.00	3.953	0.043

R-sq.(adj) = 0.74 Deviance explained = 76.2%.

The levels of salinity in this study were between 1.8 and 4.5 ppt, which is ideal for Nile tilapia [29,56,57]. The fish yield increased with the salinity, but at a decreasing rate. Moderate salinities (0–8 ppt) promote Nile tilapia growth [56,58]. The under-ground water in arid areas has a high salt level, ranging from 0.27 to 2.53 ppt [59], but is within the optimal level for Nile tilapia culture. Salinity levels above 16 ppt reduce food intake and feed conversion efficiency and divert more energy to maintaining homeostasis than growth [10,60,61].

The stocking density ranged from 2 to 9 fish/m^2 and was comparable to that found by Mmanda et al. [62] in other regions of

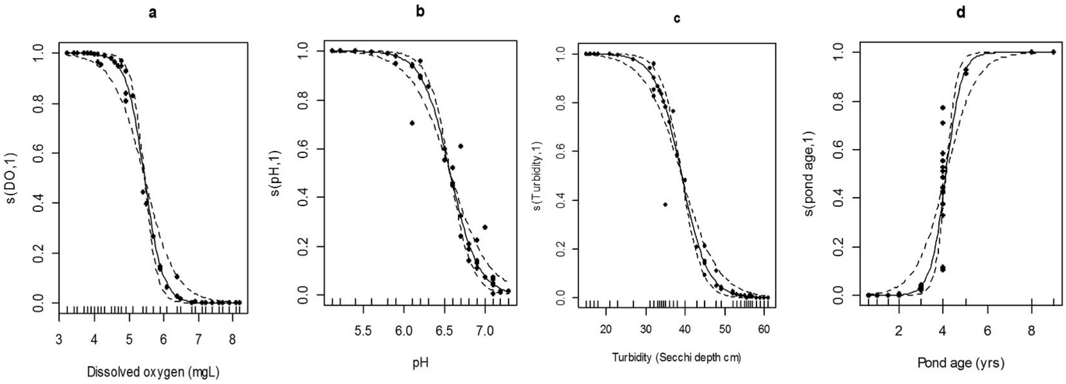

Fig. 3. Logistic GAM-predicted smooth splines of disease incidences as a function of: (a) dissolved oxygen, (b) pH, (c) Secchi visibility depth, and (d) pond age. The degrees of freedom for non-linear fits are in parenthesis on the y-axis. The dashed curves show pointwise 2-SE limits for the fitted curves.

Tanzania. There was a unimodal relationship between fish yield (kg) and stocking density. A maximum yield was achieved at a stocking density of about 5 fish per m^2 and then began to fall. High stocking density reduces fish growth due to stress, competition for food and living space [63–65].

The levels of DO, pH, turbidity, and pond age were associated with the likelihood of disease occurrence in the fish ponds. Water quality has a strong influence on fish health by increasing the occurrence of pathogens and reducing the resistance of fish against pathogens [11,66]. Poor water quality stresses the fish, making them vulnerable to opportunistic pathogens [13,66]. A study by Hasan et al. [18] found that months with poor water quality had higher incidences of fish diseases. Fish that have been exposed to low, nonlethal levels of DO for an extended period of time will become chronically stressed, reduce feed intake, and become more susceptible to disease [67]. According to Evans et al. [67], sub-lethal levels of DO make fish more susceptible to disease than the acceptable level. The sub-lethal levels of DO induce a stress response that weakens their innate resistance to pathogens [66,68,69]. High pH increases the toxicity of ammonia to fish, whereas low pH increases the toxicity of aluminium and copper [70–72]. Pond age increases fish diseases by influencing the quality of water and bacterial abundance [73,74]. Furthermore, pond age contributes to the buildup of organic waste, phosphorus, and nitrogen, influencing water quality [75].

Sustainable development of aquaculture in arid and semi-arid areas requires good management practises and water-saving strategies, including the harvesting of run-off water, recycling pond and waste water, aquaponics, biofloc technology, and the use of brackish water, which is not suitable for human consumption or agriculture. These practises have proved successful in different countries, such as Israel [76,77], Egypt [78,79], Algeria, and Oman [79]. Apart from improving the efficiency of water use, these aquaculture methods reduce waste discharge to the environment [80]. Successful implementation of modern aquaculture practises, however, requires capacity building among farmers through training, technical assistance, and extension services. Financial support can help overcome the initial costs of adopting technological innovations. Investment in research and development policies can help identify new technologies and practises that are suitable for local conditions.

5. Conclusion

The study shows an association between the source of water for aquaculture, management practises, and pond water parameters. On the other hand, the pond water parameters were associated with fish yield and the likelihood of disease incidence. Thus, to expand aquaculture development in arid regions, efficient use of water through integrated aquaculture and good management practises are recommended. This can be achieved through training farmers on the importance of good management practises and aquaculture integration. The development of aquaculture research is essential to identifying challenges facing specific areas and formulating interventions.

Due to the unavailability of equipment, other water parameters were not measured. In addition, water turbidity was evaluated by using the Secchi disc method, which has a low accuracy level. The chemical parameters of the water used in aquaculture might have also affected the pond water properties. The majority of the farmers were new to the aquaculture industry and didn't keep records; thus, it was difficult to get accurate information related to diseases experienced and the amount of manure applied in the ponds. Thus, we recommend further studies that will control different settings of the aquaculture system.

Author contribution statement

Rosemary Peter Mramba: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Emmanuel Jacob Kahindi: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e16753.

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