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Assessment of wetland ecosystem services and human wellbeing nexus in sub-Saharan Africa: Empirical evidence from a socio-ecological landscape of Ghana

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ABSTRACT

In a rapidly urbanized socio-ecological landscape like that of the Keta Lagoon Complex Ramsar Site (KLCRS) with the increasing trend of anthropogenic and natural stresses, careful understanding of the relationship between ecosystem services (ESs) and human wellbeing (HWB) is central to its sustainability. We use subjective quantitative indicators and structural equation model (SEM) based on the MA framework to assess the complex relationship between ESs and HWB while considering the mediating effect of subjective social status (SSS). Using a semi-structured questionnaire, primary data was collected randomly from 794 household heads in six communities within the KLCRS enclave. SSS provided a good cumulative indicator of status across different aspects of socioeconomic standing. Our results showed that the contentment levels of provisioning, regulatory, and cultural ESs were low and moderate for most of the respondents, but there were significant community variations attributed to the differences in livelihood opportunities and prevailing environmental challenges. The study communities accounted for more than 40% of the variations in respondents' wellbeing levels. High and moderate levels of wellbeing exclusively coincided with areas where respondents had high and moderate contentment with each ESs. From the SEM, provisioning ESs had the strongest positive effect on respondents' wellbeing and hence suggesting that HWB has mainly been achieved through provisioning ESs. Therefore, provision of alternative livelihood options, scaling-up restoration of vital habitat, and development of comprehensive strategic spatial plans were recommended to relevant stakeholders to help improve the capacity of the KLCRS to supply the regulatory services and the other ESs.

1. Introduction

Wetlands are some of the very important ecosystems on earth. They provide biological, ecological, hydrological, as well as geological functions to support human societies. Wetlands hold and support numerous varieties of species and habitats on the planet (Mwakaje, 2009). By definition, wetlands are permanent or temporary areas of swamps, marshes, peatland, fens, and others that are either natural or artificial, with water and vegetation (Ramsar, 1971). The aquatic system of a wetland is either stagnant, flowing, dry, brackish, or salt and may sometimes include marine areas with a depth not exceeding 6 m at low tide (Finlayson et al., 2005). The sustainability of wetlands depends on numerous factors including the supply and loss of water (MA, 2005). Globally, wetland ecosystems, including inland waters; coastal and near-shore marine wetlands; and artificial wetlands are estimated to be 12.1 million km^2 (Davidson et al., 2018). At the regional level, Africa has a wetland area of 9.9% with about 160 Ramsar Sites. About 10% of the total land area of Ghana is occupied by marine or coastal, inland, and man-made wetlands (Everard, 2018).

Globally, coastal wetlands including ecosystems of mangrove, salt marshes, seagrass beds, coral reefs, beaches, and coastal waters only account for 7.2% of the continental wetland area (Davidson et al., 2018).

Abbreviations: CESs, Cultural Ecosystem Services; ESs, Ecosystem Services; HWB, Human Wellbeing; KLCRS, Keta Lagoon Complex Ramsar Site; MA, Millennium Ecosystem Assessment; PESs, Provisioning Ecosystem Services; RESs, Regulatory Ecosystem Services; SSS, Subjective Social Status; SEM, Structural Equation Model.

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They are key components of the coastal landscape globally, and increasingly provide diverse ecosystem goods and services (Gardner and Finlayson, 2018). Some of the goods and services of the coastal wetlands include fish products, forest products, clean water supply, coastal protection, flood regulation, climate regulation, recreational and ecotourism opportunities, aesthetic appreciation, and a sense of place (MA, 2005). Coastal wetlands also contribute to groundwater recharge, nutrient and pollution retention in a floodplain, and provide support for rich wildlife and fisheries as well as the provision of fertile soil for agriculture (Barbier, 1993; Wiegleb, 2016). The provisioning, regulatory, and cultural services provided by coastal wetlands play a major role in determining human wellbeing (HWB) improvement (MA, 2005; Sun et al., 2018). Even though HWB is an evolving and multi-dimensional concept with no single accepted definition, MA (2005) has provided five basic elements that define HWB. The important contributions of wetlands to basic human needs, which is an important determinant of the overall wellbeing of people can be direct or indirect through the transformations of other forms of livelihood capital (McCartney et al., 2015).

Despite being fundamental to human welfare, global wetlands including those in coastal areas remain exposed to various natural and anthropogenic stressors which invariably affect the physical, chemical, and biological characteristics that are critical to their health and functioning. Global projections of about 5–20% losses of the coastal wetlands by 2080s due to sea-level rise would be smaller than that of human destruction (Kumi et al., 2015). The decline in wetland areas for the last 100 years across the globe is attributed to drainage and conversion, mainly for urban development and agriculture (Gardner and Finlayson, 2018). Previous studies (Duku et al., 2021; Ekumah et al., 2020; Issaka et al., 2019; Lamptey et al., 2013; Finlayson et al., 2000) have been active in gathering information on the trends and status of coastal wetland ecosystems in Ghana. These authors explored among other issues, the interactions that exist among the diverse wetland species, and the underlying processes of change. Their works, however, did not relate the condition of these metrics to the delivery of services to society. Most often, the focus is on climate-related effects on ecosystem services (ESs). As a result, the critical relationship between ESs and HWB has not been studied. So, knowledge of this key link, which is at the heart of the development-environment debate, has been lacking. A careful understanding of this relationship is central to the development of strategic response plans by stakeholders that will increase both HWB and ESs (Pereira et al., 2005). This paper, therefore, uses subjective quantitative indicators and a structural equation model that matches the MA framework to assess and understand the interactions among the ESs as well as their linkages with HWB using a Ghanaian case study. Importantly, this paper for the first time, draw on quantitative data to measure HWB and analyse its relationship with wetland ESs as well as the subjective social status (SSS) of individuals at the community level in a socio-ecological landscape of Ghana.

This research paper forms part of a broader study on "Dynamics of Coastal Wetlands and its Implications for HWB" which was conducted between November 2020 and November 2021, in the Keta Lagoon Complex Ramsar Site (KLCRS) of the Southern part of the Volta Region in Ghana (see Fig. 1).

2. Human wellbeing and ecosystem services

The concept of wellbeing, as a measure of a person's change in status, has emerged largely in both developed and developing countries because of its association with national development. Therefore, the understanding of human wellbeing is a core task for both researchers and policymakers (Clark and Mcgillivray, 2007). Its emergence as a composite measure can be traced back to the Physical Quality of Life Index (PQLI) which was later eclipsed by the Human Development Index (HDI) (Clark, 2014). The HDI represents an important first step toward a more comprehensive assessment of the human condition by including

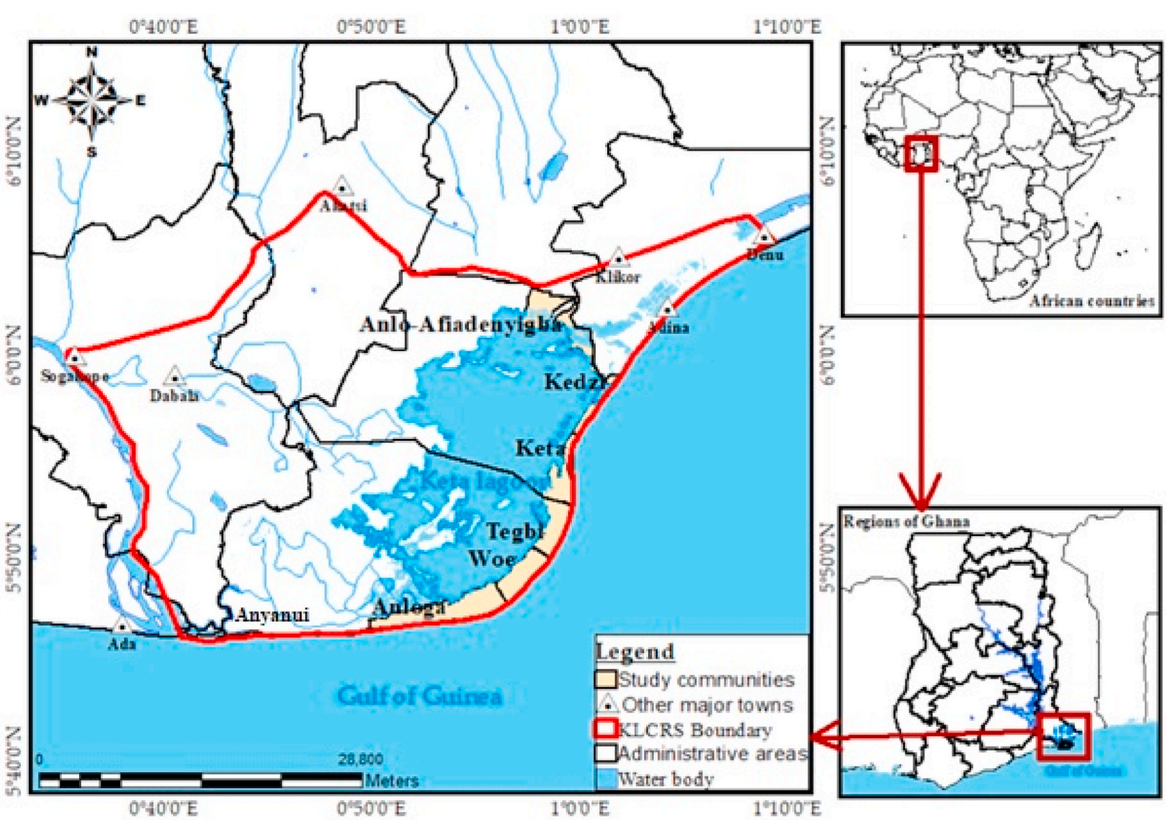

Fig. 1. Map showing the study area and communities.

health, education and material living conditions (Agarwala et al., 2014). Different conceptualizations and approaches have been used to measure wellbeing in various contexts owing to their flexibility (Clark, 2014). Yang et al. (2013) argued that before the MA, the measures of HWB such as the Happy Planet Index (HPI), the Life Satisfaction Index, the quality of life of the World Health Organization (WHOQOL), and HDI itself focused primarily on economic, psychosocial and health factors and did not identify ES as the driving force of HWB.

It is because of this that the current study was rooted in the MA framework that recognizes the contribution of ESs to HWB. It also acknowledges the multidimensionality of HWB and assumed that HWB has multiple constituents including the basic material for a good life, health, security, good social relations, and freedom of choice and action (Hori and Makino, 2018; MA, 2005). The basic material for a good life was defined to encompass enough food, shelter, clothing, access to goods, and above all secure and adequate livelihoods. The health dimension of wellbeing includes feeling well and having a healthy physical environment which is achieved when the individuals secure clean air, have access to clean water, and feel comfortable among others. Security has been conceptualised as the ability for an individual to secure access to natural and other resources, personal safety, and security from natural and human-made disasters while good social relation is centred around mutual respect, social cohesion, and the ability to help others and provide for children. The opportunity of an induvial to achieve what he or she values doing is captured by the freedom of choice and action dimension of wellbeing. It has been argued that no single component of HWB exists entirely independent of another component because of its complex nature (Biedenweg et al., 2016). This points to the fact that wellbeing is a multidimensional construct that cannot be assessed using a single item about life satisfaction and happiness, or a limited set of items regarding the quality of life (Dolan and White, 2007; Huppert, 2014; Kahneman and Krueger, 2006). As such, developing a composite measure with multiple items that constitute a summary of how an individual performs across the five constituents of wellbeing derived from ESs is preferable to a single item. Recent research (Ruggeri et al., 2020) supports this composite measure by indicating that the use of a single item method in wellbeing assessment fails to provide any insight into how individuals perceive the components of their life that are crucial to critical outcomes. This composite wellbeing index is an indispensable measure of environmental accountability toward a sustainable society (Smith et al., 2012). Wellbeing as experienced and perceived by people is context-dependent reflecting demographic, social, institutional, and personal factors as well as individuals' experiences in life (Diener et al., 2009).

Hypothesis 1a. Based on this, we hypothesize that there are significant variations in the levels of wellbeing across the Volta Delta communities.

Historically, the term "ecosystem services" was coined by Ehrlich and Ehrlich in 1981, but it gained widespread public recognition when the work of Costanza et al. (1997) titled "The value of the world's ecosystem services and natural capital," and that of Daily (1997) was published in 1997 (Braat and Groot, 2012; Roberts et al., 2015). After demonstrating the relevance of ecosystems in providing the biophysical underpinnings for societal development and all human economies in the 1990s, there has been an explosion of policy and research focused on ESs (Roberts et al., 2015). The MA through their comprehensive assessment of the world's ecosystems has been at the forefront when it comes to ecosystems and human wellbeing linkages. They established the ESs concept and provided a framework (Millennium Ecosystem Assessment Framework; MA, 2005) to guide researchers and practitioners in the assessment of ecosystems, ESs, and HWB. Ecosystems are the source of substantial necessities such as food, wood and fibre, fuel, and freshwater, but they also provide intangible services such as climate regulation, disease control, flood protection, pollination, decomposition of organic waste, aesthetic and enable recreational activities within the urban and rural space. All these critical services are termed ESs (MA, 2005). ESs have been categorised into four including supporting, provisioning, regulatory, and cultural services. Trade-offs exist among the four categories of ESs. For example, actions taken to enhance the supply of provisioning ecosystem services (PESs) are involuntary the results of the most changes to regulating services (MA, 2005). Supporting services differ from the other three ESs in that they are defined as the services needed to provide all other ESs (MA, 2005). Compared to other ESs, the impacts of supporting services on people according to the MA (2005) are indirect or occur over a very long time. Above all, it is through the aforementioned services that ecosystems underpin the wellbeing of humanity (Masterson et al., 2019). Some studies (Brookhuis and Hein, 2015; Chaigneau et al., 2019; Hossain et al., 2018; Plieninger et al., 2013; Song et al., 2016) have opened the pathways through which ESs can have deep impacts on HWB in a diverse setting. These pathways include the determination of household food and income through food supply directly from the local ESs; supply of freshwater from the underground aquifer and springs to vulnerable communities; flood control and erosion potential of diverse ecosystems; green spaces contributing to creating liveable microclimate conditions and clean air in cities to reduce the risk of disease for residents; and social cohesion and relationships derive from cultural ecosystem services (CESs). This suggests that ESs have a direct link with HWB. However, there has been a growing debate after the MA's assessment on "why ESs were found to be declining while global wellbeing had increased over the last fifty years" (Duraiappah, 2011).

Hypothesis 2a. We expect that the perceived contentment level of ESs derived from the wetland ecosystem of KLCRS will differ significantly across the Volta Delta communities.

Hypothesis 2b. We hypothesize that the perceived contentment level of PESs derived from the KLCRS will have a significant positive impact on HWB.

Hypothesis 2c. The CESs derived from the KLCRS has a significant positive effect on HWB

Hypothesis 2d. The regulatory ecosystem services (RESs) derived from the KLCRS have a significant positive relationship with HWB.

Hypothesis 2e. The PESs derived from the KLCRS have a significant positive correlation with RESs.

Hypothesis 2f. There is a significant positive correlation between CESs and PESs.

Hypothesis 2g. We expect a significant positive correlation between RESs and CESs.

Aside from the influence of ESs on HWB, the MA also reorganised the influence of other factors such as economic, social, and cultural factors on HWB. These factors collectively define an individual's socioeconomic status which is said to be captured in the SSS measurement (Sanchón--Macias et al., 2013). SSS is described as an individual's belief in his or her position on the social ladder. Studies (Adler et al., 2000; Ferreira et al., 2018; Operario et al., 2004) have empirically revealed a strong association between SSS and socioeconomic variables (like occupation, income, and education) as well as ownership of capital. More importantly, there is a growing interest concerning the influence of SSS on human health and wellbeing (Karlsson, 2017). Therefore, as in the case of economic, social, and cultural factors, SSS has the potential to mediate the strength of the relationship between ESs and HWB, but it is absent in ESs and HWB studies. As a single measure, Operario et al. (2004) argue that the SSS measure may provide a good cumulative indicator of status across different aspects of socioeconomic standing. The metrics take into consideration both income and what that income cannot buy. Compared to income and other conventional variables, Goldman and Cornman (2006) suggested that subjective measures may offer greater insights into social inequalities. Therefore, as an innovative approach, we use the SSS measure to capture the economic and socio-cultural factors and explored its relationship with the ESs and HWB.

Hypothesis 3a. We expect each type of ES (i.e., PESs, CESs, RESs) to have a significant positive effect on SSS.

Hypothesis 3b. We also expect a significant positive effect of SSS on respondents' wellbeing.

3. Materials and methods

3.1. Setting the stage

The study adopted a quantitative survey design underpinned by the MA framework because it facilitated the discovery of complex interrelationships between ESs and HWB while acknowledging the potential effect of other factors. The KLCRS is in the south-eastern Coastal Zone of Ghana and located between latitudes 5° 40′ N and 6° 10′ N and Longitudes 0° 40′E and 1° 10′ E (see Fig. 1). The KLCRS has been recognised for its critical role in supporting numerous species of migratory and resident birds and a home to the threatened endemic Western African Sitatunga (McPherson et al., 2016; Tufour, 1999). There are also 15 families of finfishes existing in the waters of the KLCRS. It is also worth noting that within the continental shelf of the site, there is extremely high biodiversity. The dominant vegetation includes marshes, scrublands, fig-trees, and mangrove forests, which are heavily exploited by resident communities for fuelwood and fishing. Towards the northern section of the area, there are short grasses and short trees with occasional occurrence of pamira palm and baobab trees. The water cover is permanent in some areas, it does not dry up and in some other areas, the water is imposed seasonally. The Keta, Angaw and Avu lagoons are the three major lagoons within the Ramsar site. Additionally, the site supports diverse livelihood activities such as fishing, farming, fuelwood harvesting, and salt extraction among others. The Ramsar site falls within the coastal savannah agro-ecological zone. In addition, it falls within the low-lying eastern coastal plain, hence the area is susceptible to coastal flooding. Rainfall in the area ranges from 800 mm to 1000 mm, with an average temperature of 30 °C coupled with low relative humidity, promoting high evapotranspiration (Keta Municipal Assembly, 2017). The area has two distinct rainfall seasons; minor (September–November) and major (May–July), but the dry season spans from January–March of each year (Lamptey and Armah, 2008). An extensive part of the lagoon dries up in the dry seasons (Ntiamoa-Baidu et al., 1998). The land area surrounding the lagoon is densely populated with an average population density of over 270 people per square kilometre due to limited land space. The population density is high, especially on the narrow sandbar that separates the ocean from the lagoon between Anyanui and Kedzi (Fig. 1).

3.2. Study population and sampling

The study randomly sampled 794 household heads from six communities distributed along the narrow sandbar that separates the Keta Lagoon (the largest lagoon in Ghana) from the Atlantic Ocean (see Fig. 1). Household heads who have inhabited the area for at least 25 years and have good knowledge of the changes that might have occurred answered the semi-structured questionnaire. The sample size formula for an infinite population (see Mensah et al., 2013; Olesia et al., 2015) was used to arrive at a representative number. The selected communities were Anloga (n = 133), Woe (n = 132), Tegbi (n = 132), Keta (n = 133), Kedzi (n = 132), and Anlo-Afiadenyigba (n = 132). The residents of these communities were considered because they depend heavily on the wetland ecosystem of KLCRS for different purposes such as fishing, farming, salt mining, and exploitation of mangrove trees for fuelwood and construction among others. For example, many people in Keta engage in lagoon fishing and harvest fish in commercial quantities for the local markets and other markets abroad (Ahmed and Sarfo, 2016). Others, particularly those living in the Anloga District also engage in vegetable farming around the lagoon (Kondra, 2016; Lamptey et al., 2013). Therefore, undertaking this study in these communities was paramount. Before the field data collection, the fishnet tool in ArcGIS 10.7 software was used to randomly select the houses which were imported into the computer-assisted personal survey tool and the Garmin GPSMAP® 62 21E001502 (Model 01102381, Taiwan). These tools served as a guide for the researcher and the trained enumerators to identify the randomly selected houses and from each of the houses, a household head was interviewed. WHO'S COVID-19 safety protocols implemented in Ghana were adhered to throughout the entire data collection period.

3.3. Questionnaire items and measurement

The semi-structured questionnaire was made up of four parts (A, B, C, and D) (see Appendix A). The introductory section (Part A) of the instrument consisted of the consent form information and the geographic coordinates of the respondents. Part B entailed the respondents' background information and household characteristics such as age, gender, occupation, net monthly income, SSS, access to basic utilities, and type of dwelling unit. Following Adler et al. (2000), the respondents' SSS as influenced by income, education, occupation, and access to resources was measured with a single Likert scale (1–10) question. Part C also consisted of nineteen Likert scale (0–10) questions measuring respondents' level of contentment with ESs derived (use or experience) from the wetland ecosystem of KLCRS in recent times compared to 15 years ago. A total of nineteen (19) questionnaire items were constructed with eight (8) capturing PESs, CESs had four (4) items, and RESs had seven (7). With regards to HWB as captured in Part D, a total of twenty (20) measurement items were constructed from previous studies (Bryce et al., 2016; Hori and Makino, 2018; McMichael et al., 2005; Pedersen et al., 2019; Yang et al., 2013) to cover the five wellbeing constituents defined by the MA (2005): basic material for a good life (five items); health (four items); security (four items); good social relations (four items); freedom of choice and action (three items). Prior to the pre-testing, the instrument was sent to experts for evaluation of the clarity of the measurement items and scale. Throughout the survey, anonymity was also maintained.

3.4. Statistical analysis

Using the Cronbach's Coefficient (α), the internal consistency of the measured indicators of perceived level of contentment with each ESs type and those constructed to measure the five constituents of HWB were checked. An 'α' of more than 0.7 shows good reliability of the measures (Mcmahan et al., 2013). The calculated 'α' for the five wellbeing constituents in the current study were as follows: basic material for good life (five items; $\alpha = 0.945$); health (four items; $\alpha = 0.973$); security (four items; $\alpha = 0.977$); good social relations (four items; $\alpha = 0.977$); freedom of choice and action (three items; $\alpha = 0.969$). A wellbeing index with scores ranging from 0 to 10 was then constructed from the measured items for the respondents' wellbeing. For a visual representation, the wellbeing index scores were then categorised into: "low wellbeing'' (0–3.99); "moderate wellbeing'' (4.0–6.99), and "High wellbeing'' (7.0–10). Similarly, calculated 'α' for each ESs types were 0.932 (PESs; eight items), 0.908 (CESs; four items), and 0.864 (RESs; seven items). For parsimony, theoretical and contextual relevance as well as visual representation, the indices scores (0–10) showing the contentment level of each ESs type derived from the KLCRS were categorised into; "low'' (0–3), "moderate/adequate'' (3.1–6), and high (6.1–10).

The structural equation model (SEM) was used to quantitatively explore the associations among the types of ESs as well as their relationships with HWB in a path diagram. This configural model excluded the supporting ESs (e.g., nutrient cycling, primary production) because it has been excluded from previous studies to avoid double counting

(Hossain et al., 2017; Santos-Martın et al., 2013; Wang et al., 2017). In the SEM, HWB was an endogenous latent variable that depends on the latent exogenous variables (i.e., PESs, CESs, and RESs). The indicators for each latent variable were the manifest variables. The fitness of the model was assessed using various relevant modification indices including Root Mean Square Error of Approximation (RMSEA $\leq$0.08); Comparative Fit Index (CFI $\geq$0.90), Incremental Fit Index (IFI $\geq$0.90); and Tucker-Lewis Index (TL $\geq$ 0.90) (Browne and Cudeck, 1992; Cavazos-Arroyo and Puente-Diaz, 2019). The one-way analysis of variance (ANOVA) was used to test the hypothesis of differences set in the second section of the study at a statistical significance level of 0.05. The SPSS Statistics Version 23 (IBM), SPSS Statistics AMOS Version 23 (IBM), and Stata SE 14.0 (StataCorp, Texas TX, USA) were used for the data analysis whiles ArcGIS 10.7 was used for the spatial representation. Fig. 2 summarise the methodological and analytical approach of the study.

4. Results

4.1. Respondents' background and household characteristics

The percentage distribution of respondents' background and household characteristics are represented in Table 1. The study sample was male dominated as females represented only 37%. Also, most (61%) of the respondents were middle-aged adults (35–55 years), with only 20% being young-adults (aged less than 35 years). A larger proportion (63%) of the respondents have been living in the study area for more than 30 years. More than half (64%) of the respondents were married and are living with their partners. A proportion of 24% of respondents had no formal education while those who had attained basic, secondary, and post-secondary education were 37%, 22%, and 17% respectively. Among the listed primary occupation, fishers were the highest (27.3%), followed by services and sales workers (25%), and 18% of public and private professional workers. In the sample, most of the respondents (48%) were low-income earners whereas 34% were within the high-income class (Table 1). Nearly 40% of the respondents were near the bottom of the societal ladder whereas 24% were those at the top. At the community level, the likelihood for most respondents to place themselves at the top of the societal hierarchy was linked to Anlonga (44%) and Woe (46%) (Fig. 3). Most of the respondents from Anlo-Afiadenyigba (54%) and Keta (41%) placed themselves in the middle of the societal ladder whereas most of the respondents from Kedzi (70%) and Tegbi (65%) considered themselves to be near the bottom of the societal ladder. Aside from the respondents' educational attainment, most (68%) of them had at least one of their household members attain either secondary or tertiary education. Again, the majority (83%) of the respondents and their household members were dwelling in cement blocks/concrete houses. The main source of cooking fuel used by most (55%) of the respondents in their household was found to be fuelwood. Liquefied petroleum gas was used by 43% of the respondents' households. A majority (58%) of the respondents' households sourced piped-borne water as their main drinking water. Other sources of drinking water were underground water (21%) and bottled/sachet water (21%).

4.2. Change in the level of contentment with PESs, RESs, and CESs derived from the wetland ecosystem of KLCRS

The results indicated that most of the respondents agreed that each ESs type they derived from the wetland ecosystem of KLCRS was either low or moderate in recent times compared to 15 years ago. For instance, the level of contentment with PESs derived from the wetland ecosystem was low for 55% of the respondents, moderate for 43% of the respondents, and high for only 2% of the respondents. In terms of RESs, it was perceived to be low by 39% of the respondents, moderate for 58% of the respondents, and high for 3% of the respondents. The level of contentment with CESs was perceived to be low for 45% of the respondents, but moderate and high for 45% and 10% of the respondents,

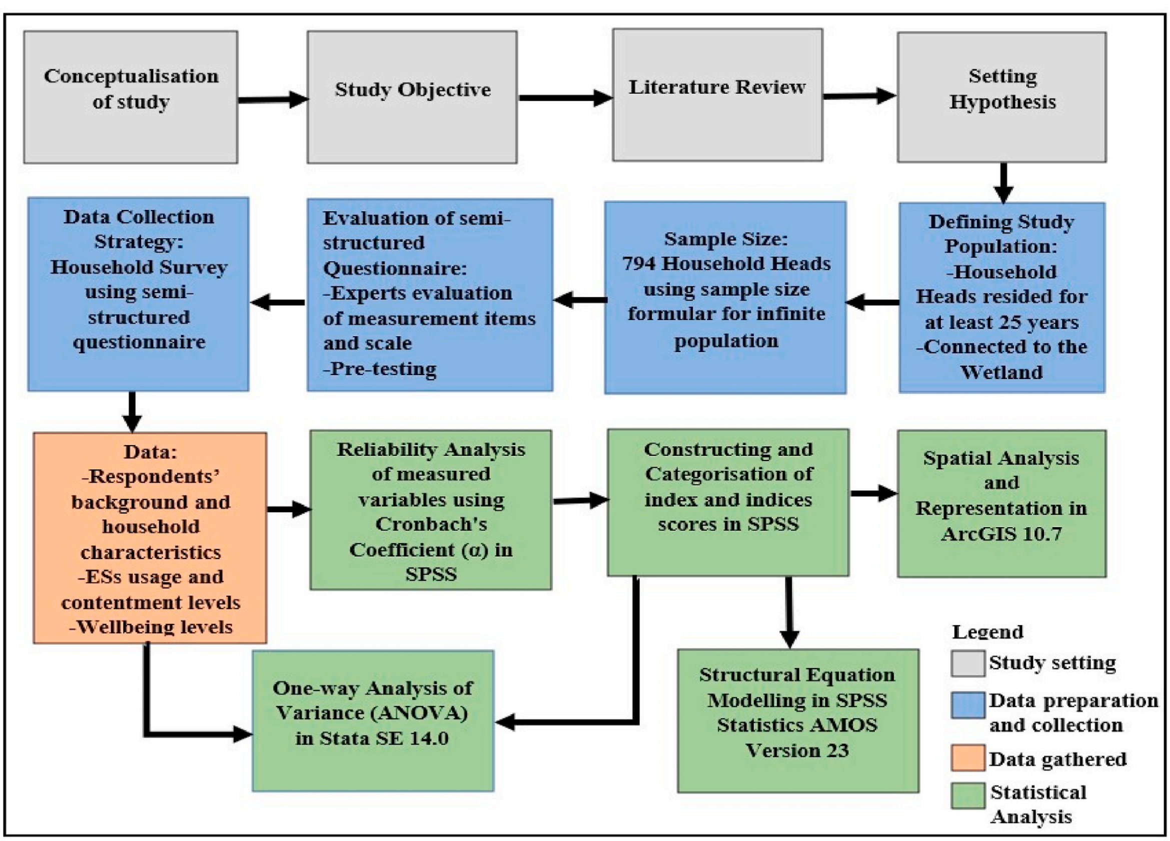

Fig. 2. Methodological and analytical approach.

Table 1
Background information of respondents.

Variables	N	%	Variables	N	%
Gender			**Income class**		
Male	502	63	Low (<GH₵700)	383	48
Female	292	37	Middle (GH₵700–999)	145	18
Age (in completed years)			High (>GH₵999)	266	34
Young adults: <35 years	153	20	**Nature of income compared to when started working**		
Middle-aged adults: 35–55	443	56	Decrease	244	31
Old-aged adults: >55 years	192	24	Unchanged	176	22
Years living in community			Increase	374	47
25–30	294	37	**SSS**		
31–35	75	9	Near bottom	317	40
More than 35	425	54	Middle	285	36
Educational attainment			Near top	192	24
No education	188	24	**Household members completed secondary/ tertiary education**		
Basic	296	37	None	257	32
Secondary	176	22	1–2	371	47
Post-secondary	134	17	More than 2	166	21
Marital status			**Type/nature of dwelling units**		
Never married	146	18	Bamboo/wooden house	35	4
Married	511	64	Palm leaf/thatch/raffia house	62	8
Divorced/separated	69	9	Cement blocks/concrete house	659	83
Widowed	68	9	Clay house	35	4
Primary occupation			Metal container	3	1
Fishers	217	27	**Household main source of cooking fuel**		
Famers	119	15	Fuelwood	436	55
Services and sales workers	199	25	Gas	341	43
Public or private professional/ manager workers	144	18	Electricity	12	1.5
Craft and related trade workers	49	6	Kerosene	5	0.5
Salt extraction workers	28	3	**Household's main source of drinking water**		
Pension	26	4	Underground water (well/ borehole/tube/pump)	167	21
Other occupations	12	2	Piped water (pubic/in dwelling)	460	58
			Bottled/sachet water	167	21

respectively. Per the sample, the level of contentment with PESs derived from the wetland ecosystem of KLCRS decreased as one moved from Anloga to Anlo-Afiadenyigba (Fig. 4). Also, RESs were moderate for most of the respondents from Anloga (92%), Woe (90%), and Keta (78%), but low for most of the respondents from Tegbi (57%), Kedzi (63%), and Anlo-Afiadenyigba (95%). Finally, a greater proportion of the respondents from Tegbi, Kedzi and Anlo-Afiadenyigba level of contentment with PESs, RESs, and CESs they derived from the KLCRS have been low in recent times compared to 15 years ago (Fig. 4a–c).

The F-Test from the analysis of variance (ANOVA) showed statistically significant differences across the study communities on perceived level of contentment with PESs (F = 310.1; Omega-Squared = 0.66; df = 5; $p < 0.001$), RESs (F = 213.21; Omega-Squared = 0.57; df = 5; $p < 0.001$), and CESs (F = 186.76; Omega-Squared = 0.54; df = 5; $p < 0.001$). The Tukey Post Hoc pairwise comparisons of ANOVA also indicated exactly between which of the study communities the differences were significant (see Table S1). For example, it showed that all the three ESs derived from the Ramsar Site were significantly higher for the respondents from Anloga than those from Tegbi, Kedzi, and Anlo-Afiadenygba.

4.3. Comparison of human wellbeing levels

As shown in Fig. 5, most of the respondents from Anlo-Afiadenyigba (67%), Anloga (63%), and Woe (63%) had high wellbeing. However, respondents from Kedzi (77%), Tegbi, (75%) and Keta (67%) had the highest percentage of low wellbeing. The ANOVA indicated that the distribution of wellbeing levels varies significantly (F = 132.07; df = 5; $p < 0.001$) across the study communities. Additionally, the effect size indices (Omega-Squared = 0.452; df = 5; 95% CI = 0.406–496) revealed that the study communities accounted for about 45% of the variation in the wellbeing levels. We then conducted a post hoc comparisons test (Table 2). Results show that a high level of wellbeing was more strongly linked to the respondents from Anloga, Woe, and Anlo-Afiadenyigba than the respondents from Tegbi, Keta and Kedzi. However, the level of wellbeing was significantly higher for respondents from Tegbi and Keta than those from Kedzi.

4.4. Structural equation model on the interrelations among ESs, SSS, and HWB

Assessment of the predictive capability of the proposed recursive model showed a good fit of the sample data based on the following relevant model fitness indices: RMSE = 0.075; NFI = 0.920; CFI = 0.934; TLI = 0.924; and $X^2 = 3729.7$ (df = 682, $p = 0.000$). Confirming our hypothesis, PESs had a strong significant positive correlation with CESs and RESs derived from the wetland ecosystem of KLCRS by the respondents (Fig. 6). The correlation between CESs and RESs was the strongest ($r = 0.95$; $p \leq 0.001$). This was followed by the correlation ($r = 0.87$; $p \leq 0.001$) between PESs and RESs and that of PESs and CESs ($r = 0.83$; $p \leq 0.001$).

In terms of the link between each ESs type and HWB, it was observed (Fig. 6) that PESs and CESs had a significant positive relationship with HWB. However, the relationship between RESs and HWB was significantly strong but reverse ($\beta = -0.87$; $p \leq 0.001$). PESs had the strongest positive effect ($\beta = 0.55$; $p \leq 0.001$) on HWB compared to CESs ($\beta = 0.374$; $p \leq 0.05$). A similar effect was observed on all the wellbeing constituents (Fig. 7). Moreover, the positive effect of PESs and CESs on the HWB constituents were strongest for security, social relations, and health than freedom of choice and action and the basic material for a good life (Fig. 7). A significant positive effect ($\beta = 0.20$; $p = 0.022$) of PES on SSS was also detected, but the positive effect of CESs and RESs on SSS was not significant at 0.05 (Fig. 6). The SSS had a strong significant effect ($\beta = 0.55$; $p \leq 0.05$) on HWB. As shown in Fig. 7, the positive association between SSS and the constituents of wellbeing was second to that of PESs.

Evaluation of the indirect effect from the path analysis showed that the indirect effect of PESs on HWB through SSS was the largest (Table 3). Comparing the direct effect and the total effect indicate that SSS significantly mediated the link between HWB and both PESs and CESs, but not RESs. All the measured variables in the structural model were observed (Fig. 6) to have significant positive relationships with their latent variables, but there were variations in the standardised regression weights (SRW). For instance, when PESs go up by 1 unit, lagoon fishery goes up by 0.72 units whiles fruits and grains increased by 0.87 units. Noise reduction was the least RES ($\beta = 0.40$; $p \leq 0.001$) that the wetland ecosystem of KLCRS can supply to support HWB whereas the highest ($\beta = 0.83$; $p \leq 0.001$) was air quality improvement. Recreation and tourism was the highest CES supplied but were just 0.02 units above aesthetics and inspiration for culture and art (Fig. 6). Table 4 shows the twenty measured variables for each of the five constituents of HWB together with their standard regression weights in the structural model.

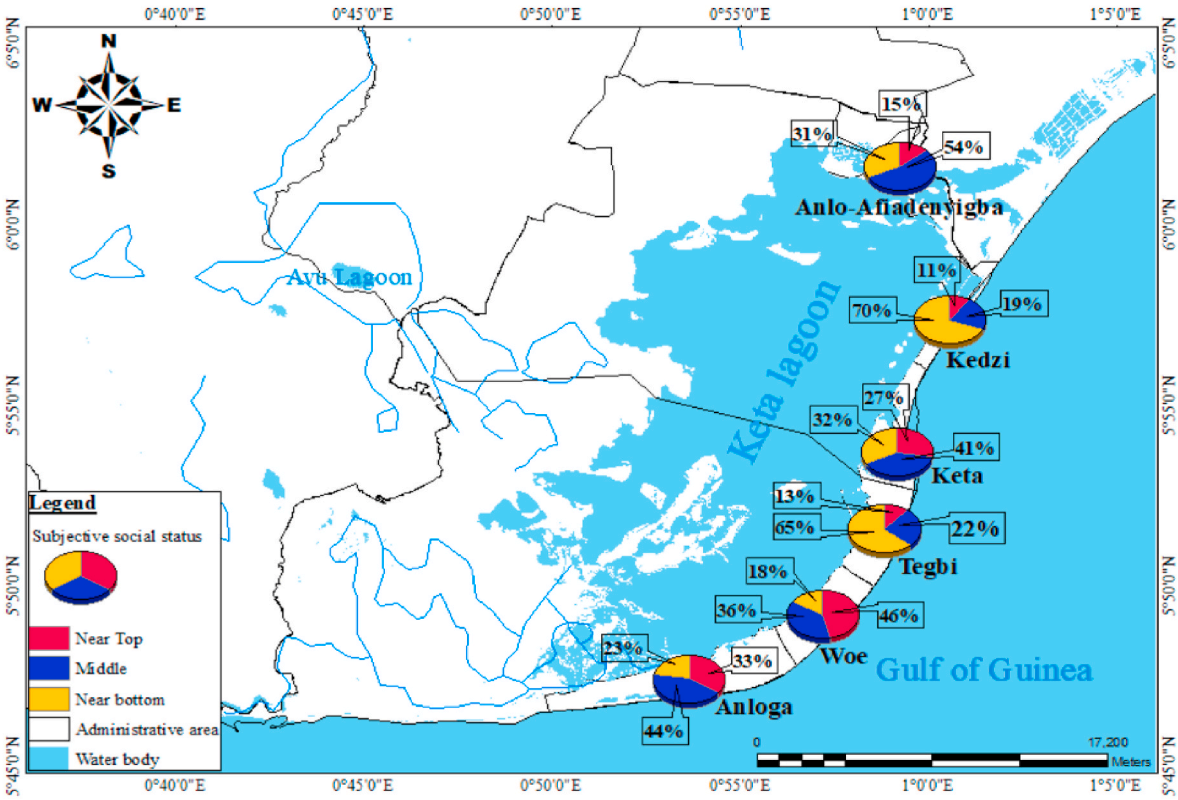

Fig. 3. Spatial distribution map of SSS across study communities.

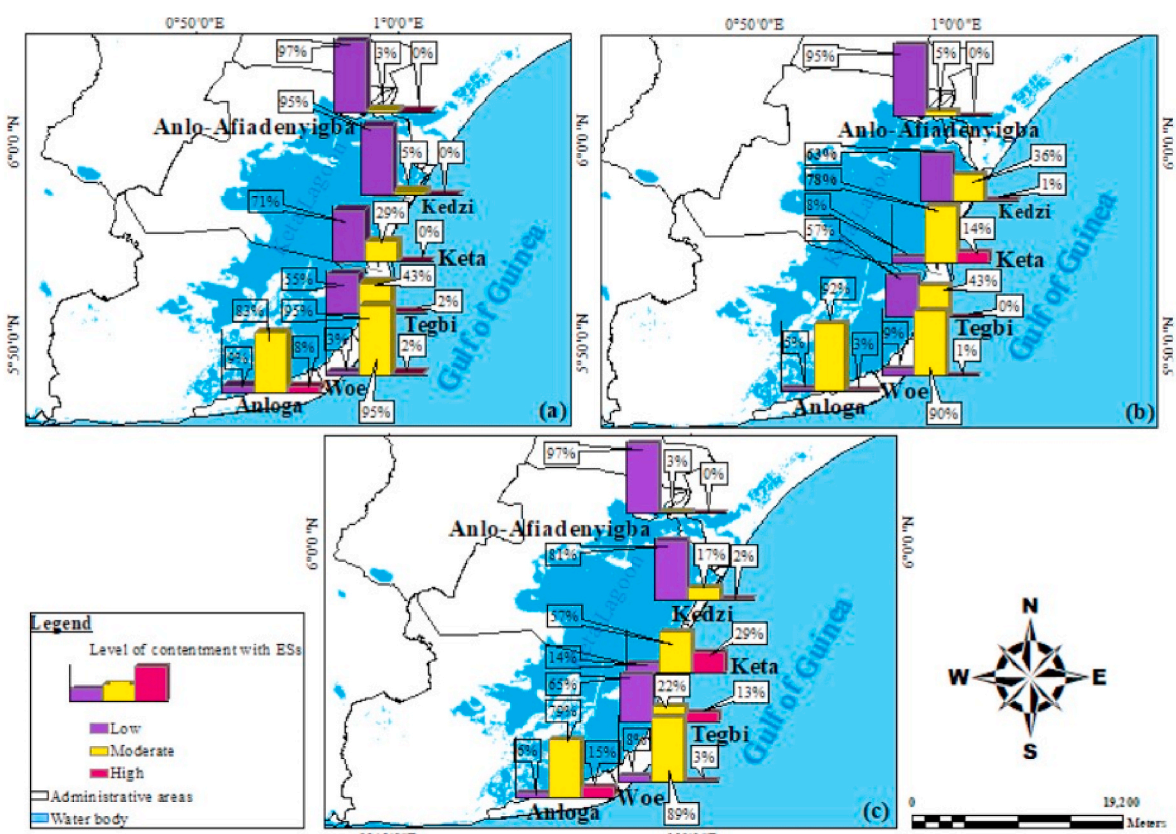

Fig. 4. Spatial distribution map of the perceived level of contentment with ESs derive from the KLCRS across the study communities. (a) PESs (b); RESs (c); CESs.

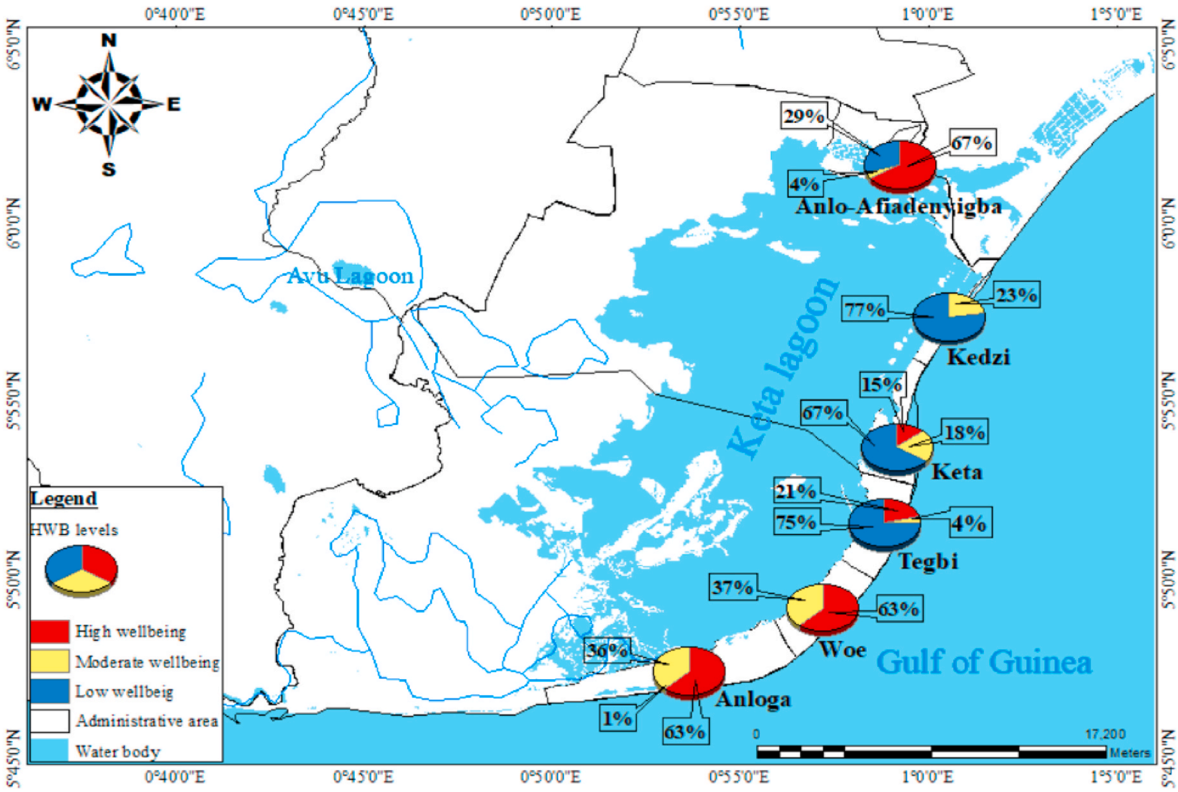

Fig. 5. Spatial distribution map of HWB levels across study communities.

Table 2
Tukey Post Hoc Pairwise comparisons of ANOVA for respondents' wellbeing levels across study communities.

Study communities	Anloga	Woe	Tegbi	Keta	Kedzi	Anlo-Afiadenyigba
Anloga						
Woe	−0.002					
Tegbi	−3.54***	−3.54***				
Keta	−3.71***	−3.71***	−0.17			
Kedzi	−4.99***	−4.99***	−1.45***	−1.28***		
Anlo-Afiadenyigba	−0.59	−0.59	2.95***	3.12***	4.40***	

*p ≤ 0.05, **p ≤ 0.01 and ***p ≤ 0.001.

5. Discussion

Despite the growing interest to understand the complex relationship between ESs and HWB at different scales, most of the studies on ESs have not quantitatively assessed these relationships while accounting for mediating factors. In Africa, several studies (Adjonou et al., 2020; Lamptey and Armah, 2008; Naidoo et al., 2019; Ndlovu et al., 2021; Orimoloye et al., 2018; Phethi and Gumbo, 2019; Serre and Karuppannan, 2018) on ecosystems within socio-ecological landscapes have used different quantitative indicators and models to assess the conditions and trends of ecosystems as well as the drivers of change. However, there is not much to say about ESs and HWB linkages, particularly, in coastal communities of sub-Saharan Africa. For regional sustainability, identifying the linkages between ESs and HWB is crucial (Huang et al., 2020; MA, 2005). With this, the current study combines subjective quantitative indicators and a covariance-based SEM to assess the nexus between ESs and HWB while reorganising the mediation effect of SSS. The overall findings of this study demonstrated the strong association between ESs and HWB in the socio-ecological landscape of Ghana and highlight the complicated consequences when one or more of these services are degraded.

This study provides much evidence to suggest that the residents derive diverse ESs from the wetland ecosystem of KLCRS in the eastern coastal zone of Ghana, with PESs and RESs being the dominant (see Fig. 6). Fuelwood including firewood and charcoal as an ES was used by most of the respondents as their main source of cooking fuel. Most of the respondents were found to be engaging in farming and fishing activities as their main occupations. Others were also found to be dependent on regulated water in the underground aquifer as their main source of drinking water. The tourism and recreational potential of the Ramsar Site as shown by the structural model cannot be ignored. Therefore, the finding supports the fact that Keta lagoon and its surrounding floodplain support a large number of people through fishing, farming, salt extraction, reed and mangrove cutting, and water supply among others (Finlayson et al., 2000). Moreover, a list of ESs provided by the wetland ecosystem of KLCRS which are vital for HWB and poverty alleviation have already been listed in a previous study (Brinks, 2017). This is why coastal lagoons are being reorganised as key sources of food and job opportunities (Newton et al., 2018). However, the results from the current study have shown that the PESs, RESs, and CESs residents derive from the wetland ecosystem have declined over the last 15 years with PESs being the most dependent. This gives us reason to suggest that the conditions of the various ecological aspects of KLCRS have changed more rapidly and extensively over the years and the trend of the changes has been downward as shown in numerous studies (Duku et al., 2021; Ahmed and Sarfo, 2016; McPherson et al., 2016; Lamptey and

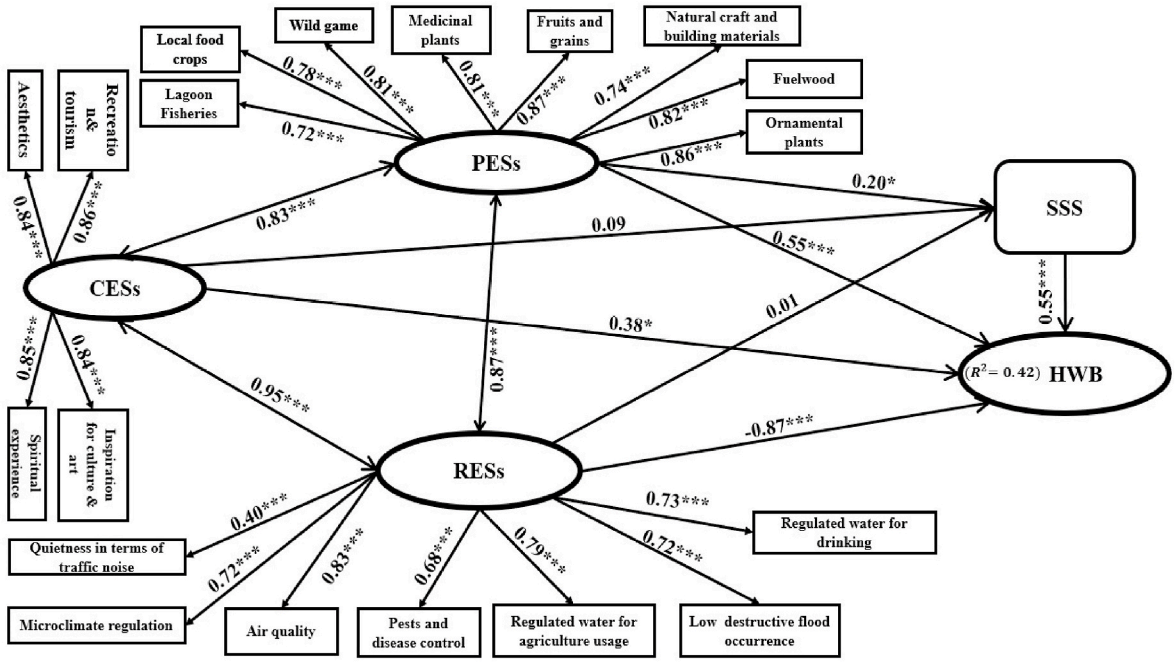

Fig. 6. Results of SEM with the measurement components and path diagram. Double-headed arrows indicate interactions with correlation coefficient (r) and single-headed arrows is standardised regression weight (β) indicating direct effect. Ellipses represent the latent variables (endogenous and exogenous), the rectangles depict the manifest/indicator variables, and SSS is a mediating variable. R^2 (Squared multiple correlations); $^*p \leq 0.05$, $^{**}p \leq 0.01$ and $^{***}p \leq 0.001$ (Significance levels).

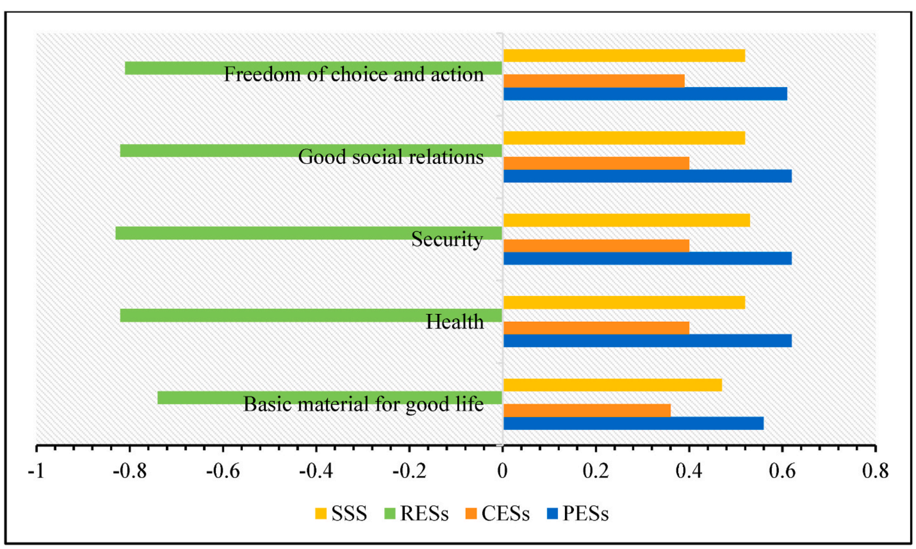

Fig. 7. Standardised total effects from the SEM. Sum of direct and indirect effects of SSS, RESs, CESs, and PESs on the HWB constituents.

Table 3
Standardize effects of exogenous latent and mediating variables on HWB.

Exogeneous latent variables	Total effect	Direct effect	Indirect effect
PES	0.655	0.547	0.108
CES	0.421	0.375	0.047
RES	−0.866	−0.869	0.003
Mediating variable			
SSS	0.552	0.552	

Ofori-Danson, 2014; Lamptey et al., 2013; Yidana et al., 2010; Lamptey and Armah, 2008; Finlayson et al., 2000; Tufour, 1999). The rapid degradation of the Ramsar Site which has probably led to the decline in each ESs type is mainly attributed to the intense pressure on the various ecological aspects probably arising from over-exploitation, environmental degradation, and irresponsible fishing to meet the growing demand. As predicted by the MA (2005) for global ecosystems, the benefits that future generations will obtain from these valuable ecosystems will substantially diminish if the current trend continues. Therefore, a conscious effort is required from all the stakeholders to restore the degraded aspects of the Ramsar site while meeting the increasing demand for its services.

The ANOVA test supported the hypothesis that the perceived level of contentment with PESs, RESs, and CESs derived from the KLCRS varies across the study communities. This suggests that the depletion of the available stocks has been faster in some localities than others, even though the aggregate use of these ESs is unsustainable. For example, our observation from the field and spatial assessment of land change of

Table 4
Measured items concerning the five constituents of HWB.

Constituents of HWB	Measured items/indicators	*SRW*	Mean
Basic material for a good life	Your household can afford/have enough food with nutrition to keep alive and healthy	0.90	4.87
	I can secure basic goods and services (e.g., food, clothe, living conditions, transportation) for a good life	0.70	3.94
	I have a regulated life environment (e.g., lifeline such as electricity, gas, and water)	0.79	4.36
	Getting the necessities for daily life	0.95	5.21
	You and your household have somewhere comfortable to live	0.95	5.16
Health	Keeping oneself in good health	0.96	5.34
	To feel comfortable	0.95	5.33
	Securing clean air and water	0.92	5.44
	To have the capacity to live, grow or develop	0.95	5.29
Security	To live with peace of mind and safety	0.95	5.48
	Protecting oneself from danger	0.96	5.30
	Ability to use resources and energy appropriately	0.96	5.31
	Giving an appropriate response when a disaster strike	0.95	5.19
Social relations	This is a close-knit neighbourhood, and I am able to produce good relationships	0.94	5.55
	In this community, you can hold someone in high esteem	0.95	5.41
	To be able to support someone	0.96	5.32
	There are many opportunities to meet and cooperate with the social community	0.93	5.56
Freedom of choice and action	A fair chance is given to everyone to succeed	0.95	5.43
	I have a chance to achieve a goal	0.94	5.30
	To enjoy one's hobbies	0.92	5.26

SRW.

KLCRS in previous studies showed that the Anloga township is closer to wetland vegetation, particularly mangroves distributed at the south-western section of the KLCRS. The exploitation of the mangroves has been an important source of income (Agbekpornu et al., 2016). Apart from fishing and mangrove harvesting (Lamptey and Ofori-Danson, 2014), residents of Anloga and Woe are well noted for their intensive vegetable and crop farming activities (Kondra, 2016), signifying their ability to transform local ecosystems to be more productive in food-yield terms. Saltpans are spread out in large areas around Anlo-Afiadenyigba, hence the residents are mainly into salt extraction together with fishing. Those in Kedzi are mainly into seine fishing (Nairn et al., 1999), but the fish catch has been declining. Many people in Keta also engage in lagoon fishing and harvest fish in commercial quantities for the people living in Keta and beyond (Ahmed and Sarfo, 2016). In addition, Kedzi and Keta townships are more prone to flooding and severe erosion (Angnuureng et al., 2013; Nairn et al., 1999). This environmental challenge has resulted in the loss of native land needed for farming and other economic activities in these areas, hence their sole dependency on the already declining lagoon and inshore marine fisheries. It is vital to remember that households choose their livelihood activities for improved wellbeing not only based on their assets and capabilities, but the ESs they derive from the local ecosystem (Yin et al., 2022). Hence, the differences in the livelihood opportunities that revolve around the wetland ESs and associated environmental challenges across the study communities could also account for the variations in the perceived contentment level of the ESs derived from the wetland ecosystem of KLCRS.

Our supposition that the wellbeing levels of the respondents vary across the study communities was supported by the findings. This significant finding is not surprising because the distribution of wellbeing levels across the study communities followed that of the ESs and the SSS. In communities where most of the respondents' level of contentment with the ESs they derive from the wetland were moderate to high, most of them also experience moderate to high wellbeing improvement. The same pattern can be said for SSS. This means that individuals who are at the top of the societal ladder have more access to ecosystem goods and services to improve their wellbeing. The only community which was exceptional in this pattern was Anlo-Afiadenyigba. Even though most of the respondents had low contentment with each of the ESs derived from the KLCRS, most of them reported high wellbeing. A plausible explanation for this is that the area is open to other livelihood opportunities such as 'Kente' weaving, indigenous salt-winning, and aquaculture development that could be used to offset the deteriorated ESs. These livelihood options are barely affected by the loss of biodiversity providing options for the residents to improve their SSS and subsequently may achieve improved wellbeing. Above all, this finding is a clear indication that high and moderate levels of wellbeing and SSS exclusively coincide with areas where the level of contentment of residents with PESs, RESs, and CESs is high and moderate with a high degree of livelihood diversification. Hamann et al. (2016) in their study also found that majority of the low wellbeing areas in South Africa overlapped with the transition and green-loop systems that are areas with medium and high direct use of ESs. This was attributed to the inability of the transition and green-loop systems to operate in comprehensive market-based economics arising from the lack of specialised and technological advancement needed to sustainably transform ecosystem structure into economic products.

The structural model affirmed the hypothesis that PESs and CESs have a positive effect on HWB. However, it did not support the positive relationship between RESs and HWB. Slightly different from the MA's framework, the study found a strong positive effect of PESs on security, health, and good social relations than that of basic material for a good life. The intensity of the linkages between CESs and the HWB was not far from that of the MA (2005), but RESs had an inverse relationship with all the HWB constituents. These findings indicate that HWB improves with increasing PESs and CESs, while RESs decline. Similar to the findings of Garcı et al. (2013), our findings also provide much evidence to suggest that the improvement of HWB is mainly achieved through PESs and CESs. A negative causal relationship between RESs and HWB is not surprising because it has been shown that ESs and HWB relationships are diverse (Liu and Wu, 2021). Moreover, previous studies (Hossain et al., 2017; Liu and Wu, 2021; Santos-Martın et al., 2013) in different settings have also found an inverse relationship with RESs. Similarly, in the global assessment, the MA found increased HWB globally despite the decline in about 60% of the ESs, with regulatory and supporting being the most decreased ESs (Raudsepp-Hearne et al., 2010). In the current study area, the effort made to improve PESs such as food crops has affected the ability of the wetland to provide sufficient RESs. However, the resulting negative implications on HWB are offset by the presence of close substitutes (such as improved drinking water) which is not sourced from the local ecosystem. Other studies have pointed to the fact that people can use other sources of income other than those directly link to ESs to acquire goods to substitute for the loss of some of the ESs sources (McMichael et al., 2005; Pereira et al., 2005). Also, it has been argued that the negative implications of decreasing ESs on human wellbeing are offset by investment in human capital (including assets like health services, education, skills, etc) and technological advancements such as water quality purification, chemical fertilizer, and alternative livelihoods (Hossain et al., 2017). However, stakeholders are to be cautious in their decisions because other significant ESs may not have a close substitute (Anthony et al. n.d.). As in the case of this study, Pereira et al. (2005) revealed that people believe that the increased use of chemicals (as a way of enriching the declining soil fertility) to increase food production could be harmful to human health and wellbeing. It could also have a detrimental effect on other ecological aspects of the natural environment. This among other factors presents the issue of trade-offs and congruence between the ESs as Anthony et al. (n.d.) explained.

The authors of the "Environmentalist's Paradox" in their argument on ESs and HWB nexus concluded by saying that the trade-offs that exist among the ESs could account for the indirect link that exists between some of the ESs and HWB (Duraiappah, 2011). There is much concern about these trade-offs, and informed management or policymakers are expected to enhance both RESs and CESs by mitigating the trade-off between provisioning and other ESs (Braat and Groot, 2012).

Our findings supported our supposition that PESs have a positive effect on an individual's SSS. With regards to CESs and RESs, even though we noticed a positive causal relationship, we did not have strong evidence to accept the association. To some extent, these relationships give us a reason to suggest that the multiple socio-cultural and economic factors that determine individuals' SSS are tied to healthy ecosystems in a socio-ecological landscape like KLCRS. Household income, occupation, and education are some of the socioeconomic characteristics found to be determinants of SSS (Singh-manoux et al., 2003). These factors are pathways through which ESs, particularly provisioning contribute to HWB. For example, marketable goods such as food, fuelwood, and water provided by ecosystems can provide cash income which will certainly improve the economic dimension of HWB (Chaigneau et al., 2019). Education, as a basic capability is fundamental to HWB. Not only do ecosystems contribute to educational progress through the incomes gotten from the transformation of their services, but they also provide a glut of learning opportunities such as the use of natural areas for teaching and scientific research (Smith et al., 2012). All these explain why SSS was observed (Fig. 6) to have a significant positive effect on HWB. It could also mediate the relationship between ESs and HWB. Moreover, other studies (Goldman and Cornman, 2006; Operario et al., 2004) have also shown that SSS have a positive relationship with self-related health as a domain of HWB. For example, in Goldman and Cornman (2006) and Operario et al. (2004), psychological and physiological functioning are both domains of HWB found to be associated with SSS (Adler et al., 2000). In addition, SSS is a better predictor of happiness (Ejrnæs and Greve, 2016) and health (Sanchón-Macias et al., 2013) than objective measures such as income, education, and labour market position. These relationships demonstrate the extent to which SSS can predict HWB.

6. Conclusions

Our study has shown that the integration of subjective quantitative indicators and a covariance-based simultaneous equations model ensures the effective analysis of the nexus between ESs and HWB in a complex socio-ecological landscape. The study has empirically validated a model (SEM) that provides the opportunity to evaluate both the direct and indirect effects of ESs on HWB. The results showed that the KLCRS at the south-eastern coast of Ghana supplies diverse ESs, but the level of contentment of residents with the ESs they derive has declined over the years. RESs are unique in that they are said to be provided without the direct involvement of humans and facilitate the provision of other ESs (Braat and Groot, 2012), yet they are most degraded in KLCRS. They are mostly trade-off to enhance the supply of PESs and CESs. Therefore, a conscious effort is required from the relevant government agencies, donor agencies, and other stakeholders by way of awareness creation, provision of alternative livelihood options, scaling up the restoration of vital habitats, and development of comprehensive strategic spatial plans to improve the capacity of the KLCRS to supply the regulatory services and the other ESs. It is important to note that the improvement of HWB and poverty alleviation in the coastal zone of Ghana is tied to the health of the available ecosystems.

Our research indicated that the study communities accounted for about 54%–67% of the variations in ESs and more than 45% of the variation in HWB levels. The findings have proven that there are significant variations in the perceived contentment level of PESs, RESs, and CESs derived from wetlands across the Volta Delta communities. The same can be said for the levels of wellbeing of the residents. Even though there were community differences in SSS, most people generally tend to see themselves as being at the bottom of the social hierarchy demonstrating that social and economic inequality exists in the KLCRS. This should be an important issue that must be mainstreamed into the district's medium-term plans. Our findings supported a positive link that HWB has with PESs and CESs but failed to support that of RESs. The results from the SEM have increased our understanding of how all the ESs are strongly related and their effects on HWB from the socio-ecological point of view and what is expected to enhance the decision making and management of the Ramsar site.

Ethical approval

Since the research involved human participants, ethical approval was provided by the Institutional Review Board (IRB), University of Cape Coast with reference number, UCCIRB/CANS/2021/03.

Author contributions

Conceptualisation, E.D.; data collection and curation, E.D.; methodology and software, E.D.; validation, P.A.D.M. and D.B.A.; formal analysis, E.D.; writing—original draft preparation, E.D.; writing—review and editing, P.A.D.M., D.B.A. and E.D.; supervision, P.A.D.M. and D.B.A. All authors have read and agreed to the published version of the manuscript. All authors reviewed and approved for submission for publication.

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.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.indic.2022.100186.

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