Journal of Materials and Environmental Science
ISSN : 2028-2508
CODEN : JMESCN

J. Mater. Environ. Sci., 2021, Volume 12, Issue 08, Page 1000-1013

http://www.jmaterenvironsci.com

Relationship between socio-economic factors and water quality status of Chania River, Kenya

Geofrey Kasyoka Robert[1]*and John Gichimu Mbaka[2]

[1*]*Department of Land and Water Management, University of Embu, Embu, Kenya*
[2]*Department of Environmental Sciences, Machakos University, Machakos, Kenya*
**Corresponding author, email: robertkasish@gmail.com & *Associate author email: mbakagichimu@gmail.com*
**Corresponding author phone number: +254716314615 & Associate author phone number: +254739606338*

Received 29 March 2021,
Revised 19 July 2021,
Accepted 20 July 2021

Keywords
- ✓ Anthropogenic activities,
- ✓ River Chania,
- ✓ Socio-economic,
- ✓ Thika,
- ✓ Water pollution,
- ✓ Water quality.

robertkasish@gmail.com & Associate author email: mbakagichimu@gmail.com

Abstract

Human related activities harm water quality. However, there is limited information on the impact of socio-economic activities on water quality in River Chania. This study focused on the determination of the effect of social and economic factors on the water quality condition of a section along the River Chania. Data used in this study were collected between October 2020 and January 2021. A survey employing cross-sectional survey design was carried out. A sample size of 60 individuals was randomly selected in study sites that were purposively sampled on the basis of human-related activities that potentially pollute River Chania. These sites were: Karimenu, Chania Estate Bridge, Ngoingwa Estate and Thika town. A semi-structured questionnaire was used to collect data. Data analysis was done using descriptive statistics (e.g., frequencies and percentages) in Statistical Package for Social Sciences (SPSS) to determine how the different socio-economic factors affect water quality at a statistical significance of 5% probability level. The study found that the education level of the respondents was a positive and significant predictor of the ability of an individual to identify water quality changes in River Chania. It is recommended that human-related perturbations should be minimal to protect water quality from further deterioration.

1. Introduction

Water is a vital renewable resource for the sustenance of life. For example, water is required by humans for purposes such as drinking, irrigation, and hydropower generation. Thus, humans are closely connected to freshwater resources, and the utilization of these resources has played a critical role in the development of societies and economies in the world [1-3]. The close association between humans and freshwater environments has resulted in adverse effects through human-related factors such as agriculture, pollution, urbanization, human population density, and invasive species [4-6]. Natural factors such as topography and climatic variations also affect freshwater environments [7].

Several studies in Kenya have investigated the relationships between water quality and factors such as land use, pollution, climate variations, and urbanization (e.g., [8-11]). For example, urbanization has been reported to result in contamination of the environment with toxicants such as heavy metals. Meanwhile, land-use practices such as small-scale agriculture have been found to contribute significantly to nutrient loads (e.g., phosphorous) and pesticides in aquatic ecosystems [9,12]. However, there is a scarcity of information on the relationship between socio-economic factors and water quality conditions of freshwater ecosystems.

Socio-economic factors such as the density of human population, education attainment, and gross domestic product are typically utilized as indicators of the impact of human-related stressors in freshwater ecosystems (e.g., [13-15]). Chen and Lu [16] reported that socio-economic factors such as human population density explained a more significant percentage (45%) of the overall river water quality variance than natural elements such as topography and some factors related to land use. The study also found that human population density was a significant predictor for phosphorous concentration, while gross domestic product mostly explained variability in electrical conductivity. Another study also reported that the human population was a significant source of disturbance to coastal wetlands and that it had a considerable influence on phosphorous and chloride concentrations [17].

Water quality has been declining in River Chania over the years, mostly as demand exceeds supply [18]. The pollution problem is mainly driven by farming activities, industrialization, and urbanization. These activities take place along the banks of the River. Pollution can also be attributed to climate change, which could potentially impact the hydrological cycle and concentration of toxicants in the aquatic environment. This could lead to increased human health risks, water scarcity, and pollution. The current study aims to evaluate the relationship between socio-economic factors and water quality status in the Chania River. It is hypothesized that socio-economic factors have an influence on respondent's perspectives on water quality status in the Chania River.

2. Materials and Methods

2.1. Description of the study area

River Chania, along with its tributaries, Thika, and Karimenu Rivers, originate from the slopes of Mountain Kinangop in the Aberdare ranges, which is the second-largest water tower in Kenya [19]. River Chania's catchment covers Kiambu, Murang'a and Nyandarua counties and lies between latitude 0.753 ^{o}S and 1.04 ^{o}S and longitude 36.58 ^{o}E and 37.07 ^{o}E [20]. River Chania is the most critical River flowing through this catchment. High levels of utilization demonstrate its significance for agricultural purposes upstream, such as subsistence farming as well as growing of cash crops (coffee, tea, and flowers) and as a significant water source for Thika town and its environs (Figure 1-Figure 3) [18].

Figure 1: Map of Africa highlighting the study area country, Kenya

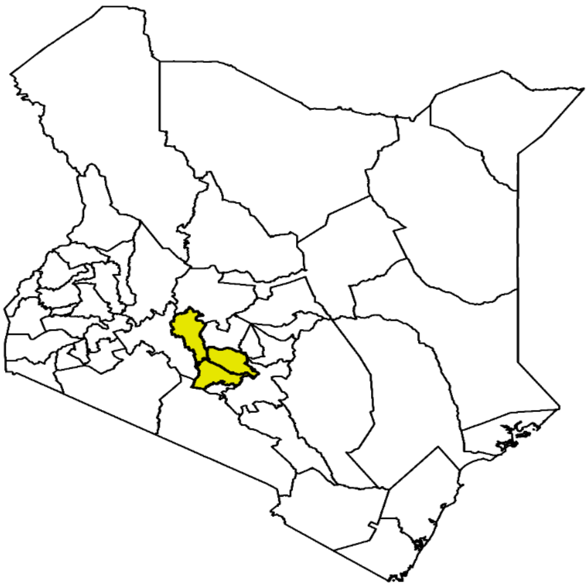

Figure 2: Map of Kenya highlighting the study area

Figure 3: Map of River Chania water catchment

Rainfall distribution in the study area is bimodal. The long rains are experienced between mid-March to May, while the short rains occur between mid-October to November. The average annual rainfall is a function of altitude, where higher regions receive 2000 mm, and lower areas of Thika town receive as low as 600 mm. The overall average for the area is 1200 mm. Temperature ranges between 7 ^{o}C in the upper highlands and 34 ^{o}C in the lower midland zones, with an average temperature of 26 ^{o}C [19].

2.2. Research design

A cross-sectional survey design was used during data collection. The data gathered assessed the human activities that affect water quality in River Chania. The total length of River Chania where data was collected is 10 km, and the study sites along the River include Karimenu, Chania Estate Bridge, Ngoingwa Estate, and Thika town. These sites were purposively sampled based on the most common human-related activities that potentially pollute River Chania. Sixty (60) individuals were randomly selected from each site. The number of individuals chosen as respondents were in line with Mugenda and Mugenda's [21] study that asserts that 30 and above respondents are representative enough of a population.

2.3. Data collection and analytical procedures

Primary survey data was gathered using a semi-structured interview schedule (Supplementary data file). The interview schedule was administered with the help of enumerators who were selected and trained. They were equipped with knowledge about the subject matter to enable them to conduct the survey successfully. A total of 60 sampled respondents were interviewed in all the sites. Before data collection, the data collection instruments were tested both for validity and reliability using a sample of 10 interview schedules administered to 10 randomly selected individuals. Questions found to be ambiguous and inadequate were modified to enhance understanding by the respondents. The information collected during the survey included social and economic demographics such as gender, age, education level, household size, average monthly income, change in households' number, residence period, meter connection, sources of households' drinking water, water quality, water quality satisfaction, and water quality issues.

2.4. Data analysis

The socio-economic characteristics data of the respondents were entered and coded using Microsoft excel. Consequently, the data were analyzed using descriptive statistics such as frequencies and percentages. To express the degree of correspondence between two variables, Chi-Square was used at a statistical significance level of 5% following Hassan and Nhemachena [22]. The Statistical Package for Social Sciences (SPSS) version 23 was used to analyze data.

3. Results and discussion

3.1. Socio-economic characteristics of the respondents

The results showed that about two-thirds (65%) of the individuals interviewed were male while the rest were female (35%). Out of this, 65% were youth aged between 18-35 years, 12% were middle-aged (36-50 years), and the rest were aged over 51 years. All of the sampled respondents had acquired formal education, and 53% of the sampled individuals had received tertiary education at either college or university levels. A majority (57%) of the respondents earned between KSh. 10,000 and 20,000 per month. It was also observed that about two thirds (67%) of the respondents had a meter connection to piped water. In contrast, a third (33%) of the respondents were not connected to metered piped water by local water authorities, Kiambu Water and Sewerage Company (KIWASCO). Out of the total number of respondents, 85% had between 1 – 5 family members, while the rest had more than five family members (Table 1).

Table 1: Socio-economic characteristics of respondents interviewed at sites located along Chania River, Kenya.

Factor	Frequency	Percentage
Gender		
Male	39	65
Female	21	35
Age (years)		
18-35	39	65
36-50	12	20
51-60	8	13
Over 60	1	2
Level of education		
Primary	11	18
Secondary	17	28
College	20	33
University	12	20
Residence period(years)		
0-5	19	32
6-10	12	20
11-20	17	28
Over 20	12	20
Household size		
1-5	51	85
Over 6	9	15
Household income per month (Kenya shillings)		
1000-10000	13	22
10000-20000	34	57
20000-30000	8	13
Over 30000	5	8
Meter connection		
No	20	33
Yes	40	67
Major economic activity		
Farming	30	50
Entrepreneurship	17	28
Employment in local industries	13	22
Main household source of drinking water		
Private piped	35	58
Public piped	2	3
River Chania	14	23
Borehole	9	15

Thirty-two percent of those interviewed have resided in the study area for between 0-5 years. The rest have stayed in the area for over six years. Half of the respondents (50%) perceived farming as the main economic activity. In comparison, other respondents identified entrepreneurship and employment in local industries (28% and 22%, respectively) as the main economic activity in the area. It was noted that 23% of the respondents used water collected directly from River Chania to meet their daily water requirements. In comparison, 15% used borehole water, while 3% bought water from licensed water vendors, and 58% were connected to piped water by KIWASCO (Table 1).

3.1.1. Effect of level of education

Results of Pearson's Chi-Squared test showed that the level of education had no significant impact on income per month, water usage, or determination of causes of water quality degradation in River Chania (Table 2). However, the level of education of respondents was significantly correlated (p=0.02) with the identification of water quality changes in River Chania in the last decade (Table 2).

Table 2: Effect of level of education on household income per month (KSh), water usage, identification of water quality changes in River Chania in the last decade and determination of causes of water quality degradation in River Chania. *p* values in bold are significant.

Factor	Pearson Chi-Square	*p*-value
Income per month (Shillings)	9.87	0.36
Water usage	1.33	0.96
Identification of water quality changes in River Chania in the last decade	9.53	**0.02**
Determination of causes of water quality degradation in River Chania	5.80	0.75

3.1.2. Effect of gender

Pearson's Chi-Squared test explored whether or not the gender of an individual was significantly related to the household income per month (KSh), water usage, identification of water quality changes in River Chania in the last decade, and determination of the causes of water quality degradation in River Chania. The results revealed no significant relationship (all p> 0.05) between gender and household income per month, water usage, identification of water quality changes in River Chania in the last decade, or determination of causes of water quality degradation in River Chania (Table 3).

Table 3: Effect of gender on household income per month (KSh), water usage, identification of water quality changes in River Chania in the last decade and causes of water quality degradation in River Chania.

Factor	Pearson Chi-Square	*p*-value
Income per month (Shillings)	1.89	0.59
Water usage	0.50	0.77
Identification of water quality changes in River Chania in the last decade	0.39	0.52
Determination of causes of water quality degradation in River Chania	1.12	0.77

3.1.3. Effect of age

Pearson's Chi-Squared test showed that the age of the respondents had no significant effect (all p>0.05) on income per month, water usage, or determination of the causes of water quality degradation in River Chania. However, the identification of water quality changes in River Chania in the last decade was almost significantly correlated to age (p=0.06) (Table 4).

Table 4: Effect of age on household income per month (KSh), water usage, identification of water quality changes in River Chania in the last decade and determination of the causes of water quality degradation in River Chania.

Factor	Pearson Chi-Square	*p*-value
Income per month (Shillings)	14.72	0.25
Water usage	5.29	0.72
Identification of water quality changes in River Chania in the last decade	9.01	0.06
Determination of causes of water quality degradation in River Chania	5.17	0.52

3.1.4. Source and treatment

It was found out that more than half of the sampled respondents (53%) identified that their primary source of drinking water had no smell, while the rest pointed out that their primary source had at least a mild odor (Table 5).

Table 5: Water quality characteristics based on views of respondents.

Factor	Frequency	Percentage
Water smell		
No smell	32	53
Mild smell	21	35
Foul smell	7	12
Taste		
Tasteless	40	67
Has a taste	20	33
Water quality satisfaction		
Dissatisfied	22	37
Fairly satisfied	18	30
Satisfied	20	33
Reason for dissatisfaction		
Poor quality	19	48
Health concerns	19	48
Turbid water	2	5
Degradation solution by households		
Treating or boiling the water before use	28	47
Buying bottled water	16	27
Buying treated water from other sources	14	23
Demand that the service provider provides treated water	2	3
Potential outcome of water quality decline in River Chania		
Increase in water borne diseases	38	63
Reduced use of the river for water users	8	13
Change in micro-climate in riparian land	7	12
Change in biodiversity	7	12
Expectation of water quality of River Chania to improve		
Yes	39	65
No	21	35

Two-thirds (67%) of the sampled individuals confirmed that their primary source of water had no taste while the rest (33%) perceived taste in the water. Most respondents (63%) were at least reasonably satisfied by the quality of water from their primary sources. In comparison, the rest (37%) were not satisfied, with 96% citing poor quality and health concerns or turbidity (5%). The majority of sampled individuals (47%) identified treating or boiling water before use as their main strategy of dealing with a decline in water quality. On the other hand, 50% identified buying bottled water or buying treated water from other sources as a solution for water quality degradation (Table 5).

3.1.5. Potential outcome of water quality decline

Most respondents (63%) stated that the potential outcome of water quality decline in River Chania would be increased waterborne diseases. At the same time, fewer (<15) indicated that the possible result of the decline in water quality is reduced usage of the River, change in micro-climate in the riparian zones, and change in biodiversity (Table 5). However, most respondents (65%) expected the water quality of the Chania River to improve in the future.

3.1.6. Demographic changes and water quality

Most respondents (90%) stated that the number of households had increased in the area and that this increase was the leading cause of water quality reduction in River Chania (Table 6). Most respondents (57%) identified a reduction in the number of households as a way of improving water quality in River Chania (Table 6).

Table 6: Effect of demographic change on River Chania as assessed by the respondents.

Factor	Frequency	Percentage
Change in household number in the study area		
Decrease	5	8
Cannot tell	1	2
Increase	54	90
How does increase in the number of households affect water quality in River Chania		
Reduction of water quality	44	73
No change	22	22
Cannot tell	5	5
How does decrease in the number of households affect water quality in River Chania		
No change	18	30
Cannot tell	8	13
Improved water quality	34	57

3.2. Relationship between socio-economic factors and water quality

Results of Pearson's Chi-Squared test in Table 2 show that the level of education had no significant impact on income per month, water usage, and determination of causes of water quality degradation in the River Chania. This could be attributed to perhaps all respondents having a formal education and being involved in almost the same tasks and their monthly incomes being virtually at par. Water usage per capita per day could be the same despite the disparity in the level of education due to the respondents leaving their homes in the morning for their different occupations and coming back in the evening. This means that the water used by different individuals will not be significantly different because water usage is primarily restricted to the hours when the respondents are at home.

Despite the level of education, determination of the causes of water quality decline in River Chania was difficult, perhaps due to the diffuse sources of pollution in the River and, therefore, difficulty in pinpointing an actual source of contamination in the study area. Likewise, Ellis and Mitchell [23] and Varekar et al. [24] assert that diffuse sources of pollution are in nature challenging to define and are mainly associated with an overland flow from rainfall. This rainfall then carries away anthropogenic and natural contaminants, finally depositing them into water bodies. It also causes atmospheric deposition of pollutants and habitat alterations such as riparian vegetation removal and hydrologic modification. However, Pearson's Chi-Squared test revealed that there was a significant correlation between the level of education and ability to identify water quality changes in River Chania in the last ten years. This implies that the more educated an individual is, the more likely to be knowledgeable about water quality issues and the easier to comprehend and identify any water quality issues in the past decade in River Chania. The literacy rate was generally high (Table 1), implying that more than half of the interviewed individuals were capable of identifying changes in water quality in River Chania that had taken place in the last ten years.

There was no significant relationship between gender and household income per month, water usage, identification of water quality changes in River Chania in the last decade, or determination of causes of water quality degradation in River Chania (Table 3). This could be attributed to both men and women having access to similar opportunities in terms of education and employment [25]. Therefore, they may have no significant disparities in income per month. Thus, their water usage, ability to identify water quality changes in River Chania over time, and determination of the causes of water quality deterioration in River Chania are almost similar. Similarly, Montanari and Bergh [26] reported that equality and expansion of education opportunities for both men and women not only stimulates productivity but also extensively grows participation in income-generating activities for both genders and spurs environmental awareness.

There was no significant relationship between the age of respondents and household income per month, water usage, or determination of the causes of water quality degradation in River Chania (Table 4). However, identification of water quality changes in River Chania over the last decade was almost significantly correlated to age, suggesting that older individuals could have gained more informal experience about the identification of environmental changes over time. Lack of relationship between age and household income could be since people of the same age group that has access to almost similar opportunities in life end up with few disparities in income generation [27].

The residence time was found to have a positive effect on the identification of water quality changes in River Chania in the last ten years. This implies that the more the residency time of an individual, the more likely the individual will perceive changes in water quality in River Chania. Likewise, the least the amount of time spent in a particular location, the least likelihood an individual will identify changes in water quality. This is in line with Armstrong and Stedman [28], who observed a positive influence of the residency time of an individual on their ability to identify changes in the physical environment. Additionally, Hoekstra and Chapagain [29] stress similar results by stating that the residency time of an individual increases his ability to perceive changes and actively engage in the conservation and rehabilitation of the physical environment.

From the findings, the majority of the respondents identified farming as the main economic activity of the study area. Farming played a significant role in water quality decline in River Chania. Madhav et al. [30] asserted that farms discharge substantial quantities of agrochemicals, organic matter, drug residues, and sediments into water bodies. According to Abhilash et al. [31], in most developed countries and many developing nations, agricultural pollution has surpassed contamination from industries and human settlements as the prime factor in water quality decline of inland and coastal waters. Indeed, globally, nitrate from agricultural practices is currently the most rampant chemical contaminant in surface waters [32, 33]. Eutrophication as a result of the accumulation of nutrients such as nitrates and phosphates in rivers weighs heavily on biodiversity, and high concentrations of nitrates in water can lead to "blue baby syndrome," a potentially fatal disease in babies [34]. According to the findings, the majority of the respondents were males who were the main participants in farming activities. This could explain the influence of male farmers on the degradation of River Chania. This is in line with Zimmerman et al. [35], who argue that approximately 70 to 90 percent of formal farmland owners are men in many Latin American countries, and similar trends are observed in sub-Saharan Africa, including Kenya [36]. This implies that males have a major role to play in farming activities and hence contribute significant pollutants in River Chania.

The more substantial part of the respondents was youths who could be the primary users of River Chania. Youths are involved in several activities within and around the River that negatively affects the quality of its water. The youths wash utensils and carry out laundry washing in the stream as well as washing of cars and motorcycles. The washing of cars and motorcycles could result in oil and grease spillage, which has adverse effects on the river ecosystem [37-39]. The most immediate effects of these compounds are toxic and mass mortality and contamination of fish and other aquatic species [40]. Long term ecological effects of these compounds include interruption of the food chain in the ecosystems, such that species populations may change or disappear entirely [41]. Detergents discharged into the River during washing have severe effects on aquatic life [42, 43]. If soaps are in sufficient quantities, they may cause the breeding ability of aquatic organisms to decrease. Also, soap lowers the surface tension of water; thus, fish absorb toxins such as pesticides and phenols more easily [44].

Most respondents indicated that they were dissatisfied with the water of the Chania River due to factors such as poor quality and health concerns (Table 5). Thus, the area residents could still be contributing to declining water quality in River Chania, possibly due to a lack of awareness about environmental matters. This agrees with Sun et al. [45] who argued that a population that is not aware of or concerned about the environment and its associated problems and which has limited knowledge, poor attitudes, low motivation, non-commitment, and inadequate skills to work individually and collectively towards solutions of current pollution problems and the prevention of new ones is at risk of exacerbating environmental challenges such as global warming, climate change, air pollution, water scarcity, and water pollution.

Respondents who obtained water from the Chania River created foot pathways as they ferried water from the River. The abstraction of water from River Chania along with other anthropogenic activities such as washing clothes, animals trampling within the stream area causes the removal of riparian vegetation. This vegetation protects water bodies from sedimentation and pollution by slowing down runoff and thereby allowing sediments and pollutants to deposit in the fringing zone [46, 47]. Removal of riparian vegetation through activities such as grazing, human settlements, the abstraction of water, weed invasion and land clearing for agriculture has led to the degradation of numerous waterways [47, 48].

A large number of respondents identified an increase in the number of households in the study area (Table 6). This implies an increase in the population occasioned by immigration, reduced mortality rate, and rural to urban migration into the cosmopolitan Thika town. An increase in the number of individuals could be a massive player in the decline of water quality in River Chania. This corroborates Halder and Islam [49], who stated that population growth and economic advancement are contributing to significant environmental calamities. These include water quality deterioration, land degradation, ecosystem interference, loss of biodiversity, and heavy pressure on land [50]. Migration into cities and towns causes physical disturbance of land due to the construction of human settlements, industries, roads, etc. Moreover, it causes inadequate sewage treatment, increases in the number of pesticides, fertilizers, and other agrochemicals to grow food, all of which lead to a negative impact on river ecosystems in the long run [51].

Conclusion

Education level was found out to be a positive and significant predictor of the ability of an individual to identify water quality changes in River Chania in the last ten years. Thus the more educated a respondent was, the higher the likelihood to identify the changes in water quality and re-adjust accordingly. This finding is in agreement with the study hypothesis that socio-economic characteristics of respondents have an effect on respondents' perspectives on water quality status in the River Chania. Therefore, more emphasis should be put on education and awareness creation of the adverse effects of pollution of river ecosystems by the relevant agencies to halt the current pollution on rivers and streams. Information on water quality decline and the strategies to cope and combat the menace should be mainstreamed and made more available to the local population. The current study was limited by the amount of time available and area sampled and a future study focusing on socio-economics and water quality should focus on larger spatial and temporal scales.

References

1. O. Al Jayyousi, Water as a human right: towards civil society globalization. *International Journal of Water Resources Development*, 23 (2007) 329-339. doi.org/10.1080/07900620601182943
2. S. Dickin, E. Bisung, J. Nansi, K. Charles, Empowerment in water, sanitation and hygiene index. *World Development* (2021). https://doi.org/10.1016/j.worlddev.2020.105158.
3. S.L. Young, E.A. Frongillo, Z. Jamaluddine, H. Melgar-Quinonez, R. Pérez-Escamilla, C. Ringler, A.Y. Rosinger, Perspective: the importance of water security for ensuring food security, good nutrition and well-being. *Advances in Nutrition* (2021). doi.org/10.1093/advances/nmab003.
4. N. Friberg, N. Bonada, D. C. Bradley, M. J. Dunbar, F. K. Edwards, J. Grey, G. U. Y. Woodward, Biomonitoring of human impacts in freshwater ecosystems: the good, the bad and the ugly. In *Advances in ecological research* 44 (2011) 1-68. Academic Press. https://doi.org/10.1016/B978-0-12-374794-5.00001-8
5. W. K. Dodds, J. S. Perkin, J. E. Gerken, Human impact on freshwater ecosystem services: a global perspective. *Environmental science & technology*, 47 (2013) 9061-9068. https://doi.org/10.1021/es4021052
6. E.O. Akindele, C.G. Alimba, Plastic pollution threat in Africa: current status and implications for aquatic ecosystem health. *Environmental Science and Pollution Research*, (28) (2021) 7636-7651. https://doi.org/10.1007/s11356-020-11736-6.
7. K. Price, Effects of watershed topography, soils, land use, and climate on baseflow hydrology in humid regions: A review. *Progress in physical geography*, 35 (2011) 465-492. https://doi.org/10.1177/0309133311402714
8. N. L. M. Budambula, E. C. Mwachiro, Metal status of Nairobi River waters and their bioaccumulation in Labeo cylindricus. *Water, air, and soil pollution*, 169 (2006) 275-291. https://doi.org/10.1007/s11270-006-2294-x
9. W. A. Shivoga, M. Muchiri, S. Kibichi, J. Odanga, S. N. Miller, T. J. Baldyga, M. C. Gichaba, Influences of land use/cover on water quality in the upper and middle reaches of River Njoro, Kenya. *Lakes & Reservoirs: Research and Management*, 12 (2007) 97-105. https://doi.org/10.1111/j.1440-1770.2007.00325.x
10. U. Adhikari, A. P. Nejadhashemi, M. R. Herman, J. P. Messina, Multiscale assessment of the impacts of climate change on water resources in Tanzania. *Journal of Hydrologic Engineering*, 22 (2017) 501-603. https://doi.org/10.1061/(ASCE)HE.1943-5584.0001467

11. C. N. Aera, C. M. M'Erimba, K. Nzula, Effect of organic effluents on water quality and benthic macroinvertebrate community structure in Njoro River, Kenya. *J Environ Anal Toxicol*, 9 (2019) 2161-0525. https://doi.org/10.4172/2161-0525.1000601
12. E. N. Ndunda, V. O. Madadi, S. O. Wandiga, Organochlorine pesticide residues in sediment and water from Nairobi River, Kenya: levels, distribution, and ecological risk assessment. *Environmental Science and Pollution Research*, 25 (2018) 34510-34518. https://doi.org/10.1007/s11356-018-3398-8
13. Y. H. Farzin, K. A. Grogan, Socio-economic factors and water quality in California. *Environmental Economics and Policy Studies*, 15 (2013) 1-37. https://doi.org/10.1007/s10018-012-0040-8
14. A.U. Khan, J. Jiang, P. Wang, Y. Zheng, Influence of watershed topographic and socio-economic attributes to the climate sensitivity of global river water quality. *Environmental Research Letters*, 12 (2017) 104012. https://doi.org/10.1088/1748-9326/aa8a33.
15. M.M.M. Islam, M.S. Iqbal, R. Leemans, N. Hofstra, Modelling the impact of future socio-economic and climate change scenarios on river microbial water quality. *International Journal of Hygiene and Environmental Health,* 221 (2018) 283-292. doi.org/10.1016/j.ijheh.2017.11.006
16. J. Chen, J. Lu, Effects of land use, topography and socio-economic factors on river water quality in a mountainous watershed with intensive agricultural production in East China. *PloS one*, 9 (2014). 10.1371/journal.pone.0102714
17. J. A. Morrice, N. P. Danz, R. R. Regal, J. R. Kelly, G. J. Niemi, E. D. Reavie, G. S. Peterson, Human influences on water quality in Great Lakes coastal wetlands. *Environmental Management*, 41 (2008) 347-357. https://doi.org/10.1007/s00267-007-9055-5
18. G. K. Robert, C. N. Onyari, J. G. Mbaka, Development of a Water Quality Assessment Index for the Chania River, Kenya. *African Journal of Aquatic Science*, (2020) 1-11. https://doi.org/10.2989/16085914.2020.1809338
19. CGK. *County Government of Kiambu: Economic Annual Planning*, Report. *Government Printers*, (2016) Nairobi, Kenya.
20. G. J. Ng'ang'a, O. B. Omondi, K. Mourad, Soil and Water Conservation in Thika-Chania catchment, Kenya. *International Journal of Sustainable Water and Environmental Systems-IASKS,* 9 (2017) 59–65. https://lup.lub.lu.se/record/c8897b4d-2dd2-4159-9e04-886d892f22d4
21. O. M. Mugenda, G. A. Mugenda, Research Methods. *Quantitative and Qualitative Approaches*, (2009) *Nairobi, Kenya.*
22. R. M. Hassan, C. Nhemachena, Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. *African Journal of Agricultural and Resource Economics*, 2 (2008) 83. 10.22004/ag.econ.56969
23. J. B. Ellis, G. Mitchell, Urban diffuse pollution: key data information approaches for the Water Framework Directive. *Water and Environment Journal*, 20 (2006) 19-26. https://doi.org/10.1111/j.1747-6593.2006.00025.x
24. V. Varekar, V. Yadav, S. Karmakar, Rationalization of water quality monitoring location under spatiotemporal heterogeneity of diffuse pollution using seasonal export coefficient. *Journal of Environmental Management*, (2021). https://doi.org/10.1016/j.jenvman.2020.111342.
25. M. Ngugi, C. Mumiukha, F. Fedha, B. Ndiga, Universal Primary Education in Kenya: Advancement and Challenges. *Journal of Education and Practice*, 6 (2015) 87-95. https://doi.org/10.1007/978-3-030-38759-4_18

26. B. Montanari, S. I. Bergh, A gendered analysis of the income generating activities under the Green Morocco Plan: Who profits? *Human Ecology*, 47(3) (2019) 409-417. doi.org/10.1007/s10745-019-00086-8
27. G. Ziervogel, F. Zermoglio, Climate change scenarios and the development of adaptation strategies in Africa: challenges and opportunities. *Climate Research*, 40 (2009) 133-146. https://doi.org/10.3354/cr00804
28. A. Armstrong, R. C. Stedman, Understanding local environmental concern: the importance of place. *Rural Sociology*, 84(1) (2019) 93-122. https://doi.org/10.1111/ruso.12215
29. A. Y. Hoekstra, A. K. Chapagain, Water footprints of nations: water use by people as a function of their consumption pattern. In *Integrated assessment of water resources and global change,* (2006) 35-48. https://doi.org/10.1007/978-1-4020-5591-1_3
30. S. Madhav, A. Ahamad, A. K. Singh, J. Kushawaha, J. S. Chauhan, S. Sharma, P. Singh, Water pollutants: sources and impact on the environment and human health. In *Sensors in Water Pollutants Monitoring: Role of Material,* 4 (2020) 43-62. doi.org/10.1007/978-981-15-0671-0_4
31. K.R. Abhilash, R. Sankar, R. Purvaja, S. V. Deepak, C. R. Sreeraj, P. Krishnan, R. Ramesh, Impact of long-term seaweed farming on water quality: a case study from Palk Bay, India. *Journal of Coastal Conservation*, 23 (2019) 485-499. doi.org/10.1007/s11852-018-00678-4
32. M. W. Beutel, R. Duvil, F. J. Cubas, D. A. Matthews, F. M. Wilhelm, T. J. Grizzard, S. Gebremariam, A review of managed nitrate addition to enhance surface water quality. *Critical reviews in environmental science and technology*, 46 (2016) 673-700. https://doi.org/10.1080/10643389.2016.1151243
33. X. Zhang, Y. Zhang, P. Shi, Z. Bi, Z. Shan, L. Ren, The deep challenge of nitrate pollution in river water of China. *Science of the Total Environment,* (2021). https://doi.org/10.1016/j.scitotenv.2020.144674.
34. Y. Kawagoshi, Y. Suenaga, N. L. Chi, T. Hama, H. Ito, L. Van Duc, Understanding nitrate contamination based on the relationship between changes in groundwater levels and changes in water quality with precipitation fluctuations. *Science of the Total Environment*, 657 (2019) 146-153. https://doi.org/10.1016/j.scitotenv.2018.12.041
35. E. K. Zimmerman, J. C. Tyndall, L. A. Schulte, G. L. D. Larsen, (2019). Farmer and Farmland Owner Views on Spatial Targeting for Soil Conservation and Water Quality. *Water Resources Research*, 4(1) (2019) 45-65. https://doi.org/10.1029/2018WR023230
36. A. R. Quisumbing, E. M. Payongayong, K. Otsuka, *Are Wealth Transfers Biased Against Girls? Gender Differences in Land Inheritance and Schooling Investment in Ghana's Western Region*. 583 (2004) 2016-3969. 10.22004/ag.econ.60311
37. P. M. Chronopoulou, G. O. Sanni, D. I. Silas-Olu, J. R. van der Meer, K. N. Timmis, C. P. Brussaard, T. J. McGenity, Generalist hydrocarbon-degrading bacterial communities in the oil-polluted water column of the N orth S ea. *Microbial biotechnology*, 8 (2015) 434-447. https://doi.org/10.1111/1751-7915.12176
38. R. Rai, S. Sharma, D.B. Gurung, B.K. Sitaula, R.D.T. Shah, Assessing the impacts of vehicle wash wastewater on surface water quality through physico-chemical and benthic macroinvertebrate analyses. *Water Science*, 34 (2020) 39-49. https://doi.org/10.1080/11104929.2020.1731136.
39. I. Monney, E.A. Donkor, R. Buamah, Clean vehicles, polluted waters: empirical estimates of water consumption and pollution loads of the car wash industry. *Heliyon*, 6(2020) eo3952. https://doi.org/10.1016/j.heliyon.2020.e03952.

40. A. Bayat, S. F. Aghamiri, A. Moheb, G. R. Vakili-Nezhaad, Oil spill cleanup from seawater by sorbent materials. *Chemical Engineering and Technology: Industrial Chemistry-Plant Equipment-Process Engineering-Biotechnology*, 28 (2005) 1525-1528. doi.org/10.1002/ceat.200407083
41. L. C. Osuji, C. M. Onojake, Trace heavy metals associated with crude oil: A case study of Ebocha-8 Oil-spill-polluted site in Niger Delta, Nigeria. *Chemistry and biodiversity*, 1 (2004) 1708-1715. https://doi.org/10.1002/cbdv.200490129
42. S. Kundu, M. V. Coumar, S. Rajendiran, A. Rao, A. S. Rao, Phosphates from detergents and eutrophication of surface water ecosystem in India. *Current science*, (2015) 1320-1325. https://www.jstor.org/stable/24905495
43. M.O. Adadu, J. Ochogwu, Acute toxicity of detergent on juveniles of African Catfish (*Clarias gariepinus*). *International Journal of Fisheries and Aquatic Studies*, 38 (2020) 38-43.
44. A. A. Adesuyi, V. C. Nnodu, K. L. Njoku, A. Jolaoso, Nitrate and Phosphate Pollution in Surface Water of Nwaja Creek, Port Harcourt, Niger Delta, Nigeria. *International Journal of Geology, Agriculture and Environmental Sciences*, 3 (2015) 14-20. 10.4236/gep.2016.41002
45. Y. Sun, N. Liu, J. Shang, J. Zhang, Sustainable utilization of water resources in China: A system dynamics model, *Journal of cleaner production*, 142 (2017) 613-625. https://doi.org/10.1016/j.jclepro.2016.07.110
46. S. Swanson, D. Kozlowski, R. Hall, D. Heggem, and J. Lin, Riparian proper functioning condition assessment to improve watershed management for water quality. *Journal of soil and water conservation*, 72 (2017) 168-182. https://doi.org/10.2489/jswc.72.2.168.
47. M.R. Fernandes, J.C. Franco, N. Pettit, A.P. Portela, O. Tammeorg, P. Tammeorg, P.M. Rodriguez-Gonzalez, S. Dufuor, Global overview of ecosystem services provided by riparian vegetation. *BioScience,* 70 (2020) 501-514. https://doi.org/10.1093/biosci/biaa041
48. N. M. Connolly, R. G. Pearson, D. Loong, M. Maughan, J. Brodie, Water quality variation along streams with similar agricultural development but contrasting riparian vegetation. *Agriculture, ecosystems and environment*, 213 (2015) 11-20. https://doi.org/10.1016/j.agee.2015.07.00
49. J. N. Halder, M. N. Islam, Water pollution and its impact on the human health. *Journal of environment and human*, 2 (2015) 36-46. DOI: 10.15764/EH.2015.01005
50. T. Panayotou, Economic growth and the environment. *The environment in anthropology*, (2016) 140-148. https://doi.org/10.1080/13504501003787638
51. Y. Wen, G. Schoups, N. Van De Giesen, Organic pollution of rivers: Combined threats of urbanization, livestock farming and global climate change. *Scientific reports*, 7 (2017) 43-89. https://doi.org/10.1038/srep43289

(2021) ; http://www.jmaterenvironsci.com