Environment Pollution and Climate Change

Sheriff and Koske. Environ Pollut Climate Change 2021, 5:3

Research Article | Open Access

Low Environmental Education: The Cause to High Socioeconomic Impacts of Climate Change Induced Flooding in Mombasa, Kenya

Salia S. Sheriff[1,2]* and James Koske[2]

[1]Department of Environmental Health and Biology, School of Environmental Studies, University of Eldoret, Eldoret, Kenya
[2]Department of Environmental Science and Education, Kenyatta University, Nairobi, Kenya

Abstract

Climate variability and change affect many coastal settlements, islands and lowland countries as result of sea level rise (SLR). Mombasa, an island is a coastal settlement in Kenya coastal region with inhabitants of about 1.2 million. It hosts East Africa's largest seaport. It is a major tourist destination along the Indian Ocean. As a coastal settlement, Mombasa had experienced several flooding in past decades due to climate variability and change. Its increasing population and fast urbanization have exposed the area to flood related hazards. Consequently, three mostly flooded towns: Kisauni, Nyali and Changamwe in Mombasa were surveyed to access the role of indigenous knowledge in mitigating climate change induced flooding impacts on human settlements and livelihoods and to enhance adaptation. The study used binary logistic regression (BLR). Primary data were obtained using open ended questionnaire randomly amongst residents using Likert IQ scale. Secondary metrological data were obtained from the Kenya Metrological Department. It was found that low environmental education and climate change awareness on sea level rise are the main reasons for low community preparedness and less adaptation plans. Also, tourism and commercial activities contribute to the lower local community's efforts to climate change adaptation action plan. It can be concluded that in order to achieve national efforts to mitigate impacts and enhance boost climate change adaptation and resilience in Mombasa, local and national governments and their including partners ought to excite more supports to Kenya's National Adaptation Action Plans by increasing science based environmental education, public awareness and integrating county specific climate change adaptation polices into national education system and construction framework that provides sustainable alternatives to overreliance of sea wall to protect Fort Jesus and other historic and tourist attraction sites naturally based resources and enhance conservation.

Keywords: Climate change; Flooding; Sea level rise, Adaptation and mitigation

Introduction

Climate change, a phenomenon attributed critically to human activities resulting to emission of greenhouse gas that alters global mean temperature and its momentous impacts on local and global climate systems that drive lives [1]. Despites the many national and international climate sensitive policies, resolutions, and aggressive industrial switch-green revolution, the targeted 20 C in reduction mean global temperature towards minimizing impacts of climate change seem unlikely [2]. Although mitigation of greenhouse gas (GHG) is highly required to reduce increasing global warming impacts, but the present sea level rise trend will continue to the next century as result of previous emissions [3]. It's predicted that by 2100, the probable impacts of climate change projects will occur concurrently if global emission trend is cut by thrice its present level [4].

There are several studies and reports on Sea Level Rise and its impacts on coastal communities as result of climate change and climate variability. It is predicted that the impacts of sea level rise due to climate variability in coastal Kenya using simulation and digital elevation model (DEM) will be high. It's estimated that by 2050, about 577,000 people within low lying coastal areas including assets worth of $5.8 billion will be exposed [5].

Though coastal zone provides enormous ecosystem services and attracts high inflow of people; though, they may be exposed to climate change induced flooding-sea level rise (SLR) [6]. Global efforts are required to mitigate impacts of flooding, particularly in lowland coastal settlements [7]. Impacts of coastal flooding and adaptation costs as result of SL in this 21th century are evaluated universally in view of varying continental data, demography, adaptation approaches and socioeconomic development [8]. The impacts vary according to local climate, geology and anthropogenic activities. In many parts of Africa, owing to low advances in technology and under-capacity institutions, there is little data on climate variability, climate change and SLR [9,10] Increasing mitigation measures and adapting to climate change will increasingly reduce impacts of climate-induced flooding and restore climate stability [11].

In coastal areas, climate change related flood impacts could be pronounced as result of SLR. This increases probability of property damage due to inundation, erosion, high waves, loss of beaches and recreation centers including ecologically important wetlands [12]. Further impacts include damage of public infrastructures such as wastewater treatment facilities, low-lying roads, piers/ports, and facilities located on coastal bluffs. Combined efforts are needed to mitigate these climate related impacts. This includes but not limited to: risks management, access to adequate climate data and information, sizable human resource, advanced technology, and finances [13]. In Kenya, increased mean air and sea temperature, sea level rise and extreme weathers are amongst the projected impacts of climate change

***Corresponding author:** Salia S. Sheriff, Teaching and Research Assistant, Department of Environmental Health and Biology, School of Environmental Studies, University of Eldoret, P.O. Box 1125-30100 Eldoret, Kenya, Tel: +254 713-106577 or +231 776-671-005; E-mail: sheriffsalia@gmail.com, s.salia99@yahoo.com

Received February 20, 2021; **Accepted** March 10, 2021; **Published** March 15, 2021

Citation: Sheriff SS, Koske J (2021) Low Environmental Education: The Cause to High Socioeconomic Impacts of Climate Change Induced Flooding in Mombasa, Kenya. Environ Pollut Climate Change. 5: 208.

and variability; these projections have begun impacting socioeconomic strata and the national environment [14]. Increase in sea surface temperature and marine biological invasion such as invasive species and harmful algal blooms affect coral reef ecosystem. Consequently, this would negatively impact the livelihoods of millions of people in the coastal region who are dependent on that ecosystem for food, income, and shoreline defense.

Notwithstanding, understanding (sound environmental education) of localized anthropogenic activities and climate change is key to formulating climate change resilience, adaption and mitigation measures for local communities in coastal areas [15]. Review has made known that climate change education is paramount to the developments of effective intervention measures [16]. Outbreak of infectious diseases, flashing flood and increase in cost of basic commodities would more be pronounced due migration of people in informal coastal settlements in sub-Saharan in Africa [17]. In Kenya, study showed that Integrated Coastal Management (ICM) policy tailored from the National Adaptation Plan (NAP) is gapped in some counties including human capacity gap, financial stress and limited access to climate change information [18]. As supported by this study, other studies [19-22]. The sound environmental knowledge, governance and management (environmental education) are principal tools to climate change adaptation and mitigation.

Methodology

The study was conducted in five wards: Junda, Bamburi, Magongo, Kisimani and Port Reitz within three constituencies of Kisauni, Nyali and Changamwe all in Mombasa County, Kenya. Structured and semi-structured questionnaire were administered to assess level of awareness and environmental education amongst permanent residents of Mombasa on climate variability and change .Three hundred seventy-one (371) respondents were interviewed, i.e., 99, 59, 66, 69, and 74 in Junda, Bamburi, Magongo, Kisimani, and Port Reitz, respectively. The sample was determined using Yamane equation [23].

$$n = \frac{N}{[1 + N^{*}(e)^{2}]}$$

Where n =the sample size, N=the population size and e=the acceptable sampling error and *95% confidence level, P=0.05 assumed. Secondary climate data were obtained from Kenya Metrological Department Mombasa substation, Moi International Airport. The data was used to correlate with primary field data using SPSS, version 23.0 [24]. One hundred ninety-nine females, 54% and one hundred seventy-two males, 46%, including heads of family and household participated views were evaluated (Table 1).

Binary Logistic Regression (BLR) was used to test the hypothesis to ascertain statistical significance of variables [25]. For example, BLR model for role environmental education to indigenous knowledge of flood prediction/forecast

$$\ln\left(\frac{p}{1-p}\right) = (-1.836) + B_2 X_2$$

Where, P is the probability of the chance/event (Environmental Education), (1-P) is the probability of either of the chances, B2 is the constant for role of environmental education and X2 is the role of environmental education variable. In this model, the H1 (alternative hypothesis) that low environmental education significantly influences indigenous' means to mitigate and adapt to flooding and climate variability and change was statistically significant, P-value < 0.05 (Table 2.). Correspondingly, at least one independent variable was statistically significant, hence, H1 was accepted. From Equation 1, the constant for the above case was -0.312. Statistical significance of Wald's test of likelihood was used [26].

Results

As shown in (Figure. 1) below, there were 371 respondents, 54% females and 46% males; 50% adults and 44% youth. It was found that 21% and 74% of participants completed primary education and beyond respectively. Of these, 69% has household size of 1 to 5 persons; 54% are formerly employed in public and private sectors; while 44% are involved in agriculture, low capital-intensive business and tourism.

In spite of the level of former education amongst respondents, it was found that there is low environmental education and awareness on climate change-induced flooding (Figure. 2) This could be as result of dependence on unscientific climate forecasting by local/indigenous means that is profoundly infiltrated by urbanization and influx of people interfering with local climate indicators. In addition, there is also interference with intense socioeconomic activities, tourism and port commerce. Similarly, there is low community awareness on climate change and related impacts and consequently lower community adaptation plan except through government (Figure. 3) Hence, disturbing socioeconomic impacts of climate change-induced flooding and sea level rise is very likely on residents' income and livelihoods.

Gender	Ward					Total	Percent
	Junda	Bamburi	Magogoni	Kisimani	Port Reitz		
Female	54	31	35	39	40	199	53.64
Male	46	29	32	31	34	172	46.36
Total	100	60	67	70	74	371	100

Table 1: Gender Summary of study participants.

How do you know when it will flood?	Ward					Total	P (%)
	Junda	Bamburi	Magogoni	Kisimani	Port Reitz		
Experience	12	20	15	27	21	95	25.60
Observation	8	6	7	17	7	45	12.12
KMD	17	10	3	8	4	42	11.32
Barazza	41	11	1	7	2	62	16.71
Media (Radio/TV)	22	13	41	11	40	127	34.23
Total	100	60	67	70	74	371	100.00

Table 2: Respondents' ability to predict occurrence of flooding in their communities.

Figure 1: Participants chart: sex, education and age group distribution.

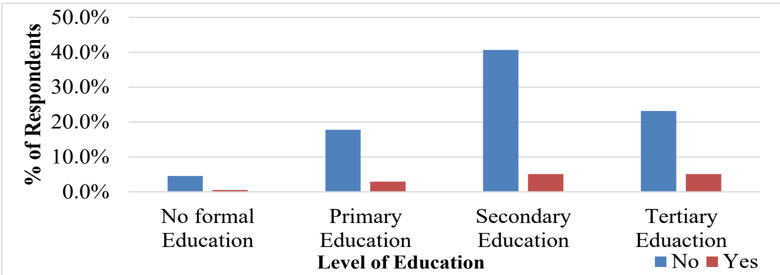

Figure 2: Levels of formal education of respondents: No formal education, Primary education, Secondary education and Tertiary education.

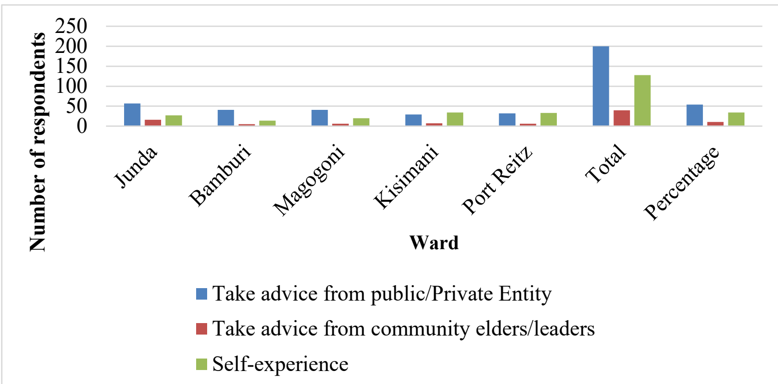

Figure 3: Community awareness and sources of information on Climate Change.

Discussion

Mitigating and adapting to climate change induced flooding impacts depends on crucial environmental education and awareness through timely scientific weather forecasts [27]. It has been reported that many disaster prevention and mitigation policies rarely address gender, [28] while women are more likely to have higher consequences [29]. Thus, formal levels of education of respondents were accessed (Figure. 4) more females, 54% participated than men, 46%.

Despite the level of formal education of respondents (Figure. 5) 38% of participants still depend on local indigenous knowledge and observation, while 34%, depend on weather forecasts on televisions and radios (Table 3). Others depend on Baraza (palaver hut discussion); hence, many depend on local indigenous knowledge and personal experience to forecast weather as agreed by Adebayo K et al. that is basic observation and experience of rural settlers increase their knowledge about flooding [30]. However, the growing portability of media devices and their accessibility is increasing information dissemination digitally.

Citation: Sheriff SS, Koske J (2021) Low Environmental Education: The Cause to High Socioeconomic Impacts of Climate Change Induced Flooding in Mombasa, Kenya. Environ Pollut Climate Change. 5: 208.

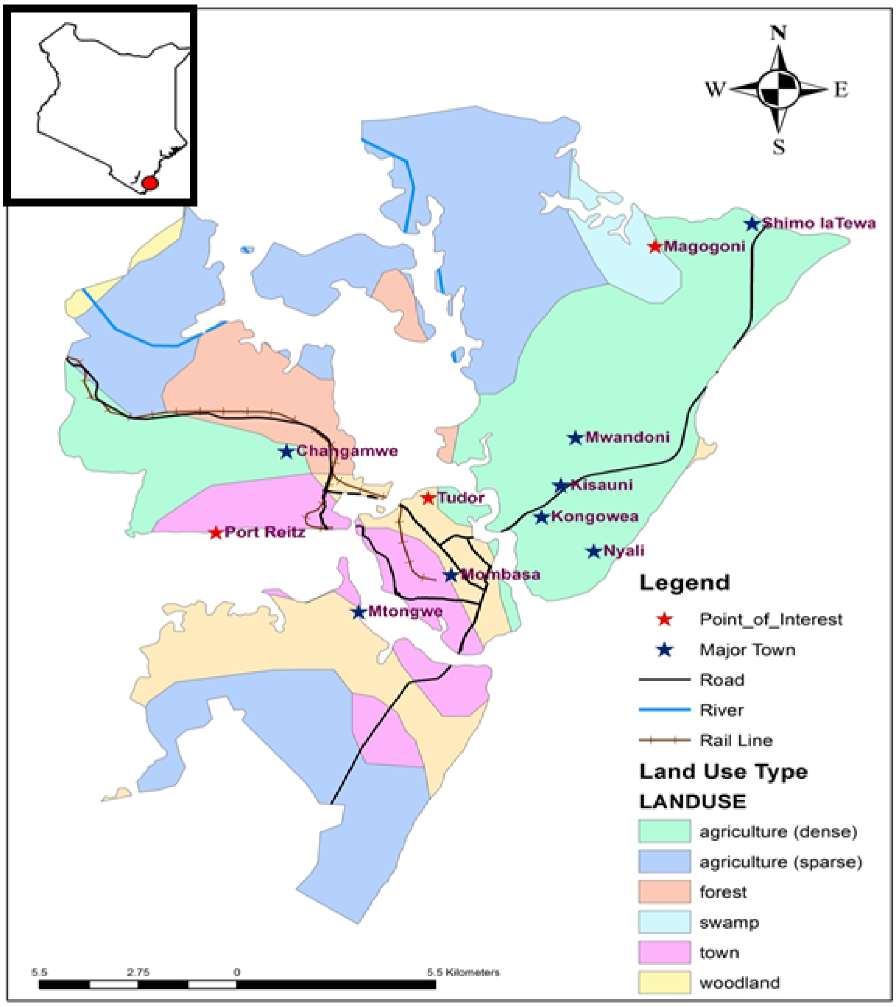

Figure 4: Study Area map showing the administrative areas and sampled communities, Ministry of Mining, Kenya, 2012.

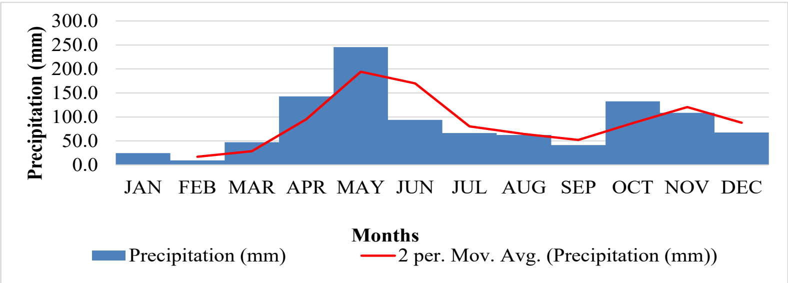

Figure 5: Monthly Rainfall (1986-2014) Average, Kenya Metrological Department, Mombasa substation, Moi International Airport, Kenya; KMD, 2017.

Reliability of prediction	Ward					Total	P (%)
	Junda	Bamburi	Magogoni	Kisi-mani	Port Reitz		
Not Reliable	1	18	10	30	8	67	18.05
Less Reliable	16	18	37	26	44	141	38.00
More Reliable	37	21	15	11	18	102	27.49
Most Reliable	46	3	5	3	4	61	16.44
Total	100	60	67	70	74	371	100.00

Table 3: Reliability of respondents' prediction on the occurrence of flooding in their communities.

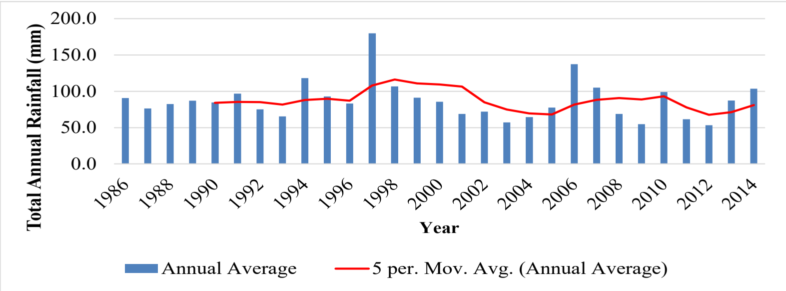

Figure 6: Total annual Rainfall in millimeter (1986-2014), Kenya Metrological Department, Mombasa substation, Moi International Airport, Kenya; KMD, 2017.

		B	S.E.	Wald	Df	Sig.	Exp-B
Step	Constant	-1.836	0.151	148.363	1	0.000	0.159

Table 4: Dependent variable for the role of low environmental education to in flood predict, mitigate and adapt to climate induced flooding.

As stated above, low environmental education and climate change awareness as well as loss of local settlements (indigenous communities) to urbanization, knowledge on climate variability and change has expressively reduced amongst locals resulting to inconsistent predictions of flood and its related environmental hazards (Table 4). This shows that individual's experience and observation are not dependable. This is consistent with that notable past flood events are mostly factors individuals use to predict future flood occurrence but such prediction may not specify the extent and magnitudes of floods they had experienced [31]. Accordingly, irregular rainfall patterns shown in KMD data (Figure. 6) support our finding that locals' prediction may be unreliable as the changing climate brings newer flood experiences. This validates finding of World -Wide Fund for Nature that long wet season contributes more annual precipitation than short wet season in East Africa attributable to agriculture, deforestation, beach sand mining, overfishing, and grazing. These anthropogenic activities interfere with indigenous knowledge system of environmental changes as reported by that precision of flood prediction by local communities has reduced due to vulnerability to climate change [32].

It was found also that females have lower indigenous knowledge on flood prevention and mitigation compared to their male counterparts, 47% and 53%, respectively; this has been reported in other studies, that women's ability to respond to flood is lower compared to men and their capacity to participate in flood management is low [33-36].

Likewise, many adults, 44% lack evidence of indigenous knowledge to predict and mitigate flood compared to youth, 37%; and yet 7% of youth have indigenous knowledge on flood prediction and mitigation measures than adults, 6% and vice versa. Notwithstanding, more adults (50 years and above) were targeted by this study, considering that long life comes with more experience and understanding of indigeneity. But this study found the contrary, however, it agrees with that indigenous knowledge lacks accountability within communities; and disagrees with that the lack of accountability is prevalent among the youth [37]. Also, 54% of participants believed lack of fitting drainage system, weak enforcement of zoning laws and poor waste management are the principal causes of flooding contrary to sea level rise and its associated factors. This finding confirms studies by Brody et al. and Douglas et al that high precipitation causes flooding; nonetheless, fast urbanization and poor environmental planning adversely facilitate occurrence and severity of flooding.

Conclusion

In effect, climate variability and change occur in Mombasa as evidenced by KMD rainfall data. High precipitation and sea level rise are significantly contributing to flooding in the study communities. Low environmental education, climate change awareness and unempirical weather forecast increase socioeconomic impacts of climate-induced flooding and as well lower climate change mitigation and adaptation efforts.change and variability occur in Mombasa. It has been, to some extend manifested by rising sea levels contributing to flooding. Anthropogenic activities and low climate knowledge are the fulcrum to the observable impacts. Hence, more attentions are needed to locally achievable policy drive and framework that supports the NAP and other global efforts. The framework must address sustainable alternatives to coastal socioeconomic reliance such as tourism, fishing and urbanization. Immediate interventions may include county specific climate-framework; nationalization of climate-based science education and improve local communities' resilience through conservation of non-renewable coastal resources.

Acknowledgement

The contributions and support of Dr. James Koske, Dean and other staff and students, Department of Environmental Studies, Kenyatta University, Kenya; & ArcelorMittal Liberia (AML) Incorporated for the postgraduate scholarship and sponsorship are hereby acknowledged.

References

1. Urry J (2015) Climate change and society. In Why the social sciences matter: Springer 45-59.
2. Nissan H, Goddard L, De Perez EC, Furlow J, Baethgen W, et al. (2019) On the use and misuse of climate change projections in international development. 10: 579.
3. Horton R, Little C, Gornitz V, Bader D, Oppenheimer MJA (2015) New York City panel on climate change 2015 report chapter 2: Sea level rise and coastal storms. 1336: 36-44.
4. Mora C, Spirandelli D, Franklin EC, Lynham J, Kantar MB, et al. (2018) Broad threat to humanity from cumulative climate hazards intensified by greenhouse gas emissions. 8: 1062-71.
5. Kebede AS, Hanson K, Nicholls RJ, Mokrech M (2009) Impacts of climate Change and sealevel rise; A case study of Mombasa, Kenya. School of Civil Engineering and the Environment University of Southampton, Southampton, SO17 1BJ, UK.
6. Kirwan ML, Megonigal P (2013) Tidal Wetlands Stability in the face of Human impacts and Sea-Level-Rise. Nature 504: 53-60.

7. McGranahan G, Blak D, Anderson B (2007) The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. Environment and Urbanisation 19: 17-37.

8. Hinkel J, Lincke D, Vafeidis AT, Perrette M, James R, et al. (2014) Coastal flood damage and adaptation costs under 21st century sea-level rise 111: 3292–7.

9. Zinyowera MC, Jallow BP, Maya RS, OkothOgendo HWO, Awosika LF, et al. (1998) Africa. In: Watson RT, Zinyowera MC, Moss RH (Editors) The Regional Impacts of Climate Change: An Assessment of Vulnerability, A Special Report of IPCC Working Group II, Cambridge University Press: Cambridge, UK, 517.

10. Brown S, Kebede AS, Nicholls RJ (2009) Sea Level Rise and Impacts in Africa, 2000-2100. Unpublished report to Stockholm Environment Institute Oxford 215.

11. Stein BA, Staudt A, Cross MS, Dubois NA, Enquist C, et al. (2013) Preparing for and managing change: climate adaptation for biodiversity and ecosystems. Frontiers in Ecology and the Environment 11: 502-10.

12. Heberger M, Cooley H, Herrera P, Gleick P, Moore E (2009) The Impacts of Sea- Level Rise on the California Coast, prepared by the Pacific Institute for the California Climate Change Center.

13. Hellmuth ME, Moorhead A, Thomson MC, Williams J Eds (2007) Climate risk management in Africa: Learning from practice. New York, NY, USA: International Research Institute for Climate and Society, Columbia University.

14. Government of Kenya (2015) Second National Communication to the United Nations Framework Convention on Climate Change; National Environment Management Authority (NEMA), Republic of Kenya.

15. He Q, Silliman BR (2019) Climate change, human impacts, and coastal ecosystems in the Anthropocene. 29: R1021-35 .

16. Monroe MC, Plate RR, Oxarart A, Bowers A, Chaves WA (2019) Identifying effective climate change education strategies: a systematic review of the research. 25: 791-812.

17. Serdeczny O, Adams S, Baarsch F, Coumou D, Robinson A, et al. (2017) Climate change impacts in Sub-Saharan Africa: from physical changes to their social repercussions. 17: 1585-1600.

18. Ojwang L, Rosendo S, Celliers L, Obura D, Muiti A, et al. (2017) Assessment of coastal governance for climate change adaptation in Kenya. 5: 1119-32.

19. Awuor CB, Orindi VA, Ochieng Adwera AJE (2008) Climate change and coastal cities: the case of Mombasa, Kenya. 20: 231-42.

20. Dodman D, Bicknell J, Satterthwaite D (2012) Adapting cities to climate change: understanding and addressing the development challenges: Routledge.

21. Kebede AS, Nicholls RJ, Hanson S, Mokrech M (2012) Impacts of climate change and sea-level rise: a preliminary case study of Mombasa, Kenya. J. of Coastal Research 28: 8-19.

22. Mwaguni S, Munga D, (2010) Integrated Coastal Zone Management: Action Plan for Kenya.

23. Yamane T (1967) Statistics, An Introductory Analysis, 2nd edition, New York, NY, USA.

24. George D, Mallery P (2016) IBM SPSS statistics 23 step by step: A simple guide and reference.

25. Midi H, Sarkar KS, Rana S (2010) Collinearity diagnostics of binary regression models. Journal of Interdisciplinary Mathematics 13: 253-67.

26. Bertsimas D, King AJ, (2017) Logistic regression: From art to science. 367-84.

27. Yang L, Scheffran J, Qin H, You Q (2015) Climate-related flood risks and urban responses in the Pearl River Delta, China. Regional Environmental Change 15: 379-91.

28. UNISDR (2012) A Study of the Integration of the Issues of Vulnerable Groups with Special Focus on Gender in the Implementation of the Hyogo Framework for Action (2005-2015) in Asia Pacific.

29. UNDP (2013) Gender and Climate Change: Asia and The Pacific Policy Brief. United Nations Development Programme Newyork US.

30. Adebayo K, Dauda TO, Rikko LS, George FOA, Fashola OS, et al. (2011) Emerging and Indigenous Technology for Climate Change Adaptation in Southwest Nigeria. Research Paper African Technology Policy Studies Network (ATPS) Nairobi, Kenya.

31. Slovic P, Fischhoff B, Lichtenstein S (1979) Rating the Risks. Environment 21: 14-39.

32. Awuor Salick J, Byg A (2007) Indigenous peoples and climate change.

33. Wiest RE, Mocellin JSP, Motsisi DT (1994) The needs of women in disasters and emergencies. Winnipeg: University of Manitoba 92.

34. Cannon T (2000) Vulnerability analysis in disasters. In Parker D ed Floods London: Routledge 43-55.

35. Few R, Ahern M, Matthies F, Kovats S (2004) Floods health and climate change: A strategic review, Tyndall Centre 63.

36. Bhatti A (2001) Risk perception, culture and communication: South Asian Experience

37. In Bhatta BR, Chalise SR, Myint AK, Sharma PN (1999) Rehabilitation of degraded lands. eds. Recent concepts, knowledge, practices and new skills in participatory integrated watershed management. Kathmandu: Participatory Watershed Management Training in Asia PWMTA: 51-68.