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Geospatial Technology for Identification of the "Far Behind" in Attaining SDGs 13, 14 and 15

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Abstract

SDGs are founded on the objective of promotion of even development at both local and international levels after the realization that a significant population is very poor who are termed "left behind". Thus, there is need to identify "those left behind" and "those far behind" for prioritization in attaining SDGs No 13 (Climate action), No. 14 (Life below water) and No. 15 (Life on land) in Kenya. This paper proposes the use of geospatial technology to identify those left behind, and their distribution within a geographical setting. Landscape analysis of Tindiret in Nandi County was conducted to identify areas of high risk to land degradation and establish the number of households within this area. Further, biomass production trend in Kenyan ASALs was analysed from 2001–2015. The landscape analysis showed that 84.5% of the residents live on 76.0% of the land with a slope of 12–55%, where soil and water conservation measures are a requirement. Those in steep slopes of more than 55% constitute 7.7% of the households living on 16.0% of the area where no farming is allowed. The ASALs biomass production analysis showed that 35.20% of the area where 31.22% of the population live experienced a declining trend. The analysis identified those far behind, including where they are located. The research recommends that for successful application of geospatial technology in identifying those left behind, capture and inclusion of; socio-economic data, environmental quality, types of pollutants, agricultural activities, climate impacts and actions, in spatial context, is necessary.

Keywords: Assessment, Far behind, Geospatial technology, Sustainable development goals.

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INTRODUCTION

The acknowledgement of the need for a common development agenda across the globe for the current and future generations led to the conception of Millennium Development Goals (MDGs) (UN, 2000), which later transformed to Sustainable Development Goals (SDGs) (UN, 2015). These concepts were necessitated by the need to shift development patterns from a sectorial to multi-sectorial form. The SDGs are 17 in total, with 169 targets covering all aspects of nature and human development. They were adopted by 193 nations across the world at the UN General Assembly Summit in September 2015, as a part of their agenda for Sustainable Development (UN, 2015).

The aims of the SDGs are to build a prosperous, equal and more secure world by the year 2030. The SDGs took effect from first January 2016. With the adoption of the 2030 Agenda for Sustainable Development, the member states pledged to ensure that 'no one will be left behind' and to 'endeavour to reach the furthest behind first' (UN, 2015). Its actualization requires concerted effort by all to end extreme poverty, curb inequalities, confront discrimination and expedite progress for the furthest behind (UN, 2015).

The implementation of the 'Leaving No One Behind' pledge recognises that some member states are more developed and enjoy better living standards compared to others (UNSDG, 2020), and are very instrumental in the pushing forward the SDGs agenda. To put into

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effect the pledge, the signatory countries agreed to act in unison and to shift the direction of human progress to enable all people to realise their full potential by the year 2030 (UNDP, 2018). In pledging to leave no one behind, the member states understood that inequalities and acute deprivation will decrease by giving priority and fast-tracking government policies and investments to the furthest behind. According to UNDP (2018), people get left behind when they lack the choices and opportunities to participate in, and benefit from, development progress. All persons living in extreme poverty can thus be considered 'left behind', as can those who endure disadvantages or deprivations that limit their choices and opportunities relative to others in society'.

Kenya is a signatory to this summit and is strongly committed to the 2030 agenda, as indicated by various initiatives and strategies it has undertaken, such as the Vision 2030 Development Policy Blueprint. Just like any other country, development within Kenya is not even. With a population of 47.5 million in 2019 (KNBS, 2019) and a poverty rate of 36.1% in 2015 (KIPPRA, 2020), it means that a significant population is still 'far behind' and is left out in matters development. To target those left behind and those far behind in relation to the three SDGs, it is prudent to not only identify where they are, but also answer the question "How many are they?"

This paper demonstrates the use of geospatial technology in identifying the geographical distribution of those left behind in attaining SDGs No. 13 (Climate action), No. 14 (Life below water) and No. 15 (Life on land) in Kenya.

THEORY

Sustainable Development Goal 13 - Climate Action: Take urgent action to combat climate change and its impacts

Climate change and variability is real and presents the biggest challenge to all forms of development; including health, agriculture, and infrastructure, across the world. Both developed and developing countries are experiencing climate change and variability related impacts indiscriminately. Widespread droughts have been reported in the eastern Africa regions (Oxfam International, 2006), floods have caused destruction of property in Kenya, affecting 5% of the population (UNEP, 2009), and over 70,000 people in Europe and 56,000 in Russia, in 2003 and 2010 respectively, died due to heat waves (Grumm, 2011). Thus, the main focus of this SDG is building and strengthening resilience; developing of adaptive capacity to climate change impacts and natural disasters in all countries; and integration of climate change measures into national policies, strategies and planning. The goal targets the implementation of scalable and affordable means of fighting the causes of climate change (UN, 2015).

Sustainable Development Goal 14 - Life Below Water: Conserve and sustainably use the oceans, seas, and marine resources for sustainable development

Life in water is directly influenced by the quality of water in that water body, which is maintained by the entire ecosystem. The introduction of human activities influences water quality in the same magnitude and, in most cases, leads to degradation of water quality. Edokpayi (2016), pointed out that eutrophication increases turbidity of the water; plants and animals' biomass increase nutrients; and sedimentation rate is increased by farming and deforestation, and anoxic conditions may develop. This change in water quality could give rise to change in dominant species of the aquatic biota, thereby decreasing biodiversity (Li et al., 2009). SDG 14 emphasis is on prevention and significant reduction of all kinds of marine pollution, in particular from land-based activities, including marine debris and nutrient pollution; and sustainably managing and protecting marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration to achieve healthy and productive oceans. In 2010, significant portions of the human population (37%) lived in coastal areas, and directly depend on oceans, coastal and marine resources (UN, 2015). The ecosystem interconnections and interdependence between the terrestrial and aquatic ecosystems informed SDG 14 structuring to aim at enhancing the conservation and sustainable use of the oceans, seas, and marine resources for sustainable development.

Sustainable Development Goal 15 - Life on Land: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Land is an integral part of the ecosystem and supports both biotic and abiotic components of the environment. Animals on land are dependent on vegetation, whose quality and quantity is influenced by soil type, land characteristics and climate (Santi et al., 2010). Kenya's dependence on life on land, in form of wildlife for tourism and pastoralism, makes significant contribution to GDP. Tourism generated Ksh 96.02 billion in 2012 (KIPPRA, 2013), while livestock contribution was 10% of the GDP in the same year. A major concern in this sector is that land degradation risk is very high. Analysis by ROK (2016), showed that 27.2% of Kenya's land in the arid and semi-arid lands (ASALs) is at very high risk of degradation. Human activities are responsible for a bigger percentage of habitats and ecosystems destruction, thereby eroding the ecosystem's ability to support life (Wong et al., 2015). The loss of land cover sets off negative chain reactions, among them being soil erosion, land degradation, aquatic ecosystems pollution and general loss of biodiversity (Pejchar and Mooney, 2009). This goal has a target of protecting, restoring, and promoting sustainable use of terrestrial ecosystems, which include the management of forests through combating acts such as deforestation and desertification (UN, 2015).

The Pledge to "Leave No One Behind"

The main aim of the 2030 Agenda for Sustainable Development is to accomplish even development for all, with priority given to those in extreme poverty. The Member States pledged to ensure that no one will be left behind and to endeavour to reach the furthest behind first (UN, 2020). This pledge means taking deliberate action to end extreme poverty and all forms of discrimation in the society, and priority given to those most left behind (UN, 2015). The foremost and critical starting point is to conduct a comprehensive baseline survey which will answer the vital questions of who is left behind, where are those left behind and how can they be included in sustainable development. Bond (2018), identified ten principles of leave no one behind to be: "Leave no one behind" should apply to all goals and targets, in all countries; recognise the importance of normative change; drive policy change; address multiple discriminations; climate change and environmental sustainability; accountability and governance; civil society partnerships; measures of progress; data gathering and disaggregation; and policy coherence.

The understanding of the leave no one behind pledge is the first and most critical step in ensuring SDGs' inclusivity policies. People are left behind in SDGs when they lack the choices and opportunities to participate in and benefit from the development agenda. Logically, the poor are 'left behind', as they are deprived of the power to make choices. In some cases, people's challenges intersect, compounding deprivation and reinforcing their disadvantaged positions. This situation makes the furthest behind the most likely to be affected by varied challenges. UNDP (2018), pointed out that whether or not people are left behind can be explained by one or more of the following five factors:

Discrimination: People are left behind when they experience exclusion, bias, or mistreatment in laws, policies, access to public services and social practices due to their identity (ascribed or assumed, and primarily relating to their gender, age, income, ethnicity, caste, religion, disability, sexual orientation, nationality, as well as indigenous, refugee, displaced or migratory status). Discrimination towards populations based on one or more such identities may cause a person to be left behind due to stigma, shame, discriminatory actions, and/or other human rights violations.

Geography: People live in different places governed by different laws and regulations, with different economic development levels and varied climatic conditions. People experiencing inequality are vulnerable to other disadvantaging situations, increasing vulnerability and exclusion to social and economic opportunities. Polluted environments and degraded natural resources make it challenging for people to sustain their livelihoods. Subjective development policies have marginalized some areas where no or very inferior infrastructure exists. The landscape settings, such as steep slopes, land degradation, and natural disasters, have isolated people and made them prone to setbacks. Globally, the developing countries are more needy and vulnerable to all forms of challenges such as unemployment,

extreme poverty, pollution, crime and violence, and low or no access to justice. Further, the people in rural areas are almost always left behind in terms of access to communication technology, social infrastructure, transport network, and other developments, compared to their urban areas counterparts.

Governance: The structures and processes that are designed to ensure accountability, transparency, responsiveness, the rule of law, stability, equity and inclusiveness, empowerment, and broad-based participation are not identical in different social settings, local and national governments. In reality, almost all developing countries have extremely poor governance structures, unlike the developed nations. The prevailing poor governance in developing countries locks its citizens from participating and enjoying the benefits of development.

Socio-economic status: The socio-economic status of an individual influence the level of inclusion in development. The poor faces deprivation and are disadvantaged in terms of low-income levels, low life expectancy, and low educational attainment. Their diets are poor, medication is low, are less educated, unemployment rates are very high, earn little to save, have many dependants, have poor social protection and financial services, and live in poor neighbourhoods. These conditions leave them out of development reach.

Shocks and fragility: The ability to recover after risk exposure differs with communities and countries, and is largely influenced by available contingency plans in place and allocated resources. The more resources available, the less fragile and the faster an individual or a community can recover from risks related to climate change, natural hazards, violence, conflict, displacement, health emergencies, economic downturns, price, and/or other shocks.

An objective method to identify those left behind and far behind is the application of geo-spatial technology, as the analysis is location based. Geospatial technology is a collective term used to describe a range of tools and equipment used to capture, process, analyse, model and display location-based data (Shellito, 2011). Further, this technology can model climate change and variability, identify and quantify the areas affected by climate variability, identify degraded lands, and sub-divide the population data by gender, economic status, level of education, or any other factor of interest (Shellito, 2011).

RESEARCH METHODS

The required data for spatial analysis comprised elevation, household, vegetation and climate (rainfall and temperature). The elevation data, Digital Elevation Model (DEM), was sourced from USGS Explorer, and household data extracted from Google Earth Pro (2020). The land degradation analysis used vegetation and precipitation spatial data of 2001–2015, downloaded from the USGS website: www.earlywarning.usgs.gov. The shapefiles for Kenya and the conservation areas were downloaded from World Resources Institute website: www.wri.org. The Kenya's gridded population data at sub-location administrative level was downloaded from Socio-economic Data and Application Center (SEDAC) website: http://sedac.ciesin.columbia.edu. This population data is version 4, projected to the year 2020 for the whole country. Both vegetation and rainfall data processing and analysis followed procedures described by Kigen and Muyekho (in press).

The areas of study were Tindiret in Nandi County, where landscape analysis was conducted, and the whole of Kenyan ASALs, where land biomass production trend was conducted. In this paper, the populations living in the areas with high risk of degradation due to farming, and degraded areas in the ASALs and biodiversity conservation areas (Sibiloi and Tsavo East and West National Parks) are deemed left behind and actions are needed.

RESULTS AND DISCUSSION

Potential land degradation areas in Nandi County from farming activities

The landscape analysis conducted in Tindiret showed that the total area analysed was 19.28 km^2, with 841 households (**Table 1**). The landscape slope ranged from 0-117%, with spatial distribution as indicated in **Figure 1**.

Using the integrated national land-use guidelines developed by National Environment Management Authority from Agriculture Act Cap 318, a big percentage (84.5%) of the landscape had a slope of

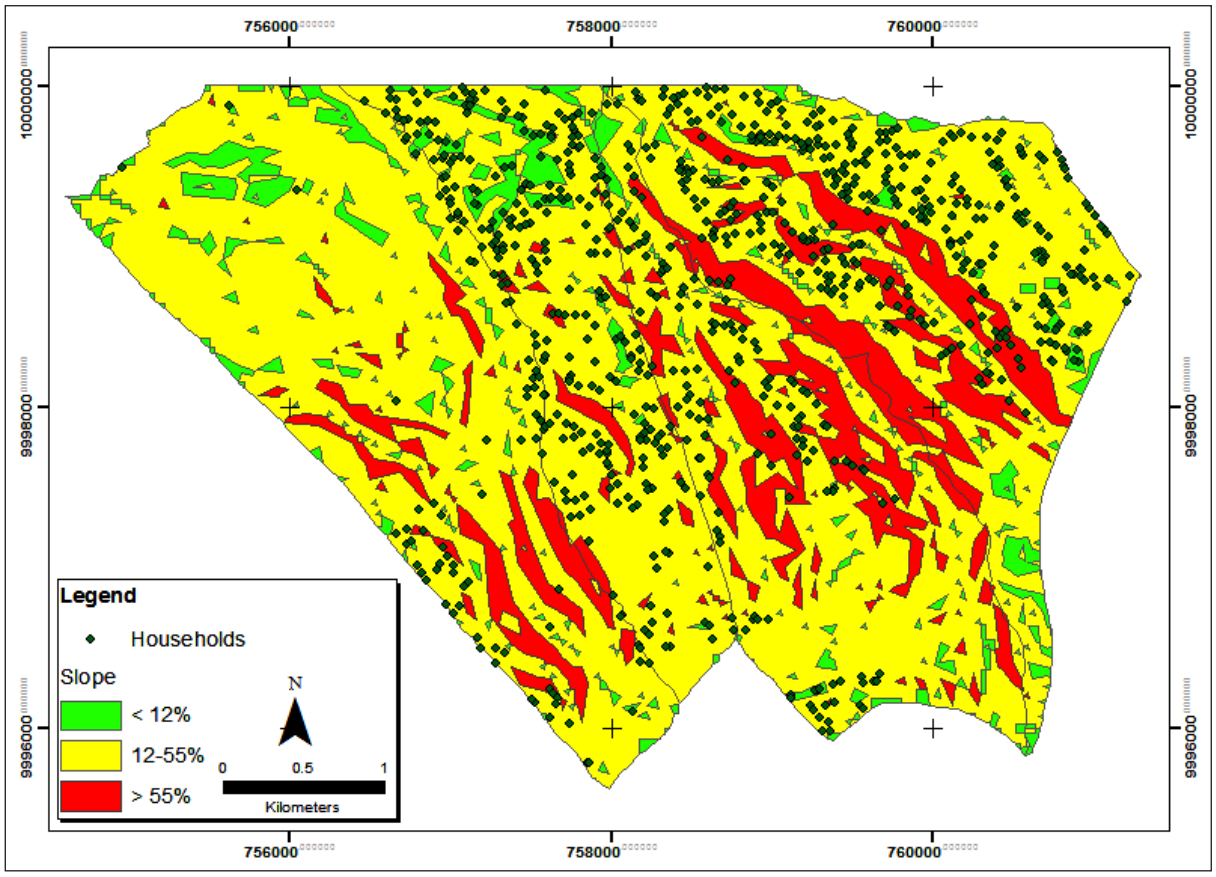

FIGURE 1
Slope analysis for land use spatial categorization
Source: Author

12–5%, and requires soil and water conservation measures to be undertaken by the 710 (84.5%) households settled in this area. The area with 55–117% slope was 3.09 km^2, where no farming activities of any kind should be undertaken, yet 65 (7.7%) households are located here. The areas with less than 12% slope cover 1.45 km^2 with 66 (7.8%) households are the best for farming with minimal restrictions. The results show that those left behind are the households living and farming where the land slope is more than 55%, and should be prioritized in the soil and water conservation measures programs. It is worth noting that land-use land cover has a direct link to both quality and quantity of water within a given waterbody (Tanaka et al., 2021). The poor the farming methods and the steeper the slopes, the poorer the water quality, leading to degradation of aquatic ecosystems. Farming decreases the soil sponge capacity by increasing surface water flow, causing soil erosion and siltation, and eutrophication of water bodies (Tanaka et al., 2021). Studies by Matima et al. (2009), Li et al. (2009), Twesigye et al. (2011) and Kilonzo (2014), have shown that change in water quality and quantity in a water body influences it biodiversity, at both population and diversity levels.

Land Degradation in Kenyan ASALs and Affected Populations

Kenya's ASALs biomass production trend from 2001–2015 indicated that the country experienced both declining and increasing biomass production, ranging between -185–202 kg/ha/yr. The total ASALs area analysed was 461,606.16km^2 (**Figure 2**), with a population of 14,508,903, which constitute 28.7% of the country's population. The areas with declining trends are spread across the country, but more pronounced in the northern, eastern, and some areas in the southern and coastal regions of the country totalling 158,968.1 km^2 (35.2%), and has a population

of 4,530,241 (31.22%) (**Table 2**). A big area of the ASALs had a positive biomass production trend, with 49.94% of the area at the range 0–20 kg/ha/yr, which has human population of 7,543,251 (51.99%). Other areas of increasing biomass trend between 20–50 kg/ha/yr covered 60,676.79 (13.44%), and more than 50 kg/ha/yr was 6,433.17 km^2 (1.42%), with human populations of 2,211,425 (15.24%) and 223,986 (1.54%) respectively. These areas with the increasing trends are spread out in the north western, north eastern and coastal regions of the country (**Figure 2**).

Focusing on selected conservation areas of Sibiloi National Park in the north, and Tsavo National Parks (**Table 3**) in the lower eastern region, a significant area is experiencing a reduction in biomass production. A total of 1027.68 km^2 (65.44%) in Sibiloi National Park has a declining trend, compared to 7,595.94 km^2 (36.84%) in the combined Tsavo National Parks. No changes were detected in some areas of 16.47% and 6.14 % in Sibiloi and Tsavo ecosystems respectively. The biomass production was noted to be increasing in 284.19 km^2 (18.1%) of Sibiloi National Park, and 11,755.22 km^2 (57.02%) of Tsavo National Parks. The net decline in vegetation production in these conservation areas poses a great threat to biodiversity (life on land) within these designated conservation areas.

In the role of identifying "those left behind" and "those far behind", the application of geospatial technology, with regard to the three SDGs, has demonstrated how useful and appropriate it is. Geospatial data has a location component, making it critical in the identification of location and distribution of the subject, and/or phenomena under analysis, thereby supporting prudent decision making. The successful implementation of the SDGs "leave no one behind pledge" is largely dependent on leaders who need to have systems in place, with the ability guide them. Using the analysis done in Tindiret Nandi County, the geospatial analysis identified the areas with different slopes and their geographical distribution. It further extracted the number of households in the different slope categories. Using this information, the concerned government agencies, dealing with soil and water conservation and land degradation, can visit the households located in slopes of more than 12% and

TABLE 1: Slope analysis output with area (km^2) and household numbers

Slope (%)	Area (km^2)	% area	Hhold no.	% Hhold
< 12	1.45	8.0	66	7.8
12-55	14.74	76.0	710	84.5
>55	3.09	16.0	65	7.7
Total	**19.28**	**100.0**	**841**	**100.0**

Source: Author

TABLE 2: Biomass production trend by areas and human populations

Trend	Area (km^2)	% Area	Population	% Population
-185 – 0	158,968.1	35.20	4,530,241	31.22
0 – 20	225,528.1	49.94	7,543,251	51.99
20 – 50	60,676.79	13.44	2,211,425	15.24
50 - 202	6,433.17	1.42	223,986	1.54
Total	**451,606.16**	**100.0**	**841**	**100.0**

Source: Author

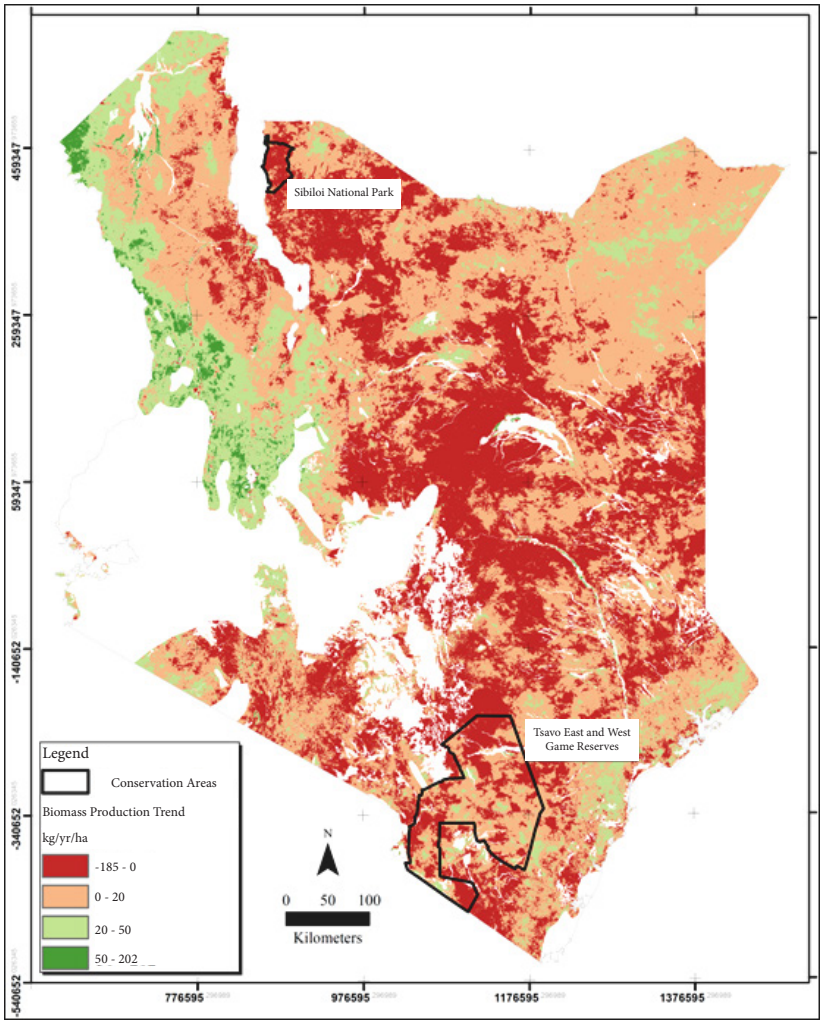

FIGURE 2
Biomass production trend in Kenyan ASALs
Source: Modified from Kigen and Muyekho (in press)

TABLE 3: Biomass production trend in conservation areas

	Sibiloi		Tsavo	
Trend	**Area (km²)**	**% Area**	**Area (km²)**	**% Area**
Negative	1,027.68	65.44	7,595.94	36.84
No change	258.60	16.47	1,265.31	6.14
Positive	284.19	18.10	11,755.22	57.02
Total	**1,570.47**	**100.0**	**20,616.47**	**100.0**

Source: Author

take appropriate action. From the analysis of trend of biomass production in the ASALs, the outcome demonstrated that a significant population is living in the areas with declining vegetation production. These are the regions supporting wildlife-based tourism and livestock keeping, meaning that significant human population of 4,530,241 is at risk of becoming worse off . It is also established that Sibiloi and Tsavo National Parks are losing the wildlife pasture, with 65.44% and 36.84% of their areas respectively indicating declining trend. The loss of vegetation in these areas is a threat to both humans and life on land, and planers need to take note of it.

CONCLUSION

The application of geospatial technology has evidently demonstrated that it is possible to not only identify those left behind, but also their geographical distribution, thus aiding in informed decision making on what kind of climate action is required; SDG No. 13 - Climate action, SDG No. 14 - Life below water, and SDG No. 15 - Life on land.

RECOMMENDATIONS

The research recommends that for a successful application of geospatial technology in identifying those left behind and those far behind, the following is required:

Capturing and inclusion of socio-economic data in spatial context to enable development of a compsite index of who is left behind and those far off; and,

Capturing and inclusion of environmental quality, types of pollutants, agricultural activities, and climate impacts and actions in spatial context.

CITED REFERENCES

Bond. (2018). *Leave no one behind: How the development community is realising the pledge*. Retrieved April 4, 2021 from https://www.bond.org.uk/sites/default/files/resource-documents/leave_no_one_behind_how_the_development_community_is_realising_the_pledge.pdf.

Edokpayi, J.N. (2016). *Assessment of the efficiency of wastewater treatment facilities and the impact of their effluent on surface water and sediments in Vhembe District, South Africa* (PhD thesis). University of Venda, South Africa. Retrieved August 3, 2021 from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7121614/

Grumm, R.H. (2011). The central European and Russian heat event of July-August 2010. *Bulletin of the American Meteorological Society*. 92(10), 1285– 1296. https://doi.org/10.1175/2011BAMS3174.1.

Kigen, C.K. & Muyekho, F.N. (In press). Geospatial analysis of rangeland vegetation biomass production and rain-use efficiency in Kenya. *Environ. Res. Commun*.

Kilonzo, N. (2014). *Assessing the impacts of environmental changes on the water resources of the Upper Mara, Lake Victoria Basin*. Netherlands: CRC Press/Balkema EH Leiden.

KIPPRA. (2013). *Kenya Economic Report 2014*. Retrieved January 4, 2021 from http://www.kippra.org.

KIPPRA. (2020). *Kenya Economic Report 2020*. Retrieved March 7, 2021 from http://www.kippra.org.

KNBS. (2019). *2019 Kenya Population and Housing Census: Volume I*. Retrieved February 22, 2021 from http://www.knbs.co.ke.

Li, Z., Liu, W. & Zhang, X. (2009). Impacts of land-use change and climate variability on hydrology in an agricultural catchment on the Loess Plateau of China. *Journal of Hydrology*. 2009: 377.

Matima, J., Mugatha, S., Reid, S., Gachimbi, L., Majule, A., Lyaruu, H., Pomery, D., Mathai, S. & Mugisha, S. (2009). The linkages between land-use change, land degradation and biodiversity across East Africa. *Afr. J. Environ. Sci. Technol*. 3(10), 310–325. http://hdl.handle.net/10568/1934.

Oxfam International. (2006). Making the case: A national drought contingency fund for Kenya. *Oxfam Briefing Paper 89*. Oxford, UK: Oxfam International.

Pejchar, L. & Mooney, H.A. (2009). Invasive species, ecosystem services and human well-being. *Trends Ecol. Evol*. 24, 497e504.

Republic of Kenya. (2016). *Land Degradation Assessment in Kenya*. Retrieved January 24, 2021 from http://www.environment.go.ke/wp-content/uploads/2018/08/LADA-Land-Degradation-Assessment-in-Kenya-March-2016.pdf.

Santi, E., Mari, E., Piazzini, S., Renzi, M., Bacaro, M. & Maccherini, S. (2010). *Community Ecology*. 11,(2), pp. 232-241.

Shellito, A.B. (2011). *Introduction to Geospatial Technology*. USA: W H Freeman & Co.

Tanaka, Y., Minggat, E. & Roseli, W. (2021). The impact of tropical land-use change on downstream riverine and estuarine water properties and biogeochemical cycles: A review. *Ecological Processes*. 10(40). Retrieved September 20, 2021 from https://ecologicalprocesses.springeropen.com.

Twesigye, C.K., Onywere, S., Getenga, Z.M., Mwakalila, S.S. & Nakiranda, J.K. (2011). The Impact of Land-Use Activities on Vegetation Cover and Water Quality in the Lake Victoria Watershed. *The Open Environmental Engineering Journal*. 4, 66-77. Retrieved September 22, 2021 from https://benthamopen.com.

UN. (2000). *United Nations Millennium Declaration*. New York: United Nations General Assembly (UNGA). Retrieved June 12, 2021 from https://www.un.org/millenniumgoals/

UN. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. New York: UNGA. Retrieved January 16, 2021 from https://sdgs.un.org/2030agenda.

UN. (2020). 2030 Agenda for Sustainable Development. Retrieved April 4, 2021 from https://sustainabledevelopment.un.org/post2015/transformingourworld.

UNDP. (2018). *What does it mean to leave no one behind*. Retrieved November 30, 2020 from http://www.undp.org/content/dam/undp/library/Sustainable%20Development/2030%20Agenda Discussion_Paper_LNOB_EN_lres.pdf.

UNEP. (2009). *Kenya: Atlas of Our Changing Environment*. Retrieved December 10, 2020 from http://www.umsl.edu/~naumannj/Geography%20PowerPoint%20Slides/atlas/UNEP_KenyaAtlas_ebook.pdf.

UNSDG. (2020). *Principle Two: Leave No One Behind*. Retrieved April 4, 2021 from https://unsdg.un.org/2030-agenda/universal-values/leave-no-one-behind.

Wong, C.P., Jiang, B., Kinzig, A.P., Lee, K.N. & Ouyang, Z. (2015). Linking ecosystem characteristics to final ecosystem services for public policy. *Ecol. Lett*. 18, 108e118.