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Distribution of Adaptation Climate Finance in Africa Region[1]

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Abstract

This study aimed at examining the distribution of adaptation climate finance flowing into the Africa region in order to understand the extent to which vulnerable countries and sectors are targeted. Developing countries receive adaptation climate finance in support of resilience to climate change and variability impacts. The anthropogenic drivers of climate change and variability are from all parts of the world with higher contribution from industrialized countries and less from poor countries - though the impacts are more intense within developing countries. Data were obtained from the Organization for Economic Cooperation and Development and the United Nations Department of Economic and Social Affairs. Cluster analysis, principal component analysis, and correlation analysis were used to understand the distribution of climate finance for adaptation by country and by sector. Adaptation climate finance flows in large amounts to the least developed countries most vulnerable to the impact of climate change and variability. Agriculture, forestry and fisheries; education; general environment protection; industry, minerals and construction; and transport and communication are the leading sectors in receiving adaptation climate finance. The findings reveal that social sectors are positively correlated with vulnerability while sectors related to infrastructure are negatively related with regard to vulnerability index. Optimal distribution of climate finance globally is expected to lead to the attainment of climate change solutions and sustainable development among countries and among sectors of the economy.

Keywords: *Adaptation, climate finance, distribution, vulnerability, Africa.*

Introduction

At the global level, adaptation climate finance is preferably allocated mostly in developing countries that are vulnerable to the impacts of climate change and variability (Ford et al., 2015; Pickering, 2012). Adaptation climate finance is essential for attaining resilience and life sustainability on the Earth. The Kyoto Protocol and the Paris agreement have well stipulated the significance of climate finance towards mitigation and resilience from the impacts of climate change (UNFCCC, 2008, 2015). Adaptation finance is part and parcel of resources that could be allocated for other day-to-day economic development in absence of climate change and variability. There are insufficient resources for attaining resilience from the impacts of climate change

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and variability among developing countries in Africa due to poverty (AfDB, 2011). The impacts of climate change and variability are intensive in developing countries, especially in Africa and Asia regions. However, developed countries which have a long history of greenhouse gases emission that cause the climate to change are not experiencing the same impacts (Cui & Gui, 2015; Cui & Huang, 2018; Meyer & Roser, 2010). It happens that Africa and Asia, the two regions adversely affected by climate change, are now competing for adaptation climate finance - a scarce resource from international sources meant for resilience against the impact of climate change and variability (Ferreira, 2017; Ford et al., 2015).

Developing countries in Africa require more adaptation support due to the fact that they are less resilient to the impacts of climate change and variability (Barrett, 2014; Betzold & Weiler, 2017; Colenbrander et al., 2018; Steckel et al., 2017). They are characterized by low technology and income. Also, the economy of most of the countries in Africa depends on agriculture which is vulnerable to the impacts of climate change and variability. Their income and available technology are not sufficient to enable them to be resilient once affected by climate change and variability. Adaptation and mitigation are both important to be attained but they differ in that adaptation to the impacts of climate change is location-specific as only vulnerable and affected places are considered while mitigation can take place anywhere (Hepelwa & Selejio, 2017; Winkler & Dubash, 2016).

The adaptation cost for developing countries is between US $70 billion and US $ 100 billion per year for the period 2010 and 2050 (IPCC, 2014). For the years 2013 to 2017 the estimated adaptation climate finance was on average US $ 9.3 billion per year with the maximum (US $ 12.9 billion) in 2017 (OECD, 2018). These statistics show that the amount of adaptation climate finance channelled to developing countries is by far less than the estimated cost. Moreover, by 2030 the cost could be two to three times more than what is estimated for the 2-degree centigrade temperature (UNEP, 2016). The adaptation climate finance received in the region is insufficient, which may hinder the attainment of resilience and sustainable development (Buchner et al., 2017; Nakhooda et al., 2014).

Studies by Hoogzaad et al.(2014); Mostafa et al.(2016), Nakhooda et al.(2011), Pauw (2017), Peterson and Skovgaard (2019), and Tirpak and Parry (2009) have been conducted on the distribution of adaptation in a general way. However, they are silent on the extent to which vulnerability to the negative impacts of climate change and variability is considered for geographical and sectoral distribution of climate finance for adaptation action. It is important to understand the extent to which vulnerability is considered in the distribution of adaptation climate finance among the countries and key sectors. These sectors include; agriculture, forestry and fishing; education; general environment protection; industry, minerals and construction; transport and communication; development assistance; disaster, rehabilitation and preparedness;

population and health; trade and tourism; water; renewable & nuclear energy; non-renewable energy and governance.

To understand the extent to which climate finance for adaptation action is distributed for the attainment of resilience among countries and among key sectors, this study applied cluster and principal component analysis. Further analysis was done to determine the relationship between climate finance and vulnerability to the negative impacts of climate change and variability using Spearman's rank-order correlation.

Methods and Materials

Adaptation climate finance from bilateral sources is considered in this study. Adaptation actions were marginalized for so many years until 2010 when various funds dedicated to finance adaptation projects were established. It is in the same period when the OECD enforced publication of data based on statistical Rio makers to indicate adaptation. Secondary data were collected for 54 countries in Africa for the period from 2010 to 2018. The data was obtained from the OECD Credit Reporting System. The OECD publishes climate finance data available its website for consumption by the public.

Economic and Environmental Vulnerability Index (EVI) was obtained from the United Nations Department of Economic and Social Affairs. The index is used to measure vulnerability to climate change and variability. It is a composite index that is computed by the committee for development policy secretariat of the United Nations Department of Economic and Social Affairs (UN DESA). The computation is based on the share of agriculture, fisheries and forestry in GDP, remoteness and landlocked-ness, export concentration, export instability, share of population living in low elevated coastal zones, population living in drylands, agricultural instability, and victims of disasters. The distribution of adaptation climate finance flows in the African region is analysed by recipient countries and sectors. Data were analysed by utilizing cluster and principal component analysis (PCA) method to work out geographical and sectoral distribution respectively. These methods were preferred relative to other related multivariate methods from the fact they do not require any prior knowledge of groups.

Cluster analysis involves grouping of elements in such a way that similarity of elements is high within groups and difference is high between groups. The data matrix for cluster analysis consisted of 27 donor countries and 54 recipient countries. Cluster analysis groups observations, thus it was applied for the distribution by country. The optimal number of clusters was estimated through hierarchical cluster analysis utilizing euclidean distance. The elbow graph was used to estimate the optimal number of clusters for determining the distribution of climate finance for adaptation action.

The PCA involves transforming a set of correlated variables into a set of new variables which are uncorrelated as a linear combination (Backhaus et al., 2016; Everitt et al., 2011; Partridge & Jabri, 2009; Ringnér, 2008). The number of components to be

retained is estimated based on the eigenvalues. The eigenvalues represent the total variance explained by the component. Components with the magnitude of eigenvalues at least one, is suggested by Karlis et al. (2003), and Zwick and Velicr (1984) to be retained. Moreover, Jolliffe (1972) suggested retaining components with the eigenvalue of at least 0.7 magnitudes. Other criteria suggest that the total variance explained by the retained component should be at least 70 to 80 percent (Zwick & Velicr, 1984). Both criteria have been met for the decision on the number of components to be retained in this study with the eigenvalue threshold of at least 0.7 and total variance explained at least 70 percent. The estimated PCA were then applied to measure the distribution of adaptation climate finance meant for adaptation action, among the key sectors.

The maximum-minimum standardization method presented in equation 1 was used to standardize the variables for principal component analysis where Var_{stdzd} is the standardized value, Var_i is the actual value of adaptation finance in the i^{th} sector, $\mathbf{Var_{min}}$ is the minimum value, and Var_{max} is the maximum value of the adaptation climate finance in a particular sector.

$$var_{stdzd} = \frac{var_i - var_{min}}{var_{max} - var_{min}} \quad (1)$$

Table 1: Test Results of the suitability of the Principal Components Analysis

Kaiser-Meyer-Olkin (KMO)	0.600
Bartlett test of sphericity	
Chi-square	360.671
Degrees of freedom	105.000
P-value	0.000

Source: Authors' analysis (2021).

KMO and Bartlett test of sphericity were applied to determine the suitability of the data for PCA. The KMO statistic ranges between 0 and 1 and tests the sampling adequacy of the data. It was estimated to be 0.6, a value greater than 0.5 and revealed the suitability of data for PCA. The null hypothesis under the Bartlett test of sphericity states that the correlation matrix is identity and being identity indicates variables to be unrelated. This null hypothesis was rejected at 5 percent level of significance (P-value = 0.000) and indicated that the variables are related. From these two tests, it was indicated that the variables were inter-related and PCA was suitable as both tests satisfied the condition for the analysis of the study variables.

Spearman rank-order correlation was used to determine the relationship between adaptation climate finance distribution and vulnerability to the negative impacts of climate change and variability. It is a non-parametric method for determining the correlation between the two variables. Since the interest was to estimate the correlation between climate finance and vulnerability index for 54 countries, the non-parametric

test was useful as it does not require any prior assumption of normal distribution. This relationship is determined by Spearman's correlation coefficient.

Results and Discussion

Figure1 presents the estimated distribution of adaptation climate finance by country and sectors in Africa from 2010 to 2018. Most of the countries in the region have received adaptation finance in the agriculture, forestry, and fisheries sector (Figure 1). The agriculture sector is one of the most vulnerable sectors to the negative impacts of climate change in Africa because of its production system being dependent on rainfall. The sector employs more than half (52.31%) of the population in Sub-Saharan Africa (World Bank, 2020). It is a relevant sector to adaptation action through climate finance as it is the source of food for human life.

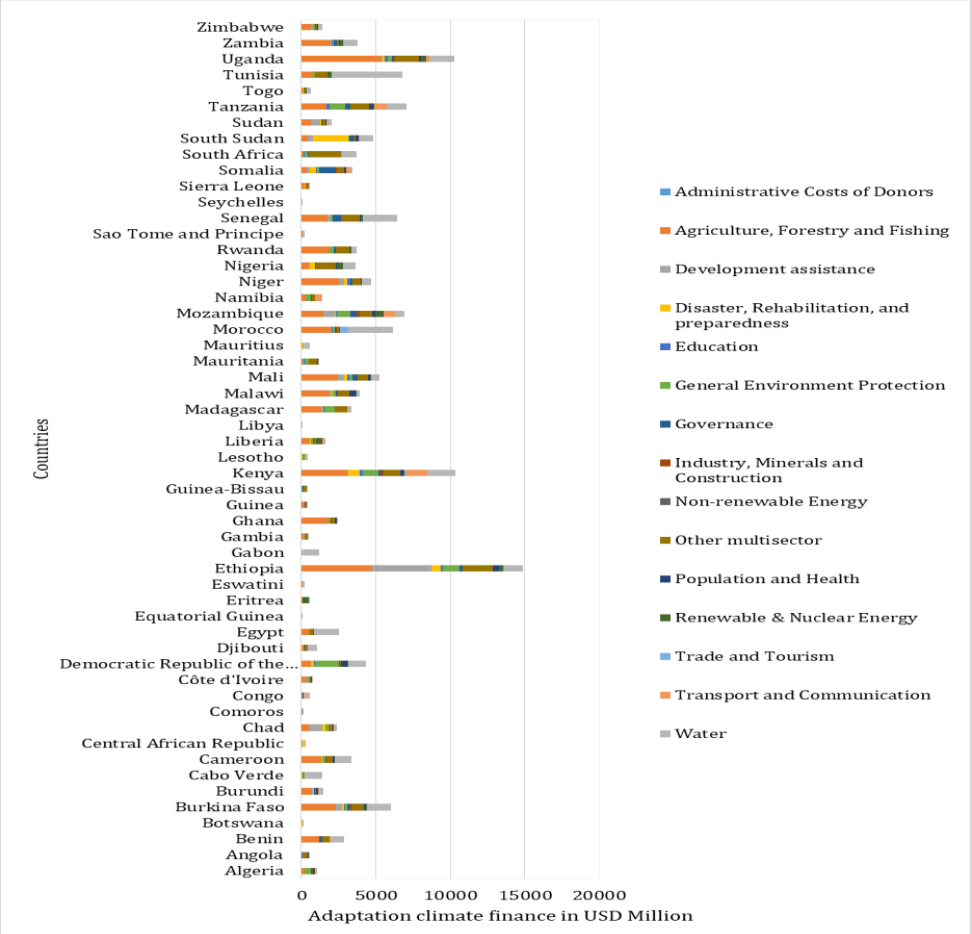

Figure 1: Distribution of adaptation climate finance by country and sector 2010 – 2018 (Us Million)
Source: Authors' analysis (2021).

Countries from the Sub-Saharan African region like Ethiopia, Kenya, Uganda, Mozambique, and Tanzania have received more than USD 6,800 million as adaptation climate finance from donor countries. Sub-Saharan Africa is the most vulnerable region to the impacts of climate change and variability (Boko et al., 2007; Nakhooda et al., 2014). Watson & Schalatek (2019) in a briefing report for the Sub-Saharan climate finance also mentioned the top recipient countries in a list of countries receiving climate finance in large amounts. These countries are among the least developed countries and submitted their national adaptation programmes of action (NAPA) to the UNFCCC between 2006 and 2008 (UNFCCC, 2017). It has been pointed out by Román et al. (2018) that countries with well-established adaptation plans are in a better position to benefit from climate finance compared to those without clear direction on climate action. All the 54 countries in Africa have received at least some amount of climate finance for adaptation action in agriculture, forestry, and fishing, general environment protection, and water. Adaptation finance flows more to countries and sectors most affected and vulnerable to climate change and variability impacts.

Clusters of countries receiving adaptation climate finance in Africa

The hierarchical cluster analysis based on euclidean distance was implemented to arrive at the optimal number of clusters with the help of the elbow graph. The method gives an informative distribution of adaptation climate finance in the region with countries sharing similar characteristics in terms of inflows of adaptation climate placed in the same group and vice versa. The elbow graph from this analysis suggests six clusters of countries receiving adaptation climate finance in the region.

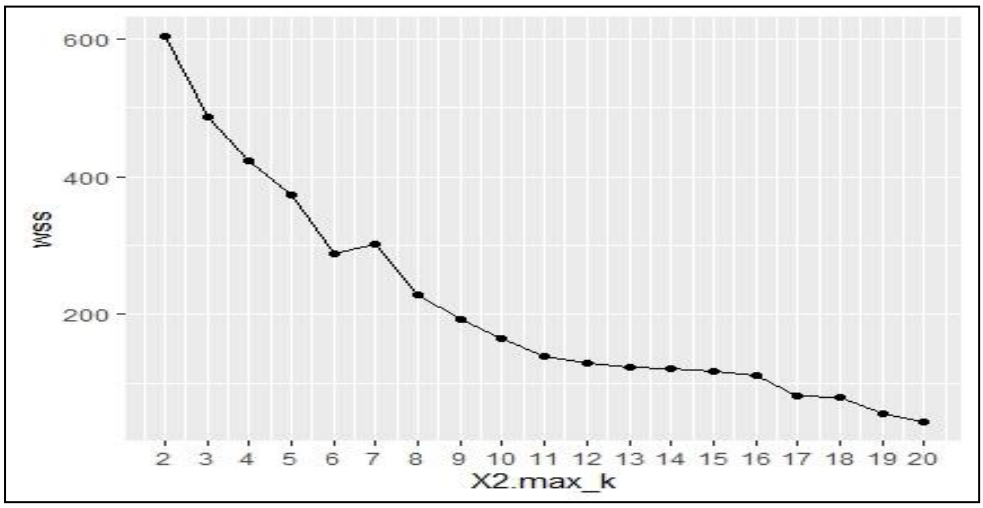

Figure 2: Elbow graph showing optimal number of clusters
Source: Authors' analysis (2021).

From the findings on the flows of adaptation climate finance (Figure 1 & Figure 3), Ethiopia, Uganda, Mozambique, Kenya and Tanzania are the top five countries in terms of receiving adaptation climate finance. According to the findings from the environmental vulnerability index developed by Kaly and Pratt (2004), the mentioned countries were identified among the most vulnerable to the negative impacts of climate change impacts. Ethiopia is the top recipient of adaptation climate finance and it is one of the countries in Sub-Saharan Africa highly vulnerable to climate change and variability (Adem & Amsalu, 2009; Mohamed, 2017). The country is susceptible to food insecurity, underdeveloped water sources and dependent on rain-fed agriculture which is hindered by low rainfall. Kenya and Tanzania are in the same cluster and are among the top five recipients of adaptation finance in Africa. The countries are from the Eastern Africa region, share a number of memberships in economic cooperations and common history from the colonial era to date. The prioritization of adaptation action has made Sub-Saharan Africa to appear in the list of regions receiving climate finance for adaptation since 2010, though it is not sufficient (Hoogzaad et al., 2014).

Egypt, Morocco, and Tunisia (Arabic-speaking countries) and Burkina Faso, Democratic Republic Congo, Niger, and Rwanda (French-speaking countries) fall in the same cluster. The two sub-clusters of these countries indicate the strength of their bilateral relationship between recipient countries and donor countries. The largest cluster has 41 countries receiving adaptation finance with a mix of recipient countries. This cluster of countries is the largest among the six estimated clusters based on adaptation financing from developed countries. Taking into account the quantity and sources of climate finance for adaptation in Africa, the countries in this cluster share homogeneous characteristics with regard to financing adaptation action. These countries have received less quantity of adaptation climate finance compared to those in the first five clusters. The composition of clusters with the member countries is presented in Figure 3.

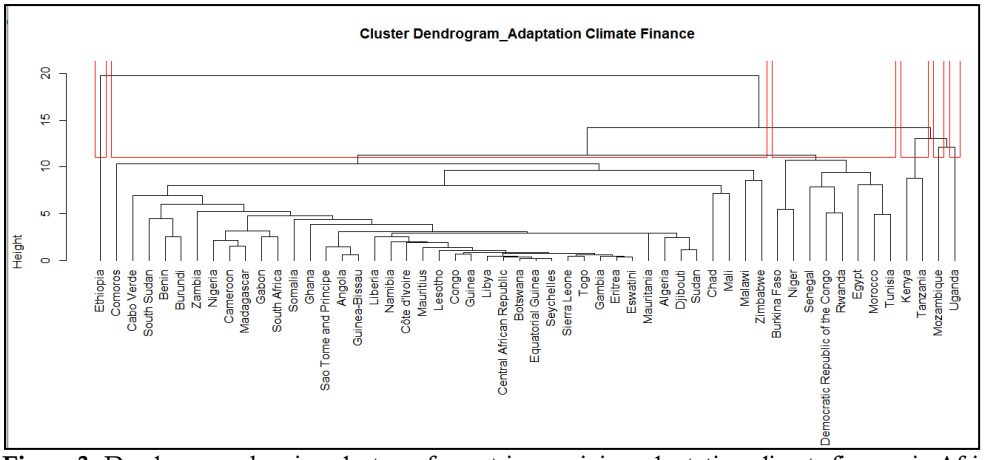

Figure 3: Dendrogram showing clusters of countries receiving adaptation climate finance in Africa
Source: Authors' analysis (2021).

Sectoral distribution of climate finance in Africa region

For the fifteen sectors receiving adaptation climate finance in Africa, only eight components are enough to explain the total adaptation distribution as a linear combination of original variables. The eight components have Eigenvalues greater than 0.7 and explain at least 70 percent of the total variation - the threshold suggested by Jolliffe (1972) for retaining the components.

Table 2: Principal components/correlation

			Number of obs.	54
			Number of comp.	8
			Trace	15
			Rho	0.854
Component	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Comp1	4.8844	3.2526	0.3256	0.3256
Comp2	1.6318	0.3243	0.1088	0.4344
Comp3	1.3075	0.0371	0.0872	0.5216
Comp4	1.2704	0.2082	0.0847	0.6063
Comp5	1.0622	0.0523	0.0708	0.6771
Comp6	1.0098	0.0840	0.0673	0.7444
Comp7	0.9258	0.2077	0.0617	0.8061
Comp8	0.7182	0.0825	0.0479	0.8540

Source: Authors' analysis (2021).

The same number of components is suggested by a scree plot with a cut-off at 8 components on the horizontal scale (Figure 4).

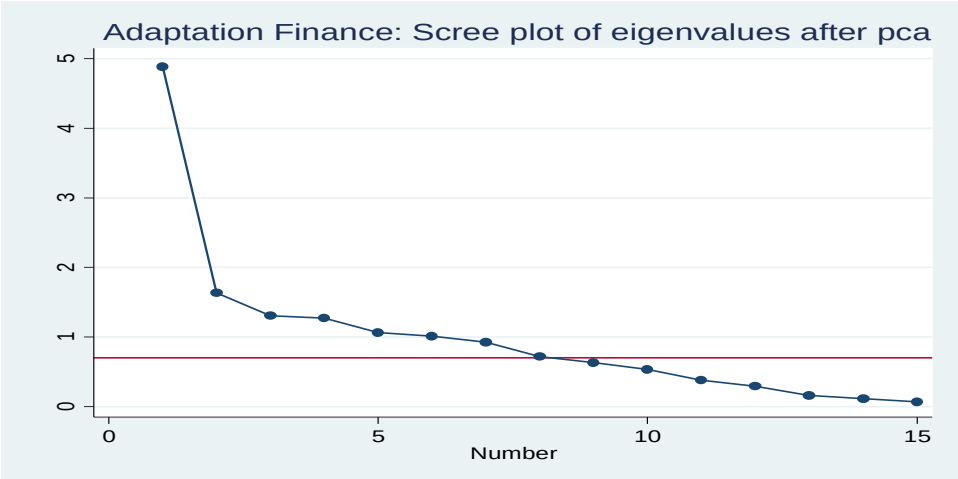

Figure 4: Scree plot of eigenvalues for the PCA
Source: Authors' analysis (2021).

Therefore, almost half of the components are enough to explain the distribution of climate finance in the region, since they explain more than 80 percent with only 15 percent explained by the components that were discarded. These eight retained components explain about 85.40 percent of total variation (Table 2). The first principal component explains more variations compared to the next components while the last explains the least. Accordingly, the first principal component explains 32.56 percent of the variation which is the maximum among the established linear combinations and the eighth component explains 8.54 percent of the total variation.

The component matrix presents the extent to which the variables are correlated or load to the respective components (Table 3). Every variable load high to one and only one component with the maximum loading. Agriculture, forestry, and fishing; and education load higher to the first component compared to the other components (second, third up to the eighth component) implying that adaptation climate finance flowing in Africa is explained mainly by these sectors. The second-largest variation attributed to the second principal component is explained by general environment protection; industry, minerals, and construction; and transport and communication. The sectors related to the first two components have also been pointed by Downing et al. (1997), and Roberts (2010) as the priority sectors for adaption.

Table 3: Components Matrix for the Sectors to which Climate Finance flows

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	Unexplained
AFF	**0.5018**	-0.1001	-0.0274	0.0873	0.0642	-0.1538	0.1445	0.0999	0.1412
ED	**0.5577**	0.1421	-0.1338	0.0079	-0.2395	-0.0838	0.1079	-0.0192	0.1417
GEP	0.2845	**0.3434**	0.1630	-0.0469	0.0050	0.0772	-0.2374	-0.2904	0.1760
IMC	-0.0937	**0.4589**	0.2800	0.0947	0.2302	0.0412	0.3494	-0.0859	0.1088
TC	0.0568	**0.7003**	-0.0691	-0.0447	0.0090	-0.0226	-0.0815	0.0915	0.1015
DA	0.2581	-0.3681	**0.4612**	-0.0690	0.1900	-0.0065	-0.0222	-0.1857	0.1910
DRP	-0.1559	0.0277	**0.6880**	0.0997	-0.1438	-0.0033	0.0592	0.2492	0.2144
PH	0.2848	0.0485	**0.3785**	-0.1009	-0.0349	-0.0176	-0.1806	-0.0881	0.2466
TT	-0.0341	-0.0026	0.0761	**0.8156**	-0.0499	-0.0007	-0.0836	-0.1221	0.1384
W	0.1838	-0.0256	-0.1450	**0.5235**	0.1195	0.0455	0.0576	0.2222	0.2860
RNE	-0.0255	0.0211	-0.0446	-0.0156	**0.8835**	-0.0452	-0.0258	0.0040	0.0647
ACD	-0.0544	0.0078	0.0039	0.0162	-0.0574	**0.8830**	0.0272	-0.0411	0.0312
OM	0.3610	-0.0891	-0.0606	-0.0665	0.1586	**0.4190**	-0.0460	0.2153	0.0906
NRE	0.0516	-0.0270	0.0098	-0.0674	-0.0407	0.0233	**0.8532**	-0.0457	0.0873
GVC	0.0236	0.0493	0.0986	-0.0748	0.0035	-0.0282	-0.0629	**0.8191**	0.1706

Note: *AFF*-Agriculture, Forestry and Fishing; *ED*-Education; *GEP*-General Environment Protection; *IMC*-Industry, Minerals and Construction; *TC*-Transport and Communication; *DA*-Development Assistance; *DRP*-Disaster, Rehabilitation, and Preparedness; *PH*-Population and Health; *TT*-Trade and Tourism; *W*-Water; *RNE*-Renewable & Nuclear Energy; *ACD*-Administrative Costs of Donors; *OM*-Other multi-sector; *NRE*-Non-renewable Energy; and *GVC*-Governance
Source: Authors' analysis (2021).

The humanitarian sectors that include development assistance; disaster, rehabilitation, and preparedness; and population and health load high to the third principal component. The first three components account for 52.16 percent of total variation and constitute the most relevant sectors to adaptation action for example agriculture, forestry and fishing; general environment protection, transport and communication; development assistance, disaster, rehabilitation and preparedness; and population and health. From the eight components, the last two components in explaining adaptation climate finance include non-renewable energy and governance which stand on their own in describing adaptation finance and they load high to the seventh, and eighth components respectively.

Relationship between vulnerability and adaptation climate finance

The findings in Table 4 measure the relationship between the distribution of climate finance for adaptation and vulnerability to the impacts of climate change and variability. The correlation between the distribution of adaptation finance and vulnerability is positive. Also, there is a positive correlation between vulnerability and the seven sectors namely: agriculture, forestry, and fisheries; development assistance; disaster, rehabilitation and preparedness; education; governance; and population and health which are positively correlated with vulnerability. These are direct and supporting sectors for adaptation activities. For example, agriculture provides food to human beings, disaster, rehabilitation and preparedness sector is key for life support from risks of climate change impacts like floods and droughts. Education plays a vital role in the dissemination of knowledge on adaptation methods. The population and health sector is important for reducing the spread of diseases associated with climate change. Sectors and sub-sectors like agriculture, fisheries, infrastructure, natural resource management, education and health are the priorities for adaptation to climate change impacts (Downing et al., 1997; Government of Saint Lucia, 2018; Roberts, 2010).

The environmental and economic vulnerability index is positively correlated with and statistically significant to development assistance and disaster, rehabilitation, and preparedness at 1 percent and 5 percent levels of significance respectively (Table 4). Climate finance in trade and tourism is negatively correlated with the vulnerability index and the findings are statistically significant at 10 percent level of significance. The findings indicate that adaptation climate finance flowing to infrastructures like transport and communication, water, non-renewable energy and renewable energy is negatively correlated with the vulnerability index. The same is observed for the tourism and trade which is a service sector. Water and transport and communication are among the sectors whose infrastructures are expensive and vulnerable to the impacts of climate change and variability.

It is revealed from the findings that developed countries prefer the provision of adaptation finance to other sectors than infrastructures. The sectors requiring construction of infrastructures are expensive and are not mostly targeted by donors

when compared to social sectors like education, health and social protection or humanitarian (Jack, 2008). Therefore, adaptation climate finance is not effectively distributed to the vulnerable infrastructures affected by climate change impacts when compared to social sectors.

Table 4: Spearman's Rank Correlation between Adaptation Finance and Vulnerability

Variables	Vulnerability Index
Agriculture, forestry, and fisheries	0.095
Development Assistance	0.374***
Disaster, Rehabilitation, and Preparedness	0.272**
Education	0.055
General environment protection	0.053
Governance	0.170
Industry, Minerals and Construction	-0.069
Non-renewable energy	-0.002
Population and Health	0.213
Renewable Energy	-0.007
Trade and Tourism	-0.258*
Transport and Communication	-0.063
Water	-0.185
Overall adaptation finance	0.089

* p<0.1, ** p<0.05, *** p<0.01

Source: Authors' analysis (2021).

A significant relationship between vulnerability and adaptation finance for development assistance; disaster, rehabilitation and preparedness, implies humanitarian support and it confirms the extent to which developed countries support adaptation actions for resilience in developing countries in Africa. The mentioned sectors having a significant relationship with vulnerability are among the sectors pointed by Handmer et al. (1999).

Conclusion

This study aimed at determining the distribution of adaptation climate finance in Africa from 2010 to 2018 from vulnerability to the negative impacts of climate change point of view. The distribution is examined in terms of countries and sectors. Adaptation climate finance flows more in the least developed countries more vulnerable to the impacts of climate change. The top five recipient countries are from Sub-Saharan Africa, the most vulnerable region to climate change and variability impacts. Recipient countries are able to attain sustainable development, notwithstanding the impacts of climate change, through adaptation climate finance. Their sectors get improved after disasters accelerated by climate change and variability like floods and drought through adaptation climate finance for resilience.

Adaptation climate finance flowing into the African region targets the social sectors vulnerable to the impacts of climate change and variability. The vulnerability index is positively correlated with agriculture, forestry, and fisheries; development assistance; disaster, rehabilitation and preparedness; education; general environment protection;

governance; and population and health. All the African countries have received at least some amount of climate finance for adaptation action in agriculture, forestry and fishing; general environment protection and water. Financing adaptation action through the water sector is also important in the region which is highly affected by drought. However, climate financing for the water sector is negatively related to the vulnerability index. The water sector is among the sectors whose infrastructures are expensive and vulnerable to the impacts of climate change and variability. Vulnerable countries need more support for the development of water projects to increase water supply. The water sector is highly affected by drought which is experienced in most parts of Africa.

Most vulnerable countries receive adaptation climate finance for development assistance; and disaster, rehabilitation and preparedness sectors for resilience from the negative impacts of climate change and variability. These sectors play a role in humanitarian support from catastrophic events like the negative impacts of climate change. Provision of financial aid for adaptation action in Africa enables countries to bear the little cost of undertaking their development activities at within the context of climate change and variability impacts and in addition they incur the little cost for resilience. There is hope to attain sustainable development at the global level from the fact that vulnerability is considered in the distribution of adaptation climate finance. Climate change solutions cannot be achieved by a single region or country and cannot be isolated from development. Optimal distribution of climate finance at the global level is expected to attain climate change solutions and sustainable development.

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