SUB-SAHARAN AFRICA: SUSTAINABILITY RISK DISCUSSION

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ABSTRACT

Africa is a rising star - one of the most desirable investment destinations in the world. Nonetheless, economic growth is uneven among African countries, and many obstacles must be overcome in order to realize the full potential of opportunity. To achieve long-term sustainable investment results, and ultimately progress towards Sustainable Development goals, many risks must be isolated, analyzed, and mitigated. This paper introduces the concept of Sustainability Risk, identifying a set of major risk components for Sub-Saharan Africa and building an integral measure to quantify the degree of remoteness of the forty-six Sub-Saharan Africa countries from the total set of threats considered. The countries are separated into distinct groups with similar characteristics in terms of Sustainability Risk, and an analysis for potential decision-making, based on the visualization of the countries' position in relation to the major sustainability threats, is performed for each group. The research identifies risks with maximum impacts.

Key words: Africa**,** Sustainability risk, Sustainable investment, Decision-making

1 INTRODUCTION

The strategic role of science and technology in the process of informed risk-based decision-making is gaining more and more importance among world government leaders, international organizations, and academic institutions (Pandor, 2010; Brito, 2010; World Economic Forum, 2010 etc.) At the opening of the 22nd CODATA International Conference (CODATA, 2010), Naledi Pandor, South African Minister of Science and Technology, emphasized the need "to move beyond good science to concrete action to improve lives" and expand the effective use of science in policy making (Pandor, 2010). In particular, the minister's address appealed to the developing world, where "poverty is exacerbated by information poverty." Africa, the second largest and the most populated continent in the world (http://en.wikipedia.org/wiki/Africa), abundant in natural resources, is facing enormous challenges in sustaining adequate infrastructure, healthcare, education, and poverty reduction.

During many decades, numerous countries in Africa have had to unwind the problems of colonialism, severe ethnic conflicts, and issues of governance and social sphere. Globalization brings along huge opportunities and challenges.

The effects of the global economic crisis were felt in Africa in 2008 when FDI (foreign direct investment) dropped 43%. In 2009, ODA (official developmental assistance) streams significantly diminished, and remittances from developed countries drastically dropped, contributing to the vulnerability of many African countries. In 2009, Sub-Saharan Africa real GDP growth slowed down to 2.1 percent in comparison with the impressive levels of growth during the previous six years (IMF Regional Economic Outlook, 2010). Mainly due to oil exports, African countries display greater disparity in their ability to sustain inflationary pressures. (UN Economic Commission for Africa, 2010). At the same time, Africa's recent economic growth was achieved largely due to proactive reforms to settle conflicts, improve macroeconomic conditions, and foster better business climates (McKinsey Global Institute, 2010).

Along with rising obstacles to meeting Millennium Development Goals by 2015, many related concerns are coming in to play: balancing economic growth and ecological balance; addressing rising unemployment as a source of corruption, crime, and instability; lessening commodity dependency and diversifying economies, along with more even wealth distribution (UN Economic Commission for Africa, 2010; McKinsey Global Institute, 2010; World Economic Forum, 2008). Pandor (2010) and Brito (2010) once again emphasized that African and global modern society challenges do not stand separately and must be addressed in a multi-disciplinary context with the use of modern scientific achievements.

The objective of the research described in this paper is to illustrate the mechanism of analysis and decision-making processes for Sub-Saharan Africa based on a sustainability (or developmental) risk model. Bakhtina and Zgurovsky (2008) isolated the key risks and modeled the position of 42 African countries[1] in relation to the totality of the most significant threats. Based on this research, most North African countries[2] were clearly standing alone as a separate cluster, and it was concluded that further refinement was needed to expand and fine-tune the results with the focus on Sub-Saharan Africa.

This paper separates key sustainability risks for 46 Sub-Saharan Africa countries, isolates groups of countries with similar risk characteristics, and illustrates how the results can be used in the decision making process.

2 SUSTAINABILITY RISK DISCUSSION

The concept of sustainability risk is very intuitive but, at the same time, extremely difficult to define. This is probably the reason why few practical illustrations and risk quantification algorithms have been implemented. Sustainable development should lead to a harmonious balance of the three pillars: social, economic, and ecological and ultimately facilitate long-term progress, where future generations have the same/or broader opportunities as the modern society. An additional dimension of sustainable development is represented by the Millennium Development Goals, which outline the world's main development challenges and the milestones that must be met to make our planet a better place in which to live. There are two major challenges that need to be taken into consideration: (1) elimination of the defining gaps in the three areas of development – social, ecological, and economic and (2) definition of a mechanism to sustain and improve the level achieved (Bakhtina & Zgurovsky, 2008). These two challenges of sustainability risk management are interrelated and can be analyzed consequently (See Figures 1 and 2).

Sustainability risk can be defined as a global threat that can impede sustainable development in any area. After all key threats are identified, a vector of global sustainability risk with coordinates consisting of indicated threats can be built. The length of the vector determines the resilience of the country to its particular set of threats.

In the first step of the current research, the key risk components are identified and incorporated into a unique sustainability risk vector for each country. The next step is to develop unique metrics to quantify and measure the risks. The risk components are the most vulnerable links that (1) most likely can impair the process of sustainable development in the future, (2) can cause tangible physical threats, and (3) may lead to breaks in the other areas of development - social, environmental, or economic. After the risks have been identified and measured for various sub-segments, a separate effort can be employed to address them. Innovative programs to target crisis areas can be developed and implemented.

Then a mechanism to manage and sustain the achieved level of development is developed. This step can be addressed by the governments, lawmakers, and private sector at a later stage after the first challenge is resolved and weak developmental links are improved.

This paper defines a methodology for measuring sustainability risk, classification of risk components, and creation of a unified measure for separating the groups of countries with similar characteristics. The resultant risk is considered on a regional basis.

The research specifies and analyzes sustainability risks for Sub-Saharan Africa and builds and analyzes the global sustainability risk as a vector of the major risks that are most critical for Africa. The distance to the cumulative vector of threats, the risk index, is computed.

This approach attempts to identify the most susceptible countries in Sub-Saharan Africa that potentially can be targeted for further reforms. The framework for sustainability risk identification, measurement, and management is shown in Figures 1 and 2.

[1] North and Sub-Saharan Africa
[2] Mauritania was not covered by the analysis previously and is included in the current list of countries.

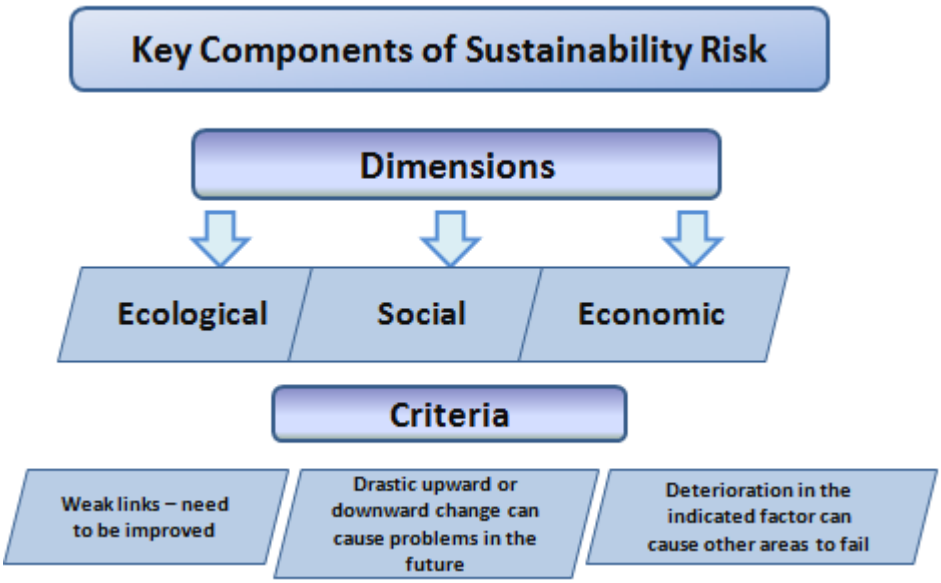


Figure 1. Sustainability risk components identification

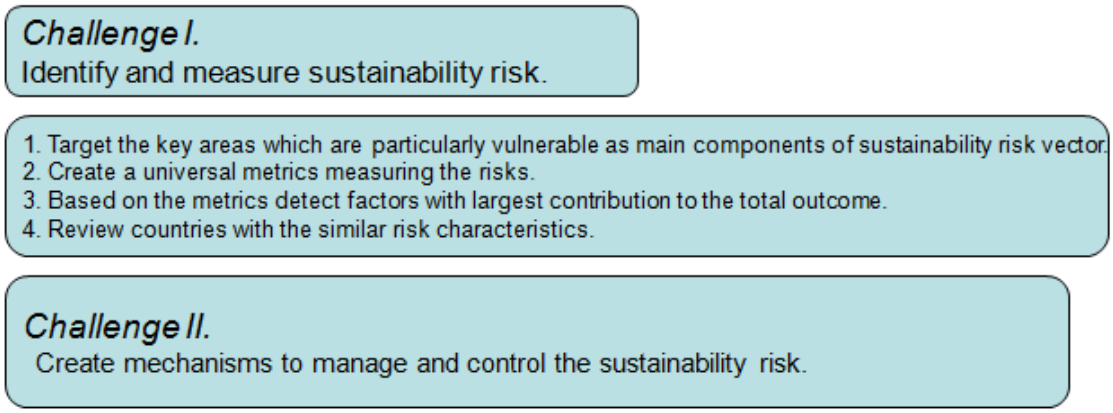


Figure 2. Sustainability risk management challenges

3 THE CONTEXT OF SUB-SAHARAN AFRICA (KEY RISKS)

This research separates Sub-Saharan Africa and Mauritania from Northern Africa. What are the main challenges that impede sustainable development of this region? The World Economic Forum in 2008 identified four main risks facing the African continent: a) food and freshwater security, b) geopolitical instability, c) economic shocks, and d) climate change challenges.

At least 28 Sub-Saharan Africa countries have been in a state of war since 1980 according to ID21 (International Development Organization) (Global Issues, 2010). Political instability, corruption, inadequate legislative mechanisms, breaches of civil rights and liberties, and ethnic violence are some of the reasons for such turmoil. Historically, inadequate regulation and policy making have been detrimental to the long-term economic prosperity of the region and foreign investment.

The increasing pace of urbanization and the voluntary and forced migration of populations to urban centers, exacerbated by the severe impact of climate change, have caused increasing problems with water security and consumption. According to World Bank statistics, in 2007 in eight African countries, over 50 percent of the population did not have access to clean potable water. In Somalia, the population with access to potable water was only 29 percent and in Ethiopia 22 percent. (World Bank, 2009) Inadequate waste and processing facilities can cause contamination or spread of water-borne diseases and be a source of pandemics (World Health Organization, 2010).

Increasing urbanization and economic growth strain the electrical grids. Lack of sufficient capacity for energy generation causes periodic blackouts and disruptions in the power supply. This impairs the ability of businesses to properly function and negatively reflects on the countries' economic capabilities.

The health of the population in Sub-Saharan Africa, especially the prevalence of HIV and malaria, is highlighted by many experts as one of the main threats to the area's well-being (UN, 2008; WHO, 2010 etc.). Under-nutrition and high death tolls among children are great concerns as well.

Climate change is the defining challenge of the XXI century and can bring unforeseen consequences to our civilization (United Nations, 2008; International Federation of Red Cross and Red Crescent Societies, 2009; UNU-IAS, 2008). Reducing the risk of natural disasters is becoming increasingly important for Africa.

The next key risk is the national level of education, science, and technology. Exceptional efforts of the International Council for Science Regional Office for Africa (ICSU ROA) are directed to transform science and technology innovation into an instrument for sustainable development via knowledge-driven economy (ICSU, 2011). The report by Muhongo, Gudyanga, Enow, and Nyanganyura (2009), which combined the latest research from African scientists, attests that science, technology, and innovation make tangible improvements in quality of life, poverty reduction, and contribute significantly to achievement of Millennium Developmental Goals.

Similarly, it is shown that educated communities in general enjoy higher levels of wealth while their economies have better productive capacities and achieve stronger economic growth (UNCTAD, 2006; United Nations Economic Commission for Africa, 2010). At the same time, growth is associated with a high degree of social participation, skills refreshment, and job creation. The overall health picture of educated communities also is positive.

More efficient mechanisms for natural disaster response, along with pioneering technologies to combat climate change, can be introduced. However, without qualified operators for the new technology, a mass of unknown and unpredictable risks can arise (UNU-IAS, 2008), which is why training and technical skills transfer are critical within the process of technology transfer.

Among other challenges for Africa, the World Economic Forum (2008) highlights economic shocks as a major risk. The recent global economic downturn has reduced remittances, negatively impacted trade, and resulted in higher unemployment in Africa. The 2010 Report by the McKinsey Global Institute emphasizes the important role of remittances as a significant source of capital and their substantial poverty-reducing effects. As for selected African countries, remittances constitute a considerable percentage of the capital inflow. A drop in remittances may significantly increase vulnerability and can bring negative results to the overall economies of the countries. Other factors emphasized in this report are high unemployment rates and vulnerable employment (informal and rural sectors). The need to focus on creating sustainable jobs to reduce poverty is also discussed. The unemployment data are not broadly available and not very accurate, omitting vulnerable jobs and gender aspects. Women and children are generally suffering most. Remittance information is available in Human Development Reports. (United Nations, 2008) Remittance inflows are related to the professional qualification of immigrants and their respective salaries, providing for more opportunities to aid their families in the home country.

There is a pressing need for African countries to diversify their economies and support the private sector via coherent regulation and enhanced institutional framework in order to attract foreign investors, protect the states against economic shocks, and make their financial systems more resilient.

The UN Economic Commission for Africa (2010), the McKinsey Global Institute (2010), and the World Economic Forum (2008) all suggest that viable investments in health, education, infrastructure, and technology, supported by private-public partnerships in these areas, would stimulate employment and sustainable growth.

Another important issue facing Sub-Saharan Africa is demography. Africa's population growth historically has been faster than that in other regions of the world. Based on various projections (Population Reference Bureau, 2010), the population of this continent will reach almost two billion by 2050. The projection results are dependent on variations of fertility forecasts, life expectancy at birth, and mortality rates. Population growth is not included in this sustainability risk model for Sub-Saharan Africa due to the complexity of population dynamics. However, it should be a topic for a separate review. All risk factors discussed above will be exacerbated with high population growth or drastic decline and will become more critical for sustainable development progress.

4 AGGREGATED VECTOR OF SUSTAINABILITY (DEVELOPMENTAL) RISK

Our current research refines and improves the previous methodology offered in Bakhtina and Zgurovsky (2008) by extending the three pillars of Sustainable Development: economic, social and ecological and reviewing Sub-Saharan Africa separately from North Africa. The research is expanded to the following countries: Mauritius, Cape Verde, Seychelles, Sao Tome and Principe, Madagascar, Malawi, Uganda, Chad, and Mauritania.

We define a global sustainability risk for a region as a cumulative vector of threats, where single threats or risks are defined by the risks mentioned in Section 2. The threats represent economic, ecological, and social risks. In this study, each country is evaluated in terms of its remoteness from the totality of threats. At first we summarize the set of threats given and then find illustrative quantitative measures, which are representative of the risks indicated.

Key risks for Africa from Section 2 are:

a) Vulnerability of the infrastructure and energy crisis,
b) Health of the population,
c) Educational level of the population,
d) Political and security risks,
e) Vulnerability to natural disasters,
f) Limitation of access to drinking water and sanitary facilities, and
g) Economic shocks.

Each of these risks can be measured by quantitative indicators reflected in publicly available statistics. Further selection of indicators is based on the following criteria: data should be representative of the risk, and the numbers should be available for all forty-six countries under consideration.

Based on expert research (United Nations Economic Commission for Africa, 2010; McKinsey, 2010; World Economic Forum, 2008; Collier, 2006; World Health Organization, 2010) and data availability, the key risks are represented by the following ratios:

a) Vulnerability of infrastructure - energy production to energy use ratio (ENPRENUSE) (World Bank, 2007);
b) Health - percent of HIV infected population (%HIV) (World Bank, 2010);
c) Education - literacy rate (LR) (World Bank, 2010);
d) Political and security risk –political stability and absence of violence index (PSAV) (World Bank, 2009) and corruption perception (CPI) index (Transparency International, 2010)
e) Vulnerability to natural disasters - disaster risk index (DRI) (United Nations Environment Program, 2010);
f) Limitation of access to drinking water and sanitary facilities - access to alternative water supply (AWS) information (World Bank, 2010); and
g) Economic shocks - remittance (REMIT) information.

Similar to Bakhtina et al. (2008) and Zgurovsky (2008), we consider a cumulative vector of threats that may change over time:

$$\vec{T}r_{j_k} = (CPI_k, HIV_k, PSAV_k, DRI_k, AWS_k, LR_k, ENPRENUSE_k, REMIT_k)$$

Where j denotes the respective country and k corresponds to a point in time.

We normalize all the coordinates of the interval [0, 1]. $\vec{T}r^{0}{}_{j_k}$ is a normalized vector of threats for country *j*. For each vector $\vec{T}r^{0}{}_{j_k}$, there exists a number $\left\|\vec{T}r_{j_k}\right\|$ that denotes the distance of the country from the selected totality of risks.

We then measure the distance of the country from the selected totality of risks with the Minkowski norm

$$\left\|\vec{T}r_{j_k}\right\| = \sqrt[3]{\sum_{l=1}^{n}(w_{ij}(t))(\vec{T}^{0}r_{jl_k})^3} \qquad \textbf{(1)}$$

Where $w_{ij}(t)$ are weights represented by functions such as $\sum_{l=1}^{n}(w_{ij}(t)) = 1$ and $\sqrt[3]{\sum_{l=1}^{n}(w_{ij}(t))\ (\vec{T}^{0} r_{jl_k})^3}$ > 0.

Based on a changing world risk outlook, the weights can potentially change. For simplicity we consider the latest time-series available, 2006 through 2008, along with constant and equal weights.

The next sections include results of the Minkowski norm computation for a set of 46 Sub-Saharan Africa countries (see Appendix 1). We separate groups of countries with similar risk characteristics, extract the components which contribute most to the sustainability risk, and analyze the clusters of countries in order to apply the results to the decision-making process.

5 SIMULATION RESULTS FOR SUB-SAHARAN AFRICA

The base assumption is that the key threats are represented by the seven factors listed in Section 2, and at the same time, each factor is represented by numerical indices. The seven factors under consideration are represented by eight numerical indices. The sustainability risk is measured by the distance of the country from the total set of threats, indicated in terms of the Minkowski norm (Eq. (1)). The shorter the distance the riskier the country appears in terms of the selected vectors-threats.

With the help of the agglomerative hierarchical clustering technique, all countries are divided into four groups (the global sustainability risk is computed on a regional level; grouping is relative to countries from the same region), based on the Minkowski norm (see Appendix 1): (1) low risk, (2) medium risk, (3) high risk, and (4) extreme natural disaster risk.

The current set of sustainability risk components covers social, ecological, and economic dimensions. The correlation matrix for the eight risk components (Figure 3) shows moderate correlations within the social dimension. The strongest correlation is between political stability and corruption perception – a higher political stability is associated with a diminished level of corruption as measured by the CPI (Corruption Perceptions Index), an index based on assessments and business opinion surveys, which is just one of many measures. According to Transparency International (2010), perceptions have proven to be reliable estimates of corruption.

The data for the selected set of countries show correlation between sound governance, better water access infrastructure, and higher educational attainment. Historically, countries with better governance have higher literacy rates, and a higher percentage of the population has access to clean water facilities.

Variables	*CPI*	*AWS*	*LR*	*HIV*	*ENPRENUSE*	*PSAV*	*DRI*	*REMIT*
CPI	**1**	**0.547**	**0.458**	**-0.300**	-0.145	**0.752**	0.132	-0.019
AWS	**0.547**	**1**	**0.630**	-0.257	-0.020	**0.518**	**0.340**	-0.130
LR	**0.458**	**0.630**	**1**	**-0.396**	0.231	**0.468**	0.200	0.082
HIV	**-0.300**	-0.257	**-0.396**	**1**	0.011	-0.273	0.045	0.045
ENPRENUSE	-0.145	-0.020	0.231	0.011	**1**	0.012	0.026	0.083
PSAV	**0.752**	**0.518**	**0.468**	-0.273	0.012	**1**	0.191	-0.260
DRI	0.132	**0.340**	0.200	0.045	0.026	0.191	**1**	-0.047
REMIT	-0.019	-0.130	0.082	0.045	0.083	-0.260	-0.047	**1**

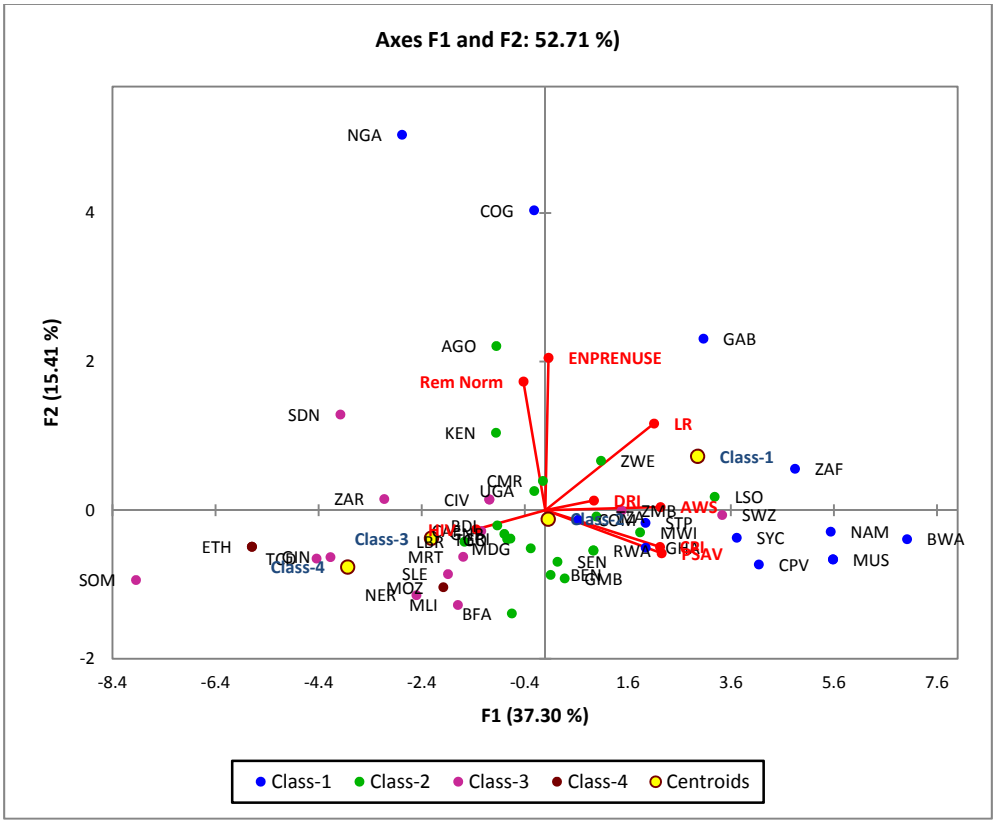
Figure 3. Correlation matrix of the sustainability risks

Principal components analysis (PCA) (Jolliffe, 2002) is used to illustrate the key risks and risk combinations with the highest impact on the global sustainability risk (see Appendix 2). The most important risk component (F1) is strongly related to political stability, literacy rate, and potable water supply, which implies that sound governance, a well-developed education system, and stable infrastructure are critical to the achievement of sustainable growth and development. The second risk component (F2) indicates that energy generation capacity, financial inflows, and successful education systems make countries more resilient to sustainability risks. The third component (F3), associated with threats to human life, indicates that countries with well-established disaster response systems and high levels of preventive medicine are more resilient to sustainability risks.

Out of eight key risk indicators only those that link to natural disasters are not under human control. With effort, all remaining six factors can be improved to more sustainable levels.

At the same time, building disaster management early warning systems, safety-nets, and timely response to natural catastrophes may significantly reduce devastating effects (United Nations, 2008; International Federation of Red Cross and Red Crescent Societies 2009; UNU-IAS, 2008). Though we have little control over disasters and their prevention, pervasive precautionary measures and education of the population via mass media can have tremendous effects.

The results of the analysis imply that global sustainability risk can be reduced via effective policies, improved governance, social inclusion, and coherent reforms in areas of health and education, along with harmonious channeling of resources, to a sustainable infrastructure implying effective investments in the areas indicated. Figure 4 represents an illustration of the above analysis and potential decision-making process.



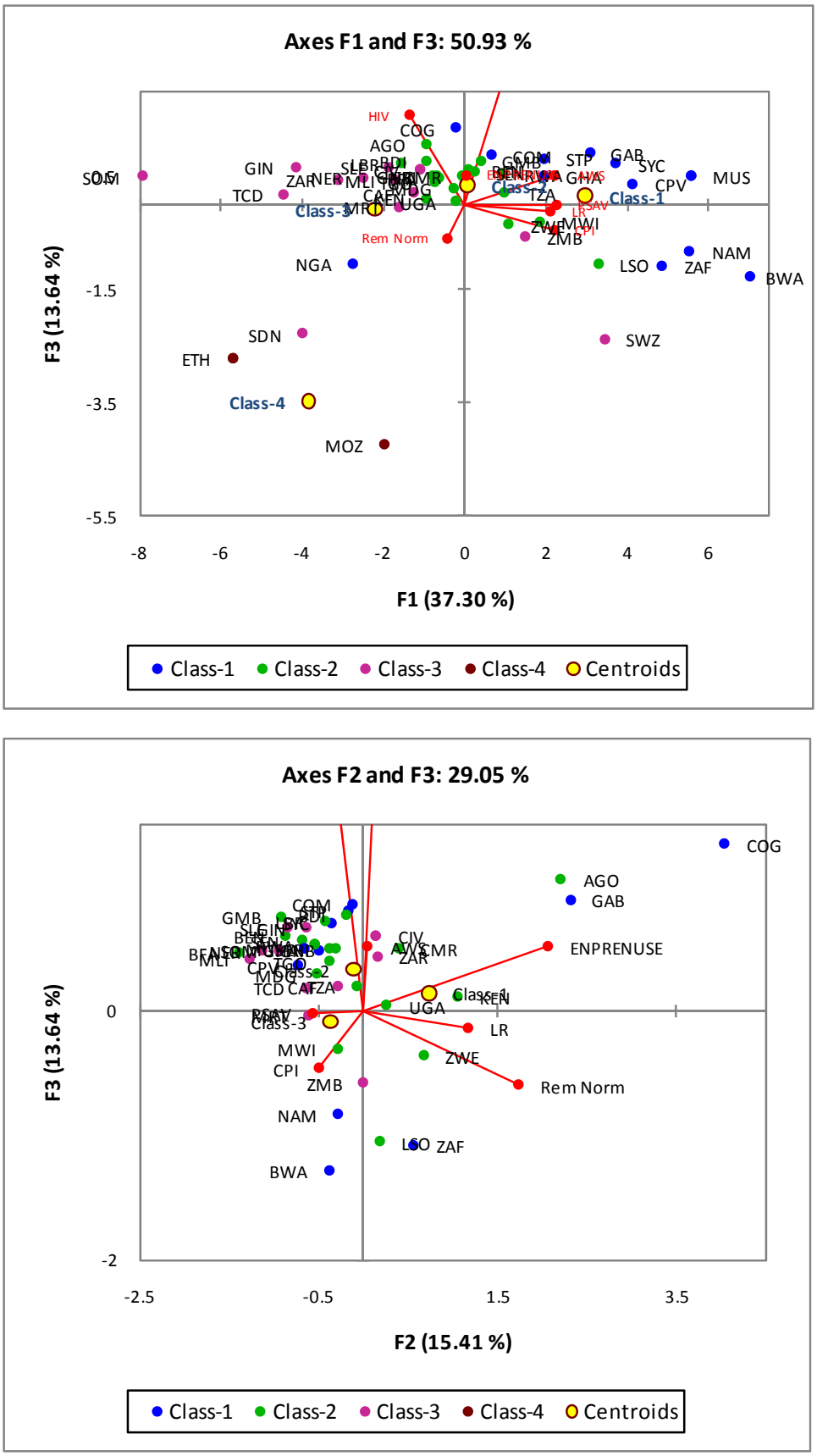


Figure 4. Groups of Sub-Saharan Africa countries with similar risk characteristics in the principal components system of coordinates (Class 1- lowest risk, class 4- highest risk)

Clustering the risk index (the Minkowski Norm) and the relative position of the countries gives us insights into using these data in decision-making. Mauritius, Cape Verde, and the Seychelles are at the top of the low risk cluster of countries. These countries have the most diversified economies, with sound governance and a commitment to developmental goals. Poverty is either "non-existent" in the traditional sense (African Development Bank Group, 2010) or appears at a much lower degree in comparison to the rest of Africa. Also the size and role of remittances are moderate compared to other countries. In these cases, the logical policy implication is to sustain the same level of sustainable development, further refine and advance their progress towards the Millennium Developmental Goals, and play a more proactive role in transformation of the continent.

Figure 5 is a detailed illustration of two countries depicted in Figure 4: Botswana and the Democratic Republic of the Congo. Botswana's risk index is 0.68 compared to the Democratic Republic of Congo (ZAR) at 0.55. Botswana belongs to the cluster of countries least vulnerable to the sustainability risk (Class 1), and the ZAR belongs to the most vulnerable countries (Class 3). Botswana is one of the most successful countries in Africa and has one of the highest Human Development indices. In contrast, the ZAR belongs to the group of countries with the lowest human development.

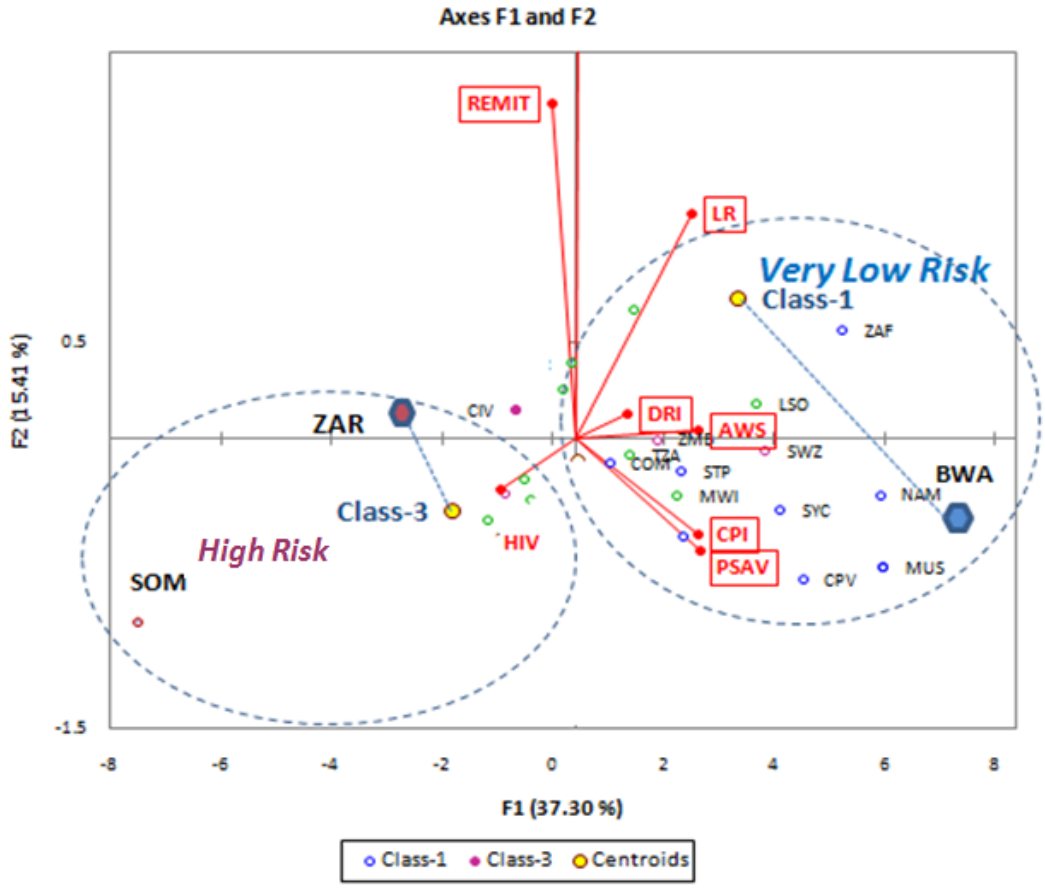


Figure 5. Democratic Republic of Congo (ZAR) and Botswana (BWA) risk characteristics.

Botswana has sound governance and political stability and is perceived to be the least corrupt in the group of forty-six countries. Ninety-five percent of the population has access to improved water supply versus 46 percent in the ZAR (World Bank, 2008). Though Botswana significantly surpasses the ZAR in literacy rates, it can benefit from investments in education and healthcare. The ZAR has large mineral resources, and opportunities in its infrastructure and energy sectors are highly underutilized. Though the political situation and investment climate have improved in comparison to the past, political stability is one of the lowest among the countries under consideration. In addition, the ZAR is considered to be one of the most corrupt countries among the forty-six (Transparency International (2010)). Additional investments in healthcare, education and infrastructure are vital.

South Africa has one of the most diversified economies in Africa and is strongly integrated with the world economy. It is also the country most impacted by the recent global recession. The government is proactively trying to find solutions to fight rising unemployment, attract more foreign direct investment (FDI), and structure innovative approaches in science, education, and technology to foster socio-economic development. South African scientists lead regional offices for science and technology and make substantial contributions to regional strategies based on the latest achievements in science. These policies allow the current position of South Africa to be sustained, progress in sustainability risk mitigation, and evolution to a higher level of socio-economic advancement via investments in science, its applications, and education (United Nations Economic Commission for Africa, 2010; McKinsey, 2010; Muhongo et al., 2009).

The low risk cluster includes the biggest oil exporters, such as Congo, Nigeria, and Gabon. Angola is among the highest performers in medium risk cluster. Clearly, oil orientation and energy production capacity are the main drivers of these countries' performance. As follows from Figure 4 (energy production to energy use is based on 2006 data and does not reflect the most recent economic slowdown in Congo related to an accident and closing of one of the major oil sites), these countries will succeed further if policy reforms focus on education and the social arena, building institutional capacity, and stimulating reforms to improve the efficiency of public expenditure. Economic diversification should also be a focus for this group of countries, led by Nigeria, where there is a considerable growth in non-oil related sectors (African Development Bank Group, 2010; McKinsey Global Institute, 2010).

Sudan and Chad are also oil rich countries, but they are heavily behind in the social arena with low political stability, a high perceived level of corruption, and lagging education systems (African Development Bank Group, 2010; McKinsey Global Institute, 2010; Transparency International, 2010; World Bank, 2010). These two countries are at the bottom quartile of the medium risk group and may require significant reforms that cover all three areas of sustainable development.

Out of the forty-six Sub-Saharan countries, Ethiopia and Mozambique clearly stand alone with their high exposure to natural disaster risks. Social and economic components should be analyzed separately for these two countries, but natural disaster risks prevail and may need more pervasive approaches to risk mitigation. The CPIA index (Country Policy and Institutional Assessment index) has been developed by the World Bank specifically for IDA (International Development Association) countries with a focus on the quality of each country's current policies and institutions (World Bank Group, 2010). The CPIA is strong for Mozambique and Ethiopia in relation to other IDA countries from the considered list. It shows commitment of government to advancement of progress in sustainable development areas.

It is crucial for decision-making that timely updates are made to these indicators. If timely updates are not made to the official numbers, it is more difficult to fit the models and come to meaningful conclusions.

The next step for decision makers after analysis of the sustainability risk model results is the detection and evaluation of the main drivers of the assessed risk indicators and a review of the set of counter-actions which can be applied in a local context, such as specific local behaviors and culture and the impact of policies, strategies, and other attainable measures used as tools for driving up developmental results. The proposed model can also be used for analysis of opportunities in the reduction of sustainability risks on a global scale.

6 CONCLUSION AND OUTLOOK

The need to bring science to decision makers and increase the role of science and innovation in policy formulation is becoming more and more apparent. The research reported here utilizes a sustainability risk model to isolate countries with similar characteristics based on recent data and illustrates a mechanism for a decision making process to focus on the most vulnerable areas. Based on the latest available public information, each country is depicted relative to the other countries of Sub-Saharan Africa. Potential areas for investment opportunities are highlighted for a selected set of countries.

The method described highlights an opportunity to perform informed risk-based decision making based on data acquired from each country. At the same time, major challenges remain to be addressed. The first and most apparent challenge is the development of consistent and comprehensive data standards and timely data availability. Information lags have serious implications for the decision making process. This current model should be used with caution and requires the most recent information updates. Due to a significant lag in data acquisition, many countries may look stronger or weaker in certain areas measured by indicators than they are at

the moment. To address the data gaps one can use resampling, taking the latest available information, or adjustment of the latest available information based on the latest country evaluation. All these approaches are not perfect and will introduce error.

The second challenge is availability of sufficient number of representative indices to reflect the key sustainability risks. With the current focus of the United Nations, governments, and non-governmental bodies on environmental and social areas, the coverage of indicators measured is significantly expanding. It is possible that with time, the set of indicators illustrating sustainability risk can be extended and the model can be fine-tuned.

This research demonstrates how illustrative multivariate statistical models can be used in proactive decision making and may inspire a more targeted effort on cross-border data standards development and improved data collection and curation.

7 ACKNOWLEDGEMENT

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APPENDIX 1

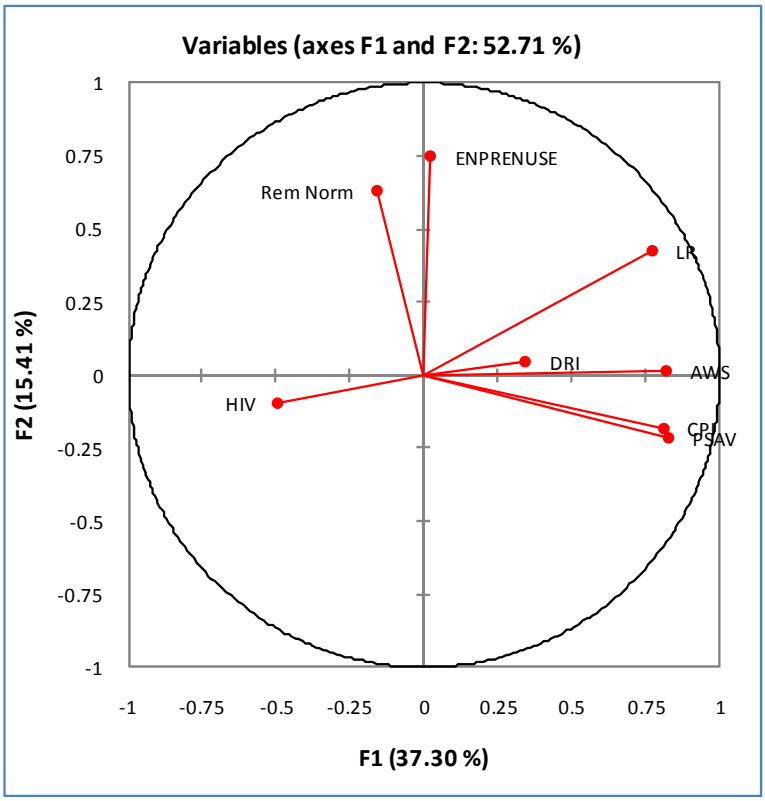
List of Sub-Saharan Africa countries - key sustainability risk indicators

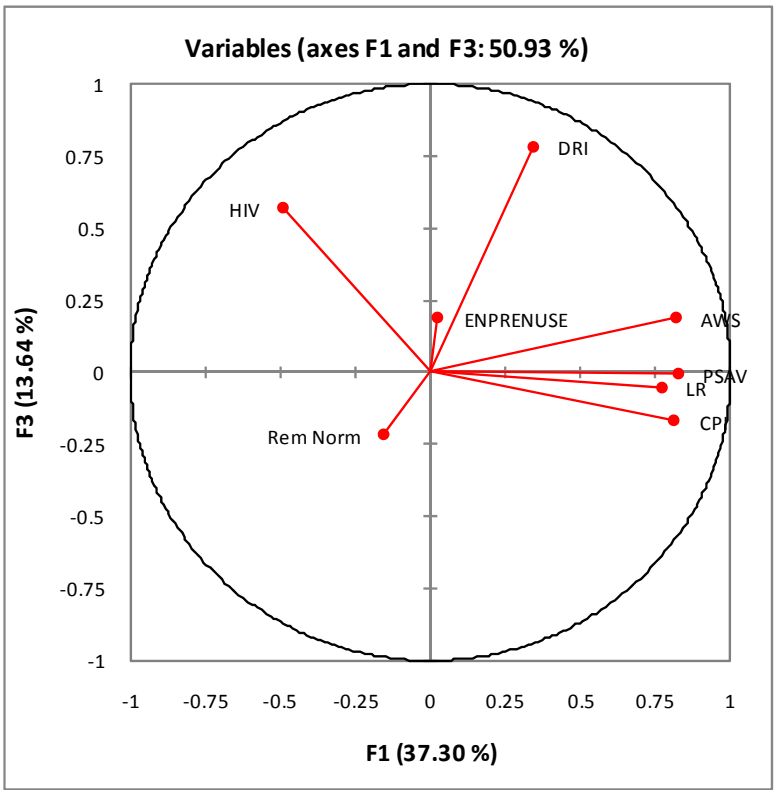
Country Code	Country Name	Risk Index	Corruptions Perception Index (CPI, 2008)	Improved water source (% of population with access), (AWS, 2007)	Literacy rate, adult total (% of people ages 15 and above), (LR, 2007)
MUS	Mauritius	0.76	5.5	100	87.4
CPV	Cape Verde	0.72	5.1	80	83.8
SYC	Seychelles	0.71	3.6	88	91.84
BWA	Botswana	0.68	5.8	95	82.9
GAB	Gabon	0.68	3	88	86.2
COG	Congo, Rep.	0.67	1.9	58	81.1
STP	Sao Tome and	0.67	2.7	79	87.9
NAM	Namibia	0.65	4.5	87	88
NGA	Nigeria	0.65	2.7	48	72
COM	Comoros	0.64	2.6	86	75.1
GHA	Ghana	0.64	3.9	75	65
ZAF	South Africa	0.64	4.9	88	88
RWA	Rwanda	0.61	3	74	64.9
SEN	Senegal	0.61	3.4	76	41.9
AGO	Angola	0.6	1.9	53	67.41
GMB	Gambia, The	0.6	2.5	82	45
MDG	Madagascar	0.6	3.4	46	70.68
BEN	Benin	0.59	3.1	67	40.5
TZA	Tanzania	0.59	3	62	72.3
BDI	Burundi	0.58	1.9	79	59.3
CMR	Cameroon	0.58	2.3	66	67.9
ERI	Eritrea	0.58	2.6	60	64.2
BFA	Burkina Faso	0.57	3.5	61	28.7
GNB	Guinea-Bissau	0.57	1.9	59	64.6
KEN	Kenya	0.57	2.1	61	73.61
LSO	Lesotho	0.57	3.2	79	82.22
LBR	Liberia	0.57	2.1	61	55.5
MWI	Malawi	0.57	2.8	73	71.8
TGO	Togo	0.57	2.7	52	53.2
UGA	Uganda	0.57	2.6	60	73.6
ZWE	Zimbabwe	0.57	1.8	81	91.2
ZAR	Congo, Dem. R	0.55	1.7	46	67.17
CIV	Cote d'Ivoire	0.55	2.1	84	48.73
MLI	Mali	0.55	3.1	50	26.2
SLE	Sierra Leone	0.55	1.9	57	38.1
ZMB	Zambia	0.55	2.8	58	70.6
MRT	Mauritania	0.54	2.8	53	55.8
NER	Niger	0.54	2.8	46	28.67
CAF	Central African	0.52	2	75	48.57
GIN	Guinea	0.52	1.6	50	29.5
SWZ	Swaziland	0.52	3.6	62	79.6
TCD	Chad	0.48	1.6	42	31.8
SOM	Somalia	0.48	1	29	0
SDN	Sudan	0.46	1.6	70	60.9
ETH	Ethiopia	0.39	2.6	22	35.9
MOZ	Mozambique	0.35	2.6	43	44.4

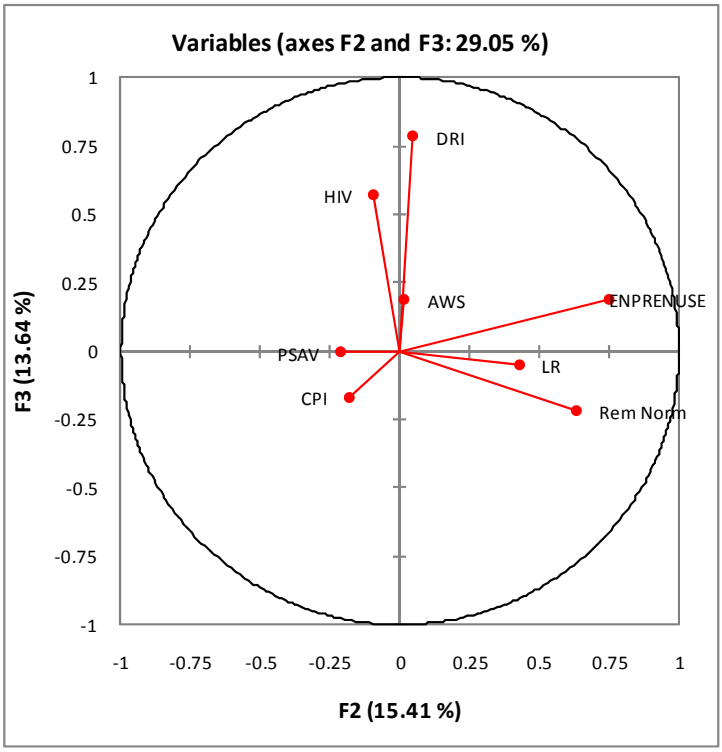
Country Code	Country Name	HIV Prevalence, latest 2007, (HIV)	Energy Production to Energy Use (ENPRENUSE), 2006	Polotical Stability and Absence of Violence (PSAV, 2008)	Disaster Risk Index (DRI)	Remittances, mil (REMIT, 2008)
MUS	Mauritius	0.6	0	0.84	0.31	215
CPV	Cape Verde	0	0	0.85	4.92	139
SYC	Seychelles	0	0	0.91	3.08	11
BWA	Botswana	24.1	0.55	0.96	1.26	141
GAB	Gabon	7.9	7.04	0.23	0	11
COG	Congo, Rep.	5.3	11.41	-0.61	0.04	15
STP	Sao Tome and	0	0	0.29	0	2
NAM	Namibia	19.6	0.24	0.96	0	17
NGA	Nigeria	3.9	2.23	-2.01	0.17	9,221
COM	Comoros	0.1	0	-1.01	6.2	12
GHA	Ghana	2.3	0.71	0.23	0.65	117
ZAF	South Africa	18.8	1.24	-0.04	19.9	834
RWA	Rwanda	3	0	-0.14	0.34	51
SEN	Senegal	0.7	0	-0.16	1.2	925
AGO	Angola	3.7	7.14	-0.43	0.13	0
GMB	Gambia, The	2.4	0	0.14	2.98	47
MDG	Madagascar	0.45	0	-0.42	4.65	11
BEN	Benin	1.8	0.65	0.35	0.94	224
TZA	Tanzania	6.5	0.93	0.01	0.8	14
BDI	Burundi	3.3	0	-1.43	0.14	0
CMR	Cameroon	5.45	1.71	-0.53	0.13	167
ERI	Eritrea	2.4	0	-0.84	0	0
BFA	Burkina Faso	2	0	-0.11	0.24	50
GNB	Guinea-Bissau	3.8	0	-0.38	0.06	29
KEN	Kenya	6.1	0.81	-1.25	0.78	1,588
LSO	Lesotho	23.2	0	-0.03	1.13	443
LBR	Liberia	0.85	0	-0.99	0.22	65
MWI	Malawi	14.1	0	0.05	2.43	1
TGO	Togo	3.2	0.8	-0.1	0.04	229
UGA	Uganda	6.4	0	-0.88	0.66	849
ZWE	Zimbabwe	18.1	0	-1.56	0.5	0
ZAR	Congo, Dem. R	3.2	0	-2.34	0.04	0
CIV	Cote d'Ivoire	7.1	1.05	-1.91	0.11	179
MLI	Mali	1.7	0.03	-0.21	0.2	212
SLE	Sierra Leone	1.6	0	-0.23	1.02	148
ZMB	Zambia	17	0.91	0.29	0	59
MRT	Mauritania	0.7	0	-0.93	52.63	2
NER	Niger	1.1	0	-0.75	0.56	78
CAF	Central African	10.7	0	-1.77	0.11	0
GIN	Guinea	1.5	0	-1.91	2.27	151
SWZ	Swaziland	33.4	0	0.22	34.77	99
TCD	Chad	3.5	0	-1.92	25.89	0
SOM	Somalia	0.9	0	-3.28	19.88	0
SDN	Sudan	1.6	1.69	-2.44	275.43	1,769
ETH	Ethiopia	1.4	0.92	-1.79	272.57	359
MOZ	Mozambique	16.1	0	0.29	327.51	99

APPENDIX 2

Risks with the highest impacts







APPENDIX 3

Factor loadings

	F1	F2	F3
CPI	**0.812**	-0.181	-0.169
AWS	**0.816**	0.015	0.188
LR	**0.770**	**0.426**	-0.051
HIV	-0.492	-0.094	**0.570**
ENPRENUSE	0.022	**0.750**	0.190
PSAV	**0.824**	-0.212	-0.005
DRI	0.344	0.047	**0.784**
REMIT	-0.155	**0.633**	-0.218

APPENDIX 4

Sustainability risk clusters

Country	Country Code	Risk Cluster
Mauritius	MUS	Low Risk
Cape Verde	CPV	Low Risk
Seychelles	SYC	Low Risk
Botswana	BWA	Low Risk
Gabon	GAB	Low Risk
Sao Tome and Principe	STP	Low Risk
Congo, Rep.	COG	Low Risk
Namibia	NAM	Low Risk
Nigeria	NGA	Low Risk
Ghana	GHA	Low Risk
South Africa	ZAF	Low Risk
Comoros	COM	Low Risk
Rwanda	RWA	Medium Risk
Senegal	SEN	Medium Risk
Angola	AGO	Medium Risk
Madagascar	MDG	Medium Risk
Gambia, The	GMB	Medium Risk
Benin	BEN	Medium Risk
Tanzania	TZA	Medium Risk
Burundi	BDI	Medium Risk
Eritrea	ERI	Medium Risk
Cameroon	CMR	Medium Risk
Lesotho	LSO	Medium Risk
Burkina Faso	BFA	Medium Risk
Uganda	UGA	Medium Risk
Guinea-Bissau	GNB	Medium Risk
Liberia	LBR	Medium Risk
Zimbabwe	ZWE	Medium Risk
Malawi	MWI	Medium Risk
Kenya	KEN	Medium Risk
Togo	TGO	Medium Risk
Cote d'Ivoire	CIV	High Risk
Sierra Leone	SLE	High Risk
Mali	MLI	High Risk
Congo, Dem. Rep.	ZAR	High Risk
Zambia	ZMB	High Risk
Mauritania	MRT	High Risk
Niger	NER	High Risk
Swaziland	SWZ	High Risk
Central African Republic	CAF	High Risk
Guinea	GIN	High Risk

Chad	TCD	High Risk
Somalia	SOM	High Risk
Sudan	SDN	High Risk
Ethiopia	ETH	Extreme Natural Disaster Risk
Mozambique	MOZ	Extreme Natural Disaster Risk

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