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QUANTIFICATION OF KEY DEVELOPMENTAL RISKS IN AFRICA

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Current research identifies six key developmental risks for Africa: (a) vulnerability of infrastructure, (b) health, (c) education, (d) political and security risk, (e) vulnerability to natural disasters and (f) limitation of access to drinking water and sanitary facilities. Key risks are combined to an integrated risk measure and their impact on 42 African countries is analyzed. Six countries most susceptible to the indicated set of risks are isolated.

INTRODUCTION

In recent years, the concepts of Sustainable Development and Millennium Development Goals (MDG) [1] are in the center of attention of the world community. At the same time, reaching the target by 2015 could represent a major challenge. Inter-agency working group, led by the United Nations, developed a system of measures to track the progress towards the MDG implementation [2]. The latest United Nations and the World Bank reports emphasize that “Africa is not on track to achieve any of the Developmental Goals on time” and lags behind in poverty reduction, human development and environmental sustainability [3]. In spite of recent economic growth, Africa faces significant challenges in the areas of healthcare, education, infrastructure and gender. According to the World Bank data for 2006 [4] Africa contains 32 of 48 world’s poorest countries and 24 countries ranked lowest in human development. According to P. Collier [5], Africa is likely to be a developmental problem in the future.

Ample research was done defining the developmental and sustainability measures. Sustainable Development Gauging Matrix methodology [6] defines a comprehensive framework which integrates economical, ecological and social components of sustainable development to a unique sustainability index. The authors attempt to compliment this methodology for Africa case and assess the Sustainable Development from the risk perspective. Similar to [7], a major set of specific threats, which could impair development and represent major setbacks, are separated, estimated and their impact is analyzed.

DEVELOPMENTAL RISK INDICATORS AND THEIR PROXIES

Based on the United Nations, World Bank, P. Collier research, and World Development reports we isolate six key risk factors-threats. These factors are

- a) vulnerability of infrastructure, in particular, severe energy crisis;
- b) health of the population, including availability of health facilities and shortage of healthcare workers (current paper focuses on HIV/Aids infected population);
- c) education;
- d) political and security risk;
- e) vulnerability of the countries to natural disasters;
- f) limitation of access to drinking water and sanitary facilities.

For each risk factor an intuitive quantifiable proxy which could be used as an input to the model is considered. The exact description of variables used and their definitions are provided in Appendix 1.

Ratio of energy production to energy use is considered as a proxy measure for vulnerability of infrastructure factor (e). For some countries electrical outages (in days) and WTTC. (World Travel and Tourism Council.) Infrastructure Index (2001) are provided as supplementary data points. Factor (b), or health of the population, is measured by percent of HIV infected population as of total country population. Number of physicians per 1000 people is used as an additional factor to fine-tune the model. Education (c) is measured by literacy rate data from WDI (World Development Report.) [3]. Appendix 2 explains how missing data points on various factors are approximated. Political and security risk (d) is approximated by political stability and absence of violence index developed by the World Bank (2006) [8]. Vulnerability to natural disasters (e) can be evaluated with the help of disaster risk index (DRI) and fine-tuned using deforestation rate. At last, limitation of access to drinking water and sanitary facilities (f) is associated with access to improved water supply variable (AWS).

Key data for 42 countries out of 56 African countries were added to the dataset. For the analysis purposes Middle East (North Africa) was not excluded. It should be noted that some partial data points were available for the remaining 14 countries but were not used. Absence of data could be an indication of a potential risk for a country, and further work is required to collect the data.

SIMULATION RESULTS

Six main variables are introduced as inputs to the model:

- Energy production to energy use (ENPRCONS).
- Percent of HIV infected population (%HIV).
- Literacy rate (LR).
- Political stability and absence of violence (PSAV).
- Disaster Risk Index (DRI).
- Access to water supply (AWS).

Initially, all variables are normalized for 42 countries in Africa. As the next step, a vector of Global Africa Risks (GAR) is formed to assess the cumulative impact and the level of remoteness of the selected countries from the indicated

threats [7]. Minkovski norm and Vard clusterization agglomerative hierarchical algorithm are used to measure the likelihood of crisis caused by the combined series of threats. Results of a simulation are provided in table 1.

Table 1.

Rank	Country	PSAV Political Stability and Absence of Violence Index, (WGI), 2006	DRI Disaster Risk Index (DRI), 2003	AWS Access to water supply, 2003	LR Literacy rate, adult total (% of people ages 15 and above) Human Development Reports (UN), 2007	ENPRCONS Energy production (kt of oil equivalent) / Energy use (kt of oil equivalent), (DDP), 2004	%HIV	Minkovski Norm after Normalization	Mean Values of Treats
Low risk									
1	Egypt	0,387	0,997	0,945	0,714	0,095	1,000	0,751	0,690
2	Congo	0,369	1,000	0,510	0,847	0,987	0,880	0,745	0,765
3	Algeria	0,384	0,983	0,940	0,699	0,420	0,998	0,737	0,737
4	Comoros	0,518	0,982	0,920	0,560	0,000	0,997	0,717	0,663
5	Libya	0,589	1,000	0,715	0,842	0,391	0,992	0,711	0,755
6	Tunisia	0,584	0,997	0,800	0,743	0,065	0,997	0,704	0,698
High risk									
7	Djibouti	0,509	0,949	1,000	0,375	0,000	0,924	0,697	0,626
8	Morocco	0,489	0,996	0,785	0,523	0,005	0,997	0,677	0,633
9	Botswana	0,769	0,996	0,950	0,812	0,045	0,388	0,674	0,660
10	Senegal	0,498	0,997	0,750	0,393	0,034	0,979	0,653	0,608
11	Niger	0,482	0,998	0,560	0,290	0,000	0,977	0,629	0,551
12	Lesotho	0,575	0,997	0,910	0,822	0,000	0,398	0,628	0,617
13	Benin	0,615	0,997	0,630	0,347	0,055	0,959	0,625	0,600
14	Gabon	0,565	1,000	0,700	0,840	0,596	0,827	0,623	0,755
15	Mali	0,547	0,999	0,600	0,240	0,000	0,962	0,622	0,558
16	Ghana	0,587	0,998	0,600	0,579	0,062	0,942	0,615	0,628
17	Sierra Leone	0,462	0,997	0,280	0,348	0,000	0,965	0,613	0,509
18	Zimbabwe	0,331	0,999	0,810	0,894	0,077	0,477	0,612	0,598
19	Eritrea	0,387	1,000	0,460	0,610	0,000	0,946	0,610	0,567
20	Burkina Faso	0,511	0,999	0,345	0,240	0,000	0,955	0,608	0,508
21	Gambia	0,578	0,991	0,620	0,420	0,000	0,947	0,608	0,593

22	Dem. Rep. Congo (Zaire)	0,125	1,000	0,450	0,672	0,086	0,930	0,604	0,544
23	South Africa	0,533	0,995	0,860	0,824	0,099	0,531	0,601	0,640
24	Burundi	0,300	1,000	0,650	0,593	0,000	0,921	0,600	0,577
25	Angola	0,453	1,000	0,380	0,674	0,504	0,920	0,600	0,655
26	Nigeria	0,184	0,999	0,530	0,691	0,193	0,912	0,596	0,585
27	Namibia	0,696	1,000	0,745	0,850	0,020	0,547	0,594	0,643
28	Togo	0,389	1,000	0,525	0,532	0,059	0,928	0,593	0,572
29	Rwanda	0,449	0,999	0,410	0,649	0,000	0,916	0,591	0,571
30	Guinea Bissau	0,438	1,000	0,490	0,260	0,000	0,919	0,582	0,518
31	Cameroon	0,505	1,000	0,570	0,679	0,150	0,875	0,577	0,630
32	Somalia	0,045	0,943	0,290	0,380	0,000	0,979	0,575	0,440
33	Kenya	0,347	0,998	0,445	0,736	0,067	0,848	0,564	0,574
34	Tanzania	0,515	0,998	0,520	0,694	0,078	0,854	0,563	0,610
35	Ivory Coast	0,165	1,000	0,710	0,487	0,087	0,835	0,554	0,547
36	Liberia	0,324	0,999	0,610	0,519	0,000	0,860	0,553	0,552
Very High risk									
37	Zambia	0,598	1,000	0,580	0,680	0,076	0,623	0,504	0,593
38	Central African Rep	0,238	1,000	0,595	0,486	0,000	0,752	0,503	0,512
39	Sudan	0,149	0,213	0,710	0,609	0,139	0,961	0,435	0,464
40	Swaziland	0,520	0,901	0,620	0,796	0,000	0,222	0,403	0,510
41	Ethiopia	0,215	0,221	0,230	0,359	0,076	0,952	0,364	0,342
42	Mozambique	0,640	0,064	0,600	0,387	0,080	0,636	0,022	0,401

The algorithm allows separate three clusters denoted as Low Risk, High Risk and Very High Risk.

North Africa clearly shows less susceptibility to the selected six risk factors. Out of five Middle East (North Africa) countries available for the analysis, four are grouped in a cluster with Low Risk (rank 1, 3, 5 and 6) relative to Sub-Saharan Africa. Morocco appears to be the riskiest country in the North Africa (ranked 8) mostly due to lower energy production and lower literacy rates in comparison to Egypt, Lybia, Tunisia and Algeria. The authors plan to consider North Africa in a separate research, perhaps, extending political risk, and adding more granularity.

Low Risk cluster includes Congo and Comoros. Congo has the highest rate of energy production, high literacy rate and very low disaster risk index. These strong components are overweighting relatively weak political stability and access to water supply components. Comoros looks stronger in relation to managing an HIV threat and access to improved water supply, with relatively low natural disaster risk.

Zambia, Central African Republic, Sudan, Swaziland, Ethiopia and Mozambique compose a Very High Risk cluster. Mozambique, Sudan and Ethiopia are most vulnerable to natural disasters in comparison to other countries. (DRI exceeds average countries by 300 times). In addition, Sudan is one of the countries with least political stability in the dataset. The other variables look promising for Sudan and show a reasonable potential to improve if the risks are paid special at-

attention to. In comparison to Sudan, Ethiopia and Mozambique need more support struggling with the risks as they show low literacy rate, are not supplying enough electricity to sustain the industry needs, and show higher percentages of HIV infected population and the lowest number of medical workers per thousand of people compared to the other countries.

Swaziland has one of the highest likelihood of natural disasters and the highest number of people infected by HIV (and only about one physician per 5000 people!). The political stability is average in comparison to other areas. Interestingly, Swaziland is one of the two countries which added forest area during the last years. Based on the data available, it is likely, that the government accentuated the efforts on environmental sustainability.

Kenya is placed at the High Risk cluster and ranked the 33rd out of 42. It is one of the riskier countries. Political stability is one of the lowest for Kenya (-1.09 compared versus the median of about -0.52 for the sample). Kenya has a descent capacity of energy production, but it covers only 81 percent of energy use. In addition, about 84 days per year have electrical outages. Some effort should be directed to manage the energy distribution. Approximately three percents of country population are HIV affected (and only about one doctor is available per 10000 people!) The numbers look striking and demonstrate how much effort should be mobilized to alter the current situation.

The simulation results showed that out of forty two African countries considered for the analysis, six countries are most vulnerable to the indicated developmental risks. These countries are Zambia, Central Africa, Sudan, Swaziland, Ethiopia and Mozambique. The research demonstrated that the natural disaster risk contributed most to this cluster of countries. The results also show that the combination of high political risk, energy production deficit, and problems with HIV/AIDS placed the countries to higher risk categories.

The simulation clearly indicates that North Africa should be analyzed separately.

SUMMARY

Africa faces serious challenges in attaining Millennium Development Goals which draws a lot of international attention. Current situation calls for a special effort to assist African countries in the most vulnerable areas and prevent critical risks' impact. We defined key developmental risks (developmental threats) for the continent and combined them to an integrated risk measure. Based on the degree of risk remoteness, African countries which are more vulnerable to the indicated risk measure are isolated. Out of six risk components, natural disasters, political risk, energy crisis and health issues contributed most to the existing ranking.

The research can potentially cover and refine the risks dataset and the results can be further expanded to (a) create likely offsets to the risks, (b) contribute to sustainable development of Africa and (c) be a supplementary tool to Millennium Developmental Goals' progress evaluation. Blending additional risk indices such as more granular political risk variables, healthcare data information, and climate related measures may add substantial granularity to the output.

APPENDIX 1

Index (Measure)	Description	Source
Politics and Freedom: Political Stability and Absence of Violence Index (PSAV)	The Political Stability and Absence of Violence indicator is a measure of "perceptions of the likelihood that the government will be destabilized or overthrown by possibly unconstitutional and/or violent means, including domestic violence and terrorism." Low scores in this variable indicate that citizens cannot count upon continuity of government policy or the ability to peacefully select and replace those in power.	http://info.worldbank.org/governance/wgi2007/ http://papers.ssrn.com/sol3/papers.cfm?abstract_id=999979
Disaster Risk Index (DRI)	Measure of vulnerability of countries to three key natural hazards: (1) earthquake, (2) tropical cyclone, (3) flood. Index is based on number of casualties as % of weighted national population. [killed per millions inhabitants].	http://gridca.grid.unep.ch/undp/
Improved access to water supply (AWS)	The access to water supply is defined in terms of the types of technology and levels of service afforded. This included house connections, public standpipes, boreholes with hand pumps, protected dug wells, protected springs and rainwater collection; allowance was also made for other locally-defined technologies. "Reasonable access" was broadly defined as the availability of at least 20 liters per person per day from a source within one kilometer of the user's dwelling. Access to water, does not imply that the level of service or quality of water is "adequate" or "safe"; these terms were replaced with "improved" Index shown as % of population	http://gridca.grid.unep.ch/undp/cntry_profile.php
Literacy rate, adult total (LR)	Shows % of people ages 15 and above	Human Development Reports (UN) http://hdrstats.undp.org/countries/data_sheets/cty_ds_BEN.html
WTTC Infrastructure Index, 2001 (WTTI)	Measure of the level of infrastructure development based on: (1) the total length of roads in a country compared with the expected length of roads, (2) the percentage of the population with access to improved sanitation facilities, (3) the percentage of the population with access to improved drinking water.	http://humandevlopment.bu.edu/dev_indicators/show_info.cfm?index_id=227&data_type=1
HIV/Aids Infected Total Population, 2005 (%HIV)	Percentage of population affected by HIV	http://www.globalhealthfacts.org/topic.jsp?i=1

Energy production to Energy use (ENPRCONS)	Energy production (kt of oil equivalent) as percentage of Energy use (kt of oil equivalent)	World Bank Data, 2004
Electrical outages of firms (ENOUT)	Electrical outages of firms (average number of days per year), World Bank Data	World Bank Data, latest available 2003-2006
Physicians per 100 people (HWDI)	Physicians per 100 people. HWDI reflects overall number of physicians per 1000 people in each country	World Development Report, latest data
Deforestation Rate (DR)	Measuring the total rate of habitat conversion. Change in forest area plus change in woodland area minus net plantation expansion for the 1990-2005 interval (the rate lost in % of forest and woodland habitat). ("- " is a positive trend)	http://rainforests.mongabay.com/deforestation/2000/

APPENDIX 2

Selected missing data points are approximated separately.

Literacy rate for Somalia is computed as average between male and female rates for 2001. For Comoros literacy rate for 2005 is used. Gambia and Eritrea literacy rates are approximated by youth literacy rates as of 1990.

For Ethiopia HIV statistical data provide low and high bounds. Average between low and high bounds is used as an approximation for HIV affected population. World Health Report estimate is used to approximate percentage of HIV affected population as of total population.

Based on [10], US Energy Administration Statistics country profiles, rates of energy production to consumption are approximated by zero for the countries where there is no natural gas, coal, electricity and no primary energy production as of 2006. The assumption covered the following countries: Burkina Faso, Burundi, CAR, Comoros, Djiboti, Eritrea, Gambia, Guinea-Bissau, Lesotho, Liberia, Mali, Niger, Rwanda, Sierra Leone, Somalia, Swaziland.

APPENDIX 3

Main Africa developmental risks (Initial data).

Country	WTT Infrastructure Index, 2001	Political Stability and Absence of Violence Index, (WGI), 2006	Disaster Risk Index(DRI), 2003	Access to water supply, 2003	Literacy rate, adult total (% of people ages 15 and above) Human Development Reports (UN), 2007	Energy production (kt of oil equivalent)/Energy use (kt of oil equivalent), (DDP), 2004	% HIV	Electrical outages of firms (average number of days per year), (DDP), 2003-2006	Physicians per 1000 of people, 2000-2005	Deforestation Rates, 1990-2005, %
Algeria	56,2	-0,89	6	94	69,87	5,04	0,06	12,42	0,2	-3,60

Angola	24,37	-0,51	0,1	38	67,4	6,05	2,01	87,27	0,1	3,10
Benin	23,77	0,38	0,9	63	34,7	0,66	1,03	77,33	0	9,1
Botswana	NA	1,23	1,3	95	81,2	0,54	15,30	21,28	0,4	3,70
Burkina Faso	NA	-0,19	0,2	34,5	24,00	0	1,13	9,61	0,1	2,80
Burundi	NA	-1,35	0,1	65	59,3	0	1,99	137,07	0	22,10
Cameroon	49,71	-0,22	0,1	57	67,9	1,80	3,12	12,94	0,2	8,40
Central African Rep	29,4	-1,69	0,1	59,5	48,6	0,00	6,19	NA	0,1	1,40
Comoros	NA	-0,15	6,2	92	56,00	0,00	0,08	NA		60,00
Congo Dem. Rep.	NA	-0,97	0	51	84,68	11,84	3,00	NA	0,2	1,10
Congo (Zaire)	NA	-2,31	0,1	45	67,2	1,03	1,74	177,97	0,1	3,10
Djibouti	65,44	-0,2	17,7	100	37,50	0,00	1,89	NA		0
Egypt	62,59	-0,87	1	94,5	71,41	1,14	0,01	13,91	0,5	0
Eritrea	13,41	-0,87	0	46	61	0,00	1,34	NA	0,1	4,30
Ethiopia	5,08	-1,82	272,6	23	35,90	0,91	1,21	NA	0	3,60
Gabon	29,34	0,11	0	70	84,02	7,15	4,34	NA	0,3	0,70
Gambia	29,45	0,18	3	62	42	0,00	1,32	NA	0,1	2,60
Ghana	39,55	0,23	0,7	60	57,9	0,75	1,45	NA	0,2	27,60
Guinea Bissau	29,01	-0,59	0,1	49	26,00	0,00	2,02	110,24	0,1	8,10
Ivory Coast	NA	-2,09	0,1	71	48,7	1,04	4,13	NA	0,1	
Kenya	42,29	-1,09	0,8	44,5	73,6	0,81	3,79	83,60	0,1	2,00
Lesotho	61,3	0,16	1,1	91	82,2	0,00	15,04	19,06	0	69,20
Liberia	NA	-1,22	0,2	61	51,94	0,00	3,50	NA	0	22,30
Libya	57,08	0,24	0	71,5	84,2	4,69	0,20	NA	1,1	0
Mali	41,87	0,01	0,2	60	24,00	0,00	0,96	10,48	0,1	4,90
Morocco	50,98	-0,31	1,5	78,5	52,31	0,06	0,06	5,79	0,5	0,30
Mozambique	30,51	0,52	327,5	60	38,7	0,96	9,09	NA	0	3,60
Namibia	58,92	0,83	0	74,5	85	0,24	11,32	19,17	0,3	9,30
Niger	20,85	-0,35	0,6	56	29,00	0,00	0,57	11,09	0	25,70
Nigeria	36,86	-1,99	0,2	53	69,12	2,32	2,20	NA	0,3	39,20
Rwanda	10,19	-0,53	0,3	41	64,9	0,00	2,10	NA	0	50,20
Senegal	47,37	-0,26	1,2	75	39,3	0,40	0,52	26,10	0,1	7,90
Sierra Leone	12,71	-0,46	1	28	34,83	0,00	0,87	NA	0	17,70
Somalia	NA	-2,75	19,9	29	38,00	0,00	0,53	NA		13,90
South Africa	65,65	-0,07	1,7	86	82,4	1,19	11,73	5,45	0,8	0,80
Sudan	42,43	-2,18	275,4	71	60,9	1,66	0,97	NA	0,2	11,60
Swaziland	NA	-0,14	34,8	62	79,6	0,00	19,45	28,61	0,2	-46,40
Tanzania	47,03	-0,17	0,8	52	69,4	0,93	3,65	60,64	0	37,40
Togo	24,69	-0,86	0	52,5	53,2	0,71	1,79	NA	0	16,40
Tunisia	NA	0,21	1,1	80	74,30	0,78	0,09	NA	1,3	2,30
Zambia	50,06	0,29	0	58	68,00	0,92	9,43	NA	0,1	14,30
Zimbabwe	49,25	-1,18	0,5	81	89,36	0,92	13,07	NA	0,2	36,80

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