Impact of Environmental Quality on Health Status: A Study of 12 Southern African Development Community (SADC) Countries between 2000 and 2008

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Abstract

This paper used two panel data models estimated by the random effects and fixed effects approach to establish the impact of environmental quality on health status in 12 SADC countries between 2000 and 2008. Proxies of environmental quality used in the paper are carbon emissions, access of people to improved water sources and improved sanitary facilities. Health status was measured by infant mortality rate. Environmental factors are found to account for about 38 percent of mortality in the region. The paper concluded that carbon emissions do not have an impact on health status of SADC countries. Access to improved water sources and sanitary facilities are found to have a greater impact on infant mortality than socioeconomic variables. The study also reports that there is significant difference in infant mortality rates between countries with environmental laws and where there are none. We conclude that it is important for SADC countries to strengthen environmental regulations meant to improve people's access to quality water and sanitary facilities among improved income, health expenditure and politically stable environment in efforts aimed to improve health status.

Key Words: Environmental Quality, Health status, SADC, Fixed Effects, Random Effects.
JEL Classification: I13, Q53, Q56.

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1. Introduction

This paper examined the impact of environmental quality on health status in 12 Southern African Development Community (SADC) countries. Environmental quality referred to the extent to which naturally occurring resources (land, air and water) are freed from impurities and degradation caused by human activity. Rapoport (1990) stated this definition as the immediate meaning of environmental quality. Measuring environmental quality is complex and there are no universal composite indicators. The paper therefore used some common indicators as used in literature (e.g., Daniel *et al*., 2002; Shen *et al*., 1997): that is carbon emissions, access to safe water and access to improved sanitary facilities. Health is a dynamic state of physical, social, spiritual and mental wellbeing of population that translates to quality life and not simply the absence of disease (CDCP, 2013) Infant mortality rate was used as the proxy for health status in this study[2]. The paper attempted to precisely measure the health consequences of caring about the environment as the two are intertwined.

There has been rising interest among epidemiologists, socialists, scientists and economists in modeling the health production function (Sanglimsuwan, 2011a; Drabo, 2010; Fayissa *et al*., 2005; Somov, 2004; Daniel *et al*., 2002; Shen *et al*., 1997). Such studies are however limited when it comes to African countries. Health, in the abovementioned studies, has been modeled as a function of income, education, health expenditure, price of medical care, wages, cigarette smoking, density of food outlets, carbon emissions and preventive environmental factors. One weakness of these studies is that they failed to give precise attention to environmental variables. These studies that attempted to establish the health environmental link pooled data from countries that are largely different in their levels of economic development as well as physical and socio-demographic characteristics. Such studies could only establish the broad health environmental link without a precise focus to a given area or region. Thus, there is no study, to the knowledge of the authors, which has attempted to precisely establish the health-environmental link in the SADC region.

The Grossman (1972) model of health production augmented by environmental, economic and social variables was employed for the purposes of our study. A similar approach to the one used by Shafik (1994) to study the relationship between economic growth and environmental quality was employed in this study. Two models were specified and estimated independently; one partially specified to find out the variation in health precisely explained by changes in environmental factors, and the other one being fully specified model of health production. Panel data estimation techniques were utilized. The study covered 12 SADC countries; namely Angola, Botswana, Malawi, Democratic Republic of Congo (DRC), Mozambique, Tanzania, Mauritius, Madagascar, Swaziland, Namibia, Zambia and Zimbabwe.

[2] Infant mortality rate is the number of infants dying before reaching one year per 1000 live births.

South Africa was excluded as it was considered big enough to distort results while Lesotho and Seychelles were excluded based on data unavailability.

The rest of the paper is organized as follows: section two (2) provides the background context of the study in attempt to situate the study, followed by section three (3) is the literature review; that is critical examination of related studies. Section four (4) narrates the data sources and methodology utilized to meet the objectives of the study while section five (5) outlines the estimation framework and we conclude in section six (6) by specifying key issues in the study and suggesting some recommendations.

2. Background Overview

The Alma Ata Declaration of 1978 noted that protecting human health is essential for human welfare (quality of life and peace), social and economic development. Health is the vital policy objective at both national and international level. That is national and international policy anchors on ensuring that people lives a long quality life. This has been demonstrated by the setting out of the Millennium Development Goals (MDGs) which are all related to health in their totality as well as effort and resources attributed to their fulfillment.

The health of a nation serves both as an important means and a basic end in efforts aimed at improving human welfare (Fayissa *et al*., 2005). Health people are able to positively contribute to economic development by active involvement in the productive sectors of the economy such as agriculture, manufacturing, mining and informal activities. This also improves their own incomes thereby reducing poverty and inequality. After recognizing that health is wealth, and that poor health is a deprivation that is part of poverty, WHO (2002) noted that governments should promote the way of life people lead and freedoms they enjoy, especially freedom from escapable mortality and avoidable illnesses.

Over the years, SADC countries made progress on issues including healthcare, health financing, health resource mobilization, effectiveness of public health systems, coordination and strengthening of public-private partnerships and effectiveness of health systems. Health outcomes have improved though the region continues to face a heavy burden of both communicable and non-communicable diseases. Infant Mortality Rate (IMR) though it has been declining, it remained unacceptably high in countries such as Angola, DRC, Mozambique and Swaziland at 102, 114, 82 and 78 deaths per 1000 live births in 2008 respectively (see Table 1 for details). Kaseje (2006) noted that many policy analysts raised fears that the current rate of progress in Sub-Saharan Africa will not be able to provide satisfactory healthcare to its inhabitants and will not achieve any of the United Nations Millennium Development Goals (MDGs).

Table 1: Infant Mortality Rates and Carbon Emissions per capita: 2000 to 2008

	Infant Mortality Rate (IMR)			Carbon emissions per capita (kilotons)		
Country	**2000**	**2004**	**2008**	**2000**	**2004**	**2008**
Angola	119	110	102	9 542	18 793	24 371
Botswana	51	34	24	4 276	4 378	4 840
DRC	117	117	114	1 646	2 281	2 816
Madagascar	67	57	48	1 874	1 936	1 911
Malawi	98	82	63	906	975	906
Mauritius	16	14	13	2 769	3 194	3 953
Mozambique	116	98	82	1 349	1 922	2 314
Namibia	48	47	36	1 764	2 497	3 968
Swaziland	77	82	78	1 188	1 030	1 093
Tanzania	78	65	53	2 651	4 353	6 465
Zambia	91	80	65	1 819	2 109	1 889
Zimbabwe	63	57	50	13 887	9 927	9 076

Source: Data adapted from the World Bank Development Indicators, 2012.

Progress conceived is a result of improved health financing and coordination mechanisms (Kaseje, 2006). Governments beefed up their commitment to healthcare, cost-effective prevention and treatment program, effective and efficient public health systems and improved health education. Physical environment as an important component of population health had been marginally considered. Efforts and commitment may equally need to be directed to environmentally sustainable production and consumption mechanisms as both complement and supplement socio-economic factors for improving population health.

SADC countries are experiencing environmental problems ranging from land degradation, pollution (air and water), biodiversity loss, deforestation, waste degeneration and disposal, veld fires and climate change among others. As shown in Table 2, average annual carbon emissions for SADC countries increased by 25% from 29 475 killotonnes (Kt) in 2000 to 36 865 in 2011. Forest area decreased by 5% from an average of 275 194 km^2 in 2000 to 261 793 in 2011. These problems are likely to threaten gains in health achieved in the African region that include decline in under-five mortality rate from 173 per 1000 live births to 95 in 2012 (WHO, 2014). In some countries such as Botswana, IMR was reported to have increased between 1992 and 2007 from 56 to 76 per 1 000 live births respectively (United Nations Children's Fund (UNICEF), 2011). Causes of such environmental problems include poverty, weak institutions, unsustainable agricultural and fishing practices, and growing population and industry non-responsive to environmental matters. Table 1 above show that carbon emissions in the SADC region are low but increasing; a condition that may result in poor concentration given to the effects of carbon emissions on health and the people's wellbeing. Donohoe (2003) argued that some of the

consequences of environmental problems such as land degradation include increased poverty, famine, weather extremes and acute and chronic medical illnesses.

TABLE 2: Environmental and Health Statistics

					Mortality Rate (per 1000 live births)				Improved Sanitation (% of rural population with access)			
	Carbon Emissions (kt)		Forest Area (sq. km)		IMR		U5MR		Rural	Urban	Rural	Urban
Country	**2000**	**2011**	**2000**	**2011**	**2000**	**2011**	**2000**	**2011**	**2000**	**2000**	**2011**	**2011**
Angola	9,542	29,710	597,280	583,552	128	107	217	177	12.50	73.00	20.90	86.20
Botswana	4,276	4,855	125,350	112,326	52	40	83	52	31.70	69.20	41.30	77.10
DRC	1,646	3,425	1,572,490	1,538,236	107	83	161	112	18.90	29.50	26.10	28.80
Lesotho		2,259	420	440	84	72	117	97	21.10	35.10	26.20	36.90
Madagascar	1,874	2,450	131,220	124,960	70	41	109	58	8.00	16.40	8.50	17.60
Malawi	906	1,206	35,670	32,040	104	54	174	85	32.20	46.20	37.80	47.00
Mauritius	2,692	3,916	387	350	16	13	19	19	89.80	93.40	92.20	93.80
Mozambique	1,349	3,282	411,880	388,106	115	68	171	98	4.70	36.90	9.30	41.60
Namibia	1,643	2,776	80,320	72,158	49	36	76	52	12.60	58.40	15.70	55.50
Seychelles	557	598	407	407	12	12	14	14	98.40	98.40	98.40	98.40
South Africa	368,611	477,242	92,410	92,410	54	37	75	50	45.60	66.00	56.50	68.60
Swaziland	1,188	1,049	5,180	5,674	84	54	128	79	48.60	62.80	55.30	63.00
Tanzania	2,651	7,301	374,620	330,246	80	40	131	59	7.20	16.30	8.00	27.30
Zambia	1,822	3,047	511,340	493,014	91	..	163	79	31.50	57.60	34.60	56.20
Zimbabwe	13,887	9,861	188,940	152,970	64	54	106	86	33.30	50.80	31.50	49.70
Average	**29,475**	**36,865**	**275,194**	**261,793**	**74**	**51**	**116**	**74**	**33.07**	**54.00**	**37.49**	**56.51**

Source: World Development Indicators, 2015

A number of factors may account for poor environmental quality in SADC countries. Urbanization and industrialization had been on the rise. In 2009, the urbanization rate was stated to be 1.1 percent in SADC countries (McGranahan *et al.*, 2009) while economic growth rate was higher than the global growth rate of 2.7 percent (UNESC, 2013). As urbanization increased, most cities and towns in the region failed to upgrade utilities and environmental services at the same rate. Industrial growth supported through pro-trade policies exerts pressure on the environment. New industries that are weakly regulated or unregulated exploit the environment through increased pollution and land degradation among other environmental threats. Specifically, urbanization and industrialization in poorly regulated environments led to increased contamination of water bodies, air pollution (carbon emissions), unsustainable resource exploitation and loss of biodiversity. In this regard, countries such as Mozambique and DRC had less than 50 percent of their population with access to improved sanitary facilities and safe water by 2008 (World Bank, 2013).

Climate change is another phenomenon threatening the SADC region. Existing evidence (Young *et al*., 2010) shows that there is increasing frequency of hot days, inter-annual variability of rainfall and droughts. Countries that include Botswana, South Africa, Namibia and Zimbabwe were predicted to

experience greatest warming of 0.2^{o}C to 0.5^{o}C per decade (Young et al., 2010). These changes in climate will most likely affect the basic natural life support systems that include safe drinking water, clean air, and sufficient food and secure shelter. The SADC region, given limited technology, economic capacity, high income inequalities, social structure, conservative and inflexible culture, pre-existing high levels of the burden of disease and fragmented health services, is vulnerable to the impact of these environmentally related changes.

The African Development Bank (AfDB) (2009) reported that the majority of people in the SADC region, specifically those in rural communities, lack access to clean water supply and sanitation. World Bank data utilized in this study shows that two thirds of SADC countries considered had less than 50 % of their population with access to safe sanitary facilities and a third of the countries had less than 60 % of their population with access to safe water. Water and sanitation are a challenge in this region. There also exist disparities in access to improved water and sanitation between urban and rural residents, and the rich and the poor. World Bank data shows that in 2011, 33% and 54% of rural and urban population had access to improved sanitation which improved to 37% and 56.5% in 2011 respectively. WHO (2013) indicated that 90% of population in the richest quintile had access to improved water sources in SSA compared to 60% of those in the poorest household quintiles. About 35% of the rural population was also found to have access to improved water sources compared to 63% in urban areas. Better access to improved water sources and sanitation remains for the rich and urban, while it is poor for the low income and rural population.

As a result the above environmental challenges, the region suffers from avoidable illness such as Cholera and Typhoid. Challenges in water supply and sanitation stem from inadequate funding of water and sanitation facilities, weaknesses in sector policy, poor infrastructure, and poor data and information for effective planning and inadequate public awareness on the importance of water for social and economic development. The region has been implementing various initiative related to improving people's access to safe water and improved sanitation as well as a better environment. Initiatives includes Emergency Rehabilitation and Risk Reduction programme, Water and Sanitation Response Programme, Community Based Water Programme, Community Water Management programme, Water Action Plans, Funding for Water Relief, Water Supply and Sanitation Technology programs, Regional Fund for Water and Basic Sanitation, inter-alia. It would be a valuable addition to evaluate the extent environmental factors continues to cause mortality and morbidity following the implementation of the above various water, sanitation and hygiene program[3].

[3] Mortality refers to death: a unique, universal, final and clearly defined event. Morbidity refers to diseases and illness, injuries, and disabilities in populations (Hopkins and Mosley, 2006)

While progress has been made in improving access to improved water sources and sanitation disparities exists between member countries in SADC and the relationship between the improvements in water and sanitation and declining child mortality is mixed. Seychelles and Mauritius had above 90% of their rural population with access to improved sanitation in 2011 while the rest of SADC countries had less than 56%; Mozambique, Madagascar and Tanzania were on the negative extremes as less than 10% of rural population had access to improved sanitation (Table 1). In Mozambique, 98% increase in the rural population with access to improved sanitation between 2000 and 2011 was accompanied by 41% declined in infant mortality rate while in Malawi an increase in rural population with access to improved sanitation was accompanied by a decline in infant mortality rates of 48%.

However, SADC countries are still experiencing environmental problems and high rates of disease and death related to these environmental challenges; Malaria, Cholera and typhoid and growing non-communicable diseases. These outcomes include increased burden of disease, poverty, food insecurity and worsening income inequalities (Sola, 2001; Weingartner, 2000; Gregory *et al*., 2005). This study precisely focused on measuring the relationship between health and the environment among SADC countries. Health outcomes were expected to improve if more effort was committed to enhance the status of the environment in the form of abating pollution, improving access of people to safe water and sanitary facilities as well as addressing other environmental concerns. Thus, it sought to provide another important channel of successfully improving health outcomes other than conventional means that include improving incomes, education and healthcare services.

3. Literature Review

There is scant literature on the subject under consideration. Theory is scarce as it proffers much insight on the health and social environment linkage without a broad consideration of the natural environment. It seems the health-physical environment linkage is regarded as obvious. In Africa, particularly the Southern part, empirical literature is little and suggests the field is of no consequence. We review below some forms of economic theories of health that are of relation to our study in an attempt to plausibly guide this study.

Preliminary work on the health-environmental relationship was developed by Andersen in the 1960s. The initial model discussed mainly factors determining use of health services with a shallow consideration of health outcomes. The model further lacked emphasis on the impact of physical environment on health as social environmental factors were given much emphasis. In an emerging model, Andersen (1995) explicitly recognized the external environment (physical, political and economic) as input of health services use and health outcomes. In this model the external environment and healthcare system has a direct impact on health and health services use. It can also indirectly affect health outcomes and services use through predisposing characteristics, enabling resources, health practices and services use. This model is insightful in linking the health outcomes to the external environment which are of particular importance for preventive and promotional health policy. However, its attention on the use of health services makes it fail to give precise concentration on the relationship between health outcomes and the environment.

Based on the ecological model of health developed by Baker (1963), both physical and social environments have a role in determining the health and the ill. The defining characteristic of this model is that individuals affect environmental changes which in turn affect individuals in an interactive, complex and nested reciprocal chain. An epidemiologic triad had been developed in the theory of disease causation that link the agent of a disease to the host and the environment. The environment plays a role in harboring disease causing agents or hosts in a manner that may or may not lead to the development of the disease or ill-health. The theory is however lame in explaining chronic diseases that can develop due to direct exposure to adverse environmental factors such as radiant heat.

Health is regarded as a durable capital stock produced by an individual using own time and market inputs according to Grossman (1972). The model importantly links a variety of factors such as medical care, exercises, diet, housing and recreation to the production of health. Precisely, the Grossman health production model provides the theoretical underpinning for augmentation of various social, economic and environmental factors in determining the state of health. Education was regarded as an important variable among other "environmental variables". One weakness of this model relate to its strong bias towards endogenous production of health yet a number of outside factors such as the physical

environment, health policy and financing are key factors affecting health outcomes. Regarding the environment, the Grossman model relates to the social environment such as education and not the physical environment. The model is therefore of importance in providing the theoretical base of modeling health.

Despite the above models slightly delineating the link between health and environment, the relationship remains complex and quite unattended empirically. It is almost well known that the physical environment has effects and some causal relationships with both chronic and communicable diseases. There is lack of an exogenous model of health that focus on interaction between humans, creatures and their environments in determining population health. However, apart from the partial theoretical linkages, the specific impact or extent of adverse health outcomes resulting from environmental factors still warrants considerable research.

Empirical literature has attempted to affirm or reaffirm the significance of the physical environment in explaining health outcomes in the world of declining forests, increased pollution and declining access to water and sanitation due to climate change and variability. Denovan *et al*. (2013) argued that natural environment has important public health effects. In a two fixed effects regression, while controlling for other factors, mortality due to cardiovascular and lower respiratory-tract illness was found to increase with increased loss of trees due to emerald ash borer. It may however be misleading to take these guiding results and apply them as such in Southern Africa where the environment is much different from that in United States of America.

An attempt was made by Sanglimsuwan (2011) to establish the relationship between health and the environment. Using panel fixed effects specification and data on 80 countries for the years 1990, 1995, 2000, and 2005, the study shows that particulate matter, access to improved water sources, improved sanitary facilities and population density are the statistically significant variables that affect infant mortality rate. A percentage point increase in particulate matter was associated with 8.6 percentage point increase in Infant Mortality Rate. Access to improved water source and improved sanitary facilities were reported to reduce infant mortality. This study is much helpful in showing the importance of a quality environment for good health; however it falls short in detailing the total effect of the environmental factors on health.

Alvarez et al. (2009) carried a study to determine factors associated with maternal mortality in Sub-Saharan Africa (SSA) against the background of prioritization of education, health spending systems and expenditure as the key factors, and stalled progress in improving health outcomes in SSA. Key findings of the study are; maternal mortality is high and enormous in SSA, maternal mortality is positively related to education, sanitary and economic factors, that there is inverse relationship between

maternal mortality and skilled health personnel, access to improved water sources, adult literacy rate, enrolment rate for females, education index, per capita expenditure and gross income. Despite the findings on sanitation and water; education, health expenditure and growth in income were prioritized in the conclusion leaving the physical environment at the periphery. Fernandes et al. (2014) further reiterated the importance health sector workforce, institutional birth coverage, government health financing and health service availability following a study on the effects of health systems strengthening in Mozambique. Health systems and financing have therefore taken more priority, but to what extent can we gain from health system without caring for the physical environment?

Fayissa and Gutema (2005) estimated a health production function for Sub-Saharan Africa based on Grossman's 1972 model of health. Social, economic and environmental factors were included in the production system and the estimated function included variables such as per capita income, illiteracy rate, food availability, and ratio of health expenditure to GDP, urbanization rate, and carbon emission per worker. The production function was estimated using one-way and two way fixed and random effects model of panel data analysis. This study was confined to 31 Sub-Saharan Africa countries and it covered the period 1990 to 2000.

The debate on heath-environment link was further popularised by Fayissa and Gutema (2005), and Fayissa and Traian (2011) who failed to support a number of environmental factors as inputs of the health production function. The studies found that income per capita, a decrease in illiteracy rate and an increase in food availability are strongly associated with an improvement in life expectancy at birth. However effects of increase in urbanization rate, decrease in alcohol consumption, decrease in carbon dioxide and decrease in population growth rate on health outcomes were not supported by statistical test of significance. Furthermore, food production index and carbon dioxide emission were found to have wrong signs and statistically insignificant. The studies covered a large number of Sub-Saharan countries thus demanding careful data handling and examination as poor data set may have compromised the results.

One key result postulated by Maheswaran et al. (2010) is that environmental factors interact with pre-existing health conditions to worsen health outcomes. The study focused on examining the impact of outdoor air pollution on survival after stroke using a population-based cohort in England, patients living in areas of higher levels of outdoor air-pollution were unlikely to survive after stroke.

Fogden (2009) asked the question, "how serious is the problem of poor access to water and sanitary facilities?" The question came upon the backdrop of declining access to safe water despite years of concerted efforts on water and sanitary investments and campaigns on access to safe water. Utilizing statistical methods of correlation analysis, the study indicated that a negative relation exists between under-five years' mortality rate and access to safe drinking water while a positive relationship exists

between life expectancy and access to safe drinking water; low human developing countries had correlation coefficients of negative 0.33 and 0.12 respectively.

Research on access to safe water and health has been further popularized by the desire to find out whether or not access to safe sources is important compared upholding safety standards at household level (Kremer et al., 2009; Clasen et al., 2006; Schmidt and Cairncross, 2009; Ahujar et al., 2010). In water, the question is, "is it important to have access to safe water sources or to treat water at household use level". The debate being that recontamination occurs during transportation and storage that may defeat the whole purpose of a safe water source. Answering the questions related to the one above, studies have utilized randomized public health studies or simply used econometric regression to reaffirm the importance of access to water sources, hence continued examination of environmental factors and health outcomes.

The above reviewed theories and empirical literature shows that the health-environment relationship has remained important in efforts aimed at improving health outcomes. Empirical literature for the impacts of various environmental variables on health is somehow contradictory: some suggests a positive relationship between environment and health outcomes while others found no evidence of factors such as carbon emissions. The subject needs vigorous research, using different approaches and in different population settings to establish results that correspond to stylised facts. Research has been undertaken to affirm or reaffirm the health-environment relationship in a dynamic world of changing health interventions; new and more evidence remains vital.

4. Data and Methodology

The study used data extracted from the World Bank, World Development Indicators (World Databank, 2012). However, data source for the ratios of health expenditure to total GDP in Zimbabwe was the World Health Statistics Report 2010, and for DRC it was the World Health Organization (WHO) Global Health Observatory Data repository. The use of this data was due to the difficulty of collecting data on a cross country basis. However, we do not rule out the possibility of measurement challenges in this macro data especially given the poor record of data in most African countries.

We used panel data estimation approach in order to avert the problem of patch data in most African countries. The same number of variables was studied for each country over the same time period: strongly balanced panel data. A period of 9 years had been considered and this represent the period when the data was mostly available for countries under study. It was intend of the study to cover all of the SADC countries. However, the results presented here are for 12 SADC countries as Lesotho and Seychelles are in short of data while South Africa was considered a big economy that give rise to the outlier problem.

In model (1) below we specified a health-environmental model without controlling for socio-economic variables. The intent was to estimate the impact of environmental factors on health outcomes. In the model, IMR represents infant mortality rate, CO represents carbon emissions, AS represents access to sanitary facilities and AW represents access to improved water sources with i and t being country and time (in years) subscripts respectively. The focus of the model is to measure the proportion of variation in health outcomes that can be explained by environmental forces included in the model.

$$\ln(IMR_{it}) = \beta_0 + \beta_1 \ln(CO_{it}) + \beta_2 \ln(AS_{it}) + \beta_3 \ln(AW_{it}) + F_i + e_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\ln(IMR_{it}) = \lambda_0 + \lambda_1 \ln(CO_{it}) + \lambda_2 \ln(AWAS_{it}) + \lambda_3 (\ln Y_{it}) + \lambda_4 \ln(Y_{it})^2 + \lambda_5 \ln(DEN_{it}) + \lambda_6 \ln(HX_{it}) + \lambda_7 (ELAW_{it}) + \lambda_8 (PTY_{it}) + F_i + e_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Model (2) fully specified the health production function that is augmented by environmental, social, economic, political and policy variables. Additional variables included in model (2) but excluded in model (1) are per capita income (Y), ratio of health expenditure to GDP (HX), population density (DEN), existence of environmental law $(ELAW)$ and political stability (PTY). Despite fully specifying this model, the main focus remained on the partial effects of environmental variables on health outcomes.

Definition of Variables

Direct measurement of health is almost impossible given the complexity of the health concept. In this study, health status is approximated by annual infant mortality rate (IMR) as the dependent variable.

This indicator is responsive to socioeconomic status of parents or local population and is also sensitive to environmental quality and avoids measurement flaws (Somov, 2004). Sanglimsuwan (2011) argued that IMR is a good measure of population health because it avoids the potential reverse-causation problems associated with the relationship between adult health and income growth, thus avoiding methodological and measurement flaws. However, Reidpath (2002) criticized IMR in favor of comprehensive measures of health on the basis that it considers a small fraction of the population to the exclusion of the rest. Based on data availability and its merits, IMR was used as the dependent variable in this study.

Carbon dioxide emissions per capita measured in kilo-tonnes (kt) were used as one of the environmental quality indicator. Burning of fossil fuels such as oil, gas, coal, diesel and petrol, and manufacturing of cement produces carbon emissions. Carbon emissions compose a greater proportion of green house gases causing global warming and climate change.

The Human Development Report (2010) stated that carbon dioxide emissions is a good if not perfect proxy of the environmental impacts of the country's economic activity on climate. This variable however excludes gross environmental effects of human activities such as land degradation, and water and land pollution which have important health implications. As more emissions are released, we expect environmental quality to be worsened, thereby increasing infant mortality rate. However, increase in carbon emissions mean more economic activity, thus higher income which can play a corrective role on the initial health effects. Carbon emissions are therefore considered to have direct and indirect effects on health. The study expected a positive relationship between IMR and CO.

The model used the percentage of population with access to improved sanitary facilities as an environmentally related variable. Access to improved sanitation facilities is defined as the percentage of the population with at least adequate access to excreta disposal facilities that can effectively prevent human, animal, and insect contact with it. These facilities include protected pit latrines and flush toilets with access to sewerage connection, correctly constructed and properly maintained. Increased access to sanitation facilities is expected to reduce mortality, thus a negative relationship between infant mortality rate and access to improved sanitary facilities was expected.

Percentage of population with access to improved water source was another explanatory variable related to environment. This represented population with access to an adequate amount of water from an improved source such as a household connection, public standpipe, borehole, protected well or spring and rain water collection. Vendors, tanker trucks, and unprotected wells and springs are some of the unimproved sources. Safe and portable water is vital for human life. As the environment is degraded,

water bodies will be contaminated resulting in increased mortality. However, humans need to adjust by improving their water bodies in order to maintain harmony. With more people having access to these improved water sources, we expect a positive corrective impact on health. The study therefore expected a negative relationship between infant mortality rate and access to improved water sources.

A composite average measure of population with an improved environment regarding access to both improved sanitary facilities and water sources $AWAS$ was developed. This was calculated as a simple product average of AW and AS .The study expected that as more people get access to improved water sources and sanitation facilities, more health risks will be avoided hence decreasing mortality. This explanatory variable is also expected to have more explanatory power in model (2) than the individual variables AS and AW included in model (1).

Income was approximated by per capita Gross Domestic Product (GDP) in the study. It has some positive and corrective effects on health. As income grows we expect people to consume improved diets, to acquire better education and housing and to have better access to medical care services. Fayissa and Gutema (2005) argued that more income can buy better health as people can move from high to less stress jobs. Other researchers argued that beyond a certain level of income, some people may adapt unhealthy lifestyle and a stressful life. Some may choose risk sexual behavior, faster cars, adverse diets and lesser exercises, all with adverse effects on health. Thus, a negative relationship can also exist between income and health status. Given the low level of income in SADC countries, we expect a negative relationship between Infant Mortality Rate and GDP per capita. In order to evaluate the possibility of negative impact of income on health (positive relationship between IMR and income) at higher levels of income, the income variable was squared. Thus the study included income squared (Y^2) as an explanatory variable.

Health expenditure included in the model is the ratio of total health expenditure to GDP. Increased health expenditure is likely to improve access of health services and the health system. As total health expenditures are considered, it covers both services provided by the public players and those provided by private players. Ratios are used instead of per capita total health expenditure in order to avoid the possibility of multicollinearity as co-movement may exist between health expenditure and income. Unlike other measures of the provision of health facilities, geographical variation in health expenditure reflects differences in both quantity and quality of these health services.

The sources of financing health services and the subsequent recipients of the funds are important in analyzing the impact of health expenditure. In the event where health financing comes from taxation or user fees, this may deprive individuals of their basic needs such as food and shelter that may give adverse health impacts. The individual may however have positive net benefits if the benefits from the health facilities are more than enough to cover for the individual benefits from preventive care. On the

part of recipients, funds spend on administrative issues may have little if no impact on health status. This is because funds spent on administration may not have significant health impacts (indirect) as compared to direct health programs and projects. Thus, we cannot give a priori expectation for the sign of the coefficient of HX in the model.

Densely populated areas can also provide easy transmission of diseases**.** Population density in the study is measured as the number of people per given square kilometer. High population density mean more pressure on agricultural land, forests and residential land implying more land degradation, biodiversity loss, land pollution, air pollution, water pollution among other environmental problems. This will increase the chances of occurrence and higher transmission of diseases.

ELAW is a dummy variable to capture the impact of environmental assessment legislation on health status. Data on the environmental assessment legislation was compiled from the SADC environmental legislation hand book (Walmsley et al., 2011 and Walmsley et al., 2007). The variable takes the value 1 if there is environmental assessment legislation in country i at time t or zero otherwise. Environmental assessment legislation has an important impact of reducing human impact on the environment.

Political stability is also a dummy variable to capture the impact of state politics on health status. In the study a country is regarded as politically stable if there are no civil wars, political violence or unconstitutional attempt to overthrow the government. The variable takes the value one if political stability exists and zero otherwise. Data source for this variable is the SADC data base on politics and political violence.

5. Estimation Framework and Results

Descriptive Statistics

Descriptive statistics below shows some huge variations in IMR, POPULATION density and GDPsq, and access to improved water sources and sanitary facilities. The data shows the minimum infant mortality across the countries of 70 per 1000, access to sanitation of 39% and mean access to improved water sources of 65%. Variation of data implies that regression analysis can be applied.

TABLE 3: DESCRIPTIVE STATISTICS

Variable	Obs	Mean	Std. Dev	Min	Max
Imr	108	69.8982	30.0765	13	119
co2em (thousands)	108	4.3775	4.9804	0.88	25.37
Acsan	108	39.2315	22.1636	9	89
Acwat	108	64.9444	20.1526	38	99
Acwatsan	108	52.2870	19.3681	25	94
gdp (US$, thousands)	108	1.2314	1.4171	0.08	4.88
gdpsq (US$, ten thousands)	108	349.7791	607.6140	0.69	2377.55
Hexp	108	4.0000	1.9189	1	10
Popdens	108	73.3889	162.2187	2	625

Model (1) and (2) above were independently estimated. In estimating the models, AS and AW were included in the models separate to the inclusion of their combined interactive term ($AWAS$). The estimation procedure for each model was as follows: estimate the model using pooled Ordinary Least Squares (OLS) analysis, secondly, estimate the model using the fixed and random effects approaches and, thirdly, apply relevant econometric tests to check robust, efficient and consistent estimates. We also applied the general to specific model estimation approach.

Multicollinearity among the variables was examined. Using the Pearson's correlation coefficients, we found out that GDP was highly correlated to both access to improved water sources and the interactive variable for improved water sources and sanitary facilities. The model specification and interpretation was therefore guided by this finding.

In model (1) the F (11, 93) of 114.68 implying that the null hypothesis of no country specific heterogeneity cannot be accepted at all levels of significance. This provides support that country specific heterogeneity is statistically significant; therefore the fixed effects model of estimation is appropriate. Model (2) further supports the fixed effects methods of estimation with an F (11, 90) of 139.96 and P-value of 0.000 implying that we fail to accept the null hypothesis that there is no country specific heterogeneity. Both models therefore support the use of fixed effects estimation method.

The Hausman test was also conducted to test for the best method of estimation between the fixed effects and random effects method. The test was run under the null hypothesis that country specific heterogeneity is not correlated with the explanatory variables. In model one, the χ^2 (3) of 8.21 and a p-value of 0.0418 means that we fail to accept the null hypothesis. However, in model (2) a χ^2 (6) of 3.26 and a p-value of 0.7756 implies that there is no evidence to reject the null hypothesis. Thus, for model (1), the fixed effects estimation procedure was the most appropriate since country specific heterogeneity is likely to be correlated with explanatory variables. Model (2) supports the random effects framework since there is no evidence that country specific heterogeneity is correlated with explanatory variables.

Discussion of Results

Regression results are presented in Tables 4 and 5 below. Based on fixed effects results for model (1), the reported R-squared (within) of 0.38 implies that about 38 percent of variations in infant mortality rates in the SADC region are explained by environmental factors. Inclusion of socio-economic variables improved R-squared to 0.56 implying that 56 percent of variation in infant mortality rate is explained by access to water and sanitary facilities, income, health expenditure, population density, environmental regulations and political stability. Coefficients of access to improved water source and access to improved sanitary facilities are statistically significant and have the expected negative signs. The study therefore underscores the importance of a health environment in bid to ensure a health population.

Table 4: Model (1) Results for the Fixed Effects (within) Regression.

Variable	Coefficient.	Std. Err.	t-(Chi-Square) value
lnco2em	-0.03	0.07	-0.42
Lnacsan	-0.79	0.27	-2.89*
Lnacwat	-0.87	0.28	-3.07*
Cons	10.49	1.10	9.51*
sigma_u			0.63
sigma_e			0.10
rho (fraction of variance due to u_i)			0.97
F test that all u_i=0: F(11, 93)			114.68*
R-sq: within			0.38
F-test that all coefficients =0: F (3, 93)			18.97*
corr(u_i, Xb)			-0.65

Note: * is significant at 1 % probability level.

Table 5: Model (2) Results for the Random-Effects GLS regression

Variable	Coefficient.	Std. Err.	z
Lnawas	-0.98	0.25	-3.86*
Lngdp	-0.19	0.08	-2.37**
Lnhexp	-0.10	0.04	-2.20**
lnpopdens	-0.17	0.08	-2.19**
envlaw _1	-0.12	0.03	-4.37*
psblty_1	-0.18	0.05	-3.89*
cons	8.54	0.99	8.65*
sigma_u		0.46	
sigma_e		0.09	
rho (fraction of variance due to u_i)		0.96	
R-sq: within		0.56	
Wald Chi2 (6)		126.66*	

Note: * and ** is significance at 1% and 5 % probability level, respectively

Access to improved water source has a larger impact on infant mortality than access to improved sanitary facilities; both variables are significant at 1 percent level. We found out that percentage increase in access to improve water sources and access to improved sanitary facilities will reduce mortality by 0.87% and 0.79% respectively. The combined (linearly combined) effect of these two variables is to reduce mortality rate by 0.98 %. This result shows the potential of investing in water and sanitary facilities for yielding positive economic effects through reduced costs of ill-health. This result is consistent with the findings by Sanglimsuwan (2011). The study concludes that, if environmental quality is interpreted as access of population to improved water and sanitary facilities, it will have a significant positive impact on health status, thus as environmental quality declines health of population worsens.

The coefficient of the dummy variable, environmental law was found to be statistically significant at 1 percent significance level. This means that there is difference in infant mortality rates for countries where there is an Environmental Impact Assessment (EIA) law compared to countries where there is none. Political laws of environmental protection play an important impact in enhancing health outcomes. Though SADC countries were criticized on the fact that environmental laws are rare, marred with corruption, poorly coordinated and institutionally weak, evidence suggests that these laws have a significant impact on health outcomes.

The study finds that neither carbon emissions nor its lags are statistically significant variables in explaining infant mortality rate. This finding is consistent with findings by Fayissa and Gutema (2005) and Fayisaa and Traian (2011) and inconsistent with findings by Greenidge and Stanford (2007). The insignificance of carbon emissions indicates that the current level of emissions in the SADC countries is not threatening human health. Carbon emissions were used as a proxy of environmental quality in this study and were found to have no impact on health outcomes. Economic sectors (agriculture, mining,

tourism and manufacturing) largely contributing to GDP in most of the countries under study are not high emitters at the current levels, not to say they are not threatening the environment. Thus, environmental focus should be on degradation, biodiversity loss, water pollution, land pollution and extinction of wild life species. Failure of carbon emissions may also draw attention to other issues such as the relationship between emission sites and affected individuals. The study concludes that carbon emissions have no impact on health outcomes in the SADC region.

The coefficient of income as measured by per capita GDP was found to be negative 0.19 and is statistically significant at 5 percent level. Or (2000) supported that income significantly improves health outcomes. Running a health production model with per capita income squared gives a coefficient of negative 0.09. The study concludes that continuous improvements in income will not proportionately improve health status. Income was therefore found to have a positive impact on health status as expected from theory. Similarly, the coefficient of total health expenditure was found to be statistically significant and has the expected negative sign from theory. The coefficient of negative 0.10 means that, other things being constant, a 1 percent increase in health expenditure reduces infant mortality by 0.10%. Investment in health infrastructure, government health programs and the spending by the private sector jointly enhances positive health outcomes.

The coefficient for population density was found to be negative 0. 17 and is statistically significant at 5 percent level. The study's finding deviates from theory which stipulates that population pressure has negative impact on health outcomes. This result is somewhat consistent with findings of Sanglimsuwan (2011) and sounds interesting. This may be the influence of social capital founded by culture and social relationships in most African setups which respect the values of the community; where ideas, decisions and cultural practices are shared, practiced and upheld in a manner that reduces stress, enhances food distribution, promotes sharing, provides with information and renders a feeling of belonging. These assertions act to improve population health.

Dummy variable on political stability was found to be statistically significant at 1 per cent level. Thus there is significant difference in infant mortality between countries where there are civil wars and political instability, violence and political upheavals compared to where there is none. Impact of politics on health outcomes has been neglected in research, however it sounds obvious that politics has direct and indirect negative impacts on health. The direct impacts may include death or increased morbidity during civil wars and times of political violence. Indirect effects include income cycles associated with political crisis, political risk of investment and the political environment of policy which directs health expenditure, projects and programs as well as health investments by both private and public players. The study concludes that governments should ensure political stability for a health population.

6. Conclusion and Recommendations

This study was carried out to find out the impact of environmental quality on health status in SADC countries between 2000 and 2008. Carbon emissions per capita, access to improved water source and access to improved sanitary facilities were used to measure environmental quality while annual infant mortality rate was the measure health status. The study also specified a model of health production that include income, income squared, population density and two dummy variables for environmental law and political stability as explanatory variables.

Two panel data models were executed; model (1) was augmented with environmental variables only while the second model is fully specified with socio-economic and political variables. Estimation of model (1) with the fixed effects technique implies that there exists country specific heterogeneity that may be correlated with some of the explanatory variables. This was expected as model (1) was not fully specified. A fully specified model (2) was estimated by the random effects estimation procedure as the inclusion of more variables narrows down country specific heterogeneity.

Results shows that carbon emissions as a proxy for environmental quality has no impact on health outcomes in the SADC region. However, the dummy variable for environmental law was found to be statistically significant implying that there is difference in infant mortality between countries where an environmental assessment law exists and the other where such laws do not exist. Other two environmentally related variables, access to improved water source and access to improved sanitary facilities were found to be statistically significant at 1 per cent level. Access of people to improved water source and sanitary facilities have the highest impact on human health compared to other socioeconomic factors. Interpreting model (1) gives the conclusion that environmental factors account for about 38 percent of mortality in the SADC region, a figure higher than the 24 percent reported by World Health Organisation (2006).

At macro-level, carbon emissions are not important explanatory of health outcomes while an environmental law, together with quality water and sanitary facilities are important in explaining differences in health outcomes. We suggest that carbon emissions are not a good proxy for the gross human impact on the environment within the SADC region because sectors contributing the larger portion of GDP are not high emitters.

The study also concludes that income, health expenditure, population density and political stability are important variables that explain health outcomes. However, increasing income will not proportionately improve health outcome. It was found that at low levels of income, increasing individual incomes will enhance health status better than at higher levels of income.

Enhancing environmental quality and consistently, environmental regulation is of prime importance in improving health outcomes within SADC countries. Environmental laws cab gross impact of human activity on the natural resources, thus reducing the burden of the disease, mortality and morbidity from environmentally induced illness. Comprehensive, respected, properly coordinated and smoothly

implemented environmental laws should be enacted in a country where there are no such laws. This has an important health dimension as indicated in the study. In other countries where there are existing environmental regulations, they should be strengthened, well-coordinated and complemented by other regulations. Corruption should be ironed out in the implementation of environmental regulations and environmental institutions should be well capacitated.

The importance of access to water sources and access to improved sanitary facilities means that quality water and quality sanitary facilities are important for human life. People should have the right to quality water and sanitary facilities. Governments should ensure accessibility by all people to quality water and sanitary services. This includes protection of water bodies and improvements in water supply systems. Small scale providers of quality water and sanitary services may also play an important role in provision of water.

The current challenges in the water system need a lasting solution in-order to speed the achievement of health related MDGs. Within the SADC region, both the urban and rural inefficient and deteriorated water systems need to be rehabilitated. Construction of new water system is also necessary as they will enhance more access to quality water. We therefore conclude that water and environmental laws should ensure standards in provision of water and protection of water bodies against contamination.

There is need for governments to ensure a politically stable environment. This will help to reduce death and morbidity related to political violence and politically induced social unrest. The political economy of environmental laws provides a way in which environmental laws, health expenditures, income growth and health investments are affected by politics. Political stability has significant impact on health outcomes and efforts should ensure a stable political environment.

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