Water and Economic Development: Correlation Between Investment in The Water Sector and Economic Growth of Developing Countries

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ABSTRACT

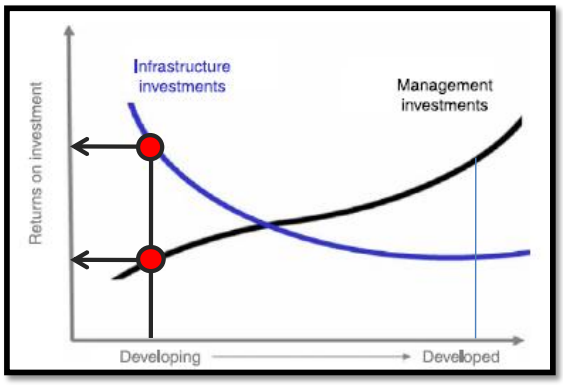
This research investigates the hypothesis that there is a relationship between rainfall and economic development and also between investment in water sector and economic development. An analysis was conducted of time series of rainfall deviation from the mean (%), national budget on water supply and sanitation (million USD per year), Official Development Assistance (ODA) in all sectors (million USD per year), ODA in water infrastructure (million USD per year), ODA in water management (million USD per year) and per capita Gross Domestic Product (GDP) (USD per year) of 22 developing countries in Africa. The analysis reveals unexpectedly that there is no statistically significant relationship between rainfall deviation from the mean and GDP per capita. However, a statistically significant relationship does exist between national budget on water supply and sanitation and GDP per capita, and also between ODA in all sectors and GDP per capita. An interesting finding of the research is that national budgets on water supply and sanitation in all 22 African countries have a much larger multiplier effect on GDP per capita compared to ODA in all sectors in those countries. This finding is a strong argument to encourage governments of developing countries to spend more of their annual budgets on the water sector. But also ODA remains important, since countries with difficult hydrologic regimes are among the world's poorest.

Keywords: economic development, rainfall variability, investment in the water sector, ODA.

Introduction

This research is a follow up study from Grey and Sadoff (2007), who claimed that there is a relationship between investment in the water sector and economic development. Using the water security concept, they assumed that a country has to achieve water security before economic growth, and in order to achieve water security, some investment in the water sector (either in water infrastructure or water management) has to be made. This statement is supported by the study from Stockholm International Water Institute [SIWI] (2005) which stated that improvements in water management (in terms of investing in water infrastructures or institutions) make a country's economy more resilient to rainfall variabilitiy – especially for agriculture and fisheries.

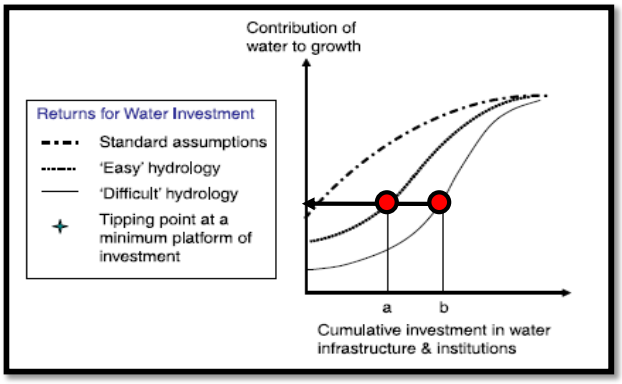
The balance between investments in water infrastructure and in water management depends on the socio-economic situation on a country. Grey and Sadoff (2007) assume that developing countries need more investment in water infrastructures compared to developed countries, whereas developed countries need more investment in institution and water managements compared to developing countries. Figure 2.1 presents the assumed relationship between investment in water infrastructures or institution and water managements and level of economic development.



Source: Grey and Sadoff, 2007

Figure 1: Relationship between returns on investment (ROI) for investment in water infrastructures or institutional and water managements between developing countries and developed countries.

One of the determinant factors of water security is climate variability. Based on climate variability, Grey and Sadoff (2007) categorized countries as having an easy hydrologic legacy or difficult hydrologic legacy. This would determine how much investment is needed to achieve economic development. They assumed that, in order to achieve the same level of economic development, countries with a difficult hydrologic legacy must invest more than countries with an easy hydrologic legacy (Figure 2). Countries with a difficult hydrologic legacy are among the world's poorest (Grey and Sadoff, 2007). This is one reason why Official Development Assistance (ODA) is important in coping this issue.



Source: Grey and Sadoff, 2007

Figure 2: Cummulative investment in water infrastructure and/or institution and water management and its contribution to economic growth.

This research also considers the role of climate on economic development. One interesting study is by Brown and Lall (2006), Using global datasets of rainfall, temperature, and GDP per capita, Brown and Lall (2006) found a statistically significant relationship between rainfall variability and GDP per capita. This result supported the hypothesis that rainfall variability is one of the important factors for economic development of the nation. Thus, increased resilience to rainfall variability will likely enhance economic development of the particular country.

Regarding the effects of infrastructure investment on economic development, several studies have been done such as by Herranz-Loncan (2007) on Spain, Fedderke, Perkins, and Luiz (2006) on South Africa, Pereira and Andraz (2005) on Portugal, and Groote et al, (1999) on the Netherlands. All these studies focus on general economic infrastructure such as transportation, telecommunication, and energy which are considered to have a direct "visible" impact on economic growth. They didn't consider water infrastructure as one of the main factors for economic development. In brief, the case studies mentioned in this review are summarized in table 1:

Table 1 Some case studies of the effect of infrastructure investment on economic development

No	Country	Reference	Input	Output	Correlation
1	The Netherlands	Groote et al., 1999	1) Equipment and machinery inv. 2) Infrastructure inv. • Transportation • Other	GDP	Yes
2	Spain	Herranz-Loncan, 2007	1) Equipment and machinery inv. 2) Infrastructure inv. 3) Labour inv.	GDP	Yes
3	Portugal	Pereira and Andraz, 2005	1) Aggregate inv. in transportation 2) National roads inv. 3) Municipal roads inv. 4) Highways inv. 5) Ports inv. 6) Airports inv. 7) Railways inv.	GDP, employment, and private inv.	Yes
4	USA and Canada	Voss, 2002	Public inv.	Private inv.	No
5	South Africa	Fedderke, Perkins, and Luis, 2005	1) Transportation inv. 2) Telecomunication inv. 3) Electricity inv.	GDP	Yes

Research Objective

From the explanation above, there is a need to understand to which degree is a country's climate (rainfall deviation from the mean) correlated with that country's economic development (of developing countries), and also to which degree is a country's government budget for water supply and sanitation, as well as its

official development assistance (ODA) received (either for all sectors, for water infrastructure or for water management) correlated with that country's economic development?

Methodology

General

In general, the methodology applied in this research consists of several phases: literature review, country selection, data search, data acquisition, data analysis, result and discussion, conclusion, and recommendation. The sequence of each phase is described in Figure 3 as follows:

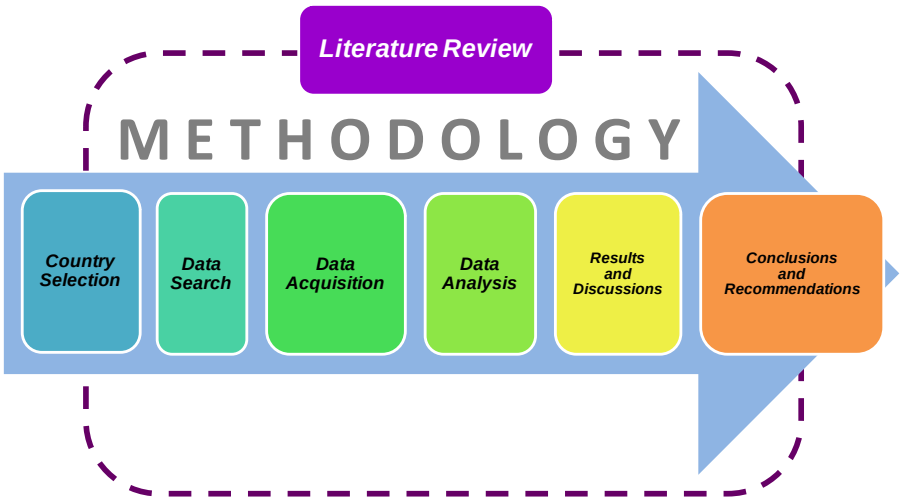


Figure 3.1 Research Methodology

Country Selection

Results and Discussions

Linear regression analysis between rainfall deviation from the mean (%) and GDP per capita growth (%) discussion

The result of linear regression analysis between rainfall deviation from the mean and GDP per capita growth shows that there is no statistically significant linear relationship. These results do not confirm the findings of Brown and Lall (2006) who claimed that there is a statistically significant relationship between rainfall variability and GDP per capita, and their findings of the importance of rainfall as one of the determining factors for economic development of nations.

The non-linear relationship of rainfall deviation from the mean and GDP per capita growth may have many different explanations, such as historical, social, political, and economic background of the particular country – which is beyond the scope of this research. The first explanation is related to the statistical context.

According to the statistical context, there is a possibility that the rainfall data used for the calculation of rainfall deviation from the mean for each country cannot represent the rainfall variability of the country as a whole. The variability of rainfall accommodated in this research is only the temporal variability and does not take spatial variability into account.
Another possibility is that both data (rainfall deviation from the mean and GDP per capita growth) cannot be represented by a linear model. The coefficient of correlation (R) and the coefficient of determination (R^2) used in the analysis only measure the strength of a linear relationship between two sets of data. Thus, it is theoretically possible that two sets of strongly (but non-linearly) correlated data have low values of R and R^2 .

Linear regression analysis between national budget on water supply and sanitation (million USD/year) and GDP per capita (USD/year) result and discussion

The result of linear regression analysis between national budget on water supply and sanitation and GDP per capita shows a statistically significant linear relationship in all 22 selected countries. These results confirm the thesis of Grey and Sadoff (2007) who claimed that there is a relationship between investment in the water sector and economic development.
One of the most interesting findings from this section is the fact that national budgets on water supply and sanitation have a great multiplier effect on GDP per capita. For example if the government of Mali would increase its annual expenditure on water supply and sanitation with 1 million USD, the results indicate that Mali's per capita GDP would increase with 163 USD. With a population of 12.4 million (2007), this represents an increase in national GDP of 2.0 billion USD; implying a multiplier effect of 2,000!
One needs to be very careful with such interpretations, but a comparative analysis with ODA budgets (see next sections) is insightful.

Linear regression analysis between ODA for all sectors (million USD/year) and GDP per capita (USD/year) result and discussion

The result of linear regression analysis between ODA for all sectors and GDP per capita show the signs of statistically significant linear relationship in 17 out of 22 selected countries.
A non-linear relationship of ODA for all sectors and GDP per capita exists in Ethiopia, Zambia, Swaziland, Lesotho, and Liberia. There must be some explanations for this from historical, social, political, and economic background of the countries – which is beyond the scope of this research. But from several literature sources, different explanations have been suggested: For Ethiopia, conflicts and political instability has been mentioned (Geda et al., 2006), for Zambia solely because of the political instability within the country (Rackner 2003), for Swaziland and Lesotho, the underspending phenomena has been suggested (Jones, 1977), and for Liberia, the Civil War has been given as an explanation (Atkinson, 1997).
Though ODA for all sectors has a significant impact on GDP per capita, the multiplier effects is much lower than national budget dedicated to water supply and sanitation. For instance if an additional one million dollar of ODA money would be invested in Mali, the effect would be an increase of 0.12 USD per

capita GDP. this represents an increase in national GDP of 1.5 million USD; implying a multiplier of (only) 1.5.
For all countries in the survey was the positive effect of the national water budgets much larger than that of ODA.

Linear regression analysis between ODA for water infrastructure (million USD/year) and GDP per capita (USD/year) result and discussion

The result of linear regression analysis between ODA for water infrastructure and GDP per capita shows no significant linear relationship in 16 out of 22 selected countries. These results do not confirm the thesis of Grey and Sadoff (2007) who claimed that developing countries investment in water infrastructure will have positive impact on economic development.
The absence of a significant linear relationship between ODA for water infrastructure and GDP per capita may have many different explanations, such as historical, social, political, and economic background of the particular country – which is beyond the scope of this research. Here only some preliminary explanations are suggested:

1) There is a possibility that the data used for this analysis do not sufficiently represent the actual conditions and dynamics. This may be the case for the data of ODA for water infrastructure and water management, which have only a time series of 11 years (1995 – 2006)
2) There is also a possibility that the amount of investment in the water infrastructure does not have any significant impact yet on reducing the effect of water related risk (flood and drought) on economic development.
3) Another possibility, referred to Grey and Sadoff (2007), is that a country does not reach the minimum level of investment to achieve water security (the tipping point of figure 2.2 (above) cumulative investment in water infrastructure and/or institution and water management and its contribution to economic growth)

Linear regression analysis between ODA for water management (million USD/year) and GDP per capita (USD/year) result and discussion

The result of linear regression analysis between ODA for water management and GDP per capita shows no significant linear relationship in 21 out of 22 selected countries, and that this relationship is negative in most countries investigated. These results do confirm the thesis of Grey and Sadoff (2007) who claimed that for developing countries, investment in the water management will have less impact on economic development compared to investment in the water infrastructure.

Multiple regression analysis between ODA for water infrastructure (million USD/year), ODA for water management (million USD/year) and GDP per capita (USD/year) result and discussion

Multiple regression analysis between ODA for water infrastructure, ODA for water management, and GDP per capita for the 22 selected countries in this research, resulted in ODA for water infrastructure

having a significant impact on GDP per capita in 4 out of 22 selected countries, whereas ODA for water management doesn't have any significant impact to GDP per capita. This finding reconfirms the finding that for developing countries, investments in water management have less impact compared to investments in water infrastructure (Grey and Sadoff, 2007). The explanation of this finding is that either the time series of the data used is too short to represent the actual condition [thus resulted in no linear correlation between ODA for water infrastructure and GDP per capita] or the effect of investment in water infrastructure itself not yet reducing the water related risk for people, economic activity and environmental sustainability, as suggested by the water security concept (Grey and Sadoff, 2007), as a result eventually there is no economic development.

Multiple regression analysis between national budget on water supply and sanitation (million USD/year), ODA for all sectors (million USD/year), rainfall deviation from the mean (%), and GDP per capita (USD/year) result and discussion

The result of the multiple regression analysis between national budget on water supply and sanitation, ODA for all sectors, rainfall deviation from the mean and GDP per capita for the 22 selected countries in this research, shows that in all 22 African countries studied, the national budget on water supply and sanitation has a significant impact to GDP per capita. Only in 12 out of 22 selected countries does ODA for all sectors have a significant impact on GDP per capita, whereas rainfall deviation from the mean doesn't have any significant impact on GDP per capita.
These findings reconfirm and strengthen the findings that the national budget on water supply and sanitation and ODA for all sectors have statistically significant impacts on economic development but that rainfall deviation from the mean does not. What is interesting is that the multiplier effect of the national budgets on water supply and sanitation on GDP per capita is much larger than that of ODA for all sectors. This finding could be used to encourage governments of developing countries to invest more of their own budget in the water sector, since Government investments in the water sector yield very high returns; much higher returns than those achieved with ODA funds.

Conclusions

RQ 1: To which degree is a country's climate (rainfall deviation from the mean) correlated with that country's economic development (of developing countries)?

Based on linear regression analysis between rainfall deviation from the mean (%) and GDP per capita (USD/year) and multiple regression analysis between national budget on water supply and sanitation (million USD/year), ODA for all sectors (million USD/year), rainfall deviation from the mean (%), and GDP per capita (USD/year), it may be concluded that rainfall deviation from the mean doesn't have any significant impact on economic development. These results do not confirm the findings of Brown and Lall (2006) who claimed that there is a statistically significant relationship between rainfall variability and GDP per capita, and their findings of the importance of rainfall as one of the determining factors for economic development of the nation.

The difference in results may be due to the different methods employed. Brown and Lall (2006) used a survey of 163 countries and conducted comparative statistics between these countries, based on average values. This study conducted for 22 African countries statistical analyses of time series with annual data for each country. So our method is focusing on individual countries, adopting a temporal perspective.

RQ 2: To which degree is a country's national budget for water supply and sanitation, as well as its official development assistance (ODA) received (either for all sectors, for water infrastructure or for water management) correlated with that country's economic development?

Based on linear regression analysis between national budget on water supply and sanitation (million USD/year) and GDP per capita (USD/year) result, linear regression analysis between ODA for all sectors (million USD/year) and GDP per capita (USD/year) result, linear regression analysis between national budget on water supply and sanitation (million USD/year), ODA for all sector (million USD/year), rainfall deviation from the mean (%) and GDP per capita (USD/year), it may be concluded that both national budget on water supply and sanitation and ODA for all sectors have statistically significant impact on GDP per capita. This confirms the thesis of Grey and Sadoff (2007) and the findings from previous studies by Herranz-Loncan (2007) on Spain, Fedderke, Perkins, and Luiz (2006) on South Africa, Pereira and Andraz (2005) on Portugal, and Groote et al (1999) on the Netherlands that investments (either in water sector or in all sectors) have positive impact on economic development.
The surprising finding is that the multiplier effects of national budget on water supply and sanitation on GDP per capita is much larger than the multiplier effects of ODA in all sectors on GDP per capita. This could become one strong argument to encourage the governments of developing countries to spend more of their annual expenditure on the water sector.
Based on linear regression analysis between ODA in water infrastructure (million USD/year) and GDP per capita (USD/year) result, linear regression analysis between ODA in water management (million USD/year) and GDP per capita (USD/year), linear regression analysis between ODA in water infrastructure (million USD/year), ODA in water management (million USD/year) and GDP per capita (USD/year), it may be concluded that both ODA in water infrastructure and ODA in water management do not have a statistically significant impact on GDP per capita. This finding only confirm part of Grey and Sadoff (2007) thesis that in developing countries investments in water infrastructure have larger impacts on economic development compared to investments in water management.
Why ODA in water infrastructure did not have a statistically significant impact on GDP per capita, may be explained as follows:

1) Water-specific data of ODA have only a time series of 11 years (1995 – 2006). There is a possibility that this data series is too short to be able to capture the actual conditions and dynamics happening on the ground.
2) There is also a possibility that the amount of ODA investments in water infrastructure is insufficient to have any significant effect yet on reducing the effect of water related risk (flood and drought) on economic development.
3) Another possibility, referred to by Grey and Sadoff (2007), is that the country has not reached the minimum platform of investment to achieve water security (the tipping point of figure 2.2 cumulative investment in water infrastructure and/or institution and water management and its contribution to economic growth).

Limitations

The major limitation of this research is that the relationships between rainfall, national budgets and ODA have been studied with statistical tools, focusing on correlation and linear regression. Such analysis cannot prove causal relationships between the phenomena studied, but rather their associations. This implies that the findings have to be interpreted with caution.

Another limitation is limited data availability and the uncertain quality of the data used. Despite the fact that water is one of the most important factors for economic development of a nation (Brown and Lall, 2006), reliable data of water and all water related activities is very hard to find in all selected countries.

Recommendations

1) There is a need of further studies regarding why rainfall does not seem to have a significant impact on economic development in semi-arid countries of Africa. It would be useful to include in the analysis the climate groups to which the different countries belong, as defined in this research.
2) There is a need of further studies regarding why national budgets on water supply and sanitation have much larger multiplier effects to GDP per capita compared to ODA. (How effective ODA is for economic development in developing countries).
3) Another surprising finding merits further in-depth study: why ODA support to water management in many African countries is negatively correlated with per capita GDP.
4) The role of storage reservoirs has not been explicit in the present study. This could be investigated, verifying the S-curve hypothesis of Grey and Sadoff (2006).

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