

*Full Length Research Paper*

# **An economic assessment of the impact of information and communications technology (ICT) on performance indicators of water resource management in West Africa: A suggested strategy for avoiding the eminent international water wars**

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Using data from 16 West African countries, this paper examines the links between Per Capita Income, Trade and Financial indicators, Education and Freedom indicators. Others are internet users, broadband and mobile cell phone subscribers. Meanwhile fresh water supply (which is assumed as a bench mark public sector-led water resource management performance indicators) and access to safe drinking water (a bench mark private sector-led water resource management performance indicators) represents indicators of water resources management. The results show that income, information and communications technology (ICT) and government trade policies influence the efficient management of cross-country water resource. Freedom indicators strongly affect water resource management performance indicators (WRMPI). Internet Users, Broadband Subscribers, and Mobile cell phones subscribers have a positive association with WRMPI. However, contrary to wide spread expectations, education does not influence WRMPI. In areas where water resource management performance indicators of safe drinking water exhibited strong correlation are: Secondary school enrollment rate (0.57), fresh water supply with consumer price inflation (0.78) and a fair correlation of safe drinking water with corruption index.

**Key words:** Information and communications technology (ICT), resource management, safe drinking water.

## **INTRODUCTION**

The diffusion of information communication technology has led to greater integration of economies around the world. An assessment of cross-country data however, reveals potential danger, as countries will definitely

engage each other in water wars in the nearest future (Sule, 2003). It is common sense that with an increase in population, there will be a corresponding rise in the demand for fresh and safe drinking water.

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Consequently, this water related crisis will fuel the tendency for governments of countries to strategise on ways to control water sources. There is a growing body of literature focusing on ICT tools, water resource management and its impact on the economy. The arguments presented by Swinford et al. (2007), Krantz and Kifferstein (2009), Shirley (2006) and Ribando et al. (1999) reveals that indicators of efficient water resource management has a significant positive impact on the gross domestic product (GDP) growth in varying degrees across the countries on the continent. Using simple descriptive statistics based on questionnaires, numerous studies have shown that ICT tools have greatly contributed to greater strategic management of the nations' water resources without necessarily escalating cross boarder tension (Van et al., 2003; Komsky et al., 2001; Swinford et al., 2007).

Based on these findings, it is plausible that in the era of the New Economy, new channels for assessing and improving water resource management is possible. Such a window may allow West African countries to fast track good governance in terms of cross country water resource and ensure more sustainable development. Thus it is important to conduct an economic assessment of the structural changes ushered in by the "New Economy" – described by Jorgenson (2007) as a mantra for faster, better and cheaper alternative systems and machines.

There is obviously a greater number of works on water economics, ICT and water resources and quality. Relatively, smaller works has been undertaken to understand in statistical terms, the impact of ICT and certain socio-economic indicators on water resources management (WRM), particularly in West African countries. For instance, Valipour (2014a) attempted to profile agriculture water management and identified platforms for this purpose. In focusing solely on West African economies, this work can add to the body of literature by addressing this salient issue. First, is an econometric assessment of the certain ICT and socio economic variables on WRM. Secondly, the direction of causality will be formally ascertained. Thirdly, other variables such as policy, civic society, and freedom can be crucial in this context.

Many papers have pointed out that water is plausible due to increasing demand on earth's water resources. More so, some other researchers have emphasized the catalysing role of citizen participation in the increased deployment of ICT (Heintz, 2004; Lagerskog, 2008; Moorhouse and Ellif, 2002; Jamieson and Fedra, 1996; Guimares et al., 2003; European Union, 2000; CET, 2003; Alder and Jacobs, 2000; Arnstein, 1969; CEC, 2001a). They argue that the increased participation of the public (through extensive use and deployment of ICT leads to more effective management of water resources as it broadens and guarantee speed of access to information and knowledge that can result in greater participation of people in decision making processes.

In Balamoune-Lutz (2003)'s words "...a reduction in information asymmetry that enhances efficiency and access to knowledge for all would prevent one party from monopolizing opportunities ... and at the same time allow participation of previously excluded groups." However, the role of ICT in effectively combating cross-border challenges is yet to be empirically tested using data from West African countries. There are ambiguous conclusions concerning the link between some economic variables, ICT and water resources challenges in West African countries. Another challenging concern is the issue of causality. Can efficiently deployed ICT resources coupled with effective policy engineering on government's part and an engaging civil society forestall the emergence of cross country water wars? This is so because Valipour (2013) argued that water management is one of the most effective parameters towards achieving sustainable development in the world.

This paper examines the relationship between water resources management indicators, ICT and a set of time tested macroeconomic and policy variables for a sample of 53 African countries. These countries are listed in Appendix 1. Specifically, the paper explores the nature and direction of the links between WRM indicators and per capita income, trade and financial liberalization, literacy and education and freedom indicators including economic freedom, liberties and political rights. The fresh water supply, and safe drinking water are used as indicators of WRM bench marks in a cross country these two basis performance indicators as well as the set of macroeconomic and policy variables mentioned above.

## DATA AND METHODOLOGY

In the words of Jorgenson and Stiroh (2002) "a new economy" is the mantra for technological and structural changes as individuals (once excluded from mainstream events) capitalize on new technologies, new opportunities and national investments in computing, information and communication technologies. Quah (2001) includes intellectual asset, electronic libraries and databases and biotechnology (Carbon – based libraries and database). On the other hand, Swinford et al. (2007) identified broadly some ICT-oriented performance indicators for water resource management: measures of openness, civil participation, accountability and trust. This paper focuses only on: WRM performance indicators (WRMPI) such as fresh water supply measured in KM<sup>3</sup>/Yr across countries and the availability of safe drinking water, ICT indicators such as mobile phone subscribers per 100 inhabitants, broadband subscription per 10,000 inhabitants and Internet users per 10,000 inhabitant. The data on these variables are for the periods of 2007 unless otherwise stated, are taken from the website of World Water.Org. Fresh water supply may be viewed as an indicator of the state to control fresh water resources within its political boundary, while safe drinking water, the second performance indicator measures the access to bottle and sachet water usually private controlled. The model proposed is:

$$WRMPI_i = \alpha + g[\Gamma] + \epsilon_i \quad (1)$$

Where the vector  $\Gamma$  contains all indicators. That is:  $WRMPI_i = \text{Fresh Water Supply/ Safe Drinking Water}$ .

**Table 1.** Correlation among ICT-water resource management performance indicators.

| Variables    | SDW/POP | In PCI  | BS       | IPI      | FWS(KM^3/YR) | SER      | PR     | HDI      | CPI    | CI      | POP    | SDW   |
|--------------|---------|---------|----------|----------|--------------|----------|--------|----------|--------|---------|--------|-------|
| SDW/POP      | 1.000   |         |          |          |              |          |        |          |        |         |        |       |
| In PCI       | 0.212   | 1.000   |          |          |              |          |        |          |        |         |        |       |
| BS           | 0.382** | 0.238   | 1.000    |          |              |          |        |          |        |         |        |       |
| IPI          | 0.656** | 0.311*  | 0.408**  | 1.000    |              |          |        |          |        |         |        |       |
| FWS(KM^3/YR) | -0.138  | -0.052  | 0.101    | -0.221   | 1.000        |          |        |          |        |         |        |       |
| SER          | 0.306*  | 0.446** | 0.461**  | 0.669**  | -0.304*      | 1.000    |        |          |        |         |        |       |
| PR           | 0.215   | 0.120   | 0.059    | -0.166   | 0.113        | -0.170   | 1.000  |          |        |         |        |       |
| HDI          | 0.314*  | 0.072   | -0.120   | -0.456** | 0.225        | -0.362** | -0.057 | 1.000    |        |         |        |       |
| CPI          | -0.076  | -0.182  | 0.086    | -0.148   | 0.776**      | -0.175   | 0.033  | 0.164    | 1.000  |         |        |       |
| CI           | 0.210   | 0.386** | 0.306*   | 0.470**  | 0.301*       | 0.496**  | -0.387 | 0.015    | -0.163 | 1.000   |        |       |
| POP          | -0.211  | -0.053  | 0.323*   | 0.010    | 0.301*       | 0.085    | 0.076  | 0.167    | -0.057 | 0.057   | 1.000  |       |
| SDW          | 0.524** | 0.305*  | 0.382*** | 0.524**  | -0.322*      | 0.569**  | 0.275* | -0.362** | -0.177 | 0.473** | -0.127 | 1.000 |

\*indicates significance at 0.1, \*\* indicates significance at 0.05,\*\*\* indicates significance at 0.01. Sources: Author's Computation, ICT indicators are from International Telecommunication Union Website (2008); indexes for Civil Liberties and Political Rights are Freedom House website (2008); Economic Freedom index is from the Heritage Foundation website (2008); Education Index is from UNDP – Human Development Report 2008; Standard and Poor's Global Water Index website (2008); all other variables are from World Development Indicators CD-ROM (World Bank, 2008).

I = per capita income, F = Index of Economic Freedom, R = Political Rights, L = Civil Liberties, SR = Secondary School Enrollment Rate, HI = Human Development Index, CI = Corruption Index, CPI = Consumer Price Index, BS=Broadband Subscribers, IU=Internet Users, MCS=Mobile Cell Phone Subscribers.

Model (1) represents an equation to be estimated and the assumption of FWS and SDW as performance assessment indicators is fairly standard and plausible on both theoretical and empirical grounds (Swinford et al., 2007; Krantz and Kifferstein, 2009; Shirley, 2006; Ribando et al.,1999). In general, the association between WRMP indicators and income is expected to be very weak. This seems to be the case given the significant correlation of 0.31 between access to safe drinking water (Sachet/Bottle Water) and natural logarithm of per capita income. It is quite expected that income is not statistically significant with FWS as this is a natural resource endowment that has no link to income status of an economy. It is still not significant to the ratio of Fresh Water Supply and Safe Drinking Water to population (Table 1). However, in areas where water resource management performance indicators of safe drinking water are exhibited, strong correlation are: Secondary school enrollment rate (0.57), fresh water

supply with consumer price inflation (0.78) and a fair correlation of safe drinking water with corruption index.

WRM performance indicator safe drinking water corrects strongly with internet penetration index (0.52) but had a weak one though statistically too with broadband subscriber (0.38).

This paper also uses freedom indicator namely Index of Economic Freedom published by the Heritage Foundation. It scores an average score of 10 indexes measured on a one to five scale with 5 indicating the lowest level of economic freedom. These variables also assess trade policy, monetary policy, capital flows and foreign investment, wage and price control, banking and bureaucracy, government intervention in the economy and the fiscal burden of the government (taxes and expenditure). Others are political rights and civil liberties. This paper is adopting approaches by Norris (2000) and Balamoune-Lutz (2003). These two indexes are published by Freedom House and measured on a one to one seven scale with 7 indicating lowest degree of freedom. The correlation safe drinking water with Liberties and political rights are (SDW: PR = -0.28, and SDW: CL = -0.36). The signs on the coefficient are negative, implying that a fall in the index (an improvement) is associated with an increase

in access to SDW. In discussing other policy variables such as financial liberalization and international trade variables, Balamoune-Lutz (2003) defined financial deepening as the ratio of broad money (M2) to GDP is used as a proxy for financial liberalization. Eke (2007) and Balamoune-Lutz (2003) argued that with increased financial deepening banks strive to make information available to their customer and generate additional income from service charge. Therefore increased deepening would empower consumers more. Many economic opportunities would be explored. This implies that financial deepening should spur establishment of more bottling water firms, civic action initiatives on better water management policy and strategies.

The correlation coefficient in Table 1 shows that there a negative (though not statistically significant correlation between financial liberation core WRM performance indicators. (FWS: FL = -0.042; SDW: FL = -0.11). This discovery could be that since (M2) and GDP were measured in dollars terms, most West African countries have experience stiff decline (in dollar terms) over the years due to weakening exchange rates. The sensitivity of these countries water industry to trends in the international market was assessed using the net financial flows (NFF),

**Table 2.** An Economic assessment of the impact of ICT on performance indicators of water resource management in west africa dependent variable: FWS KM<sup>3</sup>/Yr.

| Equations               | 1              | 2               | 3              | 4              |
|-------------------------|----------------|-----------------|----------------|----------------|
| Number of observations  | 53             | 53              | 53             | 53             |
| Adjusted R <sup>2</sup> | 0.651          | 0.160           | 0.129          | 0.661          |
| Constant                | 35.366         | 23.008          | -24.260        | 52.252         |
| PCI                     | 0.0005(0.009)  | 0.0003(0.014)   | 0.0009(0.013)  | 0.0007(0.009)  |
| IEF                     | 0.331(0.290)   | -0.0004(0.435)  | -0.0002(0.432) | 0.349(0.301)   |
| PR                      | 10.665(23.643) |                 |                | 0.588(25.055)  |
| CL                      | -8.000(31.381) | 18.669(21.895)  | 23.364(19.707) | -4.781(32.682) |
| SER                     | -1.257(0.911)  | -1.208(1.396)   | -1.481(1.239)  | -1.642(1.072)  |
| HDI                     | 0.009(0.510)   | 0.706(0.776)    | 0.575(0.720)   | 0.0002(0.542)  |
| CI                      | -3.839(28.718) | -19.157(44.073) |                | -4.780(31.906) |
| CPI                     | 2.207(0.278)   |                 |                | 2.157(0.295)   |
| NFF                     |                |                 | 0.0005(0.012)  | 0.0005(0.009)  |
| BS                      |                |                 |                | 0.0002(0.292)  |
| IU                      |                |                 |                | -0.0004(0.018) |
| MCS 2007                |                |                 |                | 0.0002(0.003)  |

Standard Errors in parentheses, Source: ICT indicators are from International Telecommunication Union Website (2008); indexes for Civil Liberties and Political Rights are Freedom House website (2008); Economic Freedom index is from the Heritage Foundation website (2008); Education Index is from UNDP – Human Development Report 2008; Standard and Poor's Global Water Index website (2008); all other variables are from World Development Indicators CD-ROM (World Bank, 2008).

however, this is not statistically significant.

However, House (1999) observed the role of ICTs in enabling greater access to water related issues/information. More so, Balamoune-Lutz (2003) argued that ICT also foster the development of NGOs and information and Knowledge based communities that are more capable (relative individual citizen) to cause institutional changes. Consequently we expected efficient management of our cross border water resources as our stock of ICT increases in depth and breath. ICT diffusion may also affect the degree of effectiveness of the civil society and structures of the water industry across West African countries. For example, because water consumers have access to indexes and statistics of water coupled with market prices on World Wide Web, they can quickly organize around a problem, mount pressure and initiate a change process. The monopoly, strict control/limited access to knowledge hoisted on the populace by most West African government would become a thing of the past. Competition in the safe drinking water industry would amount to efficient use of resource and civic society watchful eyes through an active online community would act as a deterrent to waste and government excesses. The coefficient of correlation between Fresh water supply, safe Drinking Water is weak and highly significant (Table 1) this may reflect increased integration of these indicators.

## DISCUSSION OF EMPIRICAL RESULTS

Equation (1) results from the model exploring the factors that influence WRM performance indicators are represented in Table 2 (Equations 1 to 4). To test the robustness of the model, four equations were estimated. Table 2 displays the statistical results from estimating the model with Fresh Water as the relevant WRMPI variable. Equation 1 uses consumer price inflation, political rights,

index of economic freedom, per capita income, human development index, corruption index, secondary school enrolment rate and civil liberties in Equation (2) we excluded consumer price inflation and political rights. In Equation (3) we excluded corruption index and brought in net financial flows while in Equation (4), ICT indicators – Internet Users, broadband subscribers and mobile cell phone subscribers were brought in. Only variable that exhibits high significance will be discussed and estimate of all models is estimated using SPSS (Version 11.00).

In Table 2, Equation (1) displays the estimates using fresh water supply as the WRMP indicators. The empirical results shows these variables are strongly significant policy variables, per capita income, political rights, and liabilities, human development index and corruption index. More so, fresh water supply is assumed to be in the government's exclusive control. The variables that returned as not significant are index of economic freedom and secondary school enrolment rates. Effective management of our water is done by experts and politicians probably. Secondary school enrollment rate, theoretically seen as crucial part, does not really add the needed value statistically. This is so because in most West African Countries you do not need much education to get involve politics. However, finding of a negative effect may suggest there is a link.

Interestingly as expected all ICT indicators reported very significant (Table 2, Equation 4) from the theoretical point view increased broadband subscribers should boost WRMPI. Having a negative effect could suggest that some members of the elite that have laptops and wireless

**Table 3.** An Economic Assessment of the Impact of ICT on Performance Indicators of Water Resource Management in West Africa Dependent Variable: SDW.

| Equations               | 1              | 2              | 3              | 4              |
|-------------------------|----------------|----------------|----------------|----------------|
| Number of observations  | 53             | 53             | 53             | 53             |
| Adjusted R <sup>2</sup> | 0.347          | 0.355          | 0.344          | 0.308          |
| Constant                | 69.579         | 68.754         | 68.433         | 73.216         |
| PCI                     | 0.0006(0.001)  | -0.0006(0.001) | -0.0006(0.001) | 0.0004(0.001)  |
| IEF                     | 0.002(0.031)   | -0.0002(0.031) | -0.020(0.031)  | 0.020(0.032)   |
| SER                     | 0.212(0.099)   | 0.204(0.097)   | 0.199(0.098)   | 0.129(0.117)   |
| HDI                     | 0.008(0.055)   | -0.084(0.055)  | -0.086(0.055)  | -0.090(0.058)  |
| CI                      | 4.729(3.107)   | 4.901(3.076)   | 5.217(3.159)   | 4.959(3.438)   |
| CL                      | -4.088(3.396)  | -2.094(1.536)  | -2.075(1.549)  | -3.616(3.521)  |
| PR                      | 1.687(2.558)   |                |                | 0.768(2.714)   |
| CPI                     | -0.0002(0.030) | 0.007(0.029)   | -0.007(0.029)  | -0.003(0.032)  |
| NFF                     |                |                | -0.0005(0.001) | 0.0001(0.001)  |
| MCS 2002                |                |                |                | 0.0018(0.002)  |
| MCS 2007                |                |                |                | -0.0014(0.000) |
| BS                      |                |                |                | -0.046(0.047)  |
| IU                      |                |                |                | 0.0001(0.002)  |

Standard Errors in parentheses, Source: ICT indicators are from International Telecommunication Union Website (2008); indexes for Civil Liberties and Political Rights are Freedom House website (2008); Economic Freedom index is from the Heritage Foundation website (2008); Education Index is from UNDP – Human Development Report 2008; Standard and Poor's Global Water Index website (2008); all other variables are from World Development Indicators CD-ROM (World Bank, 2008).

web access are yet not actively involved in water issues. If there is an increase in number of subscribers in the future then there could be a point where safe drinking water would be solely private sector controlled. The segment of the industry would be comprised of bottle and sachet water companies, private water distributors, and bore hole drilling firms.

In Table 3, the R-squared is fairly low compared to Fresh Water which is very low. Access to safe drinking water appears to be most influenced by internet Users. In addition, results indicate that factor such as secondary school enrolment rates, corruption index, civil liberties; human development index and political rights are not statistically significant. This is not surprising as corruption in the water sector is negligible. Pricing data and orders placed on the net or otherwise distributed are basically the essential ingredients that is expanding this industry in Africa. Competition is the order of the day in countries such as Ghana and Egypt. Since this is private sector led and statistics seems to solidly support the idea; market oriented variable such as per capita income index of economic freedom, consumer price inflation, net financial flows, political rights, mobile phone subscribers, internet users were strongly significant.

If you compare the relevant variables in Table 3 (private sector) to Table 2 (public sector) you will notice that the difference in policy is statistically relevant. For instance, net financial flows and index of economic freedom were not significant variables in influencing fresh water supply but were highly significant in influencing

access to safe drinking water which within the domain of the private sector as against the former assumed to be exclusively controlled by the various West African states. Also, comparing Equations 1 to 4 in Table 3, you notice that equation that has all policy (irrespective of the sector) provides the best results in terms of R-square, 0.481.

The impact of population dynamics on Fresh water supply informed the use of the ratio – FWS/POP. This indicates the tendency of nation states to go war on water issues due to pressures arising from population dynamics. Both equations capture the process and show corruption index the most influential. Others are index of economic freedom, human development index and civil liberties. But human development index has a wrong sign (though statistically significant). It simply shows that improvement in human capital in West African countries does not necessarily translated into improving their water situation. This finding is similar to Broadband Subscribers notwithstanding, human capital and broadband subscribers must have positive roles in the effective management of fresh water supply but may be one possible reason for this anomaly. There could have been serious data measurement error.

In summary, the empirical results provide strong support for the role of ICT indicator as a major determinant of effective water resources management. This is consistent with the conclusion the studies of Van et al. (2003), Koinsky et al. (2001) and Swinford et al. (2007). Similarly all freedom indicators namely civil

**Table 4.** An Economic assessment of the impact of ICT on performance indicators of water resource management in West Africa Dependent Variable: FWS/POP.

| Equations               | 1             | 2             | 3             | 4               |
|-------------------------|---------------|---------------|---------------|-----------------|
| Number of observations  | 53            | 53            | 53            | 53              |
| Adjusted R <sup>2</sup> | 0.135         | 0.153         | 0.153         | 0.078           |
| Constant                | 28.821        | 35.095        | 34.002        | 38.063          |
| PCI                     | 0.006(0.002)  | -0.006(0.002) | -0.006(0.002) | 0.006(0.002)    |
| IEF                     | 0.03(0.069)   | -0.03(0.067)  | -0.03(0.067)  | 0.030(0.070)    |
| SER                     | -0.662(0.217) | -0.663(0.215) | -0.663(0.215) | -0.711(0.255)   |
| HDI                     | 0.06(0.122)   | -0.07(0.119)  | -0.07(0.119)  | -0.070(0.128)   |
| CI                      | 0.661(6.639)  | -0.150(6.776) | -0.150(6.776) | -0.328(7.418)   |
| CL                      |               | -0.655(3.366) | -0.655(3.366) | -1.0256(3.615)  |
| PR                      | 0.371(2.583)  |               |               |                 |
| CPI                     | -0.008(0.064) |               |               |                 |
| MCS 2002                |               |               |               | -0.0008(0.004)  |
| MCS 2007                |               |               |               | -0.00009(0.001) |
| BS                      |               |               |               | -0.03(0.089)    |
| IU                      |               |               |               | 0.0002(0.004)   |

Standard Errors in parentheses, Source: ICT indicators are from International Telecommunication Union Website (2008); indexes for Civil Liberties and Political Rights are Freedom House website (2008); Economic Freedom index is from the Heritage Foundation website (2008); Education Index is from UNDP – Human Development Report 2008; Standard and Poor's Global Water Index website (2008); all other variables are from World Development Indicators CD-ROM (World Bank, 2008).

liberties, political rights and index of economic freedom influence the performance of WRM (Table 4).

#### Impact of selected economic and social development indicators on west water resource management

$$WRMPi = \alpha + \delta'Z_i + \varepsilon_i \quad (2)$$

Where the vector  $Z$  contains economic and social indicators and  $\varepsilon_i$  is white noise. The only significant variable (though moderate) is fresh water supply followed by internet penetration index that showed  $p$  value. Meanwhile Equation (2) shows access to safe drinking water and internet penetration index returns significant (Table 5). In Table 6, Equation (1) report estimates of the impact of selected economic and social indicators as well as WRMPI on income (log transformation of per capita income). ICS, Inter Country scale is a dummy variable for representing UNDP's classification based on HDI as high, medium and low. In our case, 1 stands for countries grouped as medium and 0 for those that were grouped low.

These results indicates that an effective management of cross border and intra border water resource in both sectors of the economy increase in the subsector of cyber and broadband application, would lead to higher per capita income. From our selection the variable that seems to influence income are secondary school enrolment rate, human development index and inter country scale. The is plausible as secondary school

enrolment in most West African economies is low. This will directly affect West Africa's Human Development Index which as a result is grossly low.

In theory education is expected to have a positive influence on management of resources. As consumer of sachet and bottle water, for instance, have access to more learning (post primary) it should in turn have a huge impact on politicians who majorly are in charge and monopolize decision making processes. However, the empirical literature presents another picture. In most West African countries school enrolment is quite low. More so, those that enrol do graduate. On the other hand having successful private sector led water firms may not necessarily mean that they are run by secondary school graduates.

In many developing countries, most powerful politicians are ex-military men with little or no formal education. The results in Table 7 seem to support this view. There is no empirical evidence in support of the influence of education on water resource management. Because economic freedom diffusion of ICT and efficient macroeconomic policies improves the changes of managing our water better thereby averting water wars, it is expected to foster economic development in an unprecedented scale as water permeates all facets of the society and economy. This is also supported in Table 8.

#### Concluding comments

This paper examined the relationship between selected social and economic development, information

**Table 5.** An Economic Assessment of the Impact of ICT on Performance Indicators of Water Resource Management in West Africa Dependent Variable: SDW/POP.

| Equations               | 1               | 2             |
|-------------------------|-----------------|---------------|
| Number of observations  | 53              | 53            |
| Adjusted R <sup>2</sup> | 0.089           | 0.093         |
| Constant                | 138.061         | 35.095        |
| PCI                     | 0.02(0.009)     | -0.006(0.002) |
| IEF                     | -0.258(0.301)   | -0.03(0.067)  |
| SER                     | 1.062(1.085)    | -0.663(0.215) |
| HDI                     | -0.361(0.540)   | -0.07(0.119)  |
| CI                      | 5.404(31.816)   | -0.150(6.776) |
| CL                      | -18.235(32.584) | -0.655(3.366) |
| PR                      | 0.08(25.118)    |               |
| CPI                     | -0.04(0.296)    |               |
| NFF                     | 0.006(0.010)    |               |
| MCS 2002                | 0.003(0.020)    |               |
| MCS 2007                | -0.004(0.004)   |               |
| BS                      | -0.036(0.433)   |               |
| IU                      | 0.01(0.020)     |               |

Standard Errors in parentheses, Source: ICT indicators are from International Telecommunication Union Website (2008); indexes for Civil Liberties and Political Rights are Freedom House website (2008); Economic Freedom index is from the Heritage Foundation website (2008); Education Index is from UNDP – Human Development Report 2008; Standard and Poor's Global Water Index website (2008); all other variables are from World Development Indicators CD-ROM (World Bank, 2008).

**Table 6.** An Economic Assessment of the Impact of ICT on Performance Indicators of Water Resource Management in West Africa. Dependent Variable: PCI.

| Equations               | 1            | 2            |
|-------------------------|--------------|--------------|
| Number of observations  | 53           | 53           |
| Adjusted R <sup>2</sup> | 0.374        | 0.377        |
| Constant                | 3.038        | 2.504        |
| IEF                     | 0.008(0.001) | 0.008(0.003) |
| SER                     | 0.031(0.010) | 0.027(0.010) |
| HDI                     | 0.013(0.005) | 0.013(0.005) |
| ICS                     | 1.513(0.889) | 1.413(0.900) |
| IPI                     | 0.037(0.039) | 0.031(0.040) |
| SDW                     |              | 0.099(0.014) |

Standard Errors in parentheses, Source: ICT indicators are from International Telecommunication Union Website (2008); indexes for Civil Liberties and Political Rights are Freedom House website (2008); Economic Freedom index is from the Heritage Foundation website (2008); Education Index is from UNDP – Human Development Report 2008; Standard and Poor's Global Water Index website (2008); all other variables are from World Development Indicators CD-ROM (World Bank, 2008).

communication technology and water resource management performance indicators, ICT are a major determinant of water resource management performance indicator. It influences civil societies providing a veritable platform for actively sharing information on an international scale and engaging government agents to further entrench the culture of excellence and corporate governance. These platforms enable West African

economies imbibe international best practices that evolve over time thereby forcing respective governments to be accountable and transparent which are hallmarks of the ongoing anti water war campaigns. Secondly, there is a strong influence of macroeconomic policies on the sector. Third, freedom improves the water resource management. Fourthly, empirical results support the notion that effective management of our water resources

**Table 7.** An Economic Assessment of the Impact of ICT on Performance Indicators of Water Resource Management in Africa. Dependent Variable: SER.

| Equations               | 1             | 2             |
|-------------------------|---------------|---------------|
| Number of observations  | 53            | 53            |
| Adjusted R <sup>2</sup> | 0.468         | 0.093         |
| Constant                | 35.422        | 35.095        |
| IEF                     | 0.048(0.045)  | -0.03(0.067)  |
| SER                     | 1.062(1.085)  | -0.663(0.215) |
| HDI                     | -0.136(0.072) | -0.07(0.119)  |
| ICS                     | 4.419(13.410) | -0.150(6.776) |
| IPI                     | 2.279(0.486)  |               |
| FWS KM <sup>3</sup> /yr | -0.019(0.015) |               |

Standard Errors in parentheses, Source: ICT indicators are from International Telecommunication Union Website (2008); indexes for Civil Liberties and Political Rights are Freedom House website (2008); Economic Freedom index is from the Heritage Foundation website (2008); Education Index is from UNDP – Human Development Report 2008; Standard and Poor's Global Water Index website (2008); all other variables are from World Development Indicators CD-ROM (World Bank, 2008).

**Table 8.** An Economic Assessment of the Impact of ICT on Performance Indicators of Water Resource Management in West Africa Dependent Variable: CL.

| Equations               | 1             | 2              |
|-------------------------|---------------|----------------|
| Number of observations  | 53            | 53             |
| Adjusted R <sup>2</sup> | 0.119         | 0.033          |
| Constant                | 7.385         | 5.066          |
| IEF                     | -0.012(0.003) | -0.0009(0.003) |
| HDI                     | -0.007(0.005) | -0.006(0.005)  |
| ICS                     | 1.247(0.894)  | 0.851(0.033)   |
| IPI                     | -0.034(0.035) | -0.655(3.366)  |
| SDW                     | 0.034(0.013)  |                |
| FWS KM <sup>3</sup> /yr |               | 0.0013(0.001)  |

Standard Errors in parentheses, Source: ICT indicators are from International Telecommunication Union Website (2008); indexes for Civil Liberties and Political Rights are Freedom House website (2008); Economic Freedom index is from the Heritage Foundation website (2008); Education Index is from UNDP – Human Development Report 2008; Standard and Poor's Global Water Index website (2008); all other variables are from World Development Indicators CD-ROM (World Bank, 2008).

will help to develop West Africa's economy. Also, enhance political rights and civil liberties. It must be pointed out here that in West African countries, based on statistical analysis, education is not associated with effective water resources management.

The present finding seems to offer some new strategies embedded in an ICT – oriented culture for managing our nation's water resources. It would also compliment concerted efforts to boost irrigation farming in West Africa as Valipour (2014b) observed that the respective government should encourage irrigation farming. There is ample evidence that managing our water resources effectively can provide an additional source of economic growth. On the other hand, this paper provides crucial insights about those ICT, economic and social development variables that are important parts of WRMPI.

### Conflict of Interest

The authors have not declared any conflict of interest.

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