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THE RELEVANCE OF OPEN SOURCE TOOLS FOR ENHANCING WATER RESOURCES MANAGEMENT IN AFRICA

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ABSTRACT

Open Source tools have received tremendous growth in the past decade. The development of applications in hydroinformatics, as in software applications, is important for effective water resources management. However, these developed software applications are sometimes too expensive for feasible use by hydrologists, engineers and researchers in Africa who may not have enough financial resources to purchase them. The open source movement has created room for water practitioners and researchers to use and apply modelling, assessment and analysis tools for effective management, monitoring and modelling of water resources. The availability of these important and necessary open source tools for water resources management and development, applicable to Africa, remains unknown. Also, the relevance, the categories and the available open source tools that could better improve water resources management in Africa is not well documented. Currently, it seems not even one document exists where one can easily find this. Therefore, this paper attempts to address this issue and to close this gap by examining and documenting available open source tools that could improve water resources planning, monitoring and management Africa. The paper presents a case of the estimation of evapotranspiration using a free source tool – ILWIS Open. In general, this paper anticipates contribution towards the importance of knowledge sharing and collaboration in research, and development in Africa.

KEY WORDS

Hydroinformatics, knowledge sharing, free and open source software, water management

1. INTRODUCTION

The 21st century has seen the growth of information technology in all spheres of our lives. Science and technology has advanced so fast in the past decade and, as a result, has also changed the manner in which we need to look at the management of water resources in general. Africa is enriched with huge water resources, but the lack of the requisite tools usually makes this difficult and, in some cases, impossible to manage these resources effectively. Necessary tools needed to support decision making, database management, modelling and forecasting of the related issues in water resources management involves the use of software, frameworks and applications. These tools are important in providing a more efficient approach to addressing the challenges of data collation, analysis and building of scenarios for addressing water related issues in Africa.

The software and applications tools that exist to support water resources management mostly come in the form of commercial packages in this modern era. A good number of African countries are predominantly facing socio-economic issues such as poverty and inadequate water supply. The advent of the open source tools in the past decade has created a promising window of opportunity for most countries in Africa to be able to acquire affordable and adaptable open source software packages and applications to support monitoring, planning and management of water resources. In addition, it is worth noting that, internet services for most African countries have improved steadily. A survey revealed that the growth of mobile penetration in Africa increased from 1% to 31% between 2000 and 2008 [1]. Since, these new open source tools can easily be downloaded via many electronic devices, it further provides chances for ensuring that knowledge sharing and technology transfer, as in the use of open source applications for water resources management, can further be enhanced and promoted. Also, the field of hydroinformatics, which is a special area that deals with the development of applications for hydrology, and general water resources modelling and management in Africa, can be boosted with the use of such open source applications. This is because, open source applications have the capability to be modified and adapted to suit different conditions.

Open source applications for water resources have been in use in the developed world but however, these developments are scattered and sometimes difficult to track all these valuable applications. Also, there is competition now between commercial and open source applications for water management and, the commercial companies have more popularity and acceptability among

users to a large extent. As a result, it seems commercial packages seem to be the best, hence causing some scholars to frown at open source tools. Notwithstanding, there is various research work done with open source applications which underscores that, truly this new direction in the development of software and applications for research in water resources management offers better chances for a more sustainable approach to water issues in the coming decades. Most developed countries have seen the relevance of open source applications to support knowledge sharing, enhance research and improve developed software and applications faster than the restrictive commercial packages. This is partly because commercial packages do not readily offer the free will of the general public to access the source code of applications and hence, not offering the opportunity for modifications to suit the coded methodologies in line with recently published science. This makes open source software and applications, a growing plus for success in most regions in Africa. Therefore, this paper documents some of the open source applications and software relevant for water resources management in Africa. The paper also enumerates some of the key areas these packages may be able to support water resources modelling, monitoring, analysis and management.

2. OVERVIEW OF OPEN SOURCE TOOLS & DEVELOPMENT

Open source is a paradigm shift in software and application development whereby people are organised and mobilised to work jointly on voluntary basis to produce complex integrated systems for providing solutions to the corporate and technological world [2]. The ability of people to cooperate, share and develop applications together result in faster production of such systems. Also, because open source movements are on voluntarily basis, it implies persons involved are truly motivated to contribute their skills, knowledge, talent and time to ensure that the goal of developing an application in question is achieved.

Open source applications to a large extent undermine the fundamental economic concepts and law of; property rights, labour, reduction of labour costs and the regulation and management of middle-men in product sales and delivery. Therefore, the growing success of open source applications and software is as a result of the mix of out-of-box integration of property rights around distribution and sharing, and combining the enormous benefits of human zealous nature and motivation beyond the norms of salary and labour concepts for work done [3]. Notwithstanding, this out-of-box initiative in open source applications has grown to become equally of good quality compared to commercial packages [4]. Part of the reason for open source applications is that, they are constantly peer reviewed by a wide variety of voluntary users who together identify problems and fix them in a shorter time. The voluntary users are usually scientific experts in the field.

A research by Tuomi [2] showed that the interest, rapid growth and growing acceptance of open source applications may be due to the following factors: (1) no licensing fees, (2) open source applications appears to be better than commercial software due to the multiple voluntary contributions, (3) availability of source code and the possibility to modify it according to one's needs, (4) room for integration of innovative ideas compared to commercial packages and checking the reliability and functionally of source code. Simply, this has facilitated the entry of open source applications to many parts of the world as a result of some of these benefits. Abdool [5] summarises these as the fact that open source applications are cost efficient, flexible and stable. Existing challenges of commercial software to allow for effective technology transfer to developing countries like those in Africa usually include [e.g. 6]: (1) developers of commercial software and applications do not reveal valuable information of packages without incentives, and (2) technology holders are interested more in the cost recovery of inventions rather than the value of contributions by the developed application. Thus intellectual property rights can inhibit knowledge transfer. However, with open source software and applications, users are not restricted to these challenges and hence can easily use, distribute and modify applications for their specific needs without any challenges. So to a large extent, open source applications and software are robust regardless of the fact that they are based on voluntary contributions [7].

This makes open applications and software an effective tool to support monitoring, modelling and management for Africa's resource managers and planners if adopted in the proper way. It must be emphasised that, most authorities and stakeholders working in water resources management in Africa already have requisite machinery to support these applications. For instance, wide use of computers and recent internet accessibility shows that, the adoption of open source tools for water resources management might be easier than a decade ago. In this case, instead of organisations to spend huge sums of money to buy proprietary packages for water resources modelling and management, a meagre portion of such financial resources can be used for building the capacities of users in this category. Consequently, a higher returns can be realised with water resources managers, researchers and experts trained with skills in the use of such applications. Another important thing worth mentioning is that, open source applications have user forums that ensure that other users can assist in trouble shooting and cross-moderation of the suggested solutions.

In addition, open source applications and software are very different from proprietary software. Hence, a user who has been using commercial applications can easily switch to open source software with greater ease and flexibility. Further, the role of hydroinformatics in Africa can be enhanced by the examination of open source tools for hydrological modelling and scoping for the development of packages that are more relevant and useful to the African climatic and weather situation.

3. APPLICATIONS FOR WATER RESOURCES MANAGEMENT IN AFRICA

Two popular websites that usually host open and free source software are SourceForge.net and http://www.freshmeat.net/. Browsing through these and other webpages reveals a lot of applications and shows records of thousands of downloads per month by users. Most packages can be used on both Windows and Linux operating systems. It is worth mentioning that Linux is a free and open source operating window system.

Table 1: List of open source tools for water resources management

Software/ Application	Area of Application in water resources management	Website	Open Source (OS)/Free
Open Hydrology	Hydrologic Processes Modelling	http://openhydrology.org/about	OS & Free
Kalypso	GIS based application for hydrologica and hydraulic modelling	http://sourceforge.net/projects/kalypso/	OS & Free
PIHM Model	Semi-distribted hydrologic model	http://www.pihm.psu.edu/	OS & Free
CUAHSI openHIS	It handles infrastructure and services for the advancement of hydrologic science and education	http://sourceforge.net/projects/open-his/	OS & Free
Hydrologic Analysis and Modelling Toolbox	Rainfall-runoff modelling of catchments	http://sourceforge.net/projects/hamtoolbox/	OS & Free
Non-Point Source Model Development Tool	Web-based modelling tool for online non-point pollution, hydrology, and water supply planning	http://sourceforge.net/projects/npsource/	OS & Free
OpenFLUID	Modelling of land fluxes as in hydrology, pollutant a	http://www.umr-lisah.fr/openfluid/	OS & Free
LARSIM	Runoff Simulation Model	http://larsim.sourceforge.net/larsim.de.php	OS & Free
dotagwa	GIS based web-interface watershed delineation and parameterization	http://sourceforge.net/projects/dotagwa/	OS & Free
OpenGMF	Ground Water Modelling support for hydrogeologists and reservoir engineers.	http://sourceforge.net/projects/open-gmf/	OS & Free
BlueModel	River basin management	http://www.bluemodel.org/	OS & Free
SWRC Fit	Soil hydraulic modelling	http://swrcfit.sourceforge.net/	OS & Free
GRASS	GIS modelling, watershed delineation and hydrological analysis	http://grass.fbk.eu/	OS & Free
QGIS	GIS modelling	http://www.qgis.org/	OS & Free
ILWIS Open	GIS and remote sensing modelling, watershed delineation and hydrological analysis, evaporation GEONETCAST toolbox for data retrieval and visualisation	http://52north.org/communities/ilwis/	OS & Free
EPANET	Water distribution, supply and water quality management	http://www.epa.gov/nrmrl/wswrd/dw/epanet.html	OS & Free
MAP-WINDOW	GIS modelling, watershed delineation and hydrological analysis, HydroDesktop for data discovery, download, visualization, editing, and integration with other modelling tools. Includes Soil Water Assessment Tool (SWAT) interface for water resources management [http://swatmodel.tamu.edu/].	http://www.mapwindow.org	OS & Free
HEC Series	Free software available for hydraulic and hydrologic modelling. These include RAS, HMS, Geo-HMs, GeoRAS, Res-Sim, HEC-SSP, EFA and DSSvue.	http://www.hec.usace.army.mil/software/	Free
WEAP/WEA	Tool for integrated water resources	http://www.weap21.org/	Free

P21	assessment and planning		
SWMM &	Rainfall – runoff modelling for urban areas	http://www.epa.gov/athens/wwqtsc/html/swmm.html	Free
XPSWMM	Dynamic modelling of storm water, sanitary and river systems	http://www.xpsoftware.com/products/xpswmm/	Free
ARCSWAT & SWAT	ArcSWAT is an ArcGIS extension for SWAT user interface	http://swatmodel.tamu.edu/software/arcswat/	Free

The table 1 is not an exhaustive list. This is because it is imperatively difficult to track all the open source applications being developed worldwide. However, the use of applications in this list, promises to provide appropriate tools for modelling purposes in water resources modelling and management in Africa. Therefore, whether it is catchment based management models needed or GIS based support modelling, there are open source tools readily available for download to support such work. An important aspect of these open source applications is that, the source code is readily available so that researchers and students in hydroinformatics for instance, can have a chance to a critical examination of the code structure, relevance and possible adaptability to other sources. It is worth mentioning here that, knowing how an application or software is written is ten times an advantage to adapting it to your specific needs. In this way, open source applications support technology transfer to users who are not smart programmers to put such software together. Hence, the open source applications, as shown in the table, can easily be tailored to satisfy specific environmental and socio-economic of a particular African region.

It is also good to add that, most of these open source applications are also like templates for revising other specific needs such as building scenarios and forecasting, and also have the possibility of integrating other socio-economic datasets into such applications (e.g. Kalypso. Hydrologic analysis and modelling toolbox and ILWIS Open). Good research implies the appropriate use of the applications and software that can improve the reliability, accuracy and efficiency of the research. This means that in African countries where governments and research authorities find it hard to fund specific water resources research due to sometimes high costs of software and applications needs, use could be made of these open source applications.

CASE EXAMPLE: SURFACE ENERGY BALANCE SYSTEM (SEBS) IN ILWIS OPEN FOR THE ESTIMATION OF EVAPOTRANSPIRATION

The SEBS model developed by [8] to estimate surface heat fluxes temporally and spatially, has been integrated into the ILWIS Open as a plug in. The SEBS model allows the use of satellite derived parameters such as land surface temperature, Normalised Differential Vegetation Index (NDVI) and the meteorological station data to estimate the various surface heat fluxes. In this case example, the SEBS model was run for a bigger extent of Zimbabwe to assess and visualise for the actual daily evapotranspiration variation from the 13-15 June 2009 (measurements in *mm*). For more details about how to derive the various land surface fluxes for use in this SEBS model, please refer to [9].

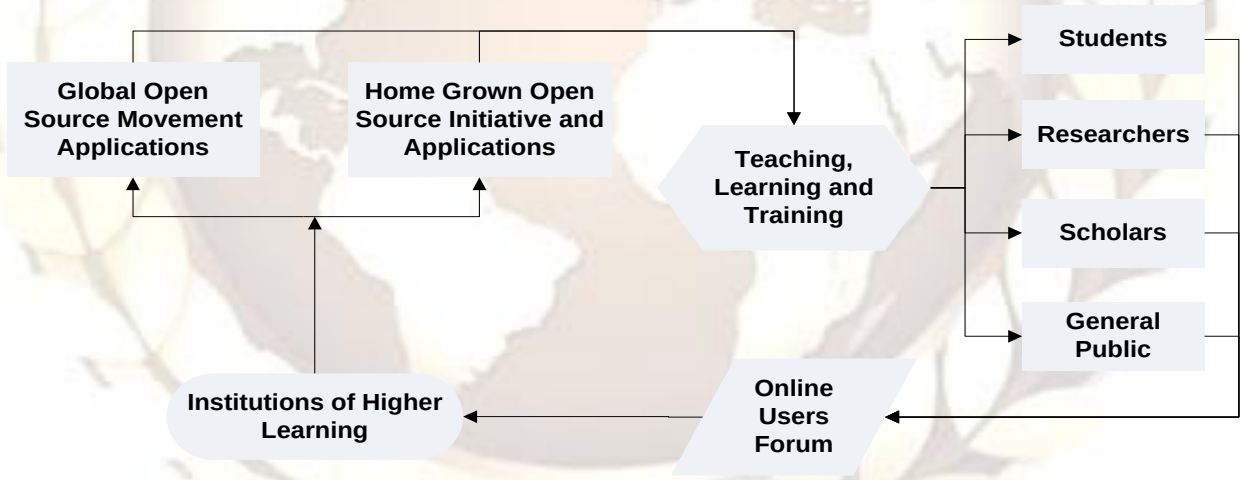
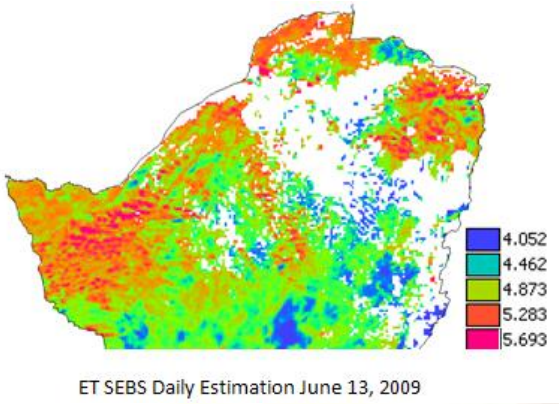
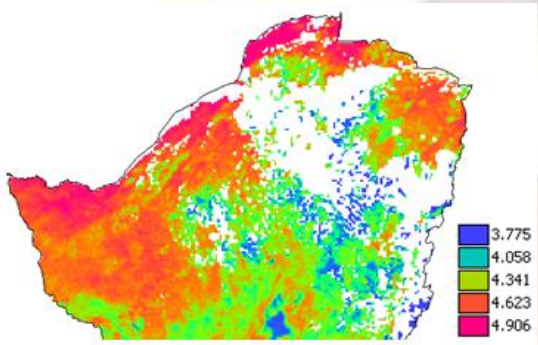


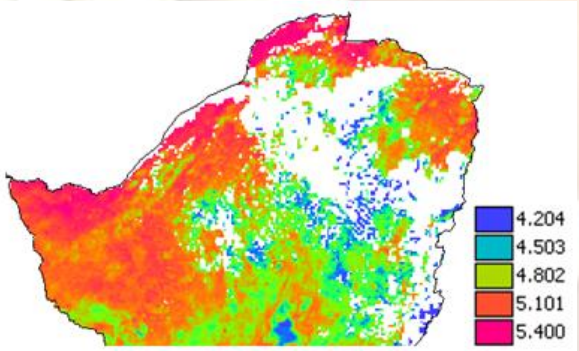
Figure 1. Adopting open source software and applications for water resources management in Africa



ET SEBS Daily Estimation June 13, 2009



ET SEBS Daily Estimation for June 14, 2009



ET SEBS Daily Estimation for June 15, 2009

Though, there are wide patches in the results; it demonstrates a spatial estimation of ET over the large northern part of Zimbabwe and hence allows for a holistic water resources planning and management in this part of Zimbabwe. This is just one example of how open source tools can be used for water resources management. Most of the open source tools mentioned can be used to derive many relevant applications for water resources management.

4. FRAMEWORK FOR ADOPTION OF OPEN SOURCE TOOLS FOR WRM IN AFRICA

The study of hydro-informatics and related courses in water resources management is usually undertaken in universities, polytechnics and related research institutions. This implies that the need and demand for the use of open source software and related applications in water resources management is there and high in institutions of higher learning. This also means that, the researchers and professionals with the ability to adapt, modify and with the requisite skills to understand the building structures behind these open source applications are also likely to be mostly found in institutions of higher learning. It is also very likely that this situation may vary in few advanced African countries. For the purposes of this paper, we consider *institution of higher learning (IHR)* to mean universities, research institutions, polytechnics and tailored programmes offered by both national and international non-governmental organisations (NGOs). IHR can promote the adoption and use of open source applications specifically for water resources modelling and management. Furthermore, the IHR and volunteer groups of interest for specific adapted software and applications in Africa should form forums to discuss best ways of improving such programs especially for providing specific needs for the Africa region. These groups should also collaborate with the founding developers of the program so that there is dialogue and constant sharing of new developments and possible upgrades of programmes. It is envisaged that, as more IHR adopt and use such open source applications in their research and training programmes, forming networks for the Africa region, and forums for resolving water related problems in Africa can be addressed.

The fact that, internet is becoming faster in Africa and available through phones and mobile phones, can truly improve the communication and sharing of ideas to improve the use of these adopted open source applications for water management. It is very likely that, the smart brains in the IHR could be able to develop more appropriate context specific applications that integrate the African operating environment. This is very possible because students and researchers in IHR can better use such applications and software to support their reporting works, projects and thesis work.

In terms of readiness of Africa to adopt open source applications, we believe that all necessary infrastructures to support this new system is available in the African region. Also, the use of open source applications can reduce the technological problems usually encountered in using commercial applications during water resource management. Take for instance, if one's licensing key is lost and project management do not have the requisite extra budget to pay for new licensing key. It implies, the earlier work done before cannot be retrieved or continued. In this case, this can be a setback to research work and the general management of water resources management projects. Another remarkable change would be the

opportunity of students and amateur researchers in most African countries to have hands-on practice in learning to use software and applications employing the state-of-the-art science and techniques at 'no cost'. This would avoid the issue of learning theories without practical hands on the software in IHR.

5. CONCLUSION

Open source software and applications have tremendous potential to support to water resources management in Africa. Africa that is already stressed as a result of socio-economic needs can channel more attention into alleviating poverty rather than spending huge large sums of money in purchasing commercial software for water resources monitoring, management and development. Globally, open source tools have proven to be of sufficient quality just like commercial software. In view of this, the paper assessed the relevance of open source applications, identified some applicable tools for water resources management and developed a simple framework for the adoption of open source applications in Africa. It is assumed that, institutions of higher learning such as universities, polytechnics, research organisations and NGOs are agencies that can act as the main conduits of transmitting, sharing, training and educating the masses on the relevance of open source applications for water resources management in Africa. As such if such organisations begin to adopt open source applications, it will champion subsequent modification and adaptation of such open sources for the tailored needs of the African people. This paper envisages a significant contribution towards the use of open source applications for managing water resources in Africa more affordably and more sustainably.

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