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Modeling and Visualization of Irrigation Potential Using Microsoft Excel

Karara, G.K.[1], Gathenya, J.M.[2], Home, P.G.[3], Ayugi, S.[4]

[1, 4] Technical University of Kenya, School of Surveying and Geospatial Sciences
P.O. Box 52428 Code 00200, Nairobi, Kenya
[2, 3] Jomo Kenyatta University of Agriculture and Technology, Biomechanical and Environmental Engineering Department

Abstract: **Lack of information about irrigation potential has caused crop failures on irrigated farms in Kenya due to unexpected climate change. The information model through annual reports in form of table and text as provided by agricultural and meteorological experts is clearly not understood by the farmers. Therefore, this paper aimed to visualize irrigation potential by modeling the rainfall and runoff using Microsoft excel. Using Microsoft 2007 in a normal computer, daily rainfall was recorded into one sheet, calculated into another sheet as runoff and visualized in the last sheet as a map of irrigation potential. One sheet was added to record actual runoff harvested in a reservoir and another to distribute the runoff onto irrigation areas. A raster map was visualized as a result of modeling the entered data implying that ease of information could be achieved almost at no extra cost to what is usually done.**

Keywords: **Modeling, Visualization, Irrigation, Potential, Microsoft excel.**

1. INTRODUCTION

Weather changes have made farming an extreme hazard where farmers' plant without assurance of rainfall and therefore harvest. They spend a lot of resources to prepare land, buy seeds, labor and fertilizers only to lose the crop due to drought. To mitigate rain-fed crop failure, they implement irrigation which is also affected by droughts. When drought affects water sources, the water apportionment authority has a right to curtail the use of water for irrigation. This catches farmers off guard sometimes after preparing and planting on land (Kenya, 1962) . It was suggested that "It's time weathermen spoke the language of farmers" (Kweyu, 2014) because farmers seemed to work without the relevant weather, soil and water information. It is one thing to collect data about rainfall in an area and water in the reservoirs and it is another thing to make the famers informed from the data. There is a missing link between the weather data producers and farming community who use that data to make decisions. Over 80% of Kenya country is arid and semi arid and therefore not suitable for crop production unless the little rainfall and runoff received is accounted for and used in decision making for irrigation.

In Kenya, the national irrigation board was established in 1966 and manages about seven major schemes. Many small irrigation projects have been started as guided by ministry of agriculture but most often made losses due to uncertainty of whether they get irrigation water or not for any particular season (Kenya, 2007). One such irrigation project was started by Jomo Kenyatta University of Agriculture and Technology at its Kabiruini show ground farm in Nyeri. In addition to problems of silting, which were addressed in 2006, water seepage and rainfall uncertainty made the project to be slowed down when in 2009; the reservoir depleted its water. As a user of weather data the university had no direct access to historical rainfall data from which trends could be assessed nor did it have design parameters of the reservoir. Access to this data could be made simple if Meteorological department, Ministry of water, ministry of agriculture and the farmer had single software on which Meteorology would daily record rainfall and in real-time irrigation potential be modeled.

1.1 MODELING IRRIGATION POTENTIAL SOFTWARE AND TECHNIQUES:

Modeling irrigation potential begins from modeling rainfall to become runoff, then modeling the runoff storage so that the required cropping season is adequately supplied with water. Reservoir storage is normally affected by the scarcity of rainfall to an extent that big reservoir such as Masinga in Kenya deplete and close the supply. The users of such water are rarely aware of depletion in advance because this happens once in so many years statistically determined as design runoff. Since the year of drought is random, the farmer in case of irrigation should be having a prior knowledge of available water for irrigation for any season before preparing land for cropping. That information comes from meteorology in case of weather, water ministry in case of water and agriculture ministry in case of crops and markets.

The irrigation potential software are grouped into those that estimate runoff, those that estimate crop water requirement and those that estimate the time of pumping or gate opening in order to satisfy the crop water requirement. There is no software connecting the farmer or extension officer with the rainfall, runoff and potential area of irrigation for each season. If they have to know the lands to irrigate any season, they have to order for rainfall and runoff data before every season or measure it themselves.

1.2 PROBLEM STATEMENT:

The problem for this paper was to inform farmers of their irrigation potential by modeling the rainfall, runoff and irrigation potential area for visualization using off the shelf Microsoft excel. Microsoft excel is among the common three spreadsheet software (garbo7441, 2009) used for viewing and exploring data (Murrell, n.d.). History of spreadsheets began from accounting in 1962 where the word signified the two facing pages of a ledger book (Fried, n.d.) The paper objective was to model rainfall into runoff and make it visible as irrigation potential area using Microsoft excel. So can modeling and visualization of irrigation potential be done in Microsoft excel? This is the question that this paper aims to answer.

1.3 JUSTIFICATION:

Most of the stakeholders in irrigation potential are government agencies such as national irrigation board, ministries of water and agriculture and the farmer who would most likely use what the government recommends. Since directorate of e-Government recommends Microsoft office 2007, then this model would save any money required to buy other specialized software for modeling and visualizing irrigation potential daily. Rainfall and runoff data are captured in Microsoft excel making it necessary to extend the capture to modeling and visualization.

2. METHODOLOGY

Rains as a crucial component of irrigation potential is recorded in micro soft excel software by Kenya Meteorological Department and that forms a good beginning for water and agriculture ministry to begin modeling their products. Water ministry applies runoff models such as SCS-CN, regression or grids to assess the potential runoff from the rainfall and then measures the reservoir water levels to confirm the runoff estimates. Ordinarily the calculated runoff would be input into mapping software such as GIS in order to show the area extent of that irrigation potential. Since Microsoft excel is a software in almost all offices, then meteorology can put the daily rainfall on a common website where users of that rainfall data can access and model it to suit their needs especially irrigation even if they have to pay for the website cost.

To record daily rainfall for different stations on the first worksheet, columns were selected and headed with name and number of the station. The first column was selected to show the dates of the season in a year. Length of each season was selected as 120 days after (Hatcho & Kay, 1992) starting from February of each year. Daily rainfall was arranged in 122 day column length in conformity with 366 days of a leap year.

The second worksheet was dedicated to estimated runoff potential from the measured rainfall for each day which summed every 122 days as a seasonal estimate for each of the three seasons. Depending on the location of each rainfall station, the estimated runoff was attributed to a specific reservoir in a catchment where the reservoir was located. In this case the reservoir was Kabiruini reservoir.

In addition to estimating the potential runoff harvest, actual runoff harvested in the reservoir was measured in terms of water depth and modeled to actual runoff using surface area of the reservoir in the third worksheet. This runoff was then compared to the estimated runoff in worksheet two.

In worksheet four, the cells were arranged to express the area as a raster map whose cell sizes or resolution was determined by extreme coordinates northwards and eastward. Using Universal Transverse Mercator (UTM) coordinates; a grid was made at 10m interval ranging from 9956510m to 9957000m northwards and from 273680m to 274270m eastwards. The area of each cell was modeled to change with changes in the coordinates and the crop water requirement for each cell was modeled to change with total water requirement of the season. The seasonal water harvest was modeled to transfer from either the estimated seasonal total or the actual seasonal total in the reservoir to this worksheet of potential irrigation. Provisional was also made for simulating irrigation potential from fictitious runoff. By the corner coordinates of the existing farms, boundaries were drawn and cells that could potentially be irrigated were selected. In each cell a formula was typed which subtracted the seasonal crop water requirement from the balance of the last cell which abstracted water from the reservoir or estimate. All the cells in the farms abstracted their water requirements, making some to be positive and others negative; depending on the available runoff. Assuming that the runoff available was not to be lost in any way, this quantity of water was fully availed to the farmer who was assured that for the area which was visualized, water would surely be delivered.

Corresponding to worksheet four, the same cells were made in worksheet five where each cell had a model which enabled it to decide whether it was potential for irrigation that season. The model was a "what if" analysis which determined if the cell had a balance of runoff equivalent to its seasonal water requirement and an environmental quantity as residue in the reservoir. A positive answer prompted the cell to display a sign that it was potential while a negative left it blank. So whatever cell had a sign was guaranteed of irrigation water and that without the sign was not.

In summary, the meteorologist typed the daily rainfall in worksheet one as the hydrologist calculated runoff in sheet two and recorded the reservoir tide gauge levels in worksheet three. The farmer and agricultural extension officers visualized the area they should prepare and decided on the most profitable crop to grow. When the models were put in place, the whole modeling and visualization of irrigation potential became automatic.

3. RESULTS AND DISCUSSION

The result was in five worksheets which were interrelated with formulae to transfer data from one to the other. In Figure1, the daily rainfall was recorded in columns per year according to dates and summed and the bottom to obtain annual rainfall. Each day's rainfall in worksheet1 was transferred to worksheet2 to be part of the Soil Conservation Service – Curve Number (SCS-CN) model for estimating potential runoff.

Rainfall station 9036223 NYERI PRISON STATION Lat 0º 25'Sng and Visualization of Irrigation Potential Using MS Excel

	Year	1970	1971	1972	1973	1974	1980	1981	1982	1983	1984	1989	1990	1995	1996	1997	1998	1999	2005	2006	2007	2008	2009	2010	
	Day																							site	
1-Jan	1	1	0	0	0	0	0	0	0	0	0	0	19	12	8	2	1	0	0	0	17	0	0	0	2
2-Jan	2	0	0	1	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	12	0	0	4	5	3
3-Jan	3	8	0	0	1	0	0	0	0	0	1	0	25	0	0	0	0	0	0	0	0	0	0	10	2
4-Jan	4	0	0	0	0	2	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	1
29-Dec	363	15	0	0	0	1	0	0	0	0	0	10	2	0	0	0	0	0	0	1	0	0	0	0	1
30-Dec	364	9	3	0	0	1	0	6	0	2	0	12	1	0	0	0	0	0	0	26	0	0	0	0	2
31-Dec	365	5	0	0	0	0	0	0	0	0	0	70	2	0	0	0	0	0	0	13	0	0	0	0	5
1-Jan	366	0	0	0	0	0	0	0	0	0	0	0	0		0		0		0			0	0		2
Annual rain mm	Rainfall mm	667	441	543	511	474	732	1139	1100	733	716	1068	999	989	711	1445	1366	563	639	1250	850	555	489	638	836
Year	Year	1970	1971	1972	1973	1974	1980	1981	1982	1983	1984	1989	1990	1995	1996	1997	1998	1999	2005	2006	2007	2008	2009	2009	

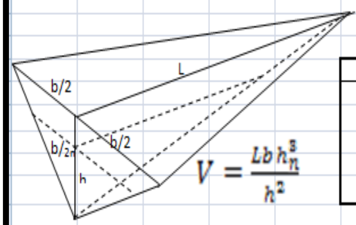
Figure 1:Worksheet1 for entry of daily rainfall

The SCS-CN model shown in Figure2 had a component to decide if the denominator part (P-0.2S) was greater than zero and therefore could estimate runoff for that particular rainfall. This action discriminated rainfall that was unable to produce runoff from the catchment. After obtaining the daily runoff in Figure2, a sum was calculated at the bottom of the column as annual runoff. Rainfall measured on site in 2010 and shown in Figure1 as 638mm had the potential of producing runoff shown in Figure2 as 28849m^3.

A	B	C	D	E	F	G	L	M	N	R	S	T	U	V	W	AL	AM	AN
		SCS-CN equation					S equation			KEY	Q= Runoff in m^3							
Nyeri Prison		$Q = \frac{(P-0.2S)^2}{(P+0.8S)} * \frac{A}{1000}$					$S = \frac{25400}{CN} - 254$				P = daily rainfall in mm							
Rainfall station	9036223																	
	Year	1970	1971	1972	1973	1974	1979	1980	1981	1985	1986	1987	1988	1989	1990	2009	2010	
	Day																site	
1-Jan	1	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	
2-Jan	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3-Jan	3	0	0	0	0	0	0	0	0	0	0	0	0	0	606	0	0	
4-Jan	4	0	0	0	0	0	0	0	0	0	0	0	0	0	606	0	0	
30-Apr	120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6063	
1-May	121	2026	0	0	0	0	0	0	0	30	5186	0	0	1694	0	0	4391	
2-May	122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
30-Dec	364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
31-Dec	365	0	0	0	0	0	0	0	0	0	0	0	0	22994	0	0	0	
1-Jan	366	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Annual runoff in m^3		13271	0	5276	1864	5177	35514	17477	93978	39950	65772	10397	40686	98247	37742	14300	28849	

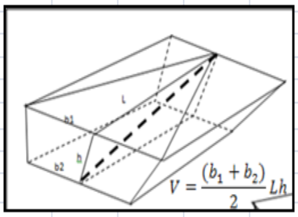
Figure 2:Worksheet2 for modeling runoff from rainfall in worksheet1

When rainfall was measured on site, there were simultaneous measurements of reservoir depth which resulted in runoff volume as shown in Figure3 by applying geometric formulae for each day and a summation at the end of each day. There were four retaining walls upstream of the main reservoir whose geometric shape was adopted as triangular and the main reservoir was taken to be trapezoidal as in Figure3. Sum of the harvested runoff constituted the physical total runoff for each day. The physical total runoff residing in the reservoir according to Figure3 on May2, 2010 compared well with the estimated annual sum of runoff for 2010 in Figure2.



DAM DIMENSIONS

Dam	Top level	b	h	L
Dam5	1,745	54	6	61.2
Dam4	1,745	8	2.15	52.74
Dam3	1,746	15	1.15	15.32
Dam2	1,750	31	3.15	78.18
Dam1	1,752	17	3	79

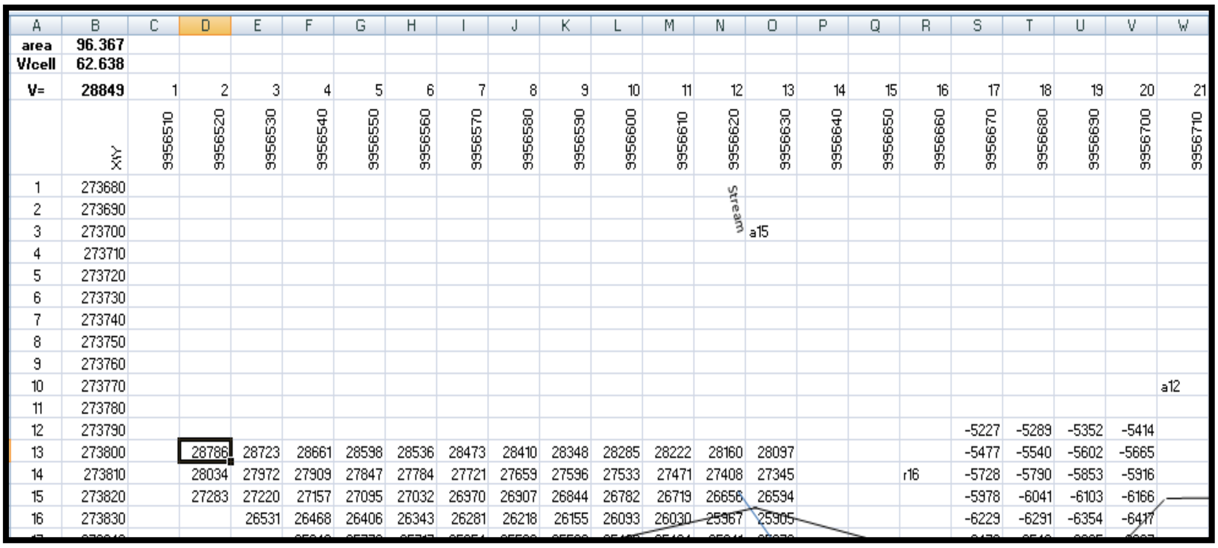


fall measurements		kabiruini	Nyeri prison	depth of water measurement in the dams					Volume of water in the dam					physical	Rise in	Fall in
Date	Rain gauge	Rainfall mm	No 9036223	Dam1 m	dam2 m	dam3 m	dam4 m	dam5 m	dam1 m^3	dam2 m^3	dam3 m^3	dam4 m^3	dam5 m^3	Total m^3	Vol. m^3	Vol. m^3
30-Apr-10	1400	42		282.5	330.5	100.0	57.0	406	1,682	2,694	75	14	22340	26,805	22340	0
1-May-10	1269	38		282.5	330.5	100.0	57.0	426	1,682	2,694	75	14	23001	27,465	661	0
2-May-10	0	0		282.5	330.5	100.0	57.0	459	1,682	2,694	75	14	24092	28,556	1091	0
3-May-10	0	0		282.5	326.5	100.0	57.0	450	1,682	2,597	75	14	23795	28,162	0	-394
4-May-10	0	0		282.5	323.5	100.0	57.0	445	1,682	2,526	75	14	23629	27,926	0	-236
5-May-10	0	0		282.5	321.5	100.0	57.0	438	1,682	2,479	75	14	23398	27,648	0	-278
6-May-10	0	0		282.5	320	100.0	57.0	435	1,682	2,445	75	14	23299	27,514	0	-134
7-May-10	0	0		282.5	319	100.0	57.0	433	1,682	2,422	75	14	23216	27,409	0	-105

Figure 3:Worksheet3 for entry of actual depth of water in the reservoir and modeling actual runoff harvested

Having estimated runoff potential, it was automatically transferred to Figure4 as V=28643 in the cell which began distributing runoff to other cells or subplots. A water requirement for each cell per season displayed as V=62.638m^3 and the area of each cell was 96.367m^2. Some cells enclosed within the confines of the XY coordinates were modeled to abstract their crop water requirement from what was left by the neighboring cell. Each cell then displayed the balance of water after it had abstracted its own requirement which formed the basis for a corresponding cell in Figure5 to decide whether it was potential for the next season or not. That decision was made subject to a residual storage of 3000m^3 left in the reservoir for environmental sustenance of aquatic life.

In Figure5, those cells which were potential for irrigation because they had a water balance greater than 3000m^3, were labeled with “irr” while those that were below the threshold remained blank. Those cells labeled “irr” in Figure5 were therefore the potential areas for irrigation on the first season of 2011. All the other areas which were blank failed the test of being potential for irrigation on that season but depending on the recording of rainfall after that first season, they could become potential. Therefore farmers and agricultural extension officers required to check Figure5 before the season end in order to decide which subplots were potential at the beginning of the next season and how much land was involved. For season one of 2011, 11 acres or 4 hectares were involved.



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
area	96.367																					
V/cell	62.638																					
V=	28849	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	X\Y	9956510	9956520	9956530	9956540	9956550	9956560	9956570	9956580	9956590	9956600	9956610	9956620	9956630	9956640	9956650	9956660	9956670	9956680	9956690	9956700	9956710
1	273680																					
2	273690																					
3	273700												Stream	a15								
4	273710																					
5	273720																					
6	273730																					
7	273740																					
8	273750																					
9	273760																					
10	273770																					a12
11	273780																					
12	273790																	-5227	-5289	-5352	-5414	
13	273800		28786	28723	28661	28598	28536	28473	28410	28348	28285	28222	28160	28097				-5477	-5540	-5602	-5665	
14	273810		28034	27972	27909	27847	27784	27721	27659	27596	27533	27471	27408	27345			r16	-5728	-5790	-5853	-5916	
15	273820		27283	27220	27157	27095	27032	26970	26907	26844	26782	26719	26656	26594				-5978	-6041	-6103	-6166	
16	273830			26531	26468	26406	26343	26281	26218	26155	26093	26030	25967	25905				-6229	-6291	-6354	-6417	

Figure 4:Worksheet4 for modeling the abstraction of irrigation water by each cell representing a subplot

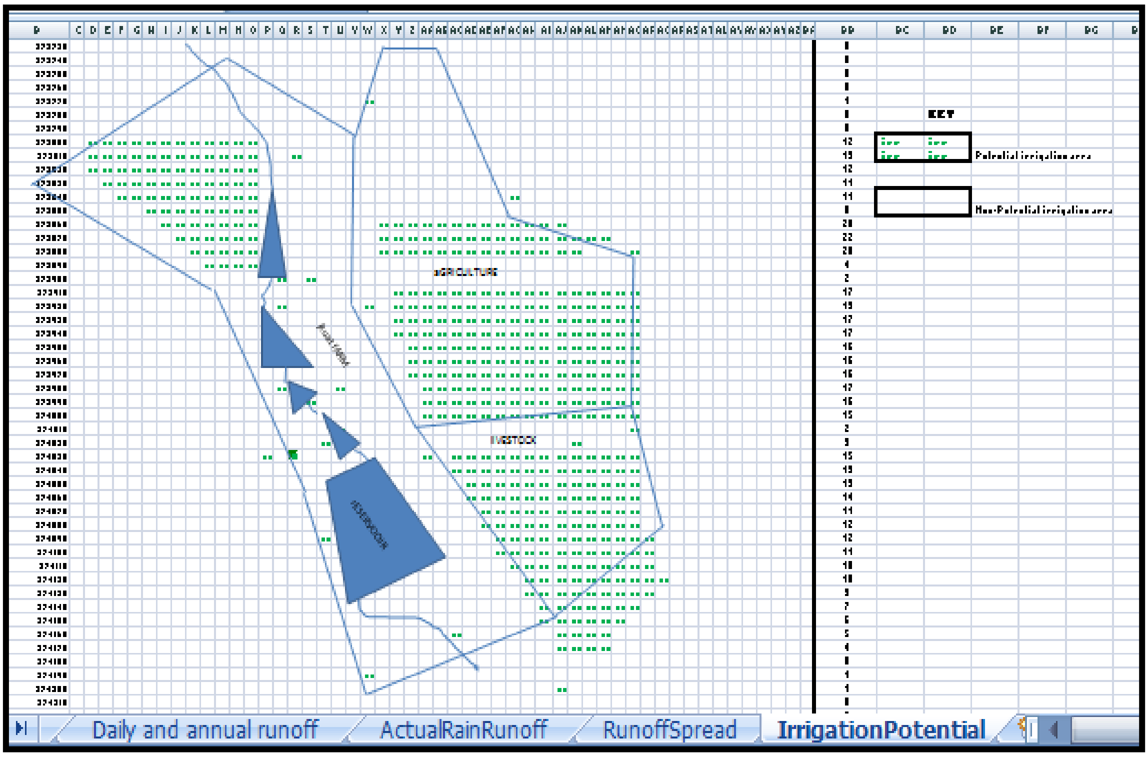


Figure 5:Worksheet5 for modeling the visualization of irrigation potential per cell

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4. DISCUSSION

The key reason of this model being used was that the software used was commonplace and that it offered visualization without having to migrate to other software. Microsoft excel has been used in Eastern Nile Irrigation ToolKit (ENTRO, 2014) for design and other cost analysis but not for spatial visualization which was the concern of the ordinary farmer. Farmer interest was which areas of their farms considered here as subplots required preparation for irrigated agriculture the following season and this was achieved in Figure5. The technical data was also modeled in the same software and this was also achieved in Figures1 to 5. The models were the same used by different technical data collectors and analyzers except that here they were allowed to flow in a coherent sequence till the farmer had no calculations to do except visualize the irrigation potential areas.

5. CONCLUSIONS AND RECOMMENDATION

4.1 SUMMARY:

A model relates different types of data or phenomena in order to show an outcome. Rainfall, runoff, reservoir storage and irrigation space were related to one another until an outcome in form of an irrigation potential map became visible. The graphic visualization was taken to be faster to interpret by the farmer than tables of irrigation potential area because as the saying goes "a picture is worth a thousand words" (wikipedia, 2014)

4.1 CONCLUSION:

The aim of the research was achieved and it was possible to model the irrigation potential from rainfall, runoff, storage and distribution of irrigation water onto a visible space in Microsoft excel in real-time. Real time status was achieved by having changes occur on the irrigation potential map each day rainfall was recorded in a year.

4.3 RECOMMENDATION:

Since it is possible to model and visualize irrigation potential in Microsoft excel, then it was recommended that relevant stakeholders agree to implement it.

Since the e-Government implementation is going on in Kenya, then water reservoirs and their irrigation potential should be mapped in real –time.

REFERENCES

[1] ENTRO, 2014. Irrigation Toolkit Fact sheet 1. [Online] Available at: nilebasin.org/index./nile./2./21-eastern-nile-technical-regional-office [Accessed 8 August 2014].

[2] Fried, B., n.d. [Online] Available at: Invent.answers.com/technology/a-short-history-of-spreadsheet-software [Accessed 9 August 2014].

[3] garbo7441, 2009. [Online] Available at: https://answers.yahoo.com/question/?qid=2009409195933AAUubEk [Accessed 8 August 2014].

[4] Hatcho, N. & Kay, M., 1992. Small Scale Pumped Irrigation: Energy and Cost In: Irrigation Water Management Training Manual. [Online] (Provisional edition) [Accessed 6 August 2014].

[5] Kenya, R.o., 2007. SESSIONAL PAPER ON IRRIGATION AND DRAINAGE. Nairobi: Government Printer Ministry of Water and Irrigation.

[6] Kweyu, 2014. It's time weathermen spoke the language of farmers. [Online] Nation Media Available at: www.nation.co.ke/business/seedsofgold/time-weathermen-spoke-language-farmers-/-/2301238/2348578/-/98hdkd/-/index.html [Accessed 9 August 2014].

[7] Murrell, P., n.d. [Online] University of Aukland Available at: https://www.stat.auckland.ac.nz/-paul/ItDT/HTML/node40.html [Accessed 9 August 2014].

[8] Wikipedia, 2014. A Picture is worth a thousand words. [Online] Available at: en.wikipedia.org/wiki/A-picture-is-worth-a-thousand-words [Accessed 6 August 2014].