Water Availability, Reliability and Affordability Among Rainfed Agriculturists of Rawashda Village in Eastern Sudan

Alredaisy[1], Samir M.A; Johayna[1], Abdulmahmoud A.; Gumaa[1], Ibrahim A.; Wadi[1], Tayeb I.; Zubair[1], Mohamed H.A.; and, Hag Ali[1], M.A.

[1]University of Khartoum, Department of Geography, Faculty of Education, Omdurman, Sudan

ABSTRACT

The objective of the study was to investigate the mechanized rainfed agricultural system in Eastern Sudan with specific focus on the Rawashda village and its environs. Water availability, reliability and affordability were assessed involving survey methods and the calculations of the mean; the standard deviation and regression. The survey was conducted during February 2009 with a sample size of 50 households representing 30% of total households chosen according to accessibility; agricultural activities involving rainfed water were studied by observations and by interviewing the farmers. Results depict that although 80% of the population has access to piped water; it was inadequate and unreliable because of physical barriers, growing populations and the substantially higher charges. Water consumption showed no tendency to be less when paying a higher price for it, or when their income was below average. Daily consumption of an individual of water of 25.9 liters is far below the recommended level by the World Health Organisation (WHO) for an individual to remain healthy. The average monthly income is 311.5 SDG which equals US$124.6 and divided by household size is equivalent of US$4.2 per day per capita which is tangible to the poverty line. Monthly expenditure for water was found to be 13.7% of the total household monthly income. Regression analysis confirmed that expenditure for water increases with marginal increase in income. Investment into mechanized agriculture did not secure drinking water for rural poor and a determination of short-term management actions and long-term strategies to improve water is proposed.

Keywords: Water; Irrigation; Agriculture; low income; drought; expenditure; climatic change, Sudan.

INTRODUCTION

Safe water is important for human health and well-being. Less than 1% of the world's fresh water is accessible for direct human uses and is available on a sustainable basis (Postel, 1996; and, Gleick, 2000). Some 1.1 billion people in developing countries have inadequate access to water (United Nations Human Development Report, 2006). "Inadequate" is defined as a single water tap shared among hundreds of people (Water encyclopedia, 2010). Demand for freshwater is increasing by 64 billion cubic meters (1 cubic meter = 1,000 liters) per year (Worldometers, 2009). Some of the poorest nations in the world bear the burden of being located in the driest parts of the planet. Even if these countries were able to develop the infrastructure and capacity to manage water supply and demand, they have little to work with. This is especially true in the arid regions of North and Sub-Saharan Africa and the Middle East where much of the world’s anticipated population growth will occur (Water, 2009). Much of the world is faced with a situation where water supplies for various uses are over allocated, with river flows much reduced, groundwater levels dropping, and important ecosystems threatened-a situation of physical water scarcity. Much of this is driven by agricultural water use. In other parts of the world, availability of water in rivers, wetlands, and aquifers is ample, but access is difficult because people have not found means to develop the water resource - a situation of economic water scarcity (IWMI, 2010).

Water resource problems in the developing countries present special management challenges. They include inadequate drinking-water supply and sanitation facilities, water pollution, floods, the siltation of river systems, and the management of rivers and large dams. Barriers to addressing water problems in the developing nations include poverty, illiteracy, rapid population growth, and ineffective institutions and policies for developing, distributing, pricing, and conserving water resources.

Water availability is a matter of quantity, quality and use. Water availability and access are key constraints to poverty reduction and food security.Three significant factors impact negatively on the local availability of freshwater including climate change, growing populations and modern lifestyles which promote activities such as high meat consumption that result in the use of large amounts of freshwater (Our World, 2010). Water resources are inextricably linked with climate, so the prospect of global climate change has serious implications for water resources and regional development (UNECA, 2000).A rise in global temperature of 4^0C would have a substantial effect on river flows and the availability of water resources (Arnell,2006). Changes in temperature, precipitation patterns and snowmelt can have impacts on water availability (IPCC, 2007). The possibility of supplying much water depends primarily on the availability of the water at its source. Availability may vary a lot over the year, or even between one year and another, on the capacity of the facility installed to withdraw the water from the water source (FAO, 2010). Water affordability and costs need to be considered together with price and subsidy. Underlying this is the premise that issues of developing communities cannot be addressed in isolation from developed communities, while at the same time recognizing that this must take place within the limitations of the country's resources (Peter, 2006). The main objectives of this paper are to:

- Measure water consumptions levels in the study area in order to compare per capita consumption of water with the world recommended levels for a person to remain healthy
- Reveal the gap between households' monthly income and expenditure on water as a reflection of the general poverty in the country.
- Discuss problems of rural water supply in an area of mechanized rainfed agriculture in Sudan which was considered to be water secured.
- Discuss problems of water supply in the study area as partially due to physical impediments and climatic change.
- Formulate at hand strategy for the promotion of water supply in rural Sudan with emphasis to the study area.

MATERIALS AND MTHODS

Rawashda village belongs to Gedaref State at 34-36^0 E. It is bordered by Kassala State in the north and Sinar State in the south, the Ethiopian borders in the east and the States of Gizira and Khartoum in the west and northwest respectively (figure 1). Its history is prior to the introduction of mechanized crop production schemes (MCPS) into Gedaref area following Second World War. It is positioned on the right side of Port Sudan- Khartoum highway apart by 30 km. east from Gedaref town.

The fieldwork survey was conducted during February 2009. The morphology of the village is of longitudinal extension east –west in accordance with Port Sudan – Khartoum highway. Streets and houses are irregular and lacking numbering. House are mainly built of straw and mud with isolated rooms scattered in the house yard. Therefore it was difficult to apply random sampling for choice of the respondents. The sample size of 50 households representing 30% of total households in the village, chosen according to accessibility and were studied by observation and interviewing. Respondents were mainly the heads of the households who were males and females, while the other relevant information, except that of the questionnaire, is collected by direct interviewing with agers.

Data is treated statistically to calculate household daily mean water consumption and household monthly income by classes, mean and standard deviation. Also, household monthly expenditure on water and its mean, standard deviation and the regression of expenditure on water on household monthly income are calculated.

RESULTS AND DISCUSSIONS

1. RESULTS

The results illustrate water availability, accessibility and affordability by the study area's population and the interrelated determining factors.

(a) Water availability

Gedaref area is a plain surface with an area of 263,75 km^2 and mainly intermitted by dispersed hills covered with alluvium. General topography of Gedaref state is divided into three major units. Firstly, highlands and isolated mountains in the southeast. Secondly, plain area dominating the state and characterized by clayey soil (45-80% clay particles) either flat or slow sloped. Thirdly, Wadis (valleys) area including depositional areas around seasonal rivers such as Atbara and Rahad (see Fig. 1). The Gedaref area- a wide flat grassy plain deep fertile soil- was chosen for the mechanized crop production schemes as it had a long tradition of Dura (sorghum) production. It was just estimated after the Second World war that of the 100000 tons of Dura marketed annually in the Sudan, 30000 tons came from the Gedaref area (Jefferson, 1949). Many parts of this grassy area were normally uncultivated because of the shortage of drinking water during the dry season, and it was anticipated that mechanization of production would solve this difficult problem by reducing the labor force required in Dura production. Most of the Gedaref area is underlain by either Basement Complex of Tertiary Basalts both of which provide little water except in the detrital material around the occasional hills and small supplies to be found along joints in the rock (Davies, 1964).

Tribes living in the area are Shukria, Habania, Bawarda, Lhwien and Kenana as well as migrants from Darfur and west Africa. Population is distributed within five Nizara (Traditional Administration) including Shukria, Dar Bakr, Gala' el Nahal, Dabania and Bani A'amir. In 1983 population was 746,714 and reached 1,148,462 in 1993 with annual growth rate of 3.7% which exceeds 2.8% for whole Sudan, due to migrations seeking agricultural Work, seasonal migration, natural increase and refugees inflowing from Ethiopia and Eritrea. There is a decrease in nomads from 3.7 % in 1983 to 1.3% in 1993 while urban population increased from 22.7% in 1983 to 25% in 1993. Rural population was almost stable (73.6% in 1983 to 73.7 in 1993). Either the nomads became urban or rural became urban and the replace by nomads (Davies,1988).

El Showak water pump station was established on the seasonal River Atbara, 80 km. eastwards from Gedaref town. It produces 15500m^3/day for Gedaref town (Water Authority-Gedaref, 2009) and supplies 80% of Rawashda population by drinking water (fieldwork,2009). River Atbara discharges from Ethiopian highlands flowing westwards into Sudan and during the rainy season rises up to 18 feet (5 m) over normal level. Demand for water is imperatively insisting in such harsh environment of the study area and very few rivers are flowing in the area restricting to eastern borders of the region. In addition some others households collect water by family members (12%) from wells or wadis while some others got water by vendors (8%). Studies done in Gedaref State showed that 25% of the state population get water from water stations, 17% from Hafirs (surface reservoirs dug out of cracking clays), 20% from surface wells, 6% from rivers and Wadis and 23% from other sources (Water Authority-Gedaref, 2009).

Basement complex prohibits well digging. Basement complex rocks of low porosity and permeability which allow little or no water to penetrate downwards except along temporary water streams where the upper part of the basement complex is weathered for few meters and is therefore porous (Farouk et al, 1982). The underground supplies are not only small, but those at depth are extremely hard whilst the shallower ones are saline.

Most of these water sources are temporal and linking with the rainy season where rainfall range is 300-900m/year. Gedaref state has two distinctive climatic belts. The first one is semi arid climate found in the north and northwest and characterized by summer seasonal rains during July-October. The second one is a wet climate found in the eastern and southern parts of the state with average rainfall of 500-900 mm/ year and maximum mean temperature of 47 ^{0}C. High annual rain variability (ca.35%) and the very high evaporation rate, ca. 3mm per day in the dry season (Farouk et al, 1982). Rainfall in some major stations during 1994 recorded 777mm. in Gedaref, 669.5mm. in Wd el Houri and 616 mm. in Gedambalia while it was 600mm in Hawata (Meteorology Office-

Gedaref,1994). According to Hulme (1990) rainfall depletion has been most severe in semi-arid central Sudan where between 1921-50 and 1956-85 annual rainfall has declined by 15 per cent, the length of the wet season has contracted by three weeks, and rainfall zones have migrated southwards by between 50 km and 100 km. This depletion has been due more to a reduction in the frequency of rain events rather than to a reduced rainfall yield per rain event. Ayoub (1999) compared long-term rainfall in four sub regions in Sudan and showed that rainfall decline had been in the magnitude of 30-40 per cent. The western parts of the Sudan (Kordofan and Darfur) experienced extreme rainfall anomalies than the eastern and central parts (Gedaref and Damazin), and had suffered greater periods of desiccation than the eastern and central parts. The decadal rainfall means showed below average rainfall for the last three decades in all these sub regions. Hulme et al (1989): assessed the role of an upper troposphere synoptic feature of importance in modulating surface rainfall over Sudan in the eastern Sahel: the Tropical easterly Jet (TEJ). The TEJ provides an example of an inter-regional circulation feature linking the Sahelian and southeast Asian monsoons and ultimately, perhaps, forced by ENSO-related anomalies.

The Gedaref state since being mainly producing Dura and animal keeping, water resources are continuously under pressure between both which impact on water availability for population. The total number of animals amounted 1630000 head in the year 2001 (Veterinary Authority-Gedaref,2009) and predicted to increase successively. This is simultaneously matched with increasing crop area which increased dramatically. According to Hugh (1996), the average daily requirement of water for an animal unit (AU) will range between 8-15 gallons per day depending on physiological and environmental conditions. Dura cultivation was successfully introduced since 1943 where In 1945/46 season 12000 feddans (1 feddan=1.038 acres) were cultivated. The total harvested area increased steadily from about 4·5 million ha in 1961 to about 14 million ha in 1996, with great year-to-year variations of harvested areas, and therefore total yields, revealing a fragile balance between production and need (Ministry of Agriculture-Gedaref, files for 1995). Irrational water use dissipated 30% during water distribution, while 20-25% is dissipated into agricultural practices where a traditional farmer over floods his field to secure water for plant growing. According to Davies (1964) two factors have made the problem of water serious in the Gedaref area. First of all it was confidently expected that searching would reveal a certain amount of suitable groundwater, but it has not; and secondly the hopes of complete mechanization of agriculture have not yet materialized. At present hand labor is still required for some of weeding and almost all of harvesting, so that in the Gedaref area water is still required for more people than was formely anticipated especially at the height of the dry season.

(b) **Water reliability**

In the year 2000, only 67% of Sudan's population have access to safe drinking water (NationMaster,2010). People of Rawashda village varies considerably in daily water consumption (table 1). The majority (50%) consumes 50-69 gallons per day which equals 200- 276 liters. The other half of the population has a segment of 18% who consumes as less as 80-116 liters/day. The average water consumption per household is 49.0 gallon= 196 liters. The big difference between the values of the mean and the standard deviation (361.6 liters) depicts big variation in amount of water consumed within households (table 1).

Some people use water for human purposes only (36%), or for human and animal purposes (30%), while some others use water for human and tree watering (10%) or for all purposes collectively (24%). Utensils used for water handling are either Jerri Cana (44%), Barrel (18%), tin (26%). The most significant factors affecting the consumption are the number of occupants in the household influences the per capita consumption but at a decreasing rate. Calculation of share of an individual of water from the total amount consumed by a household with average size of 7.6 persons gives 25.9 liter/ individual. This daily consumption of an individual of water of 25.9 liters is far below than the recommended level by WHO (1983) for an individual to remain healthy, as it stipulated 40-50 liters (0.04 - 0.05 m^3) per day per person is adequate. 80% of the interviewers confirmed water as tasty and some others (10%) denied.

Table (1): Household daily water consumption in British gallon (1 gallon=4 liters)

classes (amount in gallon)	freq. (f)	class interval(C)	C x f	deviat. from a proposed class interval (H)	H x f	Hf^2	$\bar{x}=\sum$ C x f / $\sum$f ; $\bar{x}$ = 2354/47 = 49.0 gallon= 196 liters/
20-29 (18%)	9	24.5	220.5	-10.0	-90.0	8,100	household size=
30-39 (10%)	5	34.5	172.5	0.0	0.0	0.0	196 liters /7.58=
40-49 (16%)	8	44.5	356	10	80	6,400	25.9 liter/
50-59 (10%)	5	54.5	272.5	20	100	10,000	individual
60-69 (40%)	20	64.5	1,290	30	600	360,000	SD=90.4 gallon
							(361.6 liters)
	47		2,311	50		384,500	

Source: Fieldwork, 2009. 1 tin=4 British gallons; 1 gallon = 4 liters; 1 tin = 16 liters

Concerning continuous supply of water for whole of the year, however, 96% of respondents denied that. 96% confirm water cut during summer season. Field survey revealed that population passed by continuous 40 days water cut and price of a tin of water (4 gallons) reached 1US Dollar. Piped water supply continued for 3 hours per day. Vendors sell a barrel of water by 3 SDG in normal times and by 4-5 SDG during crisis which is healthy suspected.

During summer season or in case of water shortages due to breakdown of facilities, water prices increase by 150% while household consumption drastically decreases to 54% of the normal consumption. Some people might use terraces to raise water level in Atbara and Rahad rivers to collect as much water as they can. They also might use Gamam (flowing subsurface water), Wadis, underground wells which their salinity might reach as high as 70% or Hafirs (water reservoirs) which are used jointly with animals. The high consumption during summer is due to the high temperature. The reduction in water consumption might be during autumn. Houses in Rawashda are built of mud and straw, which also create high water demand similar to animals kept by households.

(c) **Water affordability**

Household size ranges between 2-12 persons; 12% of the households have 2-4 persons, 34% with 5-7 while 38% have 8-10 and still the last category has more than 10 persons. Only 12% could be considered as small households while the remaining 88% are big households. The calculated average household size was 7.6 heads. This demographic characteristic was expected since it is being shared all over the Sudan where growing population is prominent. Davies (1988) indicated that percentage of population increase between 1955-1983 in Gedaref state was over 150% due to increased use of rain land for mechanized agriculture and an increase in the availability of water supplies for stock in the Butana through drilled boreholes and excavated *hafirs*. Also settlement of the nomads, influx of refugees from Eritrea and Ethiopia into rural areas near the frontiers and into such tows as Kassala and Gedaref.

From table (2), few households could be considered as having somehow high monthly income (10%). Even those who are somehow better off households, if weighted by the recommended income for life needs; they could be classified as poor. The 1000 SDG monthly income they earn equals only 400 USD per month (13.3 USD /day or 33 SDG). It is far lacking the daily life needs in Sudan. In many areas of Sudan, such big households as those in Rawashda spend nearly 6 SDG to buy bread only, while the remaining 27 SDG should be allocated for buying other food items, transportation, education, medical curing, clothing, etc. So, it is misleading to consider such households as better off as it might seem by huge figures. Monthly household income in Rawashda concentrated mostly into low income group of 100-299 SDG by 68%, followed respectively by income groups of 300-499 SDG, 700-900 and lastly 500-699 SDG (table 2).

Table (2): Household monthly income by classes and calculations of the mean and the standard deviation in Rawashda village

classes (Sudanese Gene SDG)	freq. (f)	class intervals(C)	C x f	deviation from proposed class interval (H)	H x f	Hf^2	$\bar{x}$= 311.5 SDG SD= 1,000 SDG
100-299(68%) 300-499(18%) 500-699(4%) 700-999 (10%)	34 9 2 5	199.5 399.5 599.5 799.5	6,783 3,595.5 1,199 3,997.5	-200 0.0 200 400	6,800 0.0 400 2000	46,240,000 00.00 160,000 4,000,000	
	50		15,575	400	4,400	50,400,000	

Source: Fieldwork,2009.

Average monthly income is 311.5 SDG which equal only 124.6 USD or 4.2 USD per day per capita (as being divide by the household size of 7.6) which is tangible to the poverty line. The difference between the values of the mean and the standard deviation is triple, indicating to wide difference on monthly income within households (table 2). So, the daily income of 4.2 USD per day per capita is unevenly distributed within the population, closely indicating to weak affordability for expenditure on water purchase and life amenities. This big average household size was opposite for low income and high monthly expenditure of 42.7 SDG per household for water.

According to the fieldwork results (table 3), 60% of Rawashda village population pays 30-39 SDG/ month for water while 68% of them earn between 100-299 SDG. This means that, if we supposed that the head of a household who earns 100 SDG would pay 30 SDG which will constitute 1/3 of his monthly income while his offset who earns 300 SDG would pay 40 SDG and would actually devote 13.3% of his income to buy water. This is in situations where 22% of heads of households are illiterate and 46% of them did not exceed basic school. Moreover, 36% of heads of households are young as lying between 20-40 years old while 60% of them are above 40 years old. All of which might have future demographic implications. The majority (72%) of the head of the households are rain fed farmers. The other remaining heads of households are distributed narrowly within traders (8%), government employee (10%) and free workers (10%). Generally 87% of el Gedaref area's population is engaged in agriculture where Dura, sesame, Arabic gum and cotton are the major produce (Information Center, Gedaref state, 2009).

Table (3): Household monthly expenditure on water (SDG) and calculations of the mean and the standard deviation in Rawashda village

classes in SDG	freq. (f)	class intervals(C)	C x f	deviat. from proposed class interval (H)	H x f	Hf^2	$\bar{x}$= 42.7 SDG Sd= 59.5 SDG
30-39 (60%) 40-49 (14%) 50-59 (10%) 60-69 (16%)	30 7 5 8	34.5 44.5 54.5 64.5	1,035 311.5 272.5 516	-10.0 00.00 10.0 20.0	100.0 00.00 100.0 400.0	10,000 00.00 10000 160,000	
	50		2,135		400	180,000	

Source: Fieldwork,2009.

The average household monthly expenditure for water by 42.7 SDG (table 3) constituted 13.7% of the total household monthly income in Rawashda. Division of monthly income by household size gives 41.0 SDG for each household member. This means that in every household a share of one member income should be sacrificed for water purchase only. These poorest households devote the greatest percentage of their income to the purchase of water, although the only major item in their household budget which can be sacrificed to make this possible is food. This will of course, reduce the share of a member in a household in the total budget devoted to buy other life needs. This is similar to what had been found in Meiyo and Karton Kassala, which are both squatter areas in Greater Khartoum. 17% in Meiyo and 56% in Karton Kassala of total household income was spent for water purchase (Sandy et al, 1992) as it was the more striking in view of the high proportion of income that was spent on water.

Regression analysis (table 4), correlating between income as independent variable and expenditure for water as dependent variable, gives 0.14 for (a) and -.9 for (b) values in the regression equation. They were used to predict expenditure on water with changing income of household. When the income was 100- SDG expenditure on water would be 31.1 SDG and when income was 300- SDG expenditure on water would be 41.1 SDG. Expenditure of water increases with increasing income. This happens although price has a significant impact on demand and water utility authorities can use price as a tool to ration or discourage water consumption in the piped connection households (Khadam,1988). Sandy et al (1992) studied squatter areas of Meiyo and Karton Kassala in Greater Khartoum and found similar situation to that in Rawashda village. In spite of the substantially higher charges, water consumption in Karton Kassala was as high as that in Meiyo. Households within these communities showed no tendency to use less water when paying a higher price for it, or when their income was below average. There was no price elasticity or income elasticity was detectable.

Table (4): Regression of expenditure on water (y) on household monthly income (x) in Rawashda village

x	y	x^2	y^2	xy	Calculations
100- 300- 500- 700-	30- 40- 50- 60-	10,000 90,000 250,000 490,000	900 1,600 2,500 3,600	3,000 12,000 25,000 42,000	$a = 1/n \sum xy - x^{-} y^{-} / Sd^2 x$ (which equals $\sum x^2 /n- (x^{-})^2$ $= 1/4 \times 82000 – 311.5 \times 42.7 / 840000/4- (311.5)^2$ $= 82000/4 - 311.5 \times 42.7 / 840000/4- (311.5)^2$ 20,500 - 4,846.45 / 210,000 - 97,032.25 = 15,653.5/112,967.75= 0.14
$\sum x$ = 1600 x^{-} =311.5 SD= 1,000	$\sum y$ = 180 y^{-}= 42.7 SD=5 9.5	$\sum x^2$ = 840,000	$\sum y^2$= 8,600	$\sum xy$= 82,000	$b = y^{-} - a x^{-} = 42.7 – 0.14x 311.5 = 42.7 - 43.61= -0.9$ then regression line of expenditure on income is: y= a x + b = .14 x + - .9 if we take the first two corresponding values of x to y in the table as follows: y=ax-b first value: .14x 100+ - 0.9= 13.1 second value: .14 X 300 + - 0.9= 41.1

CONCLUSION AND RECOMMENDATIONS

Mechanized rainfed agriculture was mainly introduced in Gedaref area for Dura production and in situ rural development. The rural community of Rawashda village is expected to have substantial base for rural and community development, among which is adequate and affordable water supply. However, fluctuating rainfall, Basement Complex structure, seasonality of Atbara River could be accepted as physical barriers for adequate water supply in the Gedaref. But, mismanagement of at hand water resources is not an excuse. The high expenditure on water in situations of low income, big households and spreading illiteracy has many consequences. One consequence is that a low-income household's consumer surplus for water is very high, amounting to a substantial proportion of its total income. This has important consequences for the economic appraisal of rural water supply. With regard to affordability, households are unable to pay for water at the current cost. High proportion would be unable to pay the actual costs of water. The revenue that may realistically be expected to be recovered from these households in the future lies somewhere between what they are able to pay and what they are presently willing to pay. Another consequence is the lack of elasticity and repercussions on expenditure for food, education, health, etc, would imperatively be retarded. In Rawashda village 96% of the population indicated to the complete absence of health guidance and the role of NGOs (98%) on community awareness in situation of water unreliable supply. The high price of water in urban Sudan is probably a major cause of the malnutrition prevalent in the squatter areas (Sandy et al, 1992).

The inadequate water supply and high expenditure on water in situations of low income, big households, high risk of failure of agriculture and spreading of illiteracy have many consequences. One consequence is that inadequate water supply is, of course, cause water related diseases. For example, in el Galabat el Shargia locality which lies southeast of the study area, mortality among infected patients with water diarrhea was 20% in the year 2006 (Ministry of Health-Gedaref, 2007) and access to in-yard water sources improved child health in China, only when mothers were relatively well educated (Mangyo, 2008).

Inadequacy, unreliability and unaffordability of water supply are closely linked with problems of rural development in Sudan. Condominium and post-independence governments believed that the future of Sudan economy lies in irrigated commercial agriculture and has failed to provide any development strategy for the traditional peasant sector which holds the majority of Sudan's population. But this does not deny for some efforts, such as improvement of the rainfed sector apart from private mechanized agriculture, development of Jebel Mara and the production of short – stapled cotton in the rain fed sector, settlements of the nomads and recommendation of the project of Desertification and Drought Relief for digging boreholes. But in our study area, however, the first start of privatization of agricultural production in the Gedaref may be on the expense of the rural poor who mainly produces for landlords. Generally, landlords do not care for community development and even more they manage their business through clients whom they mostly work thoroughly for surveillance other than caring for poor agriculturalist.

Determinations of short-term management actions and long-term strategies to improve water are essential for Rawashda village and other similar geographic settings in Sudan (figure 2). The short-term management actions mostly work to utilize physical properties of the area. Since most of the Gedaref area is underlain by either Basement Complex of Tertiary Basalts both of which provide little water except in the detrital material around the occasional hills and small supplies to be found along joints in the rock (Davies, 1964), such physical property can be utilized in our suggestions for short term management. Sustainable small scale treatment systems which are suitable for developing countries and remote areas including Ceramic pot filters , slow sand filters, solar disinfection etc.(Bas Heijman ,2010) are effective and non expensive for short term management of water resources. Such management requires timely and accurate information about the current and future state of the water resource. Aspects of rainfall information availability in the light of historical archived data, automatic, near real-time rainfall monitoring, and both seasonal and decadal rainfall forecasting are necessary. The measurement and monitoring of rainfall are to be used in the climate management process (figure 2).

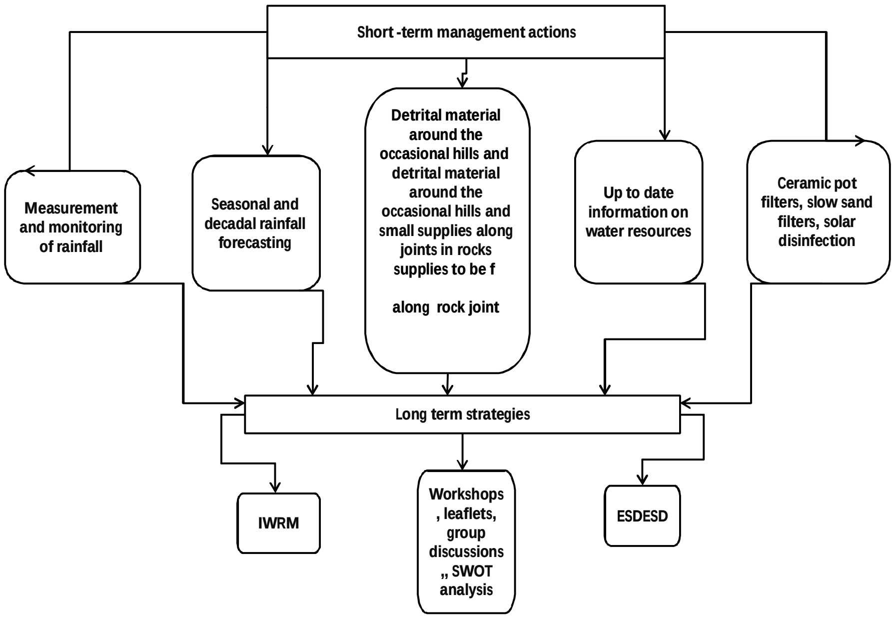

Figure (2): Short-term management actions and long-term strategies to improve water in Rawashda village, Gedarief state, eastern Sudan

However, long-term strategies to improve water work towards Integrated Water Resources Management (IWRM) where community education for sustainable development (ESD) is essential. The experience of el Helba area, a rainfed agriculturalists community in the western White Nile state might be beneficial for Rawashda village and elsewhere (Alredaisy et al, 2009). Community education as part of Education for sustainable Development "ESD' was taken as a tool for water resources sustainable development in el Helba area. Stakeholders are the ever socially active persons in the community.

The root society was motivated to collect and use water rationally. Methodology for implementing ESD targeted Stakeholders who are middle leaders in the area, including executive committee of local non-governmental organization, local leaders including religious and tribal leaders, local Public committee and official Officers and teachers. Awareness creation is a step towards drawing attention and building capacities of the stakeholders to deal with the challenges of water resources, and to ensure local sustainable development in the change project area. Stakeholders were traced by participants to see how far the project is going on. They have contacted basic schools students and enhance youth clubs during and after rainy season to aware local population about proper water use.

The plan for creating awareness towards water supply in el Helba area included nomination of the stakeholders and communication and networking. Plan of Activities included workshops, leaflets, group Discussions and SWOT Analysis. The SWOT Analysis is a method applied to introduce a proper method of creating awareness among the community in particular and, developing the water supply in the project area in general. For building local awareness among the local leaders, the change project held lectures on concept of Sustainable Development (SD), concept of integrated water resources management (IWRM).

The experience of el Helba area was proved to be successful and applicability in Rawashda village is possible to secure water for local community through community participation which became a core issue in rural development thought.

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