Survey of Indigenous Water Management and Coping Mechanisms in Africa: Implications for Knowledge and Technology Policy

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1. Introduction

Water is the most fundamental and indispensable of natural resources and is an element of life and human quality of life. Water constitutes about 70% of the human body, by weight and several body functions depend on this resource. It is no wonder then that much of the history of mankind is caught up in the struggle for and use of water. Not only does every living thing require water to sustain life, it is man's efforts to improve his quality of life (Olokesusi, 1987; 1990).

In addition to rainfall and huge groundwater resources, Africa is blessed with both freshwater and salt water sources. The freshwater bodies include large rivers such as the Nile (the world's longest river), the Congo (which discharges over 41,700 tonnes of water per second into the Atlantic Ocean), the Mano, Niger, Volta, Zambezi and the Orange; she also has a number of large lakes which includes Lakes Victoria, Tangayika, Malawi and Chad etc. The saltwater bodies include the Indian Ocean and the Red Sea to the east and the Atlantic to the west. The Mediterranean in the north, and both the Indian Ocean and the Atlantic in the south, surround Africa.

Despite the impressive water resource endowments, Africa lags behind other continents in per caput access to safe water, volume of irrigation water, and food security and tops the league of poor countries. Some of the answers to this lamentable situation could be found in the rising population which in year 2000 stood at 784.4 million, but projected to rise to about 1.1 billion in 2015 (UN-Habitat, 2003); massive degradation of the natural resource base (water, soils and vegetation), increasing rainfall variability, recurrent droughts, and low level of science and technological development.

This paper attempts to unravel this complex and bewildering situation by resting on the premise that, before colonization, people in African kingdoms and empires, had deep traditional knowledge of science and technology which was employed in many facets of life like food production, soil and water management, textiles, craft, iron and stone works and jewelry, etc. In spite of this enviable past, why has the continent been unable to unlock her wealth, especially in the realm of sustainable water resources development and management? What were the indigenous water management and coping mechanisms? What factors account for the stunted growth of indigenous water management techniques? How can these challenges be met adequately using the instrumentality of new knowledge to integrate western science and technology with traditional African science and technology?

The objective of this paper is to appraise the indigenous water management and coping mechanisms in Africa, so as to, provide opportunities for improving the environmentally beneficial techniques and sustain them for present and future generations. In this context, the specific objectives of the paper are to:

- define the concepts of water resources management and indigenous knowledge systems;
- provide documentary evidence of indigenous water management techniques and the underlying rationale;
- discuss the evolution of the water management techniques;
- discuss the environmental implications of the water management and coping mechanisms;
- identify the possible and probable ethno-religious and spiritual forces driving the water management and coping mechanisms; and
- enumerate the appropriate strategies for integrating new knowledge with documented indigenous water management and coping mechanisms for sustainable development.

2. Definitions of Water Resources Management and Indigenous Knowledge Systems

2.1 Water Resource Management

Water resources management is essentially the modification of the hydrological cycle for socio-economic development. It involves not only the beneficial use of water resources but also the prevention, avoidance or minimization of the effects of water excess (flood) or deficiency (drought) (Douglas, 1973; Ayoade, 1975). Consequently, the major elements of water resources management include water supply for domestic, municipal and industrial uses, agriculture, hydro-electric power, navigation improvement, drainage and flood control, outdoor recreation, fish and wildlife conservation. This paper focuses more on the application of indigenous knowledge systems for water management mainly for agriculture, domestic, drainage and flood control and conservation purposes.

2.2 Indigenous Knowledge Systems

In order to understand the concept of indigenous knowledge, it is important to start from the concept of knowledge. The latter refers to the "know-how" and "do-how". Knowledge includes formal and informal, modern and traditional "know-how" and "do-how". Given the simple definition of knowledge above, one can now proceed to clarify what really indigenous knowledge is.

Indigenous knowledge (IK), or indigenous technical knowledge (ITK) systems are facts to those who see them as ways of knowing or looking at the world. Some aspects of indigenous knowledge are facts as western scientists know and define fact. Some of it is belief as philosophers and theologians define belief. And a lot of it is folk wisdom or common sense. Indigenous knowledge systems are learned ways of knowing and looking at the world. They have evolved from very many years of experience and trial and error problem solving by groups of people working to meet the challenges they face in their local environments, drawing upon the resources they have at hand.

Indigenous knowledge systems or indigenous technical knowledge systems have been defined in various ways by a number of researchers over the years. For instance, Warren and Cashman (1988) characterize IK systems as the sum of experience and knowledge for a given group that forms the basis for decision making with regard to familiar and unfamiliar problems and challenges. Similarly, Altieri (1988) characterize such knowledge as accumulated knowledge, skills and technology of the local people derived from the direct interaction of humans and the environment. IKS consist of integrated systems of production and consumption with the following key components: organized technical knowledge, social institutions, decision making, and management of diverse natural resources, technology, and skilled labour. Some IKS are responding creatively to challenges through local adaptation, experimentation, and innovation under diverse and heterogeneous conditions. Successful adaptations are preserved and passed on from generation to generation, through oral and/or experimental means. Thus, indigenous knowledge is dynamic (Titilola, 1990; Olokesusi, 2004).

Indigenous knowledge applied to environmental conservation has been described by the Canadian based Dene Cultural Institute as traditional environmental knowledge (TEK) and is defined as a body of knowledge and beliefs transmitted through oral tradition and first-hand observation. It includes a system of classification, a set of empirical observations about the local environment, and a system of self-management that governs resource use.

Ecological aspects are closely tied to social and spiritual aspects of the knowledge system. The quantity and quality of TEK varies among community members, depending on gender, age, social status, intellectual capability and profession (hunter, spiritual leader, healer, etc). With its roots firmly in the past, TEK is both cumulative and dynamic, building on the experience of earlier generations and adapting to the new technological and socio-economic changes of the present.

Whereas research on IKS gained prominence in the search for enhanced food security and environmental conservation, it is now well documented that this knowledge system was and is still in use in many aspects of human endeavor covering soap making, food processing, medicine, wood carving, textiles and construction among others. The focus of this paper is on the water resources management component of TEK within ITK systems.

3. Survey of the Application of Indigenous Knowledge to Water Resources Management

3.1. Introduction

According to the theory of evolution, man, through the Darwinian postulation of "natural selection, had battled many odds, obstacles and catastrophes, and survived them". The theory's so-called "survival of the fittest" has endowed Homosapiens with the socio-cultural, cognitive, physical and physiological prowess to survive. It is this struggle for survival that spurred Africans to devise several water management techniques in order to cope with their peculiar circumstances.

Some of the existing literature indicate that the first anatomically modern human emerged in the southern part of the African continent. The first groups of Africans hunted diverse wildlife, and learned the use of fire for vegetation control. There is ample evidence that about 9,000 years ago, sorghum, millet, rice, yam, oil palm, as well as cattle were domesticated in the area between the Sahara desert and the equator (Haverkort *et al*, 2002).

Traditionally, water is managed for two major purposes, namely agriculture and domestic consumption, although this distinction is blurred sometimes. Sources of such waters vary from direct rainfall to waters from runoffs, rivers, streams, creek flows and seepage. Underground water resources are also harnessed. The water so collected has been used to meet domestic needs in addition to requirements for watering livestock, for runoff farming and irrigation. Available literature reveal that more innovative indigenous water management techniques have been developed in the climatically dry areas and in mountainous regions of Africa.

3.2. Water Management for Agricultural Purposes

For agricultural purposes, traditional African farmers have devised techniques such as terrace building, pitting systems, drainage ditches and small earth dams in valley floors to conserve soil and water. Virtually all the on-farm water management techniques are typical examples of low external inputs combined with the use of locally available resources. While water is being retained, some of the techniques also provide effective check against soil erosion and loss of soil fertility.

In reality therefore, such techniques conserve both soil and water resources for agricultural production and to prevent soil degradation. Johda (1990) refers to these techniques as "ethno-engineering". These techniques involve the collection and concentration of water run-off and rainwater for enhanced and more reliable plant production (Reij *et al* 1988). In wetter regions, these techniques are usually combined with other techniques such as crop rotation, shifting cultivation, crop mixture, manure application and the protection of nitrogen-fixing plants.

The ingenuity of the African farmer could be gleaned from the realization that different water management techniques are used depending on the amount of rainfall. According to Reij (1990), farmers in Tunisia have developed the *tabias* and *jassours* for harvesting floodwater within a streambed in a region with a mere 100 to 200 millimetres (mm) annual rainfall. On the other hand, where the rainfall rises to 400mm/year in the same country, farmers have developed the *mesket* and *mankee*. Under the same rainfall regime in Eastern Sudan, the *teras* system has merged. *Teras* is used to describe the earthen bund which surrounds three sides of each cultivated plot and impounds runoff from the plains. Based on their empirical research in the Kassala border area of East Sudan Van Dijk and Ahmed (1993), describes the *teras* technique of water harvesting as widespread and offers good opportunities for run-off manipulation and moisure storage. (Tables 1 and 2) and (Plate 1). In those countries where the rainfall is 500mm or more, emphasis is placed more on techniques for *in-situ* moisture conservation. Agro-forestry practices as hinted above are used appropriately in this situation.

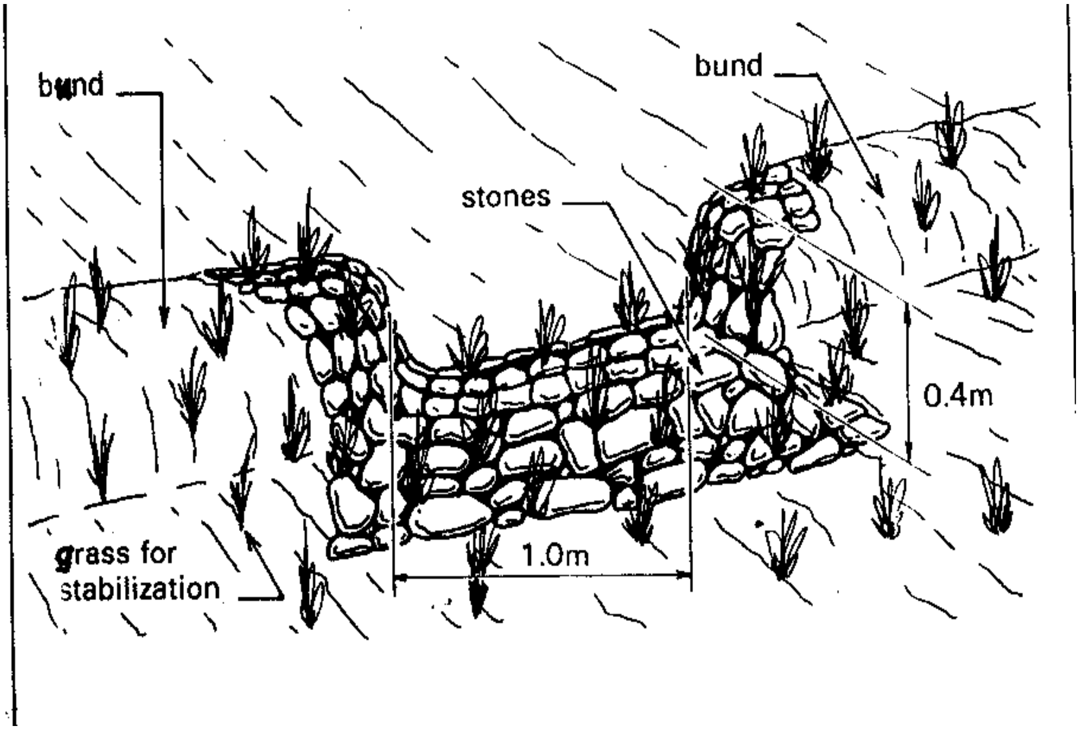


Plate 1: Bunds and Spillways for Cropped Areas Receiving Runoff from External Catchments in Tropics Forming Contour Ridges

Source: Barrow (1983); Critchley (1984)

Table 1: Ethno-Engineering Techniques in some African Countries' Farming Systems

Ethnic Group	Country*	Average Altitude (Feet)*	Average Rainfall (inches)	Population denswity inhabit per sq mile	b	c	d	e	Main Crop f
Malinke (1)(	Senegal Guinea	1,600-3,000	39	26			X		Millet, rice, maize
Baule (2)	Ivory Coast	1,600	47-55	51			X		Yams, banana, taro
Kita (3)	Mali	1,600-3,300	39	26			X		Millet
Dogon (4)	Dahomey	2,000	31	51-129	X	X	X		Millet, yams, banana
Bobo (5)	Dahomey	1,600	31	51-129		X			Millet, yams, banana
Gurensi (6)	Dahomey	1,600-3,300	31	51-129			X		Millet, yams, banana
Nunuma (7)	Dahomey	1,600-3,300	31	51-129			X		Millet, yams, banana
Manprusi (8)	Ghana	1,600-3,300	31	51-129			X		Millet, yams, banana
Losso (9)	Togoland	1,600-2,600	39-79	129-258			X		Millet, ground nut, yam
Kabre (10)	Togoland	2,600-3,000	59	568			X	X	Millet, yams, rice
Mandara (11)	Nigeria	1,600	31	129-181			X		Millet, beans
Kamuku (12), Kanuri (13), Chamba (14)	Nigeria	1,600-3,300	31	129-258					Millet, yams, banana
Bauchi (15), Berrm (16)	Nigeria	1,600-3,300	31	129-258	X		X		Millet
Sokoto (17), Kano (18)	Nigeria	1,600-3,300	31-39	310-516	X	X	X		Millet, g/nut, cassava
Batta (19), Mundang (20), Mandji (21), Bamum (22), Dama (23), Musgu (24)	Cameroons	2,600-5,000	31-39	129-258			X		Millet, yams, banana
Bana (25), Adamawa (26)	Cameroons	5,000-6,600	31-59	258-387	X	X	X	X	Millet, beans, earth pea
Kuru (27), Bari (28)	Sudan	1,600-3,300	29-55	77-129			X		Millet
Konso (29)	Ethiopia	5,000	39-47	490	X	X	X	X	Millet, cotton, maize
Tigre (30)	Ethiopia	5,000-6,600	24-39	258-387					
Kipsigi (31), Kikuyu (32), Nandi (33), Suk (34), Keyu (35)	Kenya	5,000-6,600	55-71	129-387	X	X	X	X	Millet, maize, cassava
Rundi (36)	Burundi	5,000-6,600	39-55	258-387	X	X			Millet, banana, yams
Rwanda (37)	Rwanda	5,000-6,600	39-55	387-516	X	X	X		Banana, millet, yams
Kiga (38)	Uganda	5,000-6,600	31-59	129-258	X	X			Millet, banana, beans
Matengo (39), Makonde (40	Tanzania	3,300-5,000	39-47	77-258	X		X		Maize, millet, cassava
Kinga (41)	Tanzania	1,600-5,000	39-55	51-258	X				Maize, millet
Sandawa (42), Iraque (43); Fipa (44); Turu (45); gogo (46)	Tanzania	2,600-5,000	31-47	26-258			X		Millet, maize, beans
Mbugu (47), Shambala (48), Pare (49), Meru (50), Teita (51)	Tanzania	5,000-6,600	59-79	129-258	X	X			Millet, maize, beans
Wakara (52)	Tanzania	4,000	63	542	X	X	X	X	Millet, cassava, rice

*The old names for Cote D'Ivoire and Benin have been retained in the references just as they are

A. See BRIGGS, G.W.G., 1941, P.8; BUCHANAN, K.M./PUGH, J.C., 1955, P.110; GOUROU, P., 1951, P.239 a. 1961, P.84; HUPPERTZ, J., 1951, P.36; JENSEN, E., 1936, P.576; JONES, G.L. 1943, P.161; KULS, W., 1958; LEMBEZAT, B., 1950, P.101; MURDOCK, G.P., 1959; NADEL, S.F., 1947, P.527; NIVEN, C.R.., 1935, P.54; NOWACK, E., 1954, P.6; PROTHEOR, E.M., 1957, P.72; SPENCER, J.E./HALE, G.A. 1961, P.1; WHITE, S., 1944, P.130.

b Terracing **c** Irrigation farming **d** Manuring **e** Stabling **f** Leading crops and important mixed crops

Source: *After C. Reij (1990); CIRAN (2004)*

Table 2: Additional Examples of Ethno-Engineering (SWC) Techniques for Crop Production in Africa

Country	Region	Ethnic Group	Rainfall (mm)	Population Density Persons/km²	Indigenous SWC Techniques	Major Crops	Information Sources
Burkina Faso	Central	Mossi	400-700		Stone lines, stone terraces, planting pits (zay)	Sorghum, millet	Savonnet (1958) Reij (1983)
Burkina Faso	South	Kassena	700-800	80-100	Stone lines	Sorghum, millet	?
Burkina Faso	Southwest	Bifirfor	1000-1100	35	Stone bunds on slopes; network of earth bandsa and drainage channels in lowlands	Sorghum, millet, maize	Savonnet (1976)
Burkina Faso	Southwest	Dagari	1000	35-80	Contour stone bunds on slopes drainage channels	Sorghum, millet	Pradeau (1975)
Cameroon	North	20 ethnic groups	800-1100	80-250	Bench terraces (0,5-3m high), stone bunds	Sorghum, peanuts	Mallaire (1972), Boulet (1975), Boutrais (1987) Riddell&Campbell, 198
Cape Verde	S. Antao Island		400-1200 (in uplands)	>100	Bench terraces (rainfed, irrigated contour stone walls (murets), flooewater control dams, river bank protection walls (bardos)	Sugarcane, maize, sweet potatoes, pigeon peas	Maagsma (1990), Kloosterber and Eppink (1989)
Mali	Djenne-Sofara	Bambara/Sourhai	400	20-30	Pitting systems	Sorghum, millet	Ayers (1989)
Morocco	Anti-Atlas Mountains	?	100-250	?	Terraces, stone banks and small stone walls	Barley	Kutsch (1982)
Niger	Ader Doutchi Maggia	Hausa	300-500		Stone lines planting pits (tassa)	Sorghum/millet	Reij, Martin (1984, 1990)
Sierra Leone					Sticks and stone bunding on fields and in gullies		Millington (1984)
Somalia	Miraan Region	Somali	150-300	?	Earth bunds with upslope wingwalls (caug) and earth bunds dividing plots of land into a grid (gawan)	Sorghum/cowpeas	Critchley, *et al* (1990)
Sudan	East Shukriya, etc	Hedwenda,	225-400	?	Earth bunds (straight) with upslope wingwalls (tear), and water spreading techniques)	Sorghum	Critchley, *et al* (1990 Randall (1963), Ibrahim(1988)
Sudan	Djebel Marra	Fur	600-1000	20-37 (1976)	Bench terraces	Millet/sorghum	Miehe (1986)
Tanzania	Uluguru mountains	Luguru	1500	100	Ladder terraces		Temple (1972)
Chad	Oluddai		250-650	5-6	Various earth-bunding systems with upslope wingwalls, in drier regions with catchment area (water harvetsting)		Sommerhalter (1986)
Tunisia	Medenine		100-200	15-25	Earth dams (tabias/jessours) within streambeds	Fruit trees, lentils, beans	Bonvallot (1986)
Tunisia	Sousse		200-300	?	Earth bunds (meskat system)	Olive trees	Cel Amami (1983)
Nigeria	Chad Basin, rural Kano	Shuwa, Kanuri, Hausa	390-970 480-1900	50(1991) 200(1991)	Earth bunds, hafirs and water spreading techniques. As above.	Millet, sorghum, beans, onions	Olokesusi *et al* (1992) NEST (1991)

Source: After C. Reij (1990); NEST (1991); Olokesusi, *et al* (1992); CIRAN (2003)

Similarly in Mali, the Dogon ethnic group usually builds small earth ridges around some sorghum or millet stands. Such ridges which are often 20 to 30cm tall possess a rectangular or a beehive shape; and are known to conserve the drops of rain falling within them.

Stone lines *(gandari)* have traditionally been used in the Ader Doutchi Maggia area of Niger Republic to conserve water and trap sand blown by the wind. This region has an annual rainfall of 250 to 450mm, and is situated on a plateau with fertile valleys and barren plateaus. The stones are laid out in straight lines (grid pattern), following the natural contour line. Once laid out, the stones are covered with sandy-clay soils known locally as *fako*, stalks of cereal and manure are strewn on the land to trap sand. Land areas treated in this way, would regain their fertility within 5 to 6 years.

The Mossi farmers of Burkina Faso have practised terracing farming for centuries. For this purpose, bunds made of stones are placed on cultivated land to build up terraces which retain water and soil moisture. The stone bunds are built up over the years, reaching about one meter height, especially during the off-farm season (dry season). The semi-permeable bunds allow for gradual seeping of water and prevent the run-off caused by the scarce but very intensive rains, thereby mitigating the risk of both crop failure and soil erosion (Plates 2, 3 and 4).

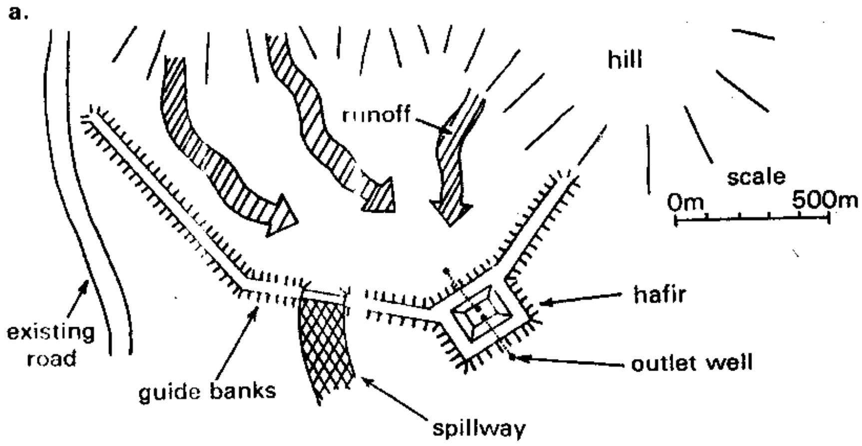
The Matengo people in the Mbinga district of Ruvuma region in Tanzania, live in very well disserted highlands and valley where the elevation ranges from 1,400 to above 2,000m. Due to this difficult terrain, the people use a technique known in Kiswahili as *ngoro* or Matengo pit system to grow maize, beans, wheat, sweet potatoes, and in some areas tobacco on rotational basis, where the slopes are quite steep. The *ngoro* involves digging of hundred of pits on the farm and spreading the earth over the grass. The depths of the pits ranges between 0.3m and 1.0m depending on the soil type and presence of stones which makes the task more arduous. Interestingly, the Matengo women are much more involved than men in pit construction (Rutatora, 1997).

In Nigeria, the Mapan and Chingwan ethnic groups in the Wokkos district of Pankshin in Plateau state, also practise terracing in a very rugged high altitude location. The crops grown are maize, sorghum, archa, banana and mango. During our interview, it turned out that these people migrated from Borno state in the north-eastern part of Nigeria. According to them, their fore-fathers were compelled to use this type of farming system in an attempt to cope with the challenges posed by their environment.

In the dry lands of the continent where there is serious patchiness in rainfall, run-off farming has been complemented with other strategies. The coping mechanism involves livestock, migrant labour, choice of crop varieties, grain storage, and food trading. Thus, quick-maturing varieties of millet provide some insurance against the rains, finishing early.

Plate 2: Terraces with Stone Bunds or Walls Used on Steep Slopes in Morocco diagram (a) the terraces receive water from an external catchment; the iompediment wall reduce the speed of runoff and spreads it whilst holding back debris; in diagram (b) contour ridges a stone bunds are combined within one system. N.B. The gradients are exaggerated.

Source: Kusch (1982)



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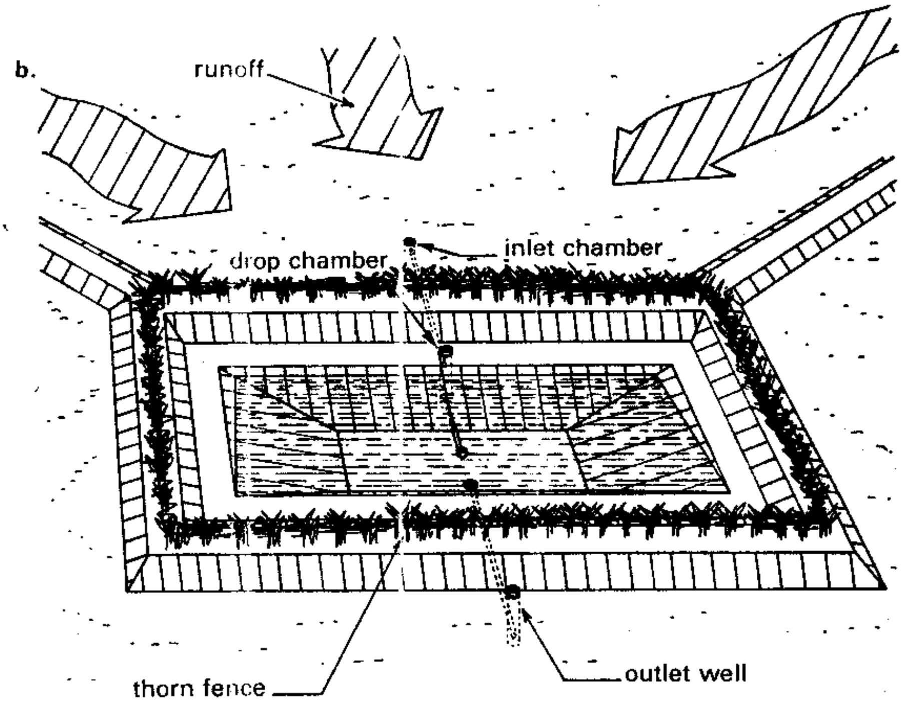

PERSPECTIVE DRAWING

Plate 4: Plan (a) and Perspective View (b) of a Somali 'hafir' (or 'balli') with Access to the Stored Water via a well. Hafirs of this sort are strongly fenced to prevent animals getting to the Water and Treading Down the Banks.

Source: Pacey and Cullis (1986)

Also in Southern Nigeria, the creeping gourd or pumkin, small vegetables, yams or raised mounds with the climbing stems trailing along poles, occasional stands of maize and cassava added later during the cultivation cycle, are all grown together as a mixed cropping system. This is a close representation of the natural ecosystem and implies the substitution of required domesticated plant species for the wild ones destroyed during the process of clearance (Harris, 1969; Agboola, 1973). The flow of energy or matter through the original system is therefore little disturbed, and net productivity rates are maintained at an almost constant level. This technique also checks soil erosion because the ground is very well covered during the wet season when run off is most intense Contour farming is also practised to check soil erosion (Richards, 1985; Agabi, *et al*, 1995).

In the wetlands of the Niger Delta region of Nigeria, water management takes another dimension due to swampy and flooded conditions. Some of the indigenous coping mechanisms for managing soil and water are regular dredging of the drainage system, placing several loads of oyster shells (obtained from the sea), on the land, planting and erection of mangrove trees and planks with a view to enhancing the firmness of the soil. Also, in this part of Nigeria, one particular type of hard soil locally known as *chikoko* is used for bunding so that the soil could be cropped (NEST, 1991; Olokesusi, *et al,* 1992).

Traditional irrigation farming system based on surface waters, actually originated from Africa. Almost all the traditional and modern irrigation technologies are based on the *Shaduf* or *Shadouf* system which originated around River Nile in Egypt many centuries ago. Typically, it consists of a long, tapering, nearly horizontal pole mounted like a seesaw. A skin or bucket is hung on a rope from the long end, and a counterweight is hung on the short end. The operator pulls down on a rope attached to the long end to fill the bucket and allows the counterweight to raise the bucket. To raise water to higher levels, a series of shadufs are sometimes mounted one above the other (New Encyclopedia Britannica Macropaedia, Vol. IX, 1994). This technology has been modified in different parts of the continent to suit socio-cultural and environmental peculiarities.

Under this system, in Nigeria, a stream or river is ponded using earthen bunds and sometimes by adding of stones. The water so collected becomes a reservoir, for inundation, for farming purposes. There is usually provision of cluices in the bunds allowing ponded water to be released to the farm plots. Usually, arable crops particularly vegetables and cereals thrive well under this farming system.

3.3 Water Management for Non-Agricultural Purposes

In most African countries, surface water bodies are regarded as common property resources. All community members are entitled to equal rights and access and use of the water. The water could be used for many purposes – drinking, laundry, livestock, cooking and irrigation farming. Rainwater collection (harvesting) is extensively practised for the purposes of domestic consumption. However, part of the harvested water is used to provide water for backyard gardens (farms), and domestic livestock. The two major techniques of water harvesting are micro-catchments and roof collection.

3.3.1 Micro-Catchment Collection

In most arid and semi-arid areas of the continent where pastoralism is the primary means of livelihood, the indigenous techniques of harnessing rainwater are by means of excavated cisterns, *hafirs,* small dams and natural water holes. The latter is more common in the wetter parts of the south of the Sahara desert, although some excavations are done for this purpose. In parts of Nigeria, Ethiopia, Kenya and Western Sudan, *hafirs* are used for rainwater collection. Contour bunding is also built during the short dry season to contain water flows (Plates 5 and 6).

In these areas, *hafirs* are typically located on land with very gentle slopes where no well-defined drainage channels or sites for small dams exist. Consequently, a *hafir* would be created by excavation while the spoils are used to construct a bund around, its perimeter. The capacity of a *hafir* may be as little as 1,500m^3 as in the Ogaden region, of Ethiopian, 9,000m^3 in Botswana; or as much as 200,000m^3 in Sudan (Pacey and Cullis, 1986). On the other hand, small ditches could be constructed at the edge of paved land near homes in order to channel rainwater to underground cisterns.

3.3.2 Roof Collection Techniques

Until the advent of western containers such as plastics and metal, Africans typically collected rainwater from roof-tops with the aid of calabashes and earthen pots. These objects are merely placed below the roof eaves and the water drops into them. Another traditional collection technique involved the construction of sliced bamboo gutters along the roof eaves, through which the water flows into calabashes and earthen pots. The water would then be taken into homes and other areas for consumption purposes.

In Botswana, rainwater collection in excavated “tanks” was very common in the past. Such “tanks” were constructed by excavating soil which is later used in supporting the top of the tank. The excavations were unlined, hence were only feasible on clay soils. Nonetheless, they retained water during the short period in every year when the rural dwellers were living on their lands. This coping mechanism indicates that the seasonal availability of rainwater was well matched to a specific need (Gibber, 1969). In many instances, the “tank” and related ground surface catchments are neither covered nor fenced, thus predisposing the water to contamination by livestock or germs.

3.4 Water Purification and Protection

In several parts of Africa, water meant for drinking is subjected to one form of treatment or the other. Whenever surface water has been collected, it is allowed to stand for some hours before it is decanted into earthen pots for storage. The precipitated materials are discarded.

Water hygiene is a top priority in most households. For example in many African societies the household prohibits anybody from using his/her own cup (calabash usually) to get water from the communal water pot. Rather, there is a container (a calabash in southern Nigeria) fastened to the pot, which all members of the household are expected to use for collecting water into their own containers for drinking.

Earthen pots are often buried in compounds rather than inside rooms in the hot arid and semi-arid areas so that the water temperature could be moderated. In the wetter parts such as parts of Yorubaland in south-west Nigeria, such earthen pots are placed inside the home for the same purpose. Locally processed shea-butter is placed at the bottom of pots before water collected from roof-tops, streams or rivers is poured into them. Again, the rationale is to ensure that the water remains cool even when the outside temperature rises.

In rural Ibadan in the south-western part of Nigeria, *Adenopus breviflorus* or *tagiri* (inYoruba) is usually placed beside the household earthen pot in the dry season so as to wade off evil spirits and "germs" causing measles. The Uhabiri Ossah clan of Igbo stock in Umuahia area, south-eastern Nigeria, attempts to improve the taste of water for human consumption by exposing the earthen water pot to the hot smoke of *Uhokiriho* seeds. For this purpose, the seeds are thrown into burning fuel wood in the traditional cooking stove, while the water pot is placed on top.

It is instructive to note that African pastoralists were quite aware that livestock posed some environmental health hazards to them. Sandford (1983) notes that in those areas where traditional *hafirs* and cisterns were most highly developed, drinking troughs and other arrangements for distributing water to livestock were carefully planned. In addition, ground rules for maintenance and use of these water sources were very well enforced. It was usual to have guards posted at *hafirs* which are sometimes also fenced. As earlier noted, there is still the possibility of infections being transmitted in the course of these processes.

4. Evolution of the Indigenous Water Management and Coping Mechanisms

From the above expose and other literature sources, it is obvious that indigenous knowledge systems have existed for centuries in Africa. However, the colonial past has somehow retarded the growth and further development of IKS and the capacity of Africans to solve their problems using locally developed technologies. We note with regret that there is paucity of empirical research and documentation of IKS in several African countries. This neglect has therefore created knowledge gaps on a spatio-temporal scale (See Table 3, and also, Pacey and Cullis, 1986:127). The implication of this critical gap is the difficulty in tracking in a systematic way, the development and improvement of any particular technique or coping mechanism over a long period of time. That is, the outcomes of deductive reasoning based on systematic longitudinal studies are very few.

Perhaps it is the necessity to close this gap that galvanized some researchers in the 1980s to take much more proactive interests in ITK systems all over the world (Warren and Cashman, 1988). These efforts led to the establishment of more than thirty indigenous knowledge resource centers around the world. Some of these centers are based in Africa e.g. Kenya Resource Centre for Indigenous Knowledge (KERIK) and African Resource Centre for Indigenous Knowledge (in NISER, Ibadan, Nigeria).

Table 3: Some Gaps in the Documentation of Indigenous Knowledge in Water Resource Management

Country	**Indigenous Ethno engineering Techniques**	**Researchers & Period of First Documentation**	**Follow up Researchers - and Period**
Tanzania (Ukara Island)		Lundwig (1968)	?
Mandara Mountains in Northern Cameroon		Studies done in 1965 – 1966. Hallaire 1971; Boulet, (1975), Boutrais (1973)	Boutrais (1987)
Doutchi Maggia in Niger	Stone lines & pitting system	Delwanle (1973) mentioned it in passing.	“Discovered” by Critchley *et al,* (1990)
Mali	The Dogan ethnic group’s unique system for rice and onion production	Gallais and Sidikou, (1978), ; Kings (1988).	Kassogue and Pansioen (1990).
Tunisia, Algeria and Morocco	Indigenous Irrigation Terraces	Heusch (1985) estimates that irrigation terraces cover some 2 million hectares yet cost-benefit data for traditional irrigation terraces are lacking	?

Source: After C. Reij (1990)

In spite of the above handicap, some of the water management and coping mechanisms highlighted in Section 3 above have undergone one form of evolution or the other. This is because indigenous knowledge systems are rooted in the past, cumulative and dynamic.

Omwenga (1984), note that in the Kissii area of Kenya, some households have metal gutters along the roof eaves which channel water into 200 litre oil drums, buckets, pots and pans, whereas thatched and timber materials were prevalent in the past. Since the 1970s when the effects of soil erosion became quite perceptible in south-eastern Nigeria, local welders (metal work artisans) have replaced the bamboo roof cutters with metal variants in addition to metal tanks of different sizes. Metal downpipes are placed either along the wall or hung on the roof gutter to channel water into the tanks which could either be buried or placed on the ground.

Also in Kenya, the *Ghala* tank evolved from the traditional granary basket or *Ghala* and it is plastered inside and outside with cement and sand mixture. Relatedly, the Dogon people of Mali have modified the adobe (mud-walled) grain bins into water tanks by the addition of wire reinforcement and a plastered cement lining (Watt, 1978). In many countries, some development partners have collaborated with local stakeholders to improve on the indigenous techniques. Keller (1982), identifies three of such:

1) unreinforced cement mortar jar;
2) plastered *Ghala* basket;
3) ferrocement tank (see also Maddocks, 1973; UNICEF, 1982, 1984).

Finally, the principles of alley crop farming technique modernized and popularized in Africa by the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria are rooted in traditional agro-forestry practices such as Taungya and shamba as described by Agboola (1975); and UNEP (1982).

5. Environmental Implications of Indigenous Water Management and Coping Mechanisms

As earlier pointed out, some of the “ethno-engineering” and water harvesting techniques have multi-purpose functions – water retention, flood and soil erosion control, enhancement of soil fertility and watershed management. Our finding in this context is that some of the techniques have proved their worth. An example is the Matengo pit system in Tanzania which soil erosion control capability has been shown to be better than conventional conservation practices, even on sites with differing degrees of slope (see Table 4). In addition, Rutatora *et al* (1995) and Schmied (1989) have confirmed that crop yields under this *ngoro* system were higher than those produced under different farming systems, such as flat and ridge cultivation. This system has also been proved to have made it possible for the Matengo people to produce adequate food crops in the mountainous area and also control soil erosion (Pike, 1938; Stenhouse, 1944).

Table 4: Effect of Conservation Practices and Slope on Seasonal Soil Loss in Tanzania

Site	Conservation Practice	Soil Loss (metric tons/ha)
A	**Bare**	**39.0**
Slope 8.9°	Ridge	7.3
	Matengo pit	2.4
B	**Bare**	**55.7**
Slope 20.5°	Ridge	14.3
	Matengo pit	5.8

Source: Miombo Woodland Agro-Ecological Research Project Report (1995:35) Report, No. 1, Tanzania.

The harvesting of rainwater from roofs maximizes the efficiency of run-off collection. This is because the characteristic pattern is the scattering of small rainwater catchments, each serving an individual farm, homestead or hamlet. Hence, we refer to this as an extensive form of development, unlike the intensive large-scale irrigation projects. The former type of development is much more environmentally friendly because it offers very good technical advantage in terms of the conservation of the scarce water resources. Moreover, the technique fits quite well into the settlement pattern.

Rainwater harvesting promotes flood and erosion control, groundwater recharge, and reduced silting at major rivers and streams. Similarly, run-off farming offers these same environmental benefits. In the Ader Doutchi Maggia region, Niger Republic, the stone lines (gandari) have been used successfully for the rehabilitation of barren degraded lands and it is being replicated elsewhere (Reij, 1990). In Kenya, the "hoop" micro-catchments have restored degraded lands without negative effects. Once the perennial grasses begin to flourish within the hoops and spread beyond them, the grass itself binds the soil together and run-off is effectively retained.

Traditional rainfed irrigation systems have proven to be more profitable than modern large-scale irrigation systems in Africa. In Chad, the World Bank (1989), for example, carried out a financial and economic rate of return (ERR) analysis for arable crop production. The study indicated the cultivation of rice, wheat and sorghum was most economically viable under the traditional rainfed irrigation system. Four models were examined:

1) Water control based only on pumping with a diesel engine;
2) Controlled flooding based on gravity, permitting partial water control;
3) Improved rainfed agriculture based on bottomland cultivation; and
4) Traditional rainfed irrigation, which accounts for 90% of rice production in Chad.

The relatively greater profitability of the improved, traditional polders is confirmed by the economic analysis which showed that cereal cultivation, particularly wheat and sorghum, had an acceptable ERR for the traditional polder whereas it was negative for the modern polder (World Bank, 1989:25). The report went on to say that stakeholders (excluding the farmers) tended to assume that farmers were interested in irrigated agriculture and failed to develop an understanding of how irrigation fits into the farmers' economic strategy. It was concluded that cultivation of traditional cereals on the traditional polders is economically viable, whereas this is not the case for the modern polders. Government and donors need to seriously re-examine the decision to invest heavily in modern polders on Lake Chad which are extremely costly in terms of both investment and operating costs (World Bank, 1989:28).

From the foregoing, a major positive impact of these water management and coping mechanisms is improved agricultural production, which enhances poverty reduction. Ready access to water also contributes to reliving both time and constraints which are both critical in rural communities. To some extent there would be improvements in personal and environmental hygiene. These developments also widen livelihood options. The implication of all these is environmental improvement due to the recursive relationship between poverty and environmental degradation.

However, there are still some problems. For instance, until the introduction of modern roofing materials like tiles and metal, African homes were roofed with thatched materials. Water harvested from such roofs were deemed clean and uncontaminated. This may not be scientifically correct. Also, the rising level of air pollution and dangerous microbes in Africa makes this coping mechanism suspect for drinking water.

Novieku (1980), contends that in West Africa, there appears to be no strong objection on grounds of taste to rain water consumption. In Botswana, the converse was the situation. Some adverse environmental effects of some of these techniques have been observed in certain parts of the continent. Excavated water storage "tanks" and hand dug wells for example have all contributed to the lowering of water tables. In small hafirs, livestock often gain access to the water by wading in at the inflow side thus contributing to soil erosion and rapid silting.

Although hand dug wells, cisterns and hafirs allow water to percolate down into the soil and eventually recharge the groundwater table, Pacey and Cullis (1986), note that in north-east Kenya, one major outcome of hafirs or hafir-dams constructed after 1969 was that majority had silted up by 1979. This development has also been observed in Nigeria (NEST, 1991).

While the entire community is involved in one way or the other in the conservation and maintenance of water quality, its open access nature and absence of property rights have been a source of concern. The community leader(s) represent the institutional authorities under a non-market framework for water management. Researchers like Hardin (1968) have argued that under this framework, each individual may try to appropriate more and more water thus leading to over exploitation and environmental degradation. This is what Hardin refers to as "tragedy of the commons". The perceived weakness of this formulation led to the development of the so-called Prisoner's Dilemma game (Sengupta, 1991). Much as this concern is genuine, we are constrained to reiterate the fact that in traditional African societies, norms and ground rules are usually followed and respected.

6. Possible and Probable Ethno-religious and Spiritual Forces driving the Water Management and Coping Mechanisms

For most rural dwellers, the spiritual, religious and cultural aspects are quite important dimensions of their livelihood and coping mechanisms, giving meaning, direction and identity to their lives. Consequently, researchers in the field of IKS now widely acknowledge that this knowledge is holistic. It cannot be compartmentalized and cannot be divorced or separated from the people who hold it. It is in fact rooted in the spiritual health, culture and language of the people. This knowledge is a way of life and comes from the spirit so as to serve (Haverkort et al, 2002).

In several African rural communities, the spiritual dimension of land tenure as well as soil and water conservation has been documented even if scantly. Traditional functionaries such as the earth priests, the spirit media and rainmakers, who are normally consulted for land and water management issues exist in many of such communities.

The Shona ethnic group in Zimbabwe, the traditional people in Northern Ghana, both the Yorubas and Igbos in Nigeria believe that the spiritual world (Gods, spirits, ancestors), the human world (including spiritual and political leaders), and the natural world (sacred groves, ritual crops and animals, food items and permanent crops) are interrelated (Haverkort et al 2002; NEST, 1991). For this reason, land, water, animals and plants are not only a factor of production with economic importance, they have their place within the sanctity of nature. Consequently, certain places are set aside and or used as locations for rituals, and sacrifices. Typical examples include sacred groves, shrines, mountains and rivers (Osunade, 1988; Millar, 1999; Gonese; 1999; Wahab, 2004).

Among the Yoruba of south-western Nigeria, for example, forest land was regularly set aside for various purposes; as hunting forests, religious groves, isolation or quarantine forests, and to serve as the abode of fairies and spirits. Various categories of such forests have been described by a geographer as follows: Igbo ode (hunting forest). These are lands located at some distance away from settlements that are mainly devoted to game. Usually igbo egan (High forest) or abandoned secondary forest when put to use for game – hunting activities is called igbo ode. The lands vary from place to place, depending on the occupation of farmers in the area. Wild and dangerous animals inhabit some of these forest lands such that the lands are named accordingly, e.g. Igbo erin (Elephant forest), igbo efon (Buffalo forest). Only brave hunters dare use such specialized forests for fear of attack from dangerous animals. Igbo oro (Religious groves) are places set aside for religious worship of many of the elements of the physical environment. They are not extensive (usually less than a quarter of a hectare) and the uncultivated forests are located on the borders of settlements and in as many separate locations as there are families of the deities. The groves are quite distinct from the neighbouring lands that are either under cultivation, recently left to fallow, or planted with tree crops. Only foot paths, which are usually unkempt, lead into the groves. They are called various names, depending on the deities and the location in Yoruba land. The names include: Igbo ale, Igbo egungun, and igbo awo.

Igbo-Egbee (religious groves): These are reserved forests for the burial of deceased pregnant women, people struck by lightening, victims of smallpox and people whose deaths are considered abnormal or mysterious. Such lands, isolated further away from settlements, were never put under cultivation in the past when diseases were rampant and sudden deaths were attributed to the anger of the gods. The lands are also referred to as the land of sorrows. Another name given to such lands is igbo iwin (abode of fairies and spirits). These are lands believed to be inhabited by fairies and fearful spirits.

The lands are designated as belonging to the gods, so-called, because of the belief that the forest and the earth are infested with queer supernatural creatures vividly portrayed in a Yoruba novel with the setting and name, Igbo Olodumare (Gods' forest). The lands have rugged topography and are usually thickly forested and located far away from human settlements and could be highly inaccessible. Only brave hunters dare enter such lands for hunting purposes. The lands are naturally unattainable for cultivation because of their rough terrain and, as such, they are still preserved in several places even today (Osunade, 1988; 1991).

7. Strategies for Integrating New Knowledge with Indigenous Water Management and Coping Mechanisms

The foregoing discussion confirms that African IKS have been employed in diverse ways for water resources management under very excruciating and challenging circumstances. Although some success stories have been recorded the short and medium term scenarios remain grim. Out of the 55 countries in the world with domestic water use below 50 liters per person per day (the minimum required set by the World Health Organization), 35 are in Africa. About 50% of all Africans suffer from one of six main water-related diseases. Only about 4% of the continent's total annual renewable water resources is used for agriculture, industry and domestic purposes (Mutume, 2004).

Inadequacy of funds and technology was identified as the key stumbling block to solving the continent's water supply and sanitation problems at a Pan-African Conference on Water in Addis Ababa, Ethiopia in December, 2003 (Mutume, 2004). This is therefore a clarion call for the integration of new knowledge with IKS in order to salvage the situation.

Although IKS differ from western, science-based knowledge systems, they have many aspects to complement science. IKS are basically local in their factual information, while science must as of necessity carry out new studies to gain the same information that already exists in IKS. Western science is regarded as having a short-term information base that it can use, whereas its indigenous counterpart has the benefit of been able to draw on a very long-term information base. Nonetheless, the two systems are based on human observation of natural events.

Integration of the two knowledge systems could be achieved if the following proposals are considered:

The small scale, private management and adaptive capacity of these water resources management techniques, make these technologies replicable in other parts of sub-Saharan Africa as the case may be. With a view to gaining new insights into these technologies, the trajectory for intervention should be within the context of farmer analysis, choice and experiment. This is because the adopters of these technologies use a phased approach following seasonal or environmental characteristics. Consequently, knowledge and improvement of any of these technologies should begin with adequate understanding of the community's social and economic relations, leadership, cultural and religious aspects and the different interests. The sustainability of water management system depends on the sustainability of community management systems or institutions. Technical options should be seen as part of a management solution, not as goals themselves. Technical improvements can however also support management solutions (Lemmerink, et al, 1999).

Experimenting communities should share results with neighbours, pass on management advice, etc. for the purposes of diffusion. An important component is the mobilization of the networks developed for information dissemination of such community experiments, while emphasizing the basic ideas and principles underlying these experiments. Following this, the new "water management solutions" could be tested in another community and insights on how to experiment, for example, testing innovative concepts, capacity building and institutional frameworks.

As part of the advocacy process, "study tours" and extensive utilization of Information, Education and Communities (IEC) materials should be used. Exchange visits between communities and water management committees would go a long way in fostering understanding and management capacities.

Appropriate efforts should be made to evaluate the tested indigenous water problem-solving strategies (i.e. the experiments) with the community in order to systematize the process and results and also ensure the sustainability of the process within the community.

Integration of the two knowledge systems must fully recognize and respect the intellectual and traditional resource rights of the people. Whenever possible such rights should be documented and patented with the appropriate authorities.

Also, the following could facilitate the integration of IKS with science and technology in Africa:

- Development of a symbiotic relationship by joining the advantages of IKS and western knowledge systems.
- Stakeholders in the two knowledge systems should create partnership through complementary action plans, participatory action research (PAR), joint ventures, capacity building and maintenance and co-management approaches.
- PAR would improve the overall project success if local and "western" experts are involved in the entire project cycle. Studies of the two systems on similar sets of water resource management problems could be initiated and pursued to their logical conclusion from which deductive reasoning would be used to identify what works and what does not work.
- The principle of co-management should guide water resource development and management. The "top-down" governance of science and technology should yield to this reality. This implies that local beneficiaries and "outside experts" work together giving equal weight to both knowledge types. This approach would yield more positive outcomes if the process of project development and acquisition of traditional knowledge are carried out in a participatory manner, rather than through consultation.
- Western science stakeholders should endeavor to establish the veracity of information from IKS stakeholders by assessing the credibility of the sources of information. Members of the community would serve as a source of credentials.

- Trust is very critical to the process of knowledge integration. Stakeholders should recognize the spiritual elements integrated into the IKS, and mutually accept that both systems are desirable and useful in designing effective strategies to solve the continent's water resource problems.
- Upscaling of specific IKS could be achieved if there is greater attention to and structuring of the methodological approaches. For example, it should be possible to develop indigenous research methodologies which include cultural protocols, values and behaviours as an integral part of these methodologies. As part of the transparent research design, full disclosure of the methodologies and results should be ensured. Documentation of the entire process would be done for replication in the future.
- For projects the economic dimensions of the approaches should be determined as part of the project appraisal process. This would serve as a guide to the efficiency of the systems and eventual decision-making.

8. Conclusion

This paper sets out with an appraisal of the indigenous water management and coping mechanisms in Africa with a view to improving them, through their integration with new scientific and technological knowledge systems. We identified different water management techniques for agricultural and domestic uses as well as ecological restitution. Such coping mechanisms depend on the people's spatial location, socio-cultural attributes and primary means of livelihood.

The major conclusion of this paper is that given the enormity of the water supply problem and food insecurity situation, the existing IKS are incapable of meeting the challenges, hence the acute necessity for integration with new knowledge. If the proposals contained in the preceding sections are adapted/adopted, there is no doubt that some reasonable progress would be made. ATPS should as a matter of priority design execute a regional study or set of studies on the theme of this paper in order to fill some of the gaps and throw some light on the process of integration. Finally, we recognize the critical nature of water policies and institutional arrangements. Consequently, deliberate efforts should be made to ensure that the knowledge integration process would include improvements in policies and institutional arrangements.

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