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Water Smart Agriculture Practices: A Path Way to Agricultural Transformation - a Review

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Abstract: In this paper, secondary data from review of literature were carried out on Google Scholar search and data were extracted from all selected studies and synthesized and empirical evidences from personal observations were presented so as to support findings from literature review. Since, higher productivity on farms, commercially orients farming, and strengthening the link between farming and other sectors of the economy is a process that leads to agricultural transformation in which agricultural openness, commercialization, product diversification as well as sector integration are key pillars. Weather it is rain-fed or irrigated agriculture, ensuring the right water at the right time for production and productivity of the agriculture sectors should be mandatory. The paper addresses the path way for agricultural transformation through Water Smart Agriculture perspective. Accordingly, Water Smart Agriculture are mainly focus on water resource use of all type, utilization efficiency and water productivity, functionality of scheme, harvesting status and practices of all type of water resource, governance and protecting, managing and controlling as well as rehabilitation of water ecological environment to get climate independent agriculture which enable yield boosting and sustainably intensify the sector, while recognizing the mandatory aspect of integrated agricultural systems for transformation of agriculture in Africa.

Keywords: Water Smart Agriculture, Agricultural Transformation, Climate Smart Agriculture, Climate Smart Irrigation, Sustainable Agricultural Intensification, Green Revolution

1. Introduction

Result from the various assessment shows that the world's population is growing rapidly and is expected to reach 9.7 Billion in 2050, mostly living in urban area, posing challenge in meeting the sharply growing water, food and energy demands. In order to feed this growing population, it is estimated that agricultural production needs to be increased by 60% globally and 100% in developing countries [1–3], where 91% globally and 79% in developing countries, the agriculture production increase would have to come from increase in yields and cropping intensity on current cultivated land [4] which indicates requirement of transformation in both rain fed and irrigated agriculture.

According to the African Center for Agricultural Transformation, agricultural transformation is a process that leads to higher productivity on farms, commercially orients farming, and strengthening the link between farming and other sectors of the economy [5-9]. The analysis of the agricultural sector conducted by the Agricultural Transformation Agency (ATA) reveals that, agriculture has been consistently contributing 35-40% to the Ethiopian GDP and has grown by 9% annually over the last five years [6]. However, although, agriculture in Ethiopia is one of the oldest in Africa, it is not yet modernized nor sufficiently transformed like with other sectors that indicate no successful structural economic transformation has occurred without first increasing agricultural productivity and reducing rural poverty [10] that urges agricultural transformation realizations.

Narratives on agricultural transformation are commonly expressed in terms of the "Green Revolution", which revolutionized agriculture in many parts of Latin America and Asia in the 1960s. Similar technologies, based on hybrid seeds, chemical fertilizers, and insecticides, and where feasible mechanization, are now being promoted as the solution for Africa, in what is sometimes called a "Second Green Revolution" [10, 11] and the question is how one attain sustainable green economy which are environmentally, socially, economically and technically feasible through adapting or mitigating impact of climate change at the same time also attain poverty, reduction, food security and transform agriculture and such a challenges require unconventional thinking and solutions.

Even if, Ethiopia emphasizes irrigation development, by a large margin, most farming are rain fed which urge better management of rain fed agriculture and/or use of supplementary irrigation at an appropriate scale which can achieve significant long-term impacts and to address such issue, Water Smart Agriculture (WaSA) as approach to farming that balances water availability, access, and use across the range of water sources, according to principles of socioeconomic, environmental, and technical sustainability are introduced [11]. One pillar of agricultural transformation enabler is working on Climate Smart Agriculture [11–13] and as a subset of CSA, Water Smart Agriculture (WaSA) are regarded as companion concepts with similar objectives, with WaSA being focused primarily on soil and water management are the main discussion and review area of the paper for the transformation of 70-80% small holder farmer of the Country which can be seen as game changing action.

Especially securing water for supplementary in rain feed agriculture and sustainable development of irrigated agriculture or Water Smart Agriculture in the changing environment is a must that indicate the level of agricultural transformation and its sustainability highly depends on how water resources of a regional or country is managed and utilized [14, 15].

At the same time, a growing body of research shows that climate-smart, low-external-input agriculture can contribute to increased food production and work within environmental limits, through sustainable intensification which enable producing more "crops" with less "drops" and shift from the first generation of "Green Revolution"[1] path to Sustainable Agricultural Intensification is recommended [10].

Specific to this paper, WaSA focus on 'water issues' first which helps ensure that investments in other inputs are more secure and in central WaSA there are conviction that better water management now provides a key to unlocking future farmer prosperity [14]. At the same time, it enhanced resilience and reduced risks, thus improving productivity, food security, income, and overall ecosystem health.

The main aim of this paper is to review theory and practices of WaSA a "water-first" perspective for climate smart agriculture as the path way to agricultural transformation.

In order to achieve the objectives highlighted above, secondary data was used. This entailed through Google Scholar search for the title of the review were made and the review of literature on potentially relevant studies and data were extracted from all selected studies and synthesized. Moreover, empirical evidences from personal observations were presented so as to support findings from literature review.

2. Water Smart Agriculture and Agricultural Transformation

2.1. WaSA, a "Water-First" Perspective for Climate Smart Agriculture

WaSA was coined in 2013 by the Cooperative for Assistance and Relief Everywhere (CARE), under the Global Water Initiative East Africa meetings for the first time which was introduced to encourage smallholder farmers of Eastern African countries (Ethiopia, Tanzania and Uganda) to adopt improved crop, soil and water practices to mitigate yield losses due to the irregularity of rainfall [11].

Since many part of East Africa are under rain feed agriculture, better management of rained agriculture and, or use of supplementary irrigation at an appropriate scale can achieve significant long terms impacts which also described by [15] as one component of Smart Agriculture.

Water-Smart Agriculture (WaSA) is an approach to farming that balances water availability, access, and use across the range of water sources, according to principles of socioeconomic, environmental, and technical sustainability and the concept includes a blend of "best-fit" water management practices that increase water availability, water access and the effectiveness, efficiency and equity of water distribution and use [11, 17].

According to [16] adapting water management to climate change entails four main pillars. These include: 1) assessment of water resources and risk to agricultural production; 2) rethinking of water storage, including banking of ground water, managing aquifer recharge and retention and conservation of soil moisture; 3) producing more food per unit of water through boosting rain fed agriculture and managing climate-induced water variability through supplementary irrigation; and 4) boosting resilience through uptake of improved agricultural and water management technologies and income diversification strategies.

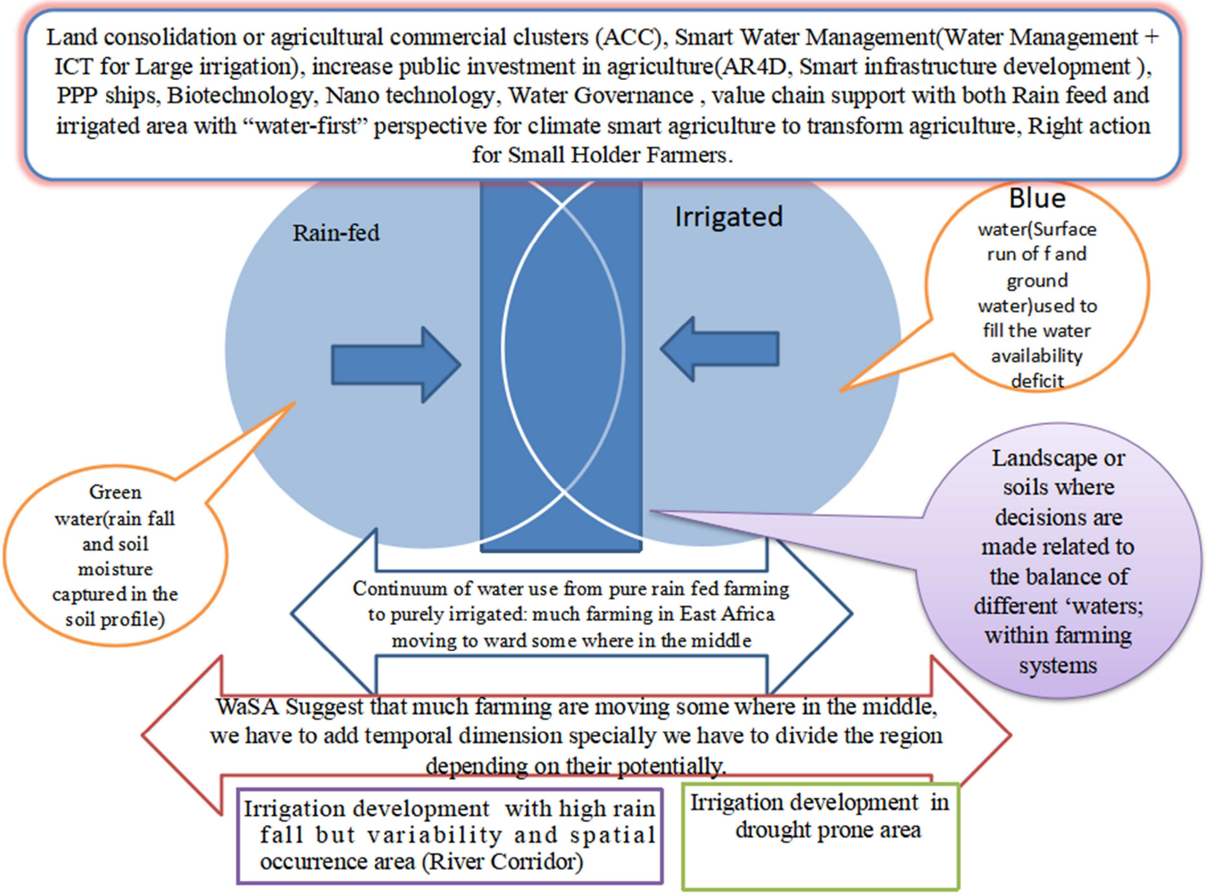
2.2. Smart Water Practices and Smart Agriculture

To date, the terms "smart water grid," "smart water supply system," "smart water system" or "smart water network" have been widely spread among urban water supply systems and automated control technology (ACT) and information communication technology (ICT) are applied to tackle existing problems in water distribution networks, where both

1 Green Revolution in the agriculture sector in recent decades is considered to be a major contributor to land and water degradation especially in South Asian area where over use and misuse of water resources, pollution, salinity and ground water depletion are resulted.

technologies play critical roles in large-scale ACT and ICT applications for urban and large irrigation systems as water smart systems [17].

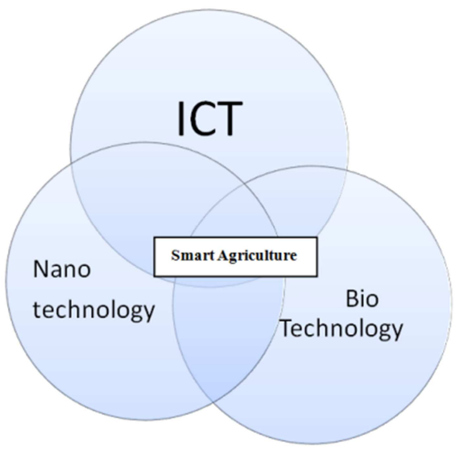
Accordingly, Water management technologies converging with ICT have been called Smart Water Management (SWM) distinguished from traditional water management technologies. SWM integrates ICTs to monitor water resources, diagnose problems, improve efficiency and coordinate management to help overcome the challenges to provide every citizen with sustainable water supply [16].



Adopted from [11]

Figure 1. *Water Smart Agriculture Conceptual Model.*

When we see the reform in agriculture area, [13], basically explain the agricultural reforms are the sum of three main domains which are bio technology, nanotechnology and Information and Communication Technology (ICT). The summation of these three distinct technological aspects leads the ideology of smart agriculture.



Source:- [13]

Figure 2. *Standing of Smart Agriculture.*

According to him, the trends in agricultural paradigm are illustrated and as a definition any system, process and domain is said to be smart if follows different levels of intelligence as initial which includes: -

1. Adapting to the change to meet any particular requirements,
2. Sensing: which can be expressed as the ability to sense the changes in surrounding or to observe any change,
3. Inferring to conclusion which is based on results and observations,
4. Learning after getting conclusions and observed results, the learning can be used to improve the methodologies used previously which involves different type of information,
5. Anticipating to thinking of something new and innovative which going to be happened or we can say it as the next level of anything,
6. Self-Organizing referred to any intelligent system which has ability to sense and monitor and then change its parameters according to the need.

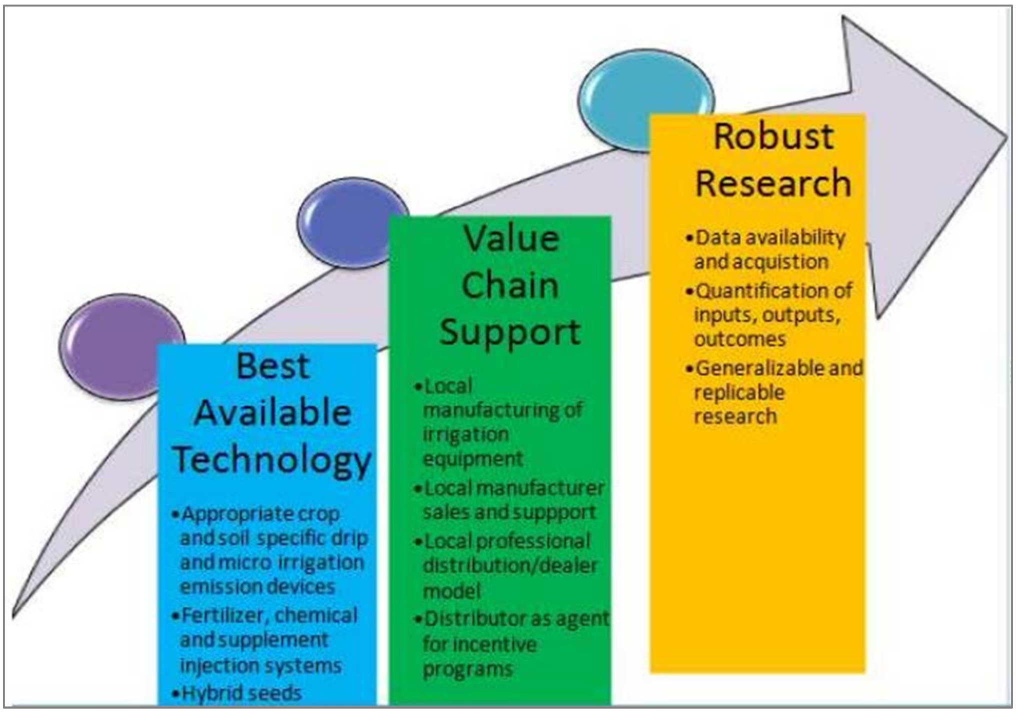
With the above 6 points smart agriculture can be composed of Smart Consumer, Smart Farmer and Smart Farm [15] which are related to recent Climate Smart Village idea in many ways which include Weather Smart (Seasonal weather forecast, ICT based agro advisories, index based insurance, climate analogs), Water Smart (aquifer recharge, rainwater harvesting, community management of water, laser leveling, on-farm water management), Carbon smart, Nitrogen smart, Knowledge smart, Energy Smart can mentioned in many literatures).

Other literature address Smart irrigation as water-saving irrigation which is comprehensive measures that effectively use rainfall and water for irrigation according water requirements of crops and the local water supply, in order to gain economic, social as well as environmental benefits of agriculture. Efficient Water-saving Irrigation mainly refers to irrigation modes such as pipe irrigation, sprinkler irrigation and micro-irrigation, which boasts efficient water distribution and production [18].

As water is the medium of expression of the impacts of climate change, land and water management will be at the center of climate change adaptation strategies, especially for agriculture. Challenges of water scarcity could effectively be addressed through adoption of smart water management interventions and modern irrigation technologies to enhance water productivity by involving combination of area specific approaches for both supply and demand side management [19].

In certain literature using "the right irrigation" which comprises a mixed approach that is technologically selective, comprehensively delivered, locally contextualized, institutionally sound, appropriately engineered and professionally supported is adopted [20].

At the same time, Climate Smart Irrigation concept as the paradigm which posits that the principal agent relationships be transformed from a donor-recipient model to a commercial relationship between the manufacturers of products in the input value chain for agricultural production, the distributors of these products who act as the professional link between the manufacturer and the grower, and the grower him or herself. Climate-smart irrigation consists of three basic principles: best products; professional support; and robust data analysis and evaluation [18].



Source: [18]

Figure 3. *Climate Smart Irrigation Model.*

According to [11, 23] in moving to the practice of WaSA as outcomes:

1. empower farmers and those working with them to address water-related risks, capture opportunities for dry-season production, strengthen and share new knowledge, skills, and other capacities, and instill stronger governance of water (and soils) in each local context, leading, in the long-term, to the wider public good of enhanced water availability for all watershed and ecosystem users;
2. accelerate gains in production based on principles of sustainable intensification, producing more but at the same time ensuring more efficient utilization of rainfall (e.g., higher production from available rainfall) before seeking additional water from other sources;
3. improve soil health by applying principles of good soil 'governance,' including soil and water conservation and landscape management in order to benefit from enhanced water storage, greater soil fertility, and, ultimately, more nutritional value from crop production;
4. support collective action at the watershed scale and establish good water governance so that water savings made in agriculture can be allocated in ways that will strengthen water security for all, including reducing potential conflict between upstream and downstream users within shared watersheds; and, in addition, conserve and enhance the services provided by ecosystems that support food security and underpin future sustainable agriculture [11, 23] are illustrated.

2.3. Agricultural Transformation and Water Smart Agriculture

Agricultural transformation comprises boosting productivity by modernizing farming and running farms as modern businesses, and strengthening the links between farms and other economic sectors in a mutually beneficial process as two main processes. It needs transformation readiness from institutional framework, governing mechanisms, and political environment, at the same time need quality of the agricultural development plan with respect to implementation capacity, setting agricultural research agenda and focus, allocating the necessary resources, quality of the agricultural development plan, finally delivery mechanisms that focus on what is needed to translate are the main transformation drivers [3].

Transformation needs shift of thought which can be started from individual sector thought, funding agency and collaboration and integration of all stakeholder from top to bottom small holder and vice versa which are even seen in Ethiopia for example in the case of irrigation. As a mandate, Ministry of Water and Energy work on medium and large scale whereas Ministry of Agriculture mandated on small scale irrigation and even Oromia Agriculture and Natural Resource Bureau can carry all three at the same time at regional level which shows institutional set up for governance of the available resource can need rethink and updated itself systematically to flourish their expectation for transformation of agriculture.

One-third of Earth's land is devoted to agriculture, more than any other industry. Yet the agricultural sector struggles to keep up with a growing global population and the demands of an expanding middle class. As estimates we will need to increase food production by 60-70% by 2050; many developing countries may even have to double food production [11, 24–27].

This illustrates, agricultural systems must adapt, even transform, to meet a growing number of challenges and constraints through changing business as usual approach. Approaches that address the actual reality of the situation now and in the future, especially with regard to climate change like Climate-Smart Agriculture (CSA) is a must which are defined as an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change [4].

Therefore, as subset of CSA and in some ways a more practical and tangible starting point to implementation and highly water centered are required which urges the governance of the systems and their underlying resources [1].

2.4. Conceptual Frame Work

Water is one of the prime channels through which the impacts of climate change on the world's ecosystems and on livelihoods will be felt. Climate change will have an impact on every element in the water cycle. Water Smart Agriculture is both rain fed and irrigated agriculture which are climate resilient agriculture through sustainable utilization of water resource because in the medium to long term, climate change will reduce the availability or reliability of water supplies in many places already subject to water scarcity [3].

Agriculture transformation are mainly focus on water resource use of all type, utilization efficiency and water productivity, functionality of scheme, harvesting status and practices of all type of water resource, governance and protecting, managing and controlling as well as rehabilitation of water ecological environment to get climate independent agriculture which enable yield boosting and sustainably intensify the sector, while recognizing the mandatory aspect of integrated agricultural.

2.5. Opportunity of Water Smart Agriculture in Ethiopia

Africa need the right irrigation with appropriate institutional mechanisms that ensure transformation in our agricultural sectors. Currently, too much willingness to transform the agricultural sector with get high attention which exhibited through increase public investment in agriculture. As illustrated in Figure 1 above, including Agricultural Research for Development (AR4D), infrastructure development such as irrigation schemes (small, medium and large) as well as rural road, initiation to utilized natural resource through preparation of national development corridors based on development potentials, participatory techniques that include farmer-based extension and accessing channels such as radio, television, mobile phones and the internet as well as utilizing all opportunity with innovative approach are promising phase to see second green revolution in African agriculture which at the same time ensure social and environmental sustainability too with trade off.

3. Water Smart Practices for Agriculture Transformation

10-year prosperity plan shows that, there are a big motion which illustrate agricultural systems are shifting from traditional subsistence systems to more diversified and commercialized systems linked with agribusiness and value chains. These require more reliable, flexible and diversified and constant water supply through transforming both rain fed and irrigation systems services, along with innovative institutional and financing arrangement is required [4]. Here, different Water Smart practices from different literature, own experience are discussed with respect to Ethiopian case specifically and from world experience in general were discussed.

3.1. Agronomic Practices to Optimize Water Use

Increasingly, water quality issues and water-use efficiency are becoming important considerations and are dependent upon adoption of better agronomic practices. Basic agronomic principles, such as crop rotation, remain relevant for increasing resilience to biotic and abiotic stresses by enhancing nutrient cycling and reducing plant diseases, while serving as a strategy to mitigate against drought [5]. Agronomic water-saving measures, including land leveling, deep plowing, balanced fertilizer, use of crop residues, introduction of adaptive varieties and high-quality seeds, etc. are discussed as follows.

3.1.1. Climate-Tolerant Crop Variety

Develop high yielding, disease-resistant and drought-tolerant crop varieties suitable for rain-fed and irrigated agriculture and optimize crop production systems to mitigate agricultural risks in the changing environment/climate are the concern. According to Oromia Research Institute, about 116 improved crop varieties on cereals, pulses, horticultural crops, oilseeds, and seed spices have been released along with improved crop, soil, and water management practices. At the same time, the national research in Ethiopia has so released and recommended a total of 53 different forage varieties belonging to grasses (25), herbaceous legumes (18), browse trees and shrub legumes (10) for the different agro-ecological zones of the country. There is a strong need to develop technologies responsive to emerging biotic and abiotic challenges (e.g., diseases, insect pests, invasive weeds, soil acidity and salinity, climate change and variability, etc.). Climate-smart agricultural technologies such as drought/heat tolerance and early maturing crop varieties are badly needed [3].

However, the use of these inputs in Ethiopia is very low compared to most African countries. Regardless of being a high agenda of the government for decades, Ethiopia is among the few countries in the world that use a small amount of these major inputs. For instance, less than 20% of agricultural land is covered by quality seed and the average chemical fertilizer use is only about 26 kg/ha [26]. The input supply sectors and their overall value chain needs to be transformed in order to transform the work of availing improved inputs variety in all aspects.

3.1.2. Adjusting Planting Date

To minimize the effect of high temperature induced spikelet sterility and reduce yield instability, adjustment in planting dates should be made such that the flowering period does not coincide with the hottest period. Adaptation measures to reduce the negative effects of increased climatic variability as normally experienced in the arid and semiarid tropics may include changing the cropping calendar to take advantage of the wet period and avoiding extreme weather events (e.g., typhoons and storms) during the growing season [5]. Cropping systems may have to be changed to include growing suitable cultivars, increasing cropping intensities or crop diversification. For example, in Hararge area of Eastern part of Ethiopia, farmers adapt to adverse cold time by passing it and at the same time, follow the cultivation of Chat, maize inside the Chat and other vegetables by irrigation if they have water and if not through water harvesting.

3.1.3. Conservation Agriculture

Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, which is aimed at increasing profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three interconnected pillars which are continuous minimum mechanical soil disturbance (minimal soil tillage), permanent organic soil cover, with crop residues or cover crops and diversification of crop species grown in sequences and/or associations (crop rotations) [17, 29] A combination of reduced tillage, retention of crop residues or maintenance of cover crops, and crop rotation or diversification application brings more than 50% higher than yields under conventionally tilled maize in Zambia [11].

3.2. Traditional CSA Practices

Various types of traditional CSA practices have been implemented and adopted in Ethiopia. Such practices include the Derashe traditional conservation agriculture, Konso Cultural Landscape, Hararghe highland traditional soil and water conservation, Hararghe cattle fattening, Hararghe small-scale traditional irrigation, Ankober manure management and traditional agro forestry in Gedeo Zone, East Shewa Zone, East Wollega Zone and West Gojam Zone. Scaling up of our traditional best practices, using all source of irrigation water in traditional systems especially its management and scheme administration should build on what we have on the ground through total participation and holistic approach.

3.3. Soil Water Management Practices

In addition to those WaSA practices already listed, other soil water management practices may be applied by smallholder farmers, especially those relevant for semi-arid environments, to optimize water capture and storage and to complement existing irrigation options. Ridging, Tied Ridges and Raised Beds: Such common practices include the building of soil ridges that may have broad tops (raised beds) or "pointed" ridges (ridging), in which seeds are planted, allowing rain and/or irrigation water to flow through and/or accumulate.

By closing (tying) selected furrows, water is stored for infiltration and soil water storage or groundwater recharge. In CA on permanent raised beds, the beds are reshaped every season prior to planting. Soil disturbance on beds is minimized. Beds alternating with furrows can facilitate furrow irrigation. More recently, this bed shaping is done simultaneously with the planting operation. Research on raised-bed wheat in The Punjab, India, has been very encouraging, both in terms of facilitating early planting to avoid heat stress during wheat maturation and to reduce irrigation costs. This method has been strongly promoted by CIMMYT's scientists. Zaï/Chololo planting pits: This soil water management technique is intended to collect and direct rainfall into planting basins. It is widely applied in Sahelian countries, such as Mali, Burkina Faso, and Niger, and promoted as a WaSA practice in rain-fed agricultural systems in Eastern Africa [14].

The Impact of Large-scale Government led Soil and Water Conservation on Runoff and Soil Loss in the Debre Mawi Watershed shows that runoff reduction was 46% after soil and water conservation program implementation [14], indicating that the interventions have resulted in reduced surface runoff as rainwater was collected and as it infiltrated in the furrows of bunds.

Generally develop appropriate technologies and information on soil fertility, acidity and salinity management, soil erosion prevention, fertility improvement and soil, water and plant as well as atmospheric interaction should be follow up, all activities that improve soil fertility, soil water availability and reduce the loss of nutrient-rich topsoil through erosion like smart in-situ and ex-situ soil conservation such as terraces, soil contour bunds, and perennial crops on sloping lands for increasing production and productivity through soil and water conservation, soil-test methods and fertilizer recommendation will be required.

3.4. Efficient Water-Harvesting and Utilization

Decreasing water availability, but also deterioration of water quality and increasing water use by different sectors (agriculture, domestics, industries etc) urges understanding present and future water use and availability of water in the region in which the relationships is very complex and poorly understood but now get high attention. At experts, managers and community or individual level, understanding of water scarcity and the interaction between its driven factors are very crucial to their level.

At the same time, utilization of water resource are inherently linked to economic development and poverty reduction which shows clear evidence that transitioning towards a more water secure environment can drive economic growth like the Republic of Korea, Malaysia, and Thailand which shows high level leaderships and focus on access to sanitation illustrated as a major driver of the economy [28]. But, even if climate change is one factors, still in a region like Sub Sahara Africa (SSA), available water resources have not been harnessed to maximize their contribution to yield increasing and minimize the impact of drought since many farm are smallholder subsistence farm which depend on rain fed agriculture [1, 31].

3.4.1. Current Status

In SSA issue like low average per capital water resource, uneven distribution of water resource over time and place within regional, national and local context which bring physical and economic scarcity and its spatial distribution is not according to spatial distribution of social economic factors such as population, arable land and mining resources. There is also several pressure on water like poor or aggressive water exploitation, poor trends of soil and water conservation and limited water harvesting and use which can see as excessive water like flood and water lose as well as soil erosion, limited water supply infrastructure which bring inefficient water resource management and integration among stakeholder as well as policy attention are very fragmented which is an outcomes of many factors in addition to natural climate change which resulted in water insecure region.

Agricultural transformation cannot gain through business-as-usual approach unless we devise approaches that address the actual reality of the situation now and in the future especially with regard to climate change [3, 4, 32].

Since, the distribution of water resource in different time is uneven across regional and local area, it is necessary to build a large number of storage facilities to overcome the dry spells and years. For example, Chine has 95.7% small reservoirs, 0.6% large reservoirs and 3.7% medium reservoirs out of 98,000 reservoirs [31], but in contrast developing Countries like SSA which luck inventory of actual and potential capacity of their natural resources especially water and land, even if we see certain improvement here and there, huge work can be ahead.

Therefore, smart infrastructure for efficient water harvesting and use together agricultural and urban water supply water saving transformation, water measurements, water saving technology and innovation promotion), raise awareness of individual, community, government body to mobilize financial and manpower by increasing planning and its implementation capacity that bring huge change together other agricultural transformation drive in fact to transform agricultural sectors in sustainable ways were compulsory.

3.4.2. Water Harvesting Systems

It involves the collection of runoffs from large areas which are at an appreciable distance from where it is being used. They include spring development, shallow well development, flood run off diversion, micro earth dam, cistern, community pond, farm house hold and family pond, roof water harvesting that should be recommended and to be adopted by end users. At the same time, in order to reach the target plan of 2030, Ethiopia need substantial investment on small, medium to large dam construction but more of small reservoir which incorporate multipurpose with its full environmental feasibility and expansion of other infrastructure to bring prosperity at country and house hold level. These require justification of using public resources and searching of diversified funding sources for implementation and their sustainability.

3.5. Irrigation Water Management

Worldwide, over 351 million hectares are currently equipped for irrigation, of which 304 million hectares are equipped for full control irrigation. Yet, the distribution of irrigated land varies widely. Almost 40% of irrigated land is in East Asia and the Pacific region, and more than 30% is in South Asia. Only 5% of harvested land in SSA is irrigated. To develop irrigation for African agriculture, it is necessary to address constraints' like climatic uncertainties and change, water and land resources scarcity, soil fertility and the sustainability in use, cultural, social and economic factors (population growth, increasing food demand, pressure on land and water exploitation, customary rules for land tenure and water rights), technical skills, institutional capacities, development of value chain activities, including market accessibility and services, to complement irrigation development, capacities of countries to undertake heavy investments in agricultural and irrigation sector [32].

Improved irrigation methods like drip irrigation, sprinkler irrigation and use of laser-aided land leveling can also help in increasing water-use efficiency. Laser aided leveling provides smooth and leveled field, which allows ideal water distribution with negligible losses of water. It facilitates uniformity in the placement of seed/seedlings and fertilizer which helps good plant stand, enhanced nutrient use efficiency and increased yield [17].

On-farm water conservation techniques, micro-irrigation systems for better water use efficiency and selection of appropriate crop-based irrigation have to be promoted. Water governance are a right based approach to water for food security and achieving sustainable development, and inclusive growth within Africa would largely be undermined if its water resources are not sustainably managed, utilized, protected and governed.

As the region strives toward improving political, economic and social stability, the importance of secure water supplies will assume increasing significance. If this is neglected, a potential for conflict exists: 1) within and between communities -through a lack of water- and sanitation-related access and services, and 2) between countries- through a lack of agreement on transboundary sharing of water resources and most importantly, 3) between societal constituencies through perceived non-inclusive and equitable sharing of water resources (distributive justice [1].

3.5.1. Managing Irrigation and Drainage Systems

Irrigation can help achieve food security however, expansion of irrigated agriculture and water development are possible in some countries especially in Africa. In most of the other context's modernization of irrigation systems is the only way forward to achieve improved water productivity and therefore food security.

Further development and improvement of global irrigation will involve multiple challenges and emerging needs, including: (i) increasing water scarcity and competition, which calls for more efficient and productive water use; (ii) rapid agriculture restructuring and transformation, which requires more reliable, flexible and diversified agriculture water services; (iii) adoption of agribusiness and value chain approaches, which implies a shift from single-headed irrigation to integrated agricultural water management (AWM); (iv) the shift from the first generation "green revolution" to sustainable agriculture intensification, which highlights social and environmental sustainability; and (v) increasing pressure to meet growing demand for meat and dairy products linked to a combination of population growth, rising incomes and urbanization. In addition to all these, climate change has brought and will bring more impacts, requiring adoption of a climate-smart approach.

Efficiency of irrigation schemes, predominantly surface irrigation schemes and systems, is rather low. If we observe the achievement of Ethiopia and particularly Oromia Region in expansion of efficient irrigation infrastructure, it is in business-as-usual option that clearly revealed by development of irrigation projects so far implemented which mainly focused on abstraction of surface (rivers, lakes) and ground water using diversion weir and Water pumps which implemented up to now. According to 2020 report of Oromia Agriculture and Natural Resource Beroue report, 581,270 hectares of land was irrigated in which 60.6%, 7.9%, 14.1% and 17.3% was traditional irrigation, modern irrigation, private and state as well as other irrigation respectively. At the same time, the report shows functionality rate of modern scheme of the Region are 57%. Similarly, Federal and Regional Government give due attention on expansion of new irrigation project starting from supply of pump, small, medium and large irrigation project in the past two years and even display to create rain fall independent agriculture.

If we observe, typology of modern irrigation scheme distribution in Oromia Region up to 2020, 93% of the schemes are small scale scheme, 6.6% are medium, 0.2 are large scheme and 0.1% is drip and sprinkler type in nature (un-published report of OANRB, 2020) which shows Smart Technology implementation is null. In the last two years, certain large scale irrigation projects are under construction in the Region at this time which includes large dam and micro dam projects and expected to be implemented in mass ahead.

Irrigated agriculture needs to perform better and with higher productivity and efficiency in order to feed the world and provide good livelihood to the farmers. This situation requires that the irrigated agriculture sector moves away from the 'business-as-usual' approach adopts innovative, forward-looking and effective governance to do more with less water. It is even more important if the goal is to achieve a sustainable water and food secure future [1]. Despite the success of implementing new irrigation facilities, equal attention should also be given to sustainability of already constructed irrigation schemes [1, 31].

Technological and technical solutions to improve efficiency and productivity of irrigation water are available, for example shifting, where appropriate, from low efficiency surface irrigation to high efficiency pressurized irrigation; lining of canals using appropriate technology, etc. These technologies and techniques are site and condition specific; and may not work if not accompanied by good operation and management. For these to be successful much needs to be done on soft side for example capacity development of not only farmers but whole chain of actors from decision makers to service providers, to farmers [1].

According to [13] combined allocation, regulation and management of multiple water sources to upgrade overall water use efficiency, reduction of non-productive or other improper agricultural water consumption, upgrading the utilization efficiency of precipitation, use of remote sensing based on ET measurement, implementation of ET-based groundwater, development of alternative water sources, upgraded drainage system standards, establish water storage for flood water are mentioned as example of adaptation measures in water management.

For many developing countries, investment in irrigation will continue to represent a substantial share of investment in agriculture, but the pattern of investment will change substantially from previous decades. Modernization of existing infrastructure can lead to making better use of existing infrastructures should be given priority. It should be based on current and future market prospects and water service needs rather than those needs for which the system was initially designed. Modernization requires serious funding, excellent training, design that has envisioned how the project will operate on a minute-by-minute basis, deliberate and slow implementation, and great attention to detail. There are no quick, magical solutions [11, 23, 35] as well as the issue of climate change and climate impact should incorporate and realizing sustainable Water Smart Agriculture.

3.5.2. Deficit or Supplemental Irrigation

Deficit (supplemental) irrigation, defined as the application of water below full crop water requirements (Evapo-transpiration-ET), is an important tool to achieve the goal of reducing irrigation water use. Deficit Irrigation (DI) is an irrigation management strategy that can be applied by different types of irrigation application methods. The correct application of DI requires thorough understanding of the yield response to water (crop sensitivity to drought stress) and of the economic impact of reductions in harvest. In areas/regions where water resources are limited and scarce it can be more Profitable for a farmer to maximize crop water productivity instead of maximizing the harvest per unit land. Deficit irrigation is one way of maximizing Water Use Efficiency (WUE) for higher yields per unit of irrigation water applied. The main objective of deficit irrigation is to increase the WUE of a crop by eliminating irrigations that have little impact on yield [13].

3.5.3. Furrow Bed (Raised Bed) Irrigation System

Furrow bed (raised bed) irrigation permits growing of crops on beds with less water. This technique has been tested for various crops and has proved quite successful for cotton, wheat and maize. Among the gravity irrigation methods, raised bed technology permits more efficient use of irrigation water as compared to basin or border irrigation. It is observed about 30% water saving for maize and cotton crops under raised beds. Under raised beds technology, the plants are grown on raised beds which not only use Irrigation water more efficiently but also ensure better crop growth under heavy rains [34].

3.5.4. Low Head Trickle Irrigation System

It is recognized that trickle (drip) irrigation system can deliver water and fertilizer to root zone of plants more efficiently than other forms of irrigation. Trickle irrigation is a mean of increasing the efficiency of irrigation water by reducing deep percolation. These are important goals for irrigated agriculture, which faces pressure to reduce environmental impacts. Drip irrigation delivers water and fertilizer directly to the roots of plants, thereby improving soil moisture conditions in some studies; this has resulted in yield gains of up to 40-100%, water savings of up to 40–80% and associated fertilizer, pesticide and labor savings over conventional irrigation systems [35].

3.5.5. Direct Seeding of Rice

The Rice-Wheat cropping pattern is one of the largest agricultural production systems in the world. There are about 1.3 billion or about 20% of the world population is dependent on the system. Rice-Wheat systems cover about 32% of total rice area and 42% of the total wheat area in four countries; Bangladesh, India, Pakistan and Nepal [1]. Dr. Muhammad Aslam of ARS, reported that planting on the raised beds in the Punjab reduces the amount of water needed for irrigation by 30% to 40% and, also improves crop yield by 15% to 25% [17].

3.5.6. Sprinkler Irrigation System

Sprinkler irrigation systems use sprinklers operating at pressure ranging from 70 to 700 kPa (10 to over 100 psi) to form and distribute rain like droplets over the land surface. Sprinkle irrigation uses a spray or jet created by expelling water from a nozzle. The spray is broken up into droplets and acts like a simulated rainfall of controlled frequency, intensity, duration, and droplet size. Sprinkle systems are designed to apply water at rates that do not exceed the soil's rate of infiltration to prevent surface runoff. Sprinkle systems are often a practical alternative for sloped or shallow soils. The uniformity of application generally depends much more on sprinkler position and placement than the soil type [13].

3.5.7. Watercourse Lining

Tertiary irrigation conveyance network in Pakistan is called watercourses. These are community channels off-taking from government/farmers-controlled irrigation canals. Averagely a watercourse commands 150-250 ha of land and serves about 40-50 farm families. Systematic work on watercourse loss measurement was initiated jointly by the Colorado State University and Water and Power Development Authority (WAPDA) [21].

3.5.8. Precision Land Leveling

Uneven soil surface has a major effect on crop germination, stand and yield and it impact water and soil moisture distribution in plant's root system. Therefore, Precision land leveling is a prerequisite for better agronomic, soil, crop and water management practices. Land leveling may minimize erosion and sediment. Leveled fields help reduce the amount of irrigation water and labor. High efficiency surface irrigation is more probable when earth moving elevations are laser leveled. Precision land leveling was introduced in Pakistan during 1976-80 and about 850,000 acres were precisely leveled in the country so far but the major area is in Punjab. Initially, bucket type scrapers were used, which have been replaced by laser beam guided automatic scrapers [15].

4. Summary and Conclusion

Water is one of the prime channels through which the impacts of climate change on the world's ecosystems and on livelihoods will be felt. There is a need for technologies and investments that improve water management efficiency. In non-irrigated areas, water conservation and water harvesting techniques are the only possible alternatives to poor farmers.

Thus, governance of all-natural resource, especially irrigation scheme needs attention right now. Macro-policies for water resource management especially with governance, improve water resource utilization (economic and social lay out verse water resource, monitoring and early warning systems, settlement pattern, over exploitation, under exploitation, flooding), Economic incentive for water saving promotion, management systems for efficient water use, introduction of un-conventional water use, construction of efficient water use infrastructure, agricultural water saving transformation, urban water supply water saving transformation, water measurement, water saving technology and equipment promotion), raise water harvesting and water saving awareness for the whole society (Individual, community, government, institution, expert, elite). This can be done by establishing three lines of defense: ecological rehabilitation, ecological management, and ecological protection as like Ethiopia green legacy to rehabilitate deforested land at all upstream area which is ex-situ and in-situ on the farmer allowable slope farming land, we have to manage our land, water, run-off etc., and protect at downstream our river, ground water, wet land and other ecological units which change the vicious circle of "low illegal cost and high compliance cost" and in the future rehabilitation of these issue will be higher.

Therefore, to harvest water at household, community, water shade level and basin which ensure integration with other determinate factors for agricultural transformation is a mandatory aspect to ensure sustainable development.

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