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Impacts of Soil Salinity on Irrigation Potential: In the Case of Middle Awash, Ethiopian Review

Fikadu Robi Borena*, Jemal Mohammed Hassen

Ethiopian Institute of Agricultural Research, Werer Agricultural Research Center, Addis Ababa, Ethiopia
Email: *fikadurb@gmail.com

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Abstract

Salt-affected soils are widespread in arid and semi-arid areas irrigated around the world, where low-quality irrigation water is common. Every minute, the world loses at least ten hectares (ha) of arable land, three hectares of which are due to salinization issues, particularly in the irrigated desert and semi-arid regions. The cost of soil salinization for agriculture is now estimated at more than $12 billion per year and is expected to increase as soils are increasingly impacted by irrigation water shortages. Twenty percent (20%) of salt-affected soils (15 million hectares) on the African continent are man-made. The total area of land affected by salinity in Ethiopia is 11,033,000 ha and ranks first in Africa. In irrigated arid and semi-arid areas of Ethiopia, particularly in the Afar region (Middle Awash), salinity is a serious problem. In the middle Awash, 2280 ha of land in Melka Sedi (500 ha), Metehara (300 ha), Kesem (145 ha), Werer State Farm (56 ha). Saline soils have a negative impact on plant development at the cellular level, due to the increased osmotic pressure in the soil solution. To reduce soil salinity, several remediation approaches have been developed, including engineering remediation and phytoremediation. The purpose of this study is to evaluate the literature on the effects of soil salinity on irrigation potential in the middle Awash of Ethiopia.

Subject Areas

Geology

Keywords

Physical Remediation, Chemical Remediation, Phytoremediation, Soil Salinity

1. Introduction

For centuries, soil salinity has been affecting humanity [1]. This soil salinization is induced by natural or human processes in the earth system. Traditionally, the physical behaviour of salt-affected soils has been characterized in terms of the combined impacts of soil salinity, assessed by the electrical conductivity of a saturation extract (ECe) and the Exchangeable Sodium Percentage (ESP), on flocculation and soil dispersion [2]. Salinization now threatens approximately 20% of the world's irrigated crops [3]. Soil salinization refers to saline, sodic, and alkaline soils [4] [5] [6] [7] [8]. It is a global problem that threatens crop growth and yield, while also preventing the long-term development of modern agriculture [9] [10].

Natural or anthropogenic processes on the earth system produce salinization of the soil. Currently, salinization threatens approximately 20% of irrigated crops around the world. In arid and semi-arid areas where rainfall is insufficient to sustain the normal percolation of precipitation through the soil and irrigation is carried out without a natural or artificial drainage system, salt-induced degradation of the land degradation is prevalent [3] [7] [11]. This is worsened in arid and semi-arid parts of the country, where saline irrigation accounts for 30% of irrigated crops [3], and is also a major problem in places where high-salt groundwater is utilized for irrigation [12] [13].

Every minute, the globe loses at least ten hectares of arable land, five hectares owing to soil erosion, three hectares due to soil salinization, one hectare due to various soil degradation processes, and one hectare due to non-agricultural uses [14]. Soil salinity is expected to affect 3,230,000 km^2 in more than 100 nations around the world, and these figures steadily increasing [7] [15] [16] [17]. Excess salt accumulation in the root zone, resulting in a partial or complete loss of soil productivity, is a common problem in irrigated areas [18]-[23].

Irrigated agriculture began in the late 1960s on the Melka Sedi and Melka Werer state farms in Middle Awash, Ethiopia. The soils of the agricultural region were generally non-saline and the area's groundwater table was less than 10 meters [24]. Over the last decade, Ethiopia's soil salinity problem has worsened to the point that farmers are experiencing major crop losses and many farms have gone out of business.

Various academics, including the Ethiopian Institute of Agricultural Research and Universities, have conducted soil salinity research in different regions of the country at different times. In the Amibara irrigation scheme, for example, the problem of soil salinity was studied and mapped by [25], soil salinity modelling [26], evaluation of soil and water salinity [27], Salinity and sodicity hazard characterization [28], salinization pattern and its spatial distribution in the irrigated agriculture of Northern Ethiopia [29], assessment of salinity and soil sodicity status of soils of Metahara Sugar Estate [30], prospects of alternative copping systems for salt-affected soils in Ethiopia [31], improving agricultural productivity on salt-affected soils in Ethiopia: Farmers perceptions and proposals [32], assessment of salinity and soil sodicity status of soils of Metahara Sugar Estate [30], top-soil salinity mapping using a Geostatistical approach in the agricultural landscape of the Timuga irrigation scheme, South Tigray, Ethiopia [33], effects of soil texture and groundwater level on salt leaching from saline fields in the Kesem irrigation scheme, Ethiopia [34], conductivity as a predictor of total cations and salinity in Ethiopian lakes and rivers: revisiting earlier models [35], land degradation: a challenge to Ethiopia [36], the effect of salinity on yield and yield-related traits of some accessions of Ethiopian lentil (*Lens culinaris* M.) under greenhouse conditions [37], the effect of salinity stress on germination of chickpea (*Cicer arietinum* L.) land race of Tigray [38], desertification in Ethiopian highlands, Norwegian Church Regional Senior Consultant on Environment and Natural Resource Management [39], characterization and classification of salt-affected soils and irrigation water in Tendaho sugarcane production farm, North-Eastern Rift Valley of Ethiopia, etc [40]. In recent years, salt-affected land has increased from 6% to 16% of Ethiopia's total area [39]. Several studies have found that Ethiopia ranks first in Africa in terms of the area of salt-affected soils caused by human and natural sources [32].

According to a recent report, approximately 44 million ha (36% of the total land of the country) are potentially susceptible to salinity problems, 33 million ha having dominant salinity problems, 8 million ha having combined salinity and alkalinity problems, and 3 million ha having dominantly alkalinity problems [26]. Salt affects approximately 12 million acres of land in the eastern and southern dry and semi-arid regions [36], and the semi-arid and arid lowlands and the mid-Awash Valleys have significant concerns about salt and alkalinity concerns [26]. This is due to the lack of rainfall (less than 400 mm) and the high evapotranspiration conditions [41]. This represents 9% of the total landmass of the country and 13% of its irrigated area [42]. These soils are located in the Rift Valley, the Wabe Shebelle River Basin, the Denakil Plains, and numerous other lowlands and valleys around the country, where approximately 9% of the population resides [43] [44].

1.1. Ethiopia's Irrigation Development: Its History and Current Status

Agriculture is Ethiopia's most important economic sector and a major source of food, and is heavily dependent on rainfall. It accounts for 43% of GDP, 80% of employment, and almost 75% of the value of export commodity values [45]. Ethiopia has a relatively new history of modern irrigation development. The development of irrigation is rarely investigated, monitored or evaluated. As a result, there is a paucity of published information on irrigation development. Even the facts and data about irrigation provided from different sources disagree. The following documents were considered in this review: published papers, annual and strategic plans, reports from the Ministries of Water, Irrigation, and Energy and Agriculture, as well as proceedings from seminars and Ministries of Agriculture. According to preliminary reports, Ethiopian small-scale irrigation development dates back more than 2000 years and certainly predates the Axum kingdom [46]. Medium- and large-scale commercial irrigated farms have begun in the Upper and Middle Awash River Basin (**Figure 1**), one of the most intensively cultivated basins in the country.

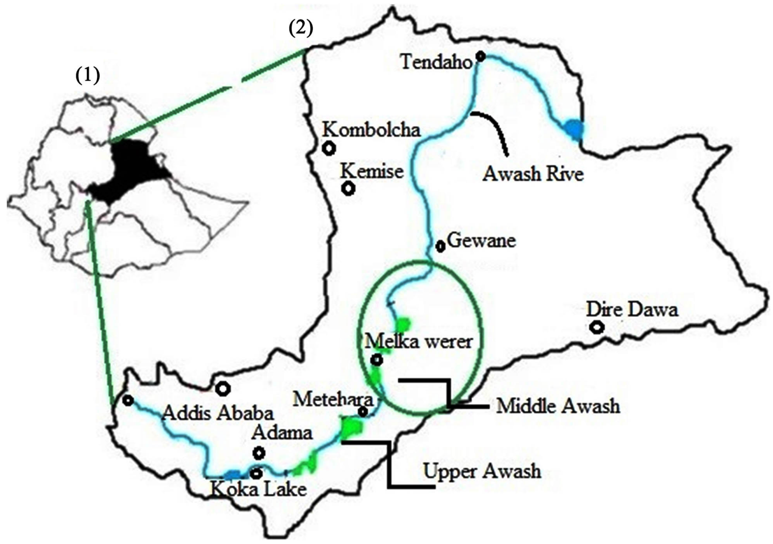

Figure 1. Location map, Ethiopia with its major river basins (1) and Awash River Basin, and (2) In the Middle Awash, Amibara, and Kesem Sugar Estate, modern irrigation has begun.

There was no significant irrigation development activity between 1991 and 1995 because it was considered a transitional time (to federalism). With the announcement and implementation of a series of national economic development plans and programs, the rise of medium- and large-scale irrigation rose dramatically. The Sustainable Development and Poverty Reduction Program (SDPRP, from 2002/03 to 2004/05); the Plan for Accelerated and Sustained Development to End Poverty (PASDEP, from 2005/06 to 2009/10); and the Growth and Transformation Plan (GTP I, from 2010/11 to 2014/15) and GTP II, from 2015/16 to 2019/20, are some of the development programs and plans implemented during that time. The development of irrigation was prioritized in all of these schemes (**Figure 2**).

Small-scale irrigation development has been critical to Ethiopian administrations' goals to ensure food security and livelihoods for the country's rural population, which represents more than 80% of the population. However, due to a lack of governmental stability and direction, its execution during the pre and post-revolutionary periods was stalled. With the implementation of the three successive programs, PASDEP, GTP I, and II, encouraging progress in the development of small-scale irrigation has been made (**Figure 3**).

According to a report by Annys, Van Passel [47] in Ethiopia, small-scale irrigation has grown from 176,105 hectares in 1991 to 197,250 hectares in 1998, 853,000 hectares in 2009/10, 2.353 million hectares in 2014, and 2.528 million hectares by the end of 2019.

1.2. Drivers and Type of Salinization in Ethiopia

Irrigated agriculture began in the late 1960s on the Melka Sedi and Melka Werer farms in Middle Awash. The soils in the agricultural region were generally non-saline

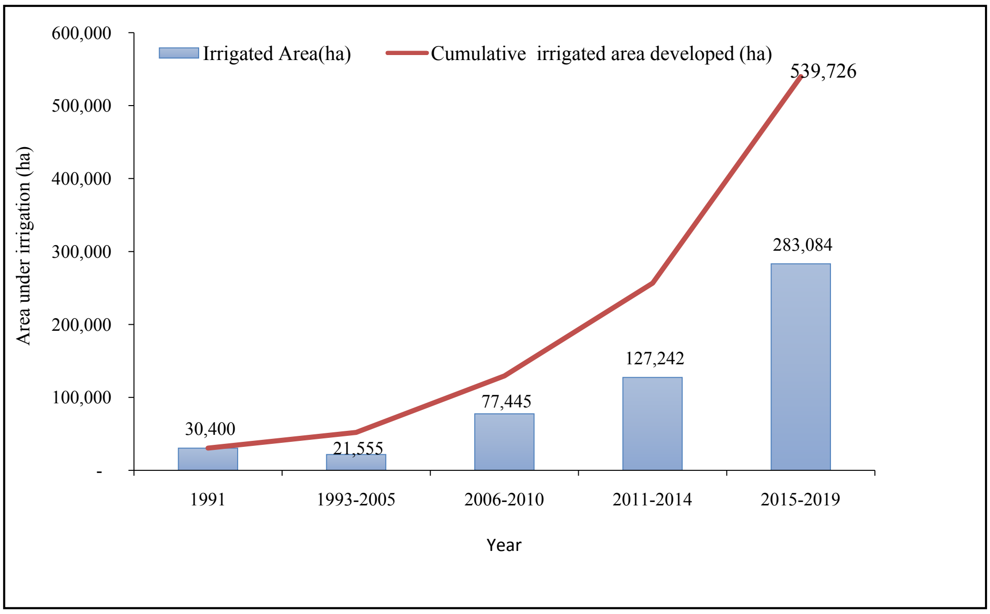

Figure 2. Over three decades, the area has been equipped for medium- and large-scale irrigation. Source (84).

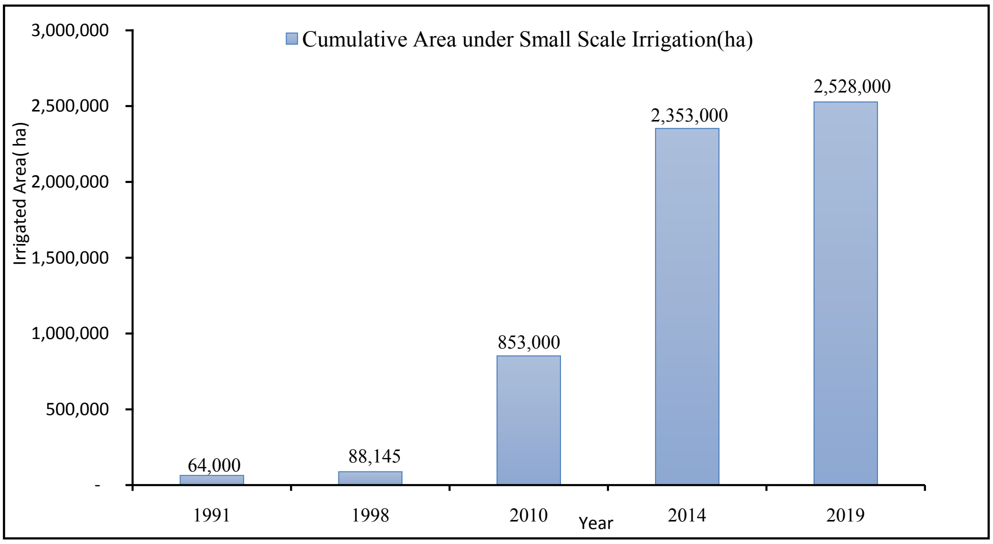

Figure 3. Over the previous three decades, the total amount of land equipped for small-scale irrigation (ha). Source: The plans and reports of MoA and MoWIE have been used to compile this list.

and the groundwater table in the area was less than 10 meters deep [24]. The evapotranspiration-induced evapo-concentration process produces an increase in salt in the crop root zone [48], and the effects of salinization on agricultural land are especially concerning in terms of future food security [11] [49]. The salt concentration rises if salts are not leached out of the crop root zone. All salts in the soil are derived primarily from the minerals found in the exposed layer of the Earth's crust. Salinization has a negative impact on the environment, agro-ecosystems, agricultural production, and sustainability [1]. This is due to the complicated degradation dynamics of soil and water resources, which has a direct influence on food security and livelihoods, further compromising the biophysical and socioeconomic foundation of the society. The use of low-quality irrigation water, along with extensive watering of soils, leads to the development of salinity-affected irrigated agriculture [50]. Ethiopia's semi-arid and arid lowlands and valleys face serious salinity and alkalinity concerns. The origins of salinization could be natural, referred to as the main causes, or man-made, referred to as secondary causes [6] [51].

1.3. Primary Salinization

The occurrence of salts through natural processes such as physical or chemical weathering and transfer from the source material, geological deposits, or groundwater is termed primary salinization. The presence of salts in irrigation water is mainly due to the chemical weathering of soil minerals [48]. Due to the components of the parent rock such as carbonate minerals and/or feldspar, soil can be salt-rich. The salt content in groundwater and, as a result, in overlying soil layers can be raised by geological occurrences or specific formations that are directly related to this. After capillary processes or evapotranspiration cause salinity-affected groundwater to rise, previously dissolved salts might concentrate at or near the surface [52] [53]. While irrigation from very saline water, such as polluted groundwater from saltwater, is the primary source of chronic or increasing salt build-up in the upper layers of the soil, minor difficulties can occur even when sufficient quality water is used [53] [54] [55].

1.4. Secondary Salinization

Secondary salinization is also known to be facilitated by poor drainage and inadequate irrigation water management [25]. Dissolved mineral salts are present in all irrigation water; however, the concentration and composition of dissolved salts vary depending on the source of the water and the time of year. Because salts can hinder plant development, water managers must understand the concentration and composition of irrigation water at various times of the year [48]. Secondary salinization is also known to be facilitated by poor drainage and inadequate irrigation water management [25]. Secondary salinization of fields occurs in the region, mainly as a result of irrigation with salty water or other ineffective irrigation practices, which are commonly paired with poor drainage conditions [12] [13]. Due to a climate dominated by low rainfall and high evapotranspiration rates, a poor drainage system, mismanagement of irrigation water, and soil characteristics that impede salt leaching, arid irrigated regions are important secondary salinization hotspots. Increasing salt build-up in the upper soil layers is caused by irrigation from highly salty water sources such as saline lakes and contaminated groundwater; however, moderate problems are discovered even when sufficient quality water is used for irrigation [53] [54] [56] [57] [58] [59].

2. Salinity Distribution in Ethiopia's Dry Lands: The Instance of Middle Awash

In irrigated areas, the issue of soil salinity is especially severe. Compaction and structural disintegration have resulted from rising levels of saline in Ethiopia's arid and semi-arid regions, causing physical and chemical degradation of irrigated lands. Large state-owned irrigated farms in the Rift Valley's Awash Valley are fast losing their agricultural yield due to increased soil salinity. Soil salinity affects roughly 80% of Dupti (Tendaho state irrigation scheme). According to recent estimates, saline soils account for 27%, saline sodic soils for 29%, and sodic soils for 24%. Between 1972 and 2014, the amount of salt-affected soils increased rapidly due to a variety of issues, such as poor irrigation techniques, the use of low quality irrigation water, and a lack of drainage systems. Groundwater levels have increased due to excessive irrigation, causing salinity to develop in these soils [31].

The soils of the Melka Sedi-Amibara irrigation scheme in the middle Awash Valley are extremely saline, with ECe values ranging from 16.6 to 18.6 dS/m (**Table 1**). The primary soluble salt elements at all levels of the profile are soluble Na^+, Ca^{2+}, Cl^-, and SO_4^{2-}. As a result, the predominant soluble salts that contribute to the exceptionally high salinity level of these soils are sodium chloride and calcium sulphate salts [30].

Salinization is becoming more common in irrigated areas as a result of inadequate irrigation and drainage management. Salinity concerns threaten 36% of the country's total land area 44 million hectares [39]. Salt-affected areas have increased from 6 % to 16 % of Ethiopia's total land area [61] (**Figure 4**).

The Impact of Salt on Irrigated Farms in the Middle of Awash

Management of soil salinity in irrigated areas requires the leaching and drainage of excess water and salt [62]. The leaching-induced soil desalinization process is a well-established and approved approach [63] [64]. Leaching is by far the most efficient way to eliminate salts from soil root zones among known salinity mitigation strategies [21] [65] [66]. Soil sodicity is also an issue in the arid and semi-arid areas of Ethiopia. As a result of the high salt concentration in the soil, the soil sodicity results in a high pH (alkaline). Approximately 425,000 hectares of Ethiopian soils are estimated to be sodic, mainly in arid, semiarid to sub humid conditions [67]. From an agricultural point of view, the main feature of sodic soils is that they contain enough exchangeable salt to inhibit the development of most crop plants.

Sodic soils are those that have an Exchangeable Sodium Percentage (ESP) greater than 15. Excess exchangeable salt has a negative impact on the physical and nutritional characteristics of the soil, resulting in a considerable or complete decrease in crop growth. High concentrations of Na^+ in sodic soils displace cations such as Ca^{2+} and Mg^{2+} and remain attached to clay particles, causing severe structural deterioration. As more exchangeable sodium is hydrolyzed, links

Table 1. Chemical composition of the soil profile of the Melka Sedi-Amibara Plain of the Middle Awash valley.

Depth (cm)	ds/m	Soluble Cations				SAR	Soluble anions			
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}		CO_3^-	HCO_3^-	Cl^-	SO_4^{2-}
0 - 25	18.6	59.4	3.7	208.1	15.4	37	Nill	1.1	165.8	77.1
25 - 50	17.8	55.5	3.3	197.6	14.4	36.4	Nill	1	160.2	71.8
50 - 70	17.5	53.1	3.7	197.5	14.1	37	Nill	1	157	68.5
70 - 90	17.2	51.5	3.4	120	13.7	22.9	Nill	1.4	147	64.3
90 - 120	16.6	47.3	3.1	132.5	10.6	26.4	Nill	1	132.4	59.9

Source: Prospects of alternative copping systems for salt-affected soils in Ethiopia [60].

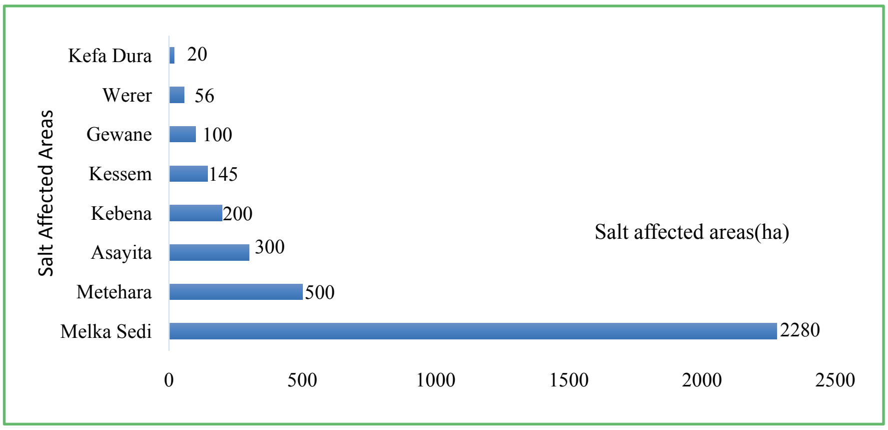

Figure 4. Salt affected soil affected by salt in the middle awash [25].

between soil particles weaken, expand, and often be detached, resulting in increased dispersibility and susceptibility to erosion by water and wind.

As exchangeable sodium is hydrolyzed to a greater extent, the links between soil particles weaken, expand, and often detach, resulting in increased dispersibility and susceptibility to erosion by water and wind [68]. In low CO_2^- low neutral salt conditions, exchangeable sodium and $CaCO_3$ react to generate a high pH and detectable Na_2CO_3 concentrations. Because arid and semi-arid soils almost always contain some calcium carbonate, an accumulation of exchangeable sodium in the absence of a significant amount of neutral soluble salts will always result in a high pH; the precise number depends on the concentration of Na_2CO_3, produced, or the degree of ESP. Sodic soils grow thick, clumped, and dispersed when natural aggregation is disturbed. At the surface of the soil, the dispersed clay can act as an adhesive, forming relatively thick crusts that impede the growth of the seedlings and their emergence. The degree of crusting is determined by the texture of the soil, the mineralogy of the clay, the exchangeable sodium concentration, the impact energy of the raindrops and the drying speed. Soils with a high concentration of montmorillonite clay will fracture when dried [21].

Between 2011 and 2014, the Werer Agricultural Research Center in Ethiopia conducted studies on four forage crop species: Cinchrus species, Panicum antidotale, Sudan grass, and Cinchrus gayana, as well as three legume species: Desmodium triflorum, Sesbania sesban and Medicago sativa, which showed promising results in terms of salinity tolerance, biomass yield, and ameliorative effects (Alfalfa). Cinchrus spp., P. antidotale, Sudan grass, and Chloris gayana were exposed to salt stress levels with mean ECe values of 8.2, 10.4, 12.7, and 17.9 dS/m, respectively. The biomass yields achieved under saline soil conditions were similar to those obtained under normal soil conditions. Compared to other grass species, C. gayana is the best suitable salt-tolerant feed crop for Ethiopian salt-affected areas. These findings back with Deifel *et al.* [69] claim that Cinchrus gayana is the most salt-tolerant grass.

Ecological Functions

The greatest influence on soil ecological functions is caused by soil salinization. Increased EC has been found to negatively impact important soil processes such as respiration, residue break down, nitrification, and denitrification by decreasing soil biodiversity and microbial activity. Saline soils contain a negative feedback loop of soil organic carbon loss in the form of decreased fertility, microbial and enzyme activity [70]. This results in reduced biomass production, which has a negative impact on the distribution and stability of soil aggregates [71]. These modifications improve the dispersion of clay particles and the rate of wind and water erosion [68]. This exacerbates the loss of organic carbon in the soil. Soil salinization, depending on its shape and stage, destroys fertile and productive land to the point of eradicating all vegetation [12] [58].

3. The Influence of Soil Salinity on Irrigation Potential

Salinization is becoming more common in irrigated areas as a result of inadequate irrigation and drainage management. Salinity concerns threaten 36% of the country's total land area 44 million hectares [39]. Salt-affected areas have increased from 6% to 16% of Ethiopia's total land area [61]. The Middle and Lower Awash are significant cotton and onion producing areas in Ethiopia. However, most agricultural land has been abandoned in the last decade due to inherent soil salinity, shallow saline groundwater, and inadequate irrigation water management. Most of the development of irrigation projects did not involve the installation of a drainage system. The construction of large-scale irrigation projects in the Amibara irrigation scheme without effective drainage systems and adequate water management technologies has resulted in a continuous increase in salty groundwater tables. In this location, almost 10,000 acres of agricultural land have been abandoned. The main farms of the scheme are currently out of production and plagued by prosopis juliflora weeds. This weed grows in harsh conditions and is very salt-tolerant.

According to reports, salt has damaged almost 11 million acres of agricultural land in Ethiopia [72] [73]. The Awash basin is an excellent example, where salinization has been a major problem in several large- and medium-scale irrigation schemes, most notably the Amibara irrigation scheme in the Middle Awash and the Metahara sugar plantation. Soil salinity is a significant factor in desertification, mainly attributable to human activity. Large sections of the middle and lower reaches of the Awash basin (Dupti, Asayta, and Afabo) are also salty or sodic or are in the process of becoming saline or sodic, and therefore potentially subject to salinization and sodicity.

The Amibara irrigation project has salt-affected soils, and 6000 to 7000 hectares of land have just been taken out of production. Cotton and onion yields have decreased due to an increase in soil salinity in the Amibara irrigation project. According to Halcrow (1983), the total agricultural land in 1999 was approximately 815.44 ha (eight hundred and fifteen hectares), 2240 ha (two thousand two hundred forty) in 2003, approximately 4000 ha (four thousand hectares) in 2009, and more than 300 ha (three hundred hectares) on the Melka Sedi farm.

3.1. Field Symptoms

A soil salinity symptom is a sign or indicator that the soil is being affected by salt. Salt crystals and stains (such as light grey or white) on surface soils are physical markers of soil salinity. A barren area of land may suggest excessive salt concentrations in the soil, which inhibits plant development and causes the soil to dry more slowly [74].

3.2. Factors Affecting Crop Salinity Tolerance

Plant tolerance to soil salt is not a fixed trait of any species or variety but can change depending on the environment. Salinity tolerance can even differ depending on the stage of crop development in the same species [21] [75]. This is often caused by unusually high salt concentrations in the shallow surface zone where seeds are placed, rather than by crops being particularly sensitive during germination. The salt left behind as the rising water evaporates near the soil surface causes these high salt concentrations. In the center of Awash, various significant crops have grown. During germination, most plants are more vulnerable to salinity than at any other stage of growth. However, the sensitivity of germinating seeds to salt varies greatly. Onions, sugarcane, wheat, maize, sorghum, peanuts, sesame, and rice are the main crops. Rice's tolerance for salinity falls as it advances from panicle development to blooming, according to an experiment done in the Werer laboratory, and salinity stress at this phase inevitably results in lower grain yields. Salinity has been found to have less of an impact on straw weight and total number of tillers than grain yield and number of productive tillers, and that inflorescence is gradually delayed and the number of sterile spikelets increases as salinity increases.

Environmental Determinants

Plant responses to salinity are strongly influenced by climatic circumstances. Under controlled conditions, effect of transpiration rate on the accumulation of sodium and chloride ions near the root surface of maize and wheat crops [76]

[77]. The salt and chloride concentration of the soil adjacent to the roots was shown to be linearly related to the total amount of water transpired by the plants as well as the water transpired per unit root length in their research. According to these studies, the amount of stress that plants experience in saline soils is governed by their evaporative requirement during growth, which could be substantially higher than the electrical conductivity of the bulk soil (**Table 2**).

3.3. Irrigation Water Quality

The main source of irrigation water in the Middle Awash Valley is the Awash River, which originates in Ethiopia's central highlands [79]. The quality of its water changes spatially and temporally from upstream to downstream. As a result, the irrigation quality of the Awash River should be monitored monthly or yearly. Dissolved salts are present in all irrigation water; however, the amount and composition vary depending on the water source and may also alter over the growing season. In irrigated agriculture, concerns about water quality include salinity, sodicity, and specific-ion toxicity.

The water and nutrients in the root become less accessible to the plant as the salt concentration of the soil water increases. Two of the most common water quality variables that influence the average penetration rate are the salinity of the water and its sodium content relative to the calcium and magnesium concentration. Excess amounts of chloride, boron, and sodium ions in irrigation water can be harmful to normal plant growth. The total salt concentration of irrigation water is the single most important salinity evaluation criterion. In dry years, prolonged use of irrigation water from the Awash River in June can create salinity-related difficulties only in susceptible crops [79].

The salinity and combined impact salinity and sodicity values were below the FAO recommendations for the irrigation water quality limitation limit. As a result, there should be no salinity issues if the Awash River water is used for irrigation in the Middle Awash region. However, in June, special attention must be paid to delicate crops. The use of water from the Awash River for irrigation does not have specific-ion toxicity hazards [79].

Table 2. Tolerance of crops to salts in two stages of growth.

Crop	Germination stage	Established stage
Barley	Very good	Good
Corn (maize)	Good	Poor
Wheat	Fairly good	Fair
Alfalfa	Poor	Good
Sugarbeet	Very poor	Good
Beans	Very poor	Very poor

Source [78].

4. Reclamation of Salt Affected Soil

The methods for recovering salt-affected soils differ depending on the kind of issue and its severity. Before any restoration operations can begin, classifications of salt-affected soils (saline, saline-sodic and sodic) must be mapped. Osmotic stress (increased osmotic pressure) limits development by reducing soil water availability and increasing the energy required to extract moisture from salty soil, which would otherwise contribute to growth [75]. Water, crop, and amendment techniques are becoming an increasingly significant tool in many parts of the world to improve agricultural output. Traditionally, reclamation has been motivated by the desire to convert marginally arable land to agricultural use by lowering the levels of salinity, exchangeable Na, and B in the soil.

As a result, crop yields and the number of crop species that can be produced in a particular area increase. However, adverse amounts of these chemicals can also be induced by other causes such as under irrigation (not supplying enough water for leaching), insufficient drainage, and irrigation with moderately saline-sodic waters. The use of such low quality waters is increasing as municipal needs for available sources of high quality water increase, as does the need to dispose of municipal waste and agricultural drainage waters. As a result, a strong grasp of soil reclamation will become an increasingly crucial component of water and soil management to ensure the long-term viability of irrigated agriculture. Understanding soil reclamation will become an increasingly critical component of water and soil management to ensure the long-term viability of irrigated agriculture. Water flow into and through soils is a major component of salt-affected soil restoration. With a decrease in soil salinity and an increase in exchangeable Na, infiltration rates and Hydraulic Conductivities (HC) decrease. Due to the mechanical impact and stirring effect of the supplied water, low soil salinity and exchangeable Na levels affect infiltration rates more significantly than hydraulic conductivities. The following are some of the most widely used or proposed methods for reclaiming salt-affected soil.

4.1. Leaching

This is by far the most efficient method for eliminating salts from the soil's root zone. The most common method of leaching is to pond fresh water on the top of the soil and allows it to permeate. When salty drainage water is discharged through subterranean drains, the leached salts are carried out of the reclamation region. When there is sufficient natural drainage, such as ponded water drainage without raising the water table, leaching may reduce salinity levels in the absence of artificial drains. When the soil moisture content is low and the groundwater table is high, leaching is advised. Because a large amount of water evaporates during the warmer season, leaching is less effective. The final decision will be based on water availability and other factors. In parts of Ethiopia's Middle Awash region, leaching is suggested before planting. This is also the only technique to divert a considerable amount of fresh water from the Awash River for reclamation purposes.

4.2. Flushing

Desalination of soils with surface salt crusts is sometimes accomplished by rushing water over the surface and washing away the accumulated salts. Because the amount of salts that may be flushed from a soil is quite modest, this approach is of little utility.

4.3. Amendments

It is a question of practical importance whether or not an amendment (such as gypsum) is required for the reclamation of salt-affected soils. Neutral soluble salts predominate in saline soils, and sodium chloride is frequently the dominant salt at high salinities, despite the presence of sufficient calcium and magnesium to meet plant growth requirements. Because sodium chloride is the most common soluble salt in saline soils, the SAR of the soil solution is likewise high.

According to Dieleman (1963) [81] and Leffelaar and Sharma (1977) [82], an amendment may not be required to reclaim saline soils with high SAR. The decision to employ an amendment for the reclamation of saline soils with surplus neutral soluble salts and a high SAR of the soil solution (saline-sodic soils) would be based on soil infiltration properties and irrigation water electrolyte levels. The application of gypsum is unlikely to benefit light-textured soils or those with a high infiltration rate. The application of an amendment is desirable in heavy textured soils and in areas where such soils are leached with low electrolyte water to expedite reclamation. When a large-scale reclamation is carried out, the necessity for changes and their quantities must be determined through small-scale testing.

5. Conclusion

In general, soil salinity is dynamic and growing internationally in more than 100 nations; no continent is totally devoid of salt. In Ethiopia, the irrigation farm in the study area of Amibara irrigation scheme of Melka sedi region (Middle Awash Valley), which spans approximately 14,200 hectares of net irrigable land in the Awash River Basin, faces variable degrees of salinization and increased water levels. The main source of salt in the Middle Awash is improper irrigation water management and inadequate drainage, resulting in a massive social and economic disaster. Salinization produces occupational and geographic shifts in the agricultural population, as well as a decrease in aggregate national income and spending. Different engineering-based remediation techniques have been developed to decrease soil salinity, including physical remediation, chemical remediation, and phytoremediation.

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Conflicts of Interest

The authors declare no conflicts of interest.

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