MANAGING RISKS OF WATER AND SOIL SALINITY ON WATER USE EFFICIENCY

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ABSTRACT

Salinity is a major problem affecting crop production all over the world. About 20% of cultivated land in the world, and 33% of irrigated land are salt-affected and degraded, which intensively affects food security. Many researches pointed to its negative impact on yield reduction. Although most previous researches addressed the problem of salinity using stochastic data, they used deterministic methods. This paper aims to use stochastic methods to assess risks of salinity on water use efficiency, and propose strategies to mitigate these risks. Management actions and policies are proposed to manage yield reduction and water use efficiency and mitigate salinity risks. This study expected yield reduction due to major causes of soil salinity. Adopting the suggested strategies could reduce or eliminate the impact of salinity.

Keywords: salinity, food security, irrigated land

Cite this Article: Mahmoud Amer*, Osama Wahed, Hany F. Abd-Elhamid and Walaa Y. El-Nashar, Managing Risks of Water and Soil Salinity on Water Use Efficiency, International Journal of Civil Engineering and Technology, 11(03), 2020, pp.177-191

<http://iaeme.com/Home/issue/IJCIET?Volume=11&Issue=3>

1. INTRODUCTION

Salinity is the presence of soluble salts in soils or waters. Salinity is natural process closely linked with landscape and soil formation processes. However, human activities accelerate salinity processes, contributing long-term land and water degradation. Salinity usually becomes when the concentration of salt or sodium adversely affects plant growth (crops, pastures or native vegetation) or degrades soil structure. It becomes a water issue when the potential use of limited saline water. Salt is derived from the weathering of the earth's crust and is transported and deposited in the landscape by hydrologic mechanisms (rainfall and water movement above and below the terrestrial surface). Salinity processes are also affecting land by agriculture distortion the natural hydrologic equilibrium in a landscape. Salinity is usually developed gradually over an extended period of time. A high salt concentration in soil solution reduces the ability of plants to acquire water, which is referred to as the osmotic or water-deficit effect of salinity. Damage occurs when the concentration is high enough to begin reducing crop growth. The osmotic effect of salinity induces metabolic changes in the plant identical to those caused by water stress-induced "wilting" [Munns, et al., (2002)]. The U.S. Salinity Laboratory in 1943 suggested one of the earliest water quality schemes of classification for irrigated agriculture [Wilcox, (1955)]. Three classes is involved; Class I, Excellent with electrical conductivity less than 1 ds/m and; Class II, Good to injurious with electrical conductivity 1-3 ds/m; Class III, Injurious to unsatisfactory with electrical conductivity more than 3 ds/m. Ikramov, (2004) studied the soil salinization caused by shallow groundwater table and waterlogging. Ibrakhimov, et al., (2011) analyzed the effects of different groundwater table on soil moisture and salinization and determined optimal ranges of groundwater table so improved drainage system is necessary to control the ground water table. Forkutsa, et al., (2009) indicated that adjusting irrigation timing and amount will be needed to lower groundwater table and reducing salinization. Kahlown and Ashraf, (2005), Cui, et al., (2010) and Soyulu, et al., (2014) studied the effect of soil water salinity and groundwater depth on the degree of water and salinity use, the transport characteristics of salinity in soil water and plant growth conditions. Guswa, et al., (2002), Il'ichev, et al., (2008) and Cui, et al., (2010) indicated that the combined effects of groundwater water level and soil water salinity are more significant in semi-arid and coastal plain regions with shallow groundwater table. Shahid, (2013) indicated that there is no single method to reclaim all types of salt-affected soils; therefore, site specific diagnostics based (salinity, sodicity in depth soil features based) integrated approach (including physical, chemical, hydrological, and biological methods) of soil reclamation is to be adopted for better results. Chen, et al., (2010) studied the effect of trickle irrigation system on salts accumulated in soil profile using two irrigation water salinity. CANADA.DEPARTMENT, (1968) showed that excess water becomes a problem when it interferes with land preparation, plant growth and other farming operations. Surface runoff, deep percolation, evaporation, and transpiration remove a lot of the excess water naturally. When the removal is impeded, either on the surface or in the subsoil, salinity and drainage problems develop and you must then provide artificial drainage. Qadir, et al., (2014) showed that salinity is an issue that will only grow in importance and urgently requires a solution because of a growing human world population and climatic

changes on a global scale. Ibrakhimov, et al., (2011) stated when the ground water (GW) tables are lowered further to reduce salinization, irrigation timing and amounts will need to be adjusted to meet the changed situation. Maas, (1984) classified the crop tolerance to salts and states the threshold of most important crops. Kurbanbaev and K., (2006) claimed the leaching required to avoid salt accumulation in soil. U.S.Salinity.Laboratory.Staff, (1954) clarified an equation to estimate the water stress caused by soil salinity on crops. Castillo, et al., (2007) studied the effect of soil salinity on osmotic stress and yield reduction for rice as a sensitive crop. Thimmappa, et al., (2015) studied the quantity of gypsum required for reclamation which depends on the amount of exchangeable sodium to be replaced in soil by laboratory tests carried out on the surface soil (0-15 cm). Christen and Ayars, (2001) studied the drainage rate required to control water table to protect the irrigated land. Katschnig, et al., (2013) studied Salicornia as a salt tolerant crop to be irrigated with seawater. Niu, et al., (2012) studied the effect of soil salinity on yield reduction of *Jatropha*. Shannon, et al., (1999) studied the effect of soil salinity on yield reduction of poplar. Pessarakli, (2016) stated the methods of soil reclamation for different types of salt-affected soil. Novikova, et al., (1981) showed the method of soil leaching using sprinkler irrigation. Vargas, et al., (2018) studied leaching of saline soils by sprinkler irrigation in combination with vertical drainage systems and chemical amelioration treatments.

This study aims to assess soil and water salinity stochastically then evaluate these risks on water use efficiency qualitatively and quantitatively and propose strategies to mitigate these salinity risks.

2. IMPACT OF SALINITY

Salinization takes place when the GW with salinity more than 3 gm/L is 2.0 m and shallower, and that the GW should not rise above 1.5 m when salinity less than 3 gm/L. [Kiseliova and Jumaniyazov, (1975)]. At this range of GW levels the actual crop yield nearly reaches the maximum attainable [Dukhovny, (1996)].

Salinity affects crop yield reduction, soil electrical conductivity values and freshwater ecosystem as following:

1. More than 20,000 ha had to be taken out of cultivation due to high level of soil salinity, and the loss is estimated at a total of 30,000 tons of cotton per year. [FAO, (1971)]
2. The yield decreased by 50% in about 30,000 ha, and the total loss is estimated at 20,000 tons of cotton per year. [FAO, (1971)]
3. The yield decreased by 20% in about 60,000 ha, and the total loss is estimated at about 18,000 tons of cotton per year. [FAO, (1971)]
4. Soil electrical conductivity (ECs) values increased with increasing salinity of irrigation water and decreased soil moisture depletion in calcareous soil [Ragab, (2000)]. Total soil salinity increased from 1.87 to 24.83 ds/m with increasing irrigation salinity from 0.58 to 3.67 ds/m [Ragab, (2000)]
5. Its considered about 20–50% of the freshwater bodies in cultivated areas could be salt affected owing to irrigation [Pitman and Läuchli, (2002)]
6. Fresh water ecosystem is threatened by soil salinization as salt free rainwater converts to highly saline after exposure to even moderate or high soil salinity levels in form of run off pollutants fresh-water systems [Neave and Rayburg, (2006)].
7. Freshwater applications needed to be nearly doubled to cope with salinization [Kurbanbaev and K., (2006)].

8. The effect of soil salinity on osmotic stress and yield reduction for rice using electrical conductivity (EC) was adjusted to 6 ds/m and 12 ds/m and yield reduction 40.5-71.9% [Castillo, et al., (2007)].

3. METHODOLOGY

Risk management methodology is used to achieve the study objectives. The methodology includes:

- i. Identification: Identify source of salinity risk
- ii. Assessment: Assess salinity risks in terms of its impact and probability of occurrence by:
 - a. Qualitative analysis using Delphi Technique.
 - b. Quantitatively analysis using expected value (EV).
 - c. Using sensitivity analysis to study the risk change on water use efficiency (Eu).
- iii. Mitigation: Develop a strategy to reduce and manage possible damage.

OSPML, (2007), El-Nashar and Elyamany, (2017) defined the risk as an uncertain condition or event that has a negative or a positive effect on at least one of project objectives, such as quality, cost or time. Risk is a combination of magnitude of consequences of the occurrence and probability of the occurrence of a defined hazard. Managing risks is an integral part of good fundamental and management of achieving good effective procurement and business of goods and services. The aims of risk management are to minimize the risks of partially achieving objectives and take the advantage of opportunities; facilitate better business; provide insight, confidence and knowledge for better decision making; reduce overall risk exposure; and increase certainty.

3.1. Identification: Identify Source of Risk

Risk identification has an important effect on the following stages so it's considered as a critical stage. Without taking all risks into consideration, the missed risks will not be evaluated and managed. The outcome of risk identification is a list of risks. Diagramming Cause-and-effect is a technique used to identify risks. Cause-and-effect (fishbone) diagrams show the relationship between the effects of problems and their causes as shown in Figure 1. This diagram shows every potential cause-and-effect of a problem and the effect that each proposed solution could have on the problem. From this diagram, the list of salinity risks is made.

The list of risks resulted from the "cause-and-effect" diagram consists of the following:

1. Effect of water table rise on increasing soil salinity
2. Effect of irrigation system on soil salinity
3. Effect of poor drainage system on soil salinity

Figure 1: Cause and Effect Diagram

1. Effect of saline irrigation water on soil salinity
2. Effect of formation of soil on increasing soil salinity
3. Yield reduction of energy crops under effect of salinity
4. Yield reduction of sensitive crops under effect of salinity
5. Yield reduction of moderate crops under effect of salinity
6. Yield reduction of tolerant crops under effect of salinity
7. Salinity effect on reduction infiltration rate of soil
8. Salinity effect on dispersion of fine soil
9. Salinity problems with infrastructure such as irrigation and drainage pipes
10. Value of water use under effect of salinity
11. Quantity of water use under effect of salinity
12. Effect of salinity on increasing water stress for sensitive crops to drought
13. Effect of salinity on increasing water stress for moderate crops to drought
14. Effect of salinity on increasing water stress for tolerant crops to drought
15. Effect of salinity on increasing water stress for energy crops
16. Salinity effect on declining population of rural communities
17. Salinity effect on loss of business (both existing and potential)
18. Value of nutrient use under effect of salinity
19. Quantity of nutrient use under effect of salinity
20. Salinity effect on increasing run off

3.2. Risk Assessment

Assessing risks in terms of probability of occurrence and severity of impact is the next step after identification of risks. Risks arising from the soil salinity are assessed by determining the probability of occurrence of each risk and the impact of that risk, if occurred. Risk assessment passes through three stages:

- a) Qualitative risk analysis.
- b) Quantitative risk analysis.

c) Sensitivity analysis.

3.2.1. Qualitative Risk Analysis

After identifying risks, the risk magnitude shall be provided by qualitative risk analysis “subjectively” based on risk probability and impact of occurrence. Delphi Technique is used to determine the impact and probability of risks using expert’s opinions [Hsu and Sandford, (2007)]. Participants in Delphi Technique aren’t gathered in the same place while generating and rating ideas. In this study, identified risks are ranked by Delphi Technique using a questionnaire sent to 40 experts. The probability and impact of soil salinity is rated by experts by using questionnaires. 31 experts responded to the questionnaire with a response rate of 77.5%. Table1 shows the used questionnaire.

Two stages are considered in Delphi Technique. In the first stage the impact and probability of each risk either as; very low, low, moderate, high or very high are assessed by asking the experts as shown in Table 1. The average probability and impact of each risk are calculated after collecting all responses as shown in Table 2. As shown in Table 2, Column (1) and (2) shows the average probability (P_{av}) and average impact (I_{av}) of each risk based on responses collected from focus group. In table 2 Column (3) shows the score of each risk (R_s). Column (4) shows the category of risks (R_C) according to its score. These categories are classified from 1 to 5, where category 1 is assigned to very low and category 5 is assigned to very high risks as shown in Table 3. These categories are determined by the focus group (31 experts) by sending the average probability and average impact of each risk to them.

Table 1: A Questionnaire for Soil Salinity Risks

RIS K CO DE	RISK	PROBABILITY					IMPACT				
		V er y lo w	Lo w	Moder ate	Hig h	Ver y high	Ver y low	Low	Moderat e	Hig h	Ver y high
P1	Effect of water table lowering on soil salinity										
P2	Effect of modern irrigation system on soil salinity										
P3	Effect of poor drainage system on soil salinity										
P4	Effect of saline irrigation water on soil salinity										
P5	Effect of formation of soil on increasing soil salinity										
P6	Yield reduction of energy crops under effect of salinity										
P7	Yield reduction of sensitive crops under effect of salinity										
P8	Yield reduction of moderate crops under effect of salinity										
P9	Yield reduction of tolerant crops under effect of salinity										
P10	Salinity effect on reduction infiltration rate of soil										
P11	Salinity effect on dispersion of fine										

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	soil										
P12	Salinity problems with infrastructure such as irrigation and drainage pipes										
P13	Value of water use under effect of salinity										
P14	Quantity of water use under effect of salinity										
P15	Effect of salinity on increasing water stress for sensitive crops to drought										
P16	Effect of salinity on increasing water stress for moderate crops to drought										
P17	Effect of salinity on increasing water stress for tolerant crops to drought										
P18	Effect of salinity on Increasing water stress for Energy crops										
P19	Salinity effect on declining population of rural communities										
P20	Salinity effect on loss of business (both existing and potential)										
P21	Value of nutrient use under effect of salinity										
P22	Quantity of nutrient use under effect of salinity										
P23	Salinity effect on increasing run off										

Table 2: Matrix of Risk Probability and Impact

Risk code	P_{av} (1)	I_{av} (2)	R_s (3)	R_c (4)
P1	4.2	4.5	18.5	4
P2	3.0	3.7	10.9	3
P3	3.0	3.7	11.0	3
P4	1.9	2.9	5.7	2
P5	1.8	2.7	5.0	1
P6	2.0	2.2	4.5	1
P7	3.9	3.7	14.6	3
P8	2.9	3.5	10.4	3
P9	2.0	2.0	4.1	1
P10	2.5	2.4	5.9	2
P11	1.8	1.3	2.3	1
P12	1.9	2.2	4.1	1
P13	3.0	3.0	8.9	2
P14	3.2	3.1	10.1	3
P15	4.0	4.0	16.1	4
P16	2.1	3.0	6.3	2
P17	1.6	2.1	3.4	1
P18	1.4	1.2	1.6	1

P19	2.8	3.5	10.0	2
P20	1.5	2.7	4.0	1
P21	1.9	2.8	5.2	2
P22	1.9	2.9	5.6	2
P23	1.5	1.4	2.1	1

Table 3: Risk Category according to Score

Category	1	2	3	4	5
Risk score	(1–5)	>(5–10)	>(10–15)	>(15 – 20)	>(20 – 25)

3.2.2. Quantitative Risk Analysis

After finalizing qualitative risk analysis quantitative risk analysis is carried out. Risks are prioritized and ranked based on its effect on water use efficiency. Quantitative risk analysis utilized expected value (EV) Analysis which determined the “Risk Magnitude” [OSPML, (2007)]. EV equals the product of the risk probability as a ratio (P%) and the risk impact (I). Risks of Categories 3 and 4 are selected initially for quantitative risk analysis. These risks are (P1, P2, P3, P7, P8, P14, P15, and P19) as shown in Table2

Table 4: Expected Value (EV)

Risk code	R _C	P (%)	I	EV = P x I
1	4	84	72.4 – 79.8%	60.8 – 67 %
2	3	60	46-115%	27.6-69%
3	3	60	37.2 – 41.6%	22.32 – 25 %
7	3	78	14 -33%	10.92 - 25.74%
8	3	58	4-20%	2.32 - 11.6%
14	3	64	100%	64%
15	4	80	40.5-71.9%	32.4-57.52%

3.2.2.1. Quantitative Analysis of P1

P1 refers to “effect of water table lowering on soil salinity”. For lowering water table to 25% and 50% from critical case at 1.2 m from soil surface, the salinity of soil decreased by 72.4%, and 79.8% respectively. [Xia, et al., (2016)]. For that decrease in soil salinity, soil leaching will decrease. EV is calculated by multiplying the probability of risk occurrence and its impact. The risk probability is converted to percentage as shown in Table 4 from scale 1–5, as presented in Table 2. For example, the average probability of P1 is 4.2 on a scale 1–5 and it is converted into 84%. As shown in Table 2, the impact and the EV of P1 (decrease in soil salinity) equals 60.8-67 % from controlled soil salinity.

3.2.2.2. Quantitative Analysis of P2

P2 refers to “effect of modern irrigation system on soil salinity”. Using modern irrigation method as trickle irrigation system salts accumulate gradually in the soil profile increased to 46% and 115% at the end of 1st crop season under the moderate saline water irrigation (E.C = 3.6 ds/m) and high saline water irrigation (E.C = 6.7 ds/m) respectively. [Chen, et al., (2010)]. This salinity increasing leads to increase soil leaching by 46 – 115%. As shown in Table 4, the average probability of P2 is 60% then the impact is increasing soil salinity by 27.6 - 69% for irrigation salinity (3.6 to 6.7 ds/m).

3.2.2.3. Quantitative Analysis of P3

P3 refers to “effect of poor drainage system on soil salinity”. By using poor drainage system the water table will rise and cause increasing salinity of the soil as P1. With shallow water table 0.3 m the salinity of the 20 cm soil layer increased by 41.6% relative to the salinity of the control soils, and with water table 0.6 m the salinity of the 50 cm soil layer salinity increased by 37.2% relative to the salinity of the control soils [Xia J., et al., 2016]. As shown in Table 4, the average probability of P3 is 60%, the impact of increasing soil salinity is 37.2 - 41.6% and the EV of increasing salinity is 22.32 - 25%.

3.2.2.4. Quantitative Analysis of P7

P7 refers to “yield reduction of sensitive crops under effect of salinity”. Sensitive crops are severely affected by salinity more than other crops where the yield is reduced by 14 - 33% per one ds/m and maximum soil salinity without yield loss threshold ranged from 1 - 1.8 ds/m [Maas, (1984)]. As shown in Table 4, the average probability of P7 is 78%, the impact is decreasing yield of sensitive crops by 14 - 33% and EV of yield reduction of sensitive crops under effect of salinity is 10.92 - 25.74% if the soil salinity increased by 1 ds/m more than threshold.

3.2.2.5. Quantitative Analysis of P8

P8 refers to “yield reduction of moderate crops under effect of salinity”. Salt moderate crops are affected by salinity less than salt tolerant crops where the yield is reduced by 4 - 20% per one ds/m and maximum soil salinity without yield loss (threshold) ranged from 2.7 - 6.8 ds/m [Maas, (1984)]. As shown in Table 4, the average probability of P8 is 58%, the impact is decreasing yield of sensitive crops by 4 - 20% and the EV of yield reduction of moderate crops under effect of salinity is 2.32 - 11.6% if the soil salinity increased by 1 ds/m more than threshold.

3.2.2.6. Quantitative Analysis of P14

P14 refers to “quantity of water use under effect of salinity”. Freshwater applications needed to be nearly doubled (increase to 100%), to cope with salinization [Kurbanbaev and K., (2006)]. As shown in Table 4, the average probability of P14 is 64%, the impact is doubling volume of irrigation water, and the EV of increasing quantity of irrigation water due to salinity is 64% of the volume of irrigation water for non-saline soil.

3.2.2.7. Quantitative Analysis of P15

P15 refers to “effect of salinity on increasing water stress for sensitive crops to drought”. For rice (as a sensitive crops), yield reduction caused by osmotic stress was measured by doubling electrical conductivity (EC) of the sodium chloride (NaCl) solution which caused yield reduction 40.5-71.9% that's lead to decreasing water use efficiency by 40.5-71.9%. The relationship between the osmotic potential (Us) and salinity electric conductivity (EC) as: $U_s (\text{bar}) = -0.36 \text{ EC (ds/m)}$ [U.S.Salinity.Laboratory.Staff, (1954)]. As shown in Table 4, the average probability of P15 is 80%, the impact is 40-71.9%, and the EV of effect of salinity on increasing water stress for sensitive crops to drought due to increasing soil salinity and osmotic pressure is 32.4-57.52%.

Water Use Efficiency (Eu)

Water use efficiency (Eu) is the ratio between effective water use and actual water withdrawal. It characterizes how to use water effectively. [FAO, (2017)]

The effect of previous risks on Eu after application of EV is as:

1. Effect of P1: For lowering water table to 25% and 50% from critical case, the soil salinity will decrease by 60.8- 67% respectively, this leads to decrease the soil leaching and increase Eu by 60.8-67%.
2. Effect of P2: For using a trickle irrigation system as modern irrigation system, the soil salinity will increase by 27.6- 69%. This leads to increase of leaching water and decrease Eu by 27.6 - 69%.
3. Effect of P3: using poor drainage system, soil salinity will increase by 37.2 - 41.6%, then soil leaching will increase and Eu will decrease by 22.32 - 25%.
4. Effect of P7: The yield reduction of sensitive crops will reduce salinity by 14 - 33% per one ds/m which means decreasing Eu by 10.92 - 25.74%.
5. Effect of P8: The yield reduction of moderate crops will decrease salinity by 4 - 20% per one ds/m which means decreasing Eu by 2.32 - 11.6%.
6. Effect of P14: The quantity of fresh water use will be doubled under effect of salinity that leads to decrease Eu by 28%.
7. Effect of P15: Increasing water stress for sensitive crops due to NaCl salts leads to decrease yield reduction by 40.5-71.9% that leads to decrease Eu by 32.4-57.52%.

3.2.3. Sensitivity Analysis (SA)

Sensitivity analysis SA is a technique of risk analysis which provides answer of “what if” questions. SA is widely used due to its ability to focus on particular estimates and simplicity. [OSPML, (2007)]. In this paper SA is used to identify the impact of a change in each risk on water use efficiency. Spider diagram (Figure 2) is drawn to show that.

Figure (2): Spider Diagram for Risks Effects on Eu

From the figure it is found that the change of lowering water table (P1) from -50% to 50% leads to a change in Eu from 51.5% to 76.3% respectively, the change of salinity of irrigation water in the trickle irrigation system (P2) from -50% to 50% leads to a change in Eu from 72.45% to 24.15% respectively, the change of using poor drainage system (P3) from -50% to 50% leads to a change in Eu from 35.49% to 13.013% respectively, the change of the yield reduction of sensitive crops (P7) from -50% to 50% leads to a change in Eu from 27.495% to 9.165% respectively, the change of the yield reduction of moderate crops (P8) from -50% to 50% leads to a change in Eu from 10.44% to 3.48% respectively, the change in used fresh water quantity (P14) from -50% to 50% leads to a change in Eu from 96% to 32%

respectively and the change of increasing water stress for sensitive crops due to NaCl salts (P15) from -50% to 50% leads to a change in Eu from 67.44% to 22.48% respectively.

3.3. Mitigation of Risks

Management of water use efficiency requires to minimize irrigation water and maximize crop yield as water use efficiency is the ratio of total biomass or grain yield to water supply or evapotranspiration or transpiration on a daily or seasonal basis [Sinclair, et al., (1984)]. All of the studied risks lead to reduction in yield so a number of management actions should be used to prevent this reduction in yield. The following list of management actions and strategies are suggested to mitigate risks of reducing water use efficiency:

- 1) Install and improve existing drainage system to control very shallow water-tables (less than 1m) that resulted mostly after irrigation but also after rainfall. It's necessary for cropping systems or whether lower water-table control criteria (water tables depths more than 1.2 m) would be adequate to protect these areas [Christen and Ayars, (2001)].
- 2) Planting salt-tolerant crops in saline agriculture to adapt with the salinity increasing [Safdar, et al., (2019)]. A few vegetable crops can be irrigated with seawater, with a NaCl concentration of about 50 ds/m. [Katschnig, et al., (2013)]. For using soil salinity 7.7ds/m the yield production of barley, cotton, sorghum, wheat is 100% -100% - 85.6% - 87.93% respectively [Maas, (1984)]
- 3) Planting energy crops in saline soil with high salinity levels and heavy metals contained[Yadav, et al., (2019)]. Energy crops may be a suitable alternative to use saline land without reclamation. Energy crops like Jojoba (50% of yield reduction occurs at 15ds/m [Egyptian Gulf Land Reclamation]), Jatropha (50% of yield reduction occurs at 9 ds/m [Niu, et al., (2012)]), Miscanthus (50% of yield reduction occurs at 10.65ds/m [O'Loughlin, et al., (2017)]) , Poplar (15% of yield reduction occurs at 7.6 ds/m [Shannon, et al., (1999)]).
- 4) Soil leaching: flooding is the main technique of soil leaching. Preparation for leaching includes defining types of salts affected soil to choice the method of reclamation [Pessarakli, (1994)]:

For Sodium chloride and sulfate which happened in Arid and semiarid causing high osmotic pressure of soil solution, toxic effect of chlorides amount of water needed to be add to leach the soil.

For Sodium ions capable of alkaline hydrolysis which occurred in semiarid, semi-humid and humid causing high PH (alkali) and poor water physical conditions PH must be lowered or neutralized by chemical amendments.

For magnesium ions which occurred in semiarid and semi-humid causing toxic effect, high osmotic pressure, Calcium deficiency chemical amendments must be added and then leaching.

For Calcium ions (mainly CaSO₄) which occurred in semiarid and arid causing low PH (acidic) toxic effect, alkaline amendments must be added.

- 1) Leaching of saline soils by sprinkler irrigation in combination with vertical drainage systems and chemical amelioration treatments are 10 times cheaper and require 4-5 times less water, than traditional leaching by flooding. The rates of soil desalinization and yield increases are the same in both cases [Vargas, et al., (2018)].

- 2) Land reclamation which depends on the quantity of gypsum required for reclamation and the amount of exchangeable sodium to be replaced in the soil. The total investment required to reclaim one hectare sodic land was varied between (10,000 LE) in 'slight' sodic category land to (12,000 LE) in 'severe' sodic category land. If there are no canal or tube-well irrigation facilities, an additional amount of (5,500 LE) per hectare investment on tube-well is required to create irrigation facility. [Thimmappa, et al., (2015)].

4. RESULTS AND DISCUSSION

The results showed that, EV for lowering water table is decreasing salinity by 60.8-67% and change for this risk from -50% to 50% leads to Eu changing from 51.5% to 76.3%, EV for using trickle irrigation system with different is increasing in soil salinity by 27.6 - 69% and change for this risk from -50% to 50% leads to Eu changing from 72.45% to 24.15%, EV for using poor drainage is increasing soil salinity by 22.32 -25% and change for this risk from -50% to 50% leads to Eu changing from 35.49% to 13.013%, Ev for yield reduction of sensitive crops by salinity is 10.92-25.74% and change for this risk from -50% to 50% leads to Eu changing from 27.495% to 9.165%, Ev for yield reduction of moderate crops by salinity is 2.32-11.6% and change for this risk from -50% to 50% leads to Eu changing from 10.44% to 3.48%, EV for quantity of used fresh water under effect of salinity is 64% and change for this risk from -50% to 50% leads to Eu changing from 96% to 32%, EV for increasing water stress for sensitive crops under effect of salinity is 32.4-57.52% and change for this risk from -50% to 50% leads to Eu changing from 67.44% to 22.48%.

5. CONCLUSION

Salinity is the major problem affecting irrigated lands, which directly affects food security and water use around the world. This paper assessed the risks of soil salinity and evaluated these risks qualitatively and quantitatively and put some strategies to mitigate these risks by applying new methodology of risk management including an identification the reasons of salinity and its effect by cause-effect diagram to study the risk of water and soil salinity on water use efficiency. Risk assessment passes through three stages: i. Qualitative risk analysis by Delphi technique to determine the probability and impact of risks, ii. Quantitative risk analysis to determine the "Risk Magnitude", this analysis is done by using Expected Value. iii. Sensitivity analysis to study the risk change on water use efficiency. Management actions and strategies are proposed to mitigate risks of salinity to increase crop yield and reduce water consumption. Soil salinization is closely linked to the use of in-efficient cropping systems (i.e., choices of crop, crop rotation, tillage practice, irrigation, and nutrient and pest management applied on a particular field over a particular period). The results showed that improve soil properties is the most efficient method to increase water use efficiency and increase yield by using efficient quantity of water, having suitable water table level, suitable irrigation system and suitable drainage system respectively then suitable crop pattern. Most strategies and management actions require time to be implemented as planting salt-tolerant crops and energy crops in saline agriculture to adapt the salinity increasing and soil improvement which is necessary to break the negative spiral of degradation, increased costs, increased inputs and environment damage.

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