

**PERFORMANCE MANAGEMENT EVALUATION  
OF MODIFIED SURFACE IRRIGATION  
SYSTEM TO RAISE ITS  
EFFICIENCY**

By

**MARWA ABD-ELNABY MOHAMED IBRAHIM**  
B.Sc. Agric. Coop. Sci., Agric. Higher Institute for Agric. Coop., 2012

**A Thesis Submitted in Partial Fulfillment  
Of  
The Requirements for the Degree of**

**MASTER OF SCIENCE  
in  
Agricultural Sciences  
(On- farm Irrigation Engineering and Drainage)**

**Department of Agricultural Engineering  
Faculty of Agriculture  
Ain Shams University**

**2021**

## ABSTRACT

**Marwa Abd-Elnaby Mohamed Ibrahim: Performance Management Evaluation of Modified Surface Irrigation System to Raise Its Efficiency, Unpublished M.Sc. Thesis, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University, 2021.**

The experiments were carried out in Biahmu Village at Al-Fayoum Governorate, Egypt, during the two seasons of 2018/2019 and 2019/2020, on wheat crop of (cv. Gemmiza 11) as a winter crop and maize crop of (S.C 2031) as a summer crop to evaluate both the traditional surface irrigation system "TSIS" and the improved surface irrigation system "ISIS"(terrace), under laser leveling with two slopes ( $S1 \approx \text{zero}\%$  and  $S2 \approx 3\%$ ). The evaluation parameters included; reduction in land loss "LL", roughness coefficient of marwa-walls, water efficiencies (i.e., water conveyance efficiency "WCE", water application efficiency "WAE" and water storage efficiency "WSE"), total applied water "TAW", yield productivity " $Y_P$ ", irrigation water productivity "IWP" and water advance, recession and opportunity times. The results concluded that improving traditional marwa, led to reduction in land loss "LL" by 49.46 and 85.5% for the two crops of wheat and maize, respectively from the area of marwa, and "WCE" increased by 83.17% in improved marwa "IM" compared to traditional marwa "TM". The highest values of water productivity ( $1.79\text{kg}_{\text{wheat}}/\text{m}^3\text{water}$  and  $2.39\text{kg}_{\text{maize}}/\text{m}^3\text{water}$ ) were achieved in "IM" at a level of 3%. Advanced time "T. Adv" (min) decreased at (50, 50.77, 27.6, 20.75, and 17.17%) and (30.9, 40.51, 22.8, 10.89 and 7.05%) for "TL and IL" for wheat crop. Consequently, Advanced time "T. Adv" (min) decreased at (44.33, 48.62, 27.1, 20.36 and 16.33%) and (22.05, 39.89, 21.09, 10.50 and 6.07%) for "TL and IL" for maize crop.

**Keywords:** Surface irrigation terraces; Improvement; Water efficiencies; yield productivity and Crops.

## CONTENTS

	<b>Page</b>
<b>LIST OF TABLES</b>	<b>III</b>
<b>LIST OF FIGURES</b>	<b>IV</b>
<b>LIST OF ABBREVIATION</b>	<b>VII</b>
<b>INTRODUCTION</b> .....	<b>1</b>
<b>REVIEW OF LITERATURE</b> .....	<b>3</b>
2.1. Surface irrigation system.....	3
2.2. Advantages and disadvantages of a surface irrigation system	4
2.3. Land leveling slope.....	5
2.4. Developed surface irrigation system.....	8
2.5. Definition of surface irrigation efficiencies.....	11
2.6. Water conveyance efficiency (WCE) .....	12
2.7. Water application efficiency (WAE) .....	14
2.8. Factor affecting surface irrigation efficiencies.....	15
2.9. Irrigation management .....	16
2.10. Roughness coefficient.....	16
<b>MATERIALS AND METHODS</b> .....	<b>18</b>
3.1. Experimental sites.....	18
3.2. Description of marwa.....	18
3.2.1. Traditional marwa.....	18
3.2.2. Improved marwa.....	19
3.3. Soil properties.....	19
3.4. Irrigation water analysis.....	20
3.5. Studied crops .....	20
3.6. Studied experimental variables.....	21
3.7. Instruments specifications.....	25
3.7.1. Auger.....	25
3.7.2. Soil core sampler.....	25
3.7.3. Wooden pegs.....	25
3.7.4. Digital balance.....	25
3.7.5. Electric oven.....	25
3.7.6. Multi- parameters meter.....	26
3.7.7. Field area measuring device.....	26
3.7.8. Marwa cross section area.....	27
3.7.9. Flowatch.....	27
3.7.10. Linen scale tape.....	29
3.3.11. Stop watch.....	29
3.8. Measurements and determinations.....	29
3.8.1. Land losses (LL) .....	29

3.8.2. Marwa roughness coefficient .....	29
3.8.3. Water efficiencies .....	30
3.8.3.1. Water conveyance efficiency "WCE" .....	30
3.8.3.2. Water application efficiency "WAE" .....	31
3.8.3.3. Water storage efficiency "WSE" .....	32
3.8.3.4. Water overall efficiency "WOE" .....	33
3.8.4. Total applied water "TAW" .....	33
3.4.5. Irrigation water productivity "IWP" .....	33
3.8.6. Water advance, recession and opportunity times .....	33
3.8.7. Cost determination .....	34
<b>RESULTS AND DISCUSSION</b> .....	<b>36</b>
4.4.1. The land losses "LL" (%) .....	36
4.4.2. Marwa roughness coefficient (n) .....	37
4.4.3. Water efficiencies (%) .....	41
4.4.3.1. Water conveyance efficiency "WCE" (%) .....	41
4.4.3.2. Water application efficiency "WAE" (%) .....	43
4.4.3.3. Water storage efficiency "WSE" (%) .....	45
4.4.3.4. Water overall efficiency "WOE" (%) .....	47
4.4. Total applied water "TAW" (m <sup>3</sup> fed <sup>-1</sup> ) .....	51
4.5. Yield productivity "Yp" (kg fed <sup>-1</sup> ) .....	54
4.6. Irrigation water productivity "IWP" (m <sup>3</sup> fed <sup>-1</sup> ) .....	57
4.7. Water advance, recession and opportunity times (min) .....	60
4.8. Cost determination .....	63
<b>SUMMARY AND CONCLUSION</b> .....	<b>65</b>
<b>REFERENCES</b> .....	<b>69</b>
<b>APPENDIX</b> .....	<b>77</b>
<b>ARABIC SUMMARY</b> .....	<b>95</b>

## LIST OF TABLES

No.		Page
1	Soil textural and physical properties, at the experimental field	21
2	Some hydro-physical properties, at the experimental field	22
3	Water analysis	22
4	The randomize experimental plots	23
5	Improved marwa (mortared half brick)cost (LE)	35

## LIST OF FIGURES

No.		Page
1	The cross-section in a traditional marwa	20
2	The cross-section in improved marwa	21
3	Layout of the experimental variables	24
4	Layout of the experiment Traditional and Improved lands area.	25
5	Auger	27
6	Wooden pegs	27
7	Digital balance	27
8	Electric oven	27
9	Multi- parameters meter	29
10	GPSMAP 64- device	29
11	Marwa cross section area	29
12	Flowatch	29
13	The average land losses "LL" (%) for different marwa types (traditional marwa "TM", in case improving traditional marwa "ITM" and improved marwa "IM")	38
14	The relation between roughness coefficient (n) of marwa walls along marwa length and water velocity (v) at traditional marwa "TM".	40
15	The relation between roughness coefficient (n) of marwa walls along marwa length and water velocity (v) at improved marwa "IM".	40
16	The relationship between average water conveyance efficiency "WCE" (%) and marwa types (mt) for wheat crop.	41
17	The relationship between average water conveyance efficiency "WCE" (%) and marwa types (mt) for Maize crop.	41
18	The average water conveyance efficiency "WCE" (%) at different marwa types (mt) and different crops (Wheat and Maize)	42
19	The relationship between water application efficiency "WAE" (%) and distance along the field (100m) for wheat crop.	44

20	The relationship between water application efficiency "WAE" (%) along the field (100m) for maize crop.	44
21	The relationship between the average water application efficiency "WAE" (%) and along the land treatments	45
22	The relationship between water storage efficiency "WSE" (%) and the (100m) field distance for the wheat crop.	46
23	The relationship between water storage efficiency "WSE" (%) and the (100m) field distance for maize crop.	46
24	The relationship between the average water storage efficiency "WSE" (%) and along the land	47
25	The relationship between the water overall efficiency "WOE" (%) and the traditional land "TL" and improved land "IL" under zero leveling slope "S1" for wheat crop.	48
26	The relationship between the water overall efficiency "WOE" (%) and the traditional land "TL" and improved land "IL" under leveling slope of 3% "S2" for wheat crop	49
27	The relationship between the water overall efficiency "WOE" (%) and traditional land "TL" and improved land "IL" under zero leveling slope "S1" for the maize crop.	49
28	The relationship between the water overall efficiency "WOE" (%) and traditional land "TL" and improved land "IL" under leveling slope of 3% "S2" for the maize crop.	50
29	The relationship between the average water overall efficiency "WOE" (%) in traditional land "TL" and improved land "IL" under different Leveling slops (S1 and S2) for different crops type (Wheat and Maize)	51
30	The relationship between the total applied water "TAW" (m <sup>3</sup> fed <sup>-1</sup> ) for traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for wheat crop.	52
31	The relationship between the total applied water "TAW" (m <sup>3</sup> fed <sup>-1</sup> ) for traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for maize crop.	53
32	The relationship between the average total applied water "TAW" (m <sup>3</sup> fed <sup>-1</sup> ) in traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for different crops type (Wheat and Maize).	55

- 33 The yield productivity "Yp" (kg fed<sup>-1</sup>) for traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for wheat crop. 55
- 34 The relationship between yield productivity "Yp" (kg fed<sup>-1</sup>) in traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for maize crop. 56
- 35 The relationship between the average yield productivity "Yp" (kg fed<sup>-1</sup>) for traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for different crops type (Wheat and Maize). 57
- 36 The irrigation water productivity "IWP"(m<sup>3</sup> fed<sup>-1</sup>) for traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for wheat crop. 58
- 37 The irrigation water productivity "IWP"(m<sup>3</sup> fed<sup>-1</sup>) for traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for maize crop. 59
- 38 The average irrigation water productivity "IWP"(m<sup>3</sup> fed<sup>-1</sup>) for traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for different crops type (Wheat and Maize). 60
- 39 Water advance, recession and opportunity times along (100m) from the field for traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for the wheat crop. 61
- 40 Water advance, recession and opportunity times along (100m) from the field for traditional land "TL" and improved land "IL" under different leveling slops (S1 and S2) for the maize crop. 63
- 41 Total cost of traditional marwa "TM" and improved marwa "IM". 64