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# MAXIMIZING CONVEYANCE EFFICIENCY THROUGH LINING MARWAS AT ON-FARM LEVEL IN OLD LANDS OF EGYP.

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## ABSTRACT

Demonstration fields were selected since 1998 to 2005 to improve the on- farm delivery system through lining marwas in eleven governorates namely; Kafr El-Shiekh, El-Gharbia, El-Behera, El-Dakahlia, El-Sharkia, and El-Menofia Governorates which represented the lower Egypt, while El-Fayum, El-Menia, Assuit, Sohag and Qena governorates represented the Upper Egypt. These demonstration fields were authorized by the On-farm Water and Soil Management Project (OWSOM) in cooperation with Central Adminstration of Agriculture Extension. The main goal of this project is to provide Egypt with a replicable and adaptable system of on-farm water management practices that are economically sound, environmentally sustainable and socially acceptable. The technical team of the project proposed and designed nine alternative options of marwa lining. After introducing these options to the farmers, they accepted the mortared bricks 40 cm width, 40 cm depth, 12 cm thickness and concrete in base.

**The obtained results could be summarized as follows:-**

The conveyance losses in earth marwas located on selected mesqas in Kafr El-Shiekh governorate were ranged from 14.47 to 21.36 %, while in El-Behera governorate, these losses were ranged from 13.43 to 21.88 % .

Concerning the adopting of the marwa lining, the project lined 205.39 Km length of earth marwas with farmer's participation in eleven governorates since 1998 to 2005. The cost per one meter paid by project was reduced from 100 L.E in 1998/99 to 9.4 L.E in 2004/2005 as a result to great participation by the farmers which reached to 75.26 % in 2005. Also, data declared that the area saved by the lined marwas was about 0.6 % of total area.

With regard to feasibility analysis, data showed that the benefit cost ratio at 10 % discount rate is higher than one (1.4), indicating that the accrued discounted benefits is higher than the discounted cost over the useful life span of major investment. Net present value is also positive (L.E 507) at 10 % discount rate indicating that investment in the project activities is profitable. The internal rate of return for the marwa lining is higher than the opportunity cost of capital in the country (19 %). This means that, it is needed 19 % interest rate to get the same benefits from a bank instead of the investment in such project.

## INTRODUCTION

Egypt is almost solely dependent on The River Nile as the main water source. Approximately 96 % of Egypt's water supply is from that main source. Nearly 85 % of the available supply, (approximately 55.5 billion cubic meters annually) is consumed by the agriculture sector. The possibility to increase water supply is limited and conditioned. An available alternative is to increase irrigation efficiency and minimize water losses under irrigation.

Improving the irrigation system constitutes the key element in achieving the national goal of increasing irrigation efficiency and fulfilling the equity of

water distribution among farmers in order to achieve the maximum crop yield. Also, farmers must be prepared to cope the decreases in water supplies and stop the over use practice of irrigation water.

Different projects and experiments have proven that the average overall irrigation efficiency is about 50 %. Most of water losses occur in mesqas, marwa and field level (Shawky and El-Kashef, 2004).

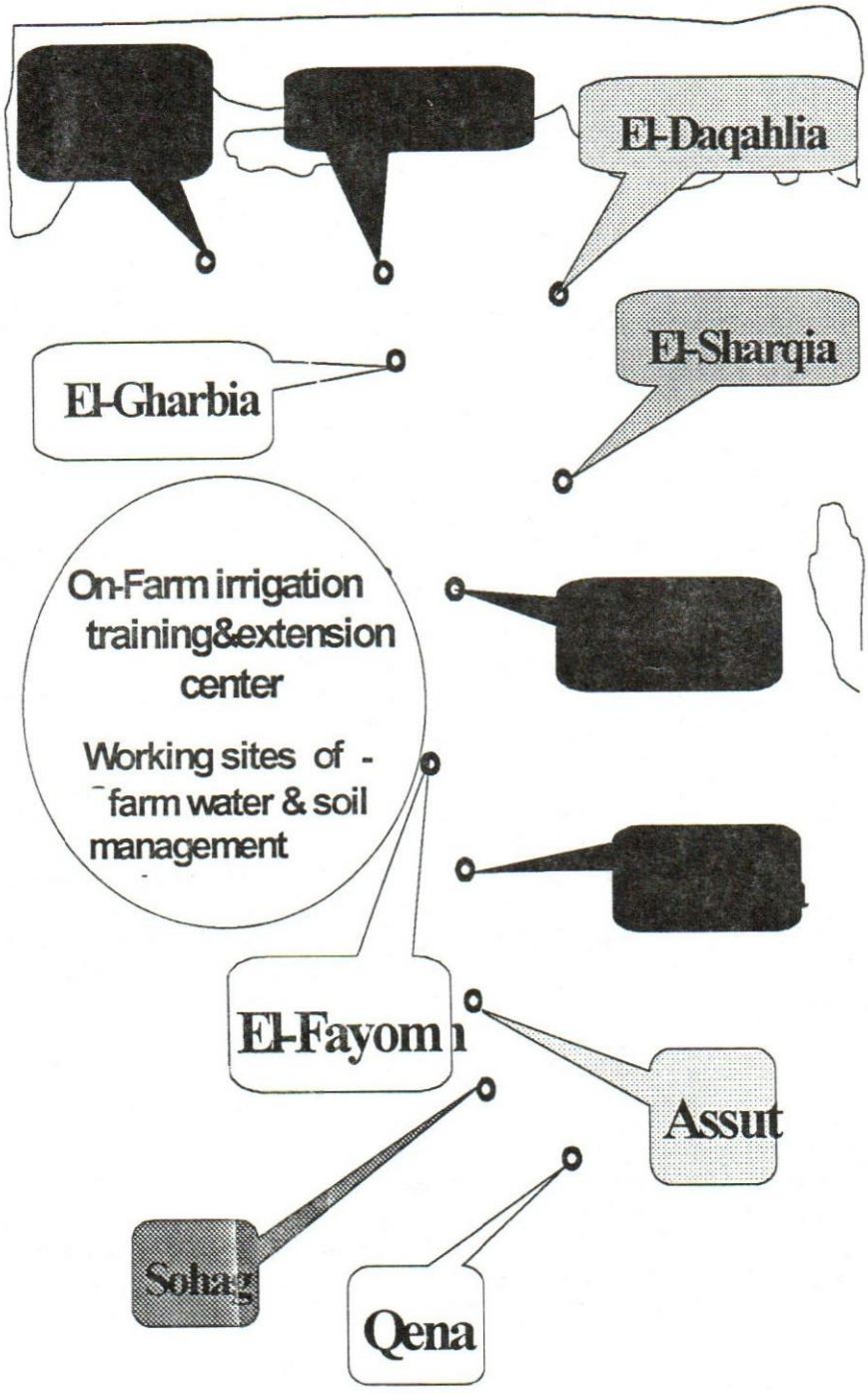
Ley et al (1984) indicated that 40 % of water might be lost from unimproved field ditches. The primary disadvantage of open irrigation ditches, is that the water used remains open to the air for long periods of time, and the water in the ditches does not flow much. Great water losses can occur due to evaporation enroute to the field. Also, water generally flows into the fields and seeps into the ground slowly, remaining exposed.

The greater focus so far has been implemented on improved water delivery systems down to mesqa level, including operation, maintenances and management. One of these improvements is lining marwas that has numerous advantages eg, minimizing seepage losses; increase the distribution velocities; minimizing evaporation losses through reduction of canal top width; saving land area; reduction of adjacent land damage due to water seepage; reduction of weed growth within canal; control water quality and reduction health problems (EWUP 1984). The on farm water and soil management (OWSOM) project started since 1997 till now in Kafr El-Sheikh and El-Gharbia Governorates and its activities were extended to eleven governorates. The main goal of the OWSOM project is to provide Egypt with a replicable and adaptable system of on-farm. water, management practices that are economically sound, environmentally sustainable and socially acceptable.

The research team of OWSOM project designed nine alternative options of marwa lining. The cross section is 40 cm width, 40 cm depth and the discharge is about 70 L/sec. These designed options (Fig.1) can be classified into:

- Mortared red bricks (25 cm. thickness) and concrete in base.
- Mortared red bricks (12 cm. thickness) and concrete in base.
- Mortared red bricks (12 cm. thickness) and base consists of sand layer (5 cm) and layer of red bricks, 12 cm thickness.
- Mortared white lime stone blocks (20 cm thickness) and concrete in base.
- Mortared white lime stone blocks (20 cm thickness) and base consists of sand layer (5 cm) and thickness white limestone.
- Pre cast non-reinforced concrete (J section shape).
- Surface reinforced concrete pipe.
- Aluminum gated pipes (15 cm diameter and 75 cm distance between gates).

  Low pressure buried pipelines (200 mm diameter) and outlets for valves on the soil surface.


El-Daqahlia
El-Sharqia
El-Gharbia
On-Farm irrigation training&extension center
Working sites of - farm water & soil management
El-Fayom
Assut
Sohag
Qena

After introducing these options to the farmers, they accepted the mortared red bricks (12 cm thickness) and concrete in base.

The purpose of this work is to investigate the conveyance losses through earth marwa, present the implementation of the OWSOM project in eleven governorates as well as financial and economic evaluation through benefit cost analysis.

## MATERIAL AND METHODS

Demonstration fields were selected to improve the on-farm delivery system through lining marwas (field canal). These demonstrations were authorized by the On-farm water and soil management project (OWSOM), in cooperation with extension sector.

The project (OWSOM) has been started since 1997 and is focusing on lining the marwas. Many different options of marwa lining were evaluated. The more acceptable one by the farmers is the mortared half red brick with concrete base (40 cm width, 40 cm depth and 12 cm thickness).

This activity started in 1998 in Kafr El-Sheikh and El-Gharbia Governorates. Farmers were persuaded with the positive impacts; consequently, the activity is disseminated year by year in the neighbor governorates. Nowadays (2005) it has been conducting in eleven governorates, namely; Kafr El-Shiekh, El-Gharbia, El-Behera, El-Dakahlia, El-Sharkia, and El-Menofia Governorates to represent the lower Egypt, while El-Fayum, El-Menia, Assuit, Sohag and Qena Governorates represented the upper Egypt, as shown in Map (1).

- **Water conveyance efficiency:**

Water Conveyance Efficiency (EC%) was measured in earth marwas located on 12 mesqas selected in Kafr El-Shiekh and El-Behera Governorates.

EC % is the ratio of flow at the second cutthroat flume (application point at 100 m distance, from the first cutthroat flume) to the flow at the first one (lifting point), (Fluume 1).

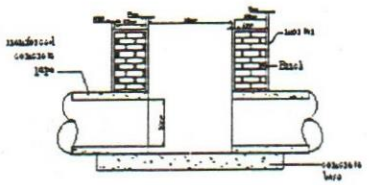
$$EC\ \% = 100 \times \frac{\text{Flow at Flume (2)}}{\text{Flow at Flume (1)}}$$ Early (1975).

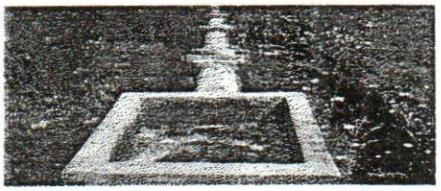
- **Irrigation water losses in earth marwas:**

Irrigation water losses consist of seepage from the canal into the underlying groundwater and of spills, which occur from leaky banks, overtopping the banks of the canal. A method of reporting the loss is the percent loss and expressed as follows:

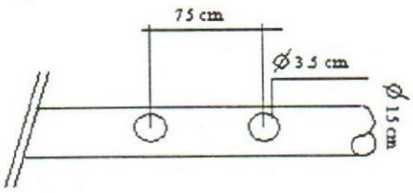
$$Loss\ \% = 100 - EC\ (\%)$$

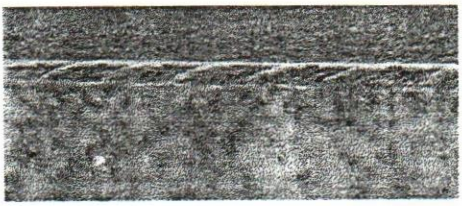
Surface reinforced concrete pipes



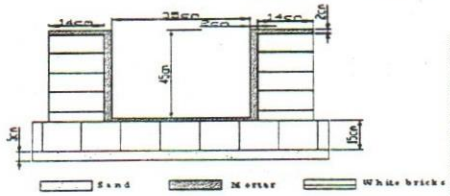


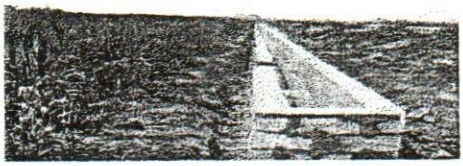
Gated pipes



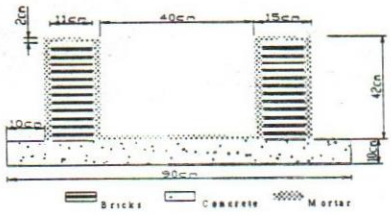



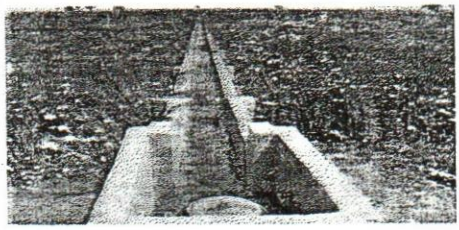
Mortared half Brick and Concrete in base



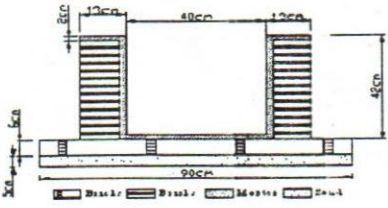



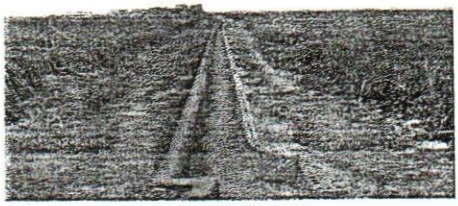
Mortared white bricks (limestone) from inside with white bricks in base on sand layer



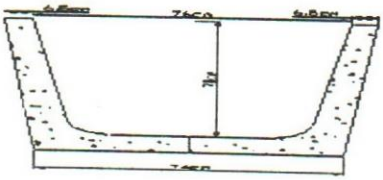



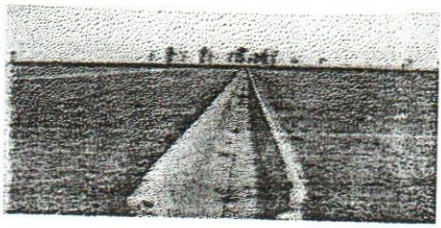
Mortared half Brick with brick on sand layer in base



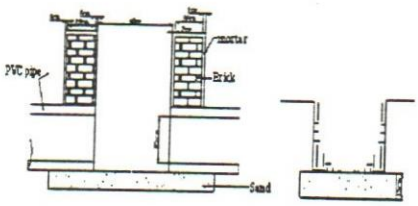



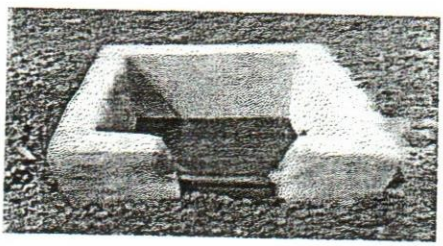
Precast nonreinforced concrete ( J – section )



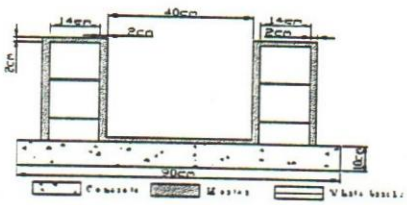


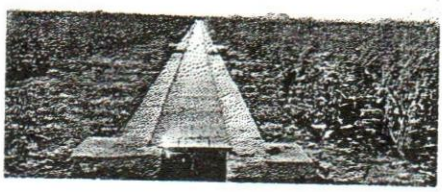
Surface PVC pipes



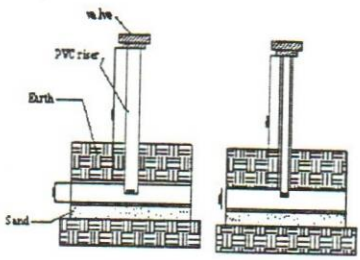



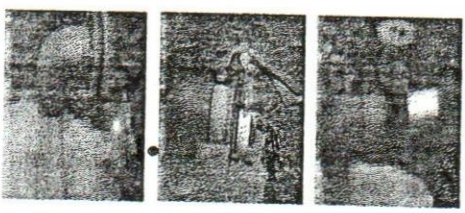
Mortared white bricks (limestone)
with unreinforced concrete in base



Low pressure buried pipelines



**Design criterion:-**

The design criterion for lined marwa follows the same procedure of the waterways conveying the gravitational flow type, in which the gravity is the main force affecting the water flow. Manning's equation is the popular one used for flow

Computations with respect to the gravitational waterways. Assuming the flow to be uniform, Manning reported the following equation:

$$Q = R \quad S^{1/2} \quad A \qquad \text{(Manning 1889).}$$

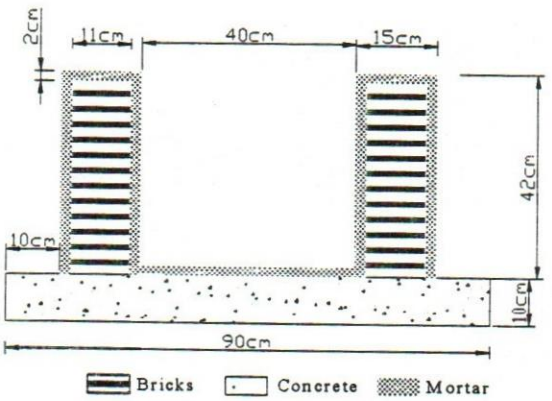
**Where:**

Q : is the flow discharge ($m^3$/ sec.).

n : is the Manning's roughness coefficient which depends on the waterway geometry and configurations.

R = is the hydraulic radius; = A/p., A : is the waterway cross-section area, P = is the waterway wetted perimeter, and.

S : is the energy line slope for uniform slope: SW = SE = So = S, where SW, SE and So are the water surface slope, energy line slope and bed slope, respectively.




**Sketch (1): Cross section of mortared half red bricks.**

**Amount and cost of building materials:**

The calculated amount and cost of building materials and labors are shown in table (1).

**Table (1): Construction cost (LE/one m length) of mortared half brick and concrete base type.**

| Item | Materials | Quantity | Price per unit in LE | Value in LE | Cost per 1 m in LE |
|---|---|---|---|---|---|
| Concrete base | Concrete: 100 m long X 0.9 m width X 0.1 m high = 9 m2 Cost of producing 9 $m^3$ concrete | | | | |
| | **Gravel Stones** | 7.2 $m^3$ | 50 | 360 | |
| | **Sand** | 3.6 $m^3$ | 20 | 72 | |
| | **Cement** | 43.2 Sack | 15 | 645 | |
| | | | | | 10.77 |
| Bricks | Side walls: 2 sides X 100 m long X 0.4 m high = 80 $m^2$ Cost of 80 $m^2$ | | | | |
| | **Bricks** | 5000 unit | 0.13 | 650 | |
| | Columns (supporting walls): every 3 m long Number of columns = 100 m long X 2 sides/ 3m = 66.5 column Cost of building materials for 80 $m^2$ | | | | |
| | **Bricks** | 400 unit | 0.13 | 52 | |
| | **Sub total bricks cost** | | | | 7.02 |
| | **Cement** | 16 sack | 15 | 240 | |
| | **Sand** | 3 $m^3$ | 20 | 60 | |
| | | | | | 3.0 |
| Mortar | 4 sides X 100 m long X 0.5 high = 200 $m^2$ cost of 200 $m^2$ | | | | |
| | **Sand** | 4 $m^3$ | 20 | 80 | |
| | **Cement** | 25 sack | 15 | 375 | |
| | | | | | 4.55 |
| Labor | Labor for all operation Labor cost per 100 m long | | | | |
| | **Concrete** | 9 $m^3$ | 25 LE/ $m^3$ | 225 | |
| | **Mortar** | 200 $m^2$ | 1 LE/ $m^2$ | 200 | |
| | **Brick** | 5400 unit | 0.03 LE/brick | 162 | |
| | | | | | 5.87 |
| Additional labor cost | Additional labor cost for the preparation of working place of the marwa (destruction of old marwa, weed elimination, tree roots, digging and soil replacement) | | | | |
| | **Man/ day** | 100 | 8 | 800 | |
| | | | | | 8.0 |
| Gates | Steel gates: 2 gates per feddan Assuming width of feddan is 40 m = 40 m/LE 120 LE 3 per m | | | | |
| | **Steel gates** | 2 gates | 60 | 120 | |
| | | | | | 1.2 |
| Overhead cost | 10 % above the overall cost | | | | |
| | | | | | 4.04 |
| Total cost | | | | | 44.45 |

**Benefit-Cost analysis:-**

Was performed according to Gittinger (1982).

## RESULTS AND DISCUSSION

**Conveyance losses in earth marwas:-**

On-farm water delivery is accomplished through a system of marwas. These marwas are difficult to maintain in good condition because the expanding nature of the soils causes repeated cracks during periods, which allows direct seepage through the cracks, deteriorate the cross sections, and prevents successful compacting of marwa banks. Significant on farm conveyance losses to leakage and dead storage have been found between outlet of valves and point of application along marwas.

Data in Table ( 2 ) show the conveyance losses for marwas located on the selected mesqas in Kafr El-Sheikh and El-Behera Governorates.

Results revealed that the mean values of conveyance losses were 18.65, 16.77 and 21.36 % for El-Bida, Om Heneesh (C) and El-Shahayna mesqas respectively that located on Dakalt Branch canal, Kafr El-Sheikh Governorate. While the conveyance losses for selected mesqas located on El-Qahwagi branch canal were 16.44, 14.47 and 15.5 % for El-Naira, Kalboosh and Mahata 21, respectively. For El-Behera Governorate, the mean conveyance losses for the selected mesqas located on Besntway branch canal were 13.43, 15.31 and 15.92 % for Sharf El-Din, El-Deeb and Abd Ella and El-Tabakh respectively. While, the conveyance losses for the selected mesqas located on El- Hamamy branch canal were 16.43, 21.88 and 17.78 % for Ganab1, El-Sheemy and El-Taweel and El-Meia El-Keblia respectively.

**Table (2) : On farm marwa conveyance efficiency and their losses during individual irrigations on some mesqas located in Kafr El Shiekh and El Behera Governorate.**

| Governorate | Branch canal | Mesqa name | Conveyance efficiency % | Losses % |
|---|---|---|---|---|
| Kafr El-Shiekh | Dakalt | El Beda (A) | 81.35 | 18.65 |
| | | Om Heneesh (C) | 83.23 | 16.77 |
| | | El Shahaina | 78.64 | 21.36 |
| | | Mean | 81.07 | 18.93 |
| | El Kahwagy | El Naira | 83.56 | 16.44 |
| | | Kalboosh | 85.53 | 14.47 |
| | | Mahata 21 | 84.5 | 15.5 |
| | | Mean | 84.53 | 15.47 |
| El-Behera | Bsentway | Sharaf El Din | 86.57 | 13.43 |
| | | El Deeb and Abd Ella | 84.69 | 15.31 |
| | | El Tabakh | 84.08 | 15.92 |
| | | Mean | 85.11 | 14.89 |
| | El Hamamy | Ganab 1 | 83.57 | 16.43 |
| | | El Sheemy and El Taweel | 78.12 | 21.88 |
| | | El Meia El Keblia | 82.22 | 17.78 |
| | | **Mean** | **81.3** | **18.7** |

Also, data indicated that the mean values of coveyance efficiency were 81.07 and 84.53 % for Dakalt and El-Kahwagy branch canals respectively in Kafr El-Sheikh Governorate. While the crosseponding values were 85.11 and 81.3 % for Bsentway and El-Hamamy branch canals in El-Behera Governorate, respectively. These results are in agreement with those reported by Shawky and El-Kashef, (2004).

**Adoptinu of the marwa lining: -**

Data in Table (3) present the adopting of marwa lining since 1998/99 until 2004/2005.

Data indicated that 2.32 Km length of earth marwa was lined in Kafr El-Sheikh and El-Gharbia Governorates and the cost was covered completely by OWSOM project in 1998/99. The marwa width was 50 cm, with 60 cm depth and 25 cm thickness; the total cost was 100 LE per meter. These works conducted through contractions with private sector without any engagement with the farmers.

In 1999/2000, the OWSOM project modified the cross section to 12 cm thickness (half bricks) and 2.685 km length of earth marwa was lined by private contractors in Kafr El-Sheikh Governorate. Accordingly, the cost was lowered from 100 LE per meter to 50 LE per meter. In 2000/2001, the project supported the farmers by all the building materials and 24.5 km length of earth marwa was lined.

It should be mentioned that, farmers in the neighbor fields arround the demonstration fields observed the benefits of lined marwa, they have been convinced and replayed to conduct this activity in their own fields. Through meeting between project staff and farmers in 2000 / 2001, the project asked them to share by at least the labour cost.

**Table (3): Adopting of marwa lining by the farmers through the period (1998/99 -2004/ 2005 ) .**

| Years | Length of lined marwa (km) | Area served (fed.) | Land area saving (fed.) | On farm water and soil manage-ment project participation % | Farmers particip ation % | Cost paid by the project LE/m | Cost paid by the farmers LE/m | Total cost LE/m |
|---|---|---|---|---|---|---|---|---|
| 1998/99 | 2.32 | 60 | 0.36 | 100 | -- | 100 | -- | 100* |
| 99/2000 | 2.685 | 65 | 0.39 | 100 | -- | 50 | -- | 50** |
| 2000/01 | 24.5 | 840 | 5.04 | 74.63 | 25.37 | 25 | 8.5 | 33.5 |
| 2001/02 | 11.875 | 510 | 3.06 | 38.81 | 61.19 | 13 | 20.5 | 33.5 |
| 2002/03 | 58.0 | 2000 | 12.00 | 34.52 | 65.48 | 11.6 | 22 | 33.6 |
| 2003/04 | 52.98 | 1700 | 10.2 | 30.5 | 69.5 | 10.76 | 24.52 | 35.28 |
| 2004/05 | 53.03 | 1800 | 10.8 | 24.74 | 75.26 | 9.4 | 28.6 | 38.0 |
| Total | 205.39 | 6975 | 41.85 | | | | | |

* In 1998/99, the cross section was 50X60 cm and the thickness of brick was 25cm.

** In 99/2000 , the cross section was 40X40 cm and the thickness was half brick .

From 2001/2002 to 2003/2004, the project activities were extended to eight Governorates (Kafr El-Sheikh, El-Gharbia, El-Beł ϵ ra, El-Dakahlia, El-Menofia, El-Sharkia, El-Fayum and Assuit).

This extension was due to dissemation the technique of marwa lining, that the farmers participation were promoted to 69.5 % including the half of the building materials and full of labours cost, while the project participated by 30.5 % in addition to the technical supervision; Consequently, the cost paid by the project was reduced from 25 LE/meter in 2001/2002 to 10.76 LE per meter in 2003/2004.

In 2004/2005, the project implemented its activities in eleven Governorates (Kafr El-Sheikh, El-Gharbia, El-Behera, El-Dakahlia, El-Menofia, El-Sharkia, El-Fayum, El-Menia, Assuit, Sohag and Qena). The project provided the farmers by 40 % of the building materials and the farmers shared by 60 % of the building materials in addition to labours cost. In this case, the farmer's participation reached to 75.26% while the project participation was 24.74%. As a result to great farmers participation, the cost paid by the project was reached to 9.4 LE per meter as shown in Fig. (2).

**Feasibility Analysis for Establishing lined marwas:**

Cost-benefit analysis (CBA) is conducted to quantitatively evaluate the impact of marwa lining. Three discounted measures are used: Benefit /Cost Ratio, Net Present Value (NPV) and the Internal Rate of Return (IRR). The CBA is conducted by weighing benefits acquired from implemented activities against its construction, maintenance and operating costs. Incremental benefits and costs are estimated on the basis of benefits acquired and cost incurred with the project intervention.

The quantified benefits include incremental net income due to yield increase as a result of soil improvement 88.5 LE/fed (about 20% of 4 meter on both the two sides of the lined marwa) and land saved 46.45 LE/fed. (about 0.05%), saving in irrigation hours (25 LE/fed.), saving in maintenance cost (34 LE/fed.).

Three discounted measures were estimated based on the following assumptions: 1) the useful life spans of major investments are 20 years. 2) The annual maintenance cost is 25 LE/fed.

**The result of CBA is reported as follows:**

B/C ratio at 8 % discount rate = 1.6
and at 10 % discount rate = 1.444
NPV at 8 % discount rate = 711 LE
and at 10 % discount rate = 507 LE
Internal Rate of Return (IRR) = 19 %

It is clearly indicated that the **BCR** at 10 % discount rate is higher than one (1.4). Indicating that the accrued discounted benefits is higher than the discounted costs over the useful life span of major investment. **NPV** is also positive (LE 507) at 10 % discount rate indicating that investment in the project activities is profitable. The Internal Rate of Return (**IRR**) for the marwa lining is higher than the opportunity cost of capital in the country (19 %). This means that it is needed 19% interest rate to get the same benefits from a bank instead of the investment in such project.

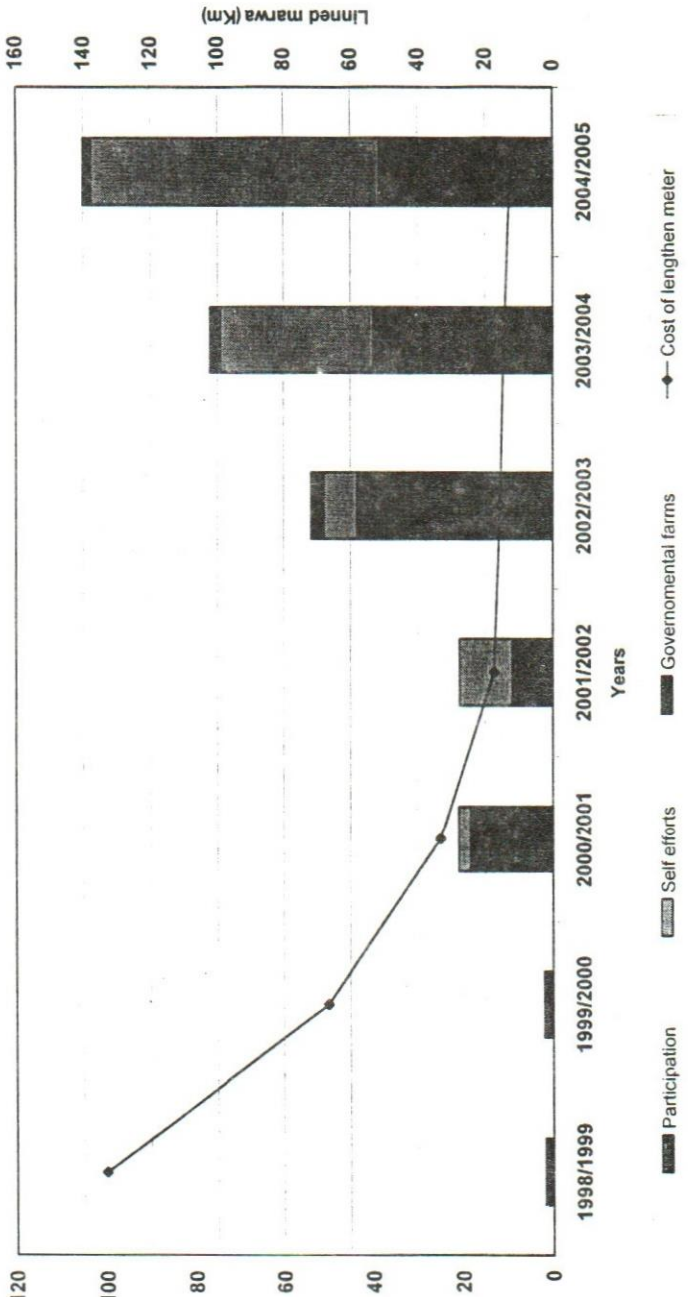



Fig (2): Achievements Of On-Farm Water& Soil Management Project for marwa development with farmers participation

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## تعظيم كفاءة توصيل مياه الري من خلال تبطين المراوي الحقلية في الأراضي القديمة

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تم اختيار حقول مشاهدة منذ عام ١٩٩٨ إلى ٢٠٠٥ لتحسين كفاءة توصيل مياه الري عن طريق تبطين المراوي الحقلية في إحدى عشرة محافظة وهي كفر الشيخ ، الغربية ، البحيرة ، الدقهلية ، الشرقية ، المنوفية وهذه المحافظات تمثل محافظات الوجه البحري بينما محافظات الفيوم ، المنيا ، أسيوط ، سوهاج ، قنا تمثل محافظات الوجه القبلي.

وهذه الحقول نفذت تحت إشراف مشروع إدارة المياه والتربة الحقلي بكفر الشيخ بالتعاون مع الإدارة المركزية للإرشاد الزراعي والهدف الرئيسي لهذا المشروع هو إمداد الزراع في الوادي والدلتا بنظام لإدارة المياه على مستوى حقولهم يمكن تكراره وتطبيقه ويكون مقبولا اقتصاديا واجتماعيا وبيئيا.

وقد قام الفريق الفني للمشروع بتصميم تسعة بدائل وتنفيذ هذه البدائل بمزرعة مركز تدريب وإرشاد الري الحقلي بسخا وكان نتيجة ذلك إقتناع معظم الزراع بالمحافظات المختلفة بنموذج التبطين بنصف طوبة والأرضية خرسانة عادية بمقطع ٤٠سم × ٤٠سم.

**ويمكن تلخيص النتائج المتحصل عليها:-**

تراوحت الفواقد المائية التي تم قياسها في المراوي الترابية على المساقي المختارة في محافظة كفر الشيخ بين ١٤,٤٦ ، ٢١,٣٦ % بينما تراوحت هذه القيم بين ١٣,٤٣ ، ٢١,٨٨ % في محافظة البحيرة.

وفيما يتعلق بإنجازات المشروع في مجال تبطين المراوي الحقلية فإن المشروع قد قام بتبطين ٢٠٥,٣٩ كيلو متر طولي من المراوي الترابية بالمشاركة مع المزارعين في إحدى عشر محافظة منذ عام ١٩٩٨ حتى ٢٠٠٥.

وقد انخفضت تكلفة المتر الطولي من ١٠٠ جنيه للمتر عام ٩٩/٩٨ إلى ٩,٤ جنيه في عام ٢٠٠٥/٢٠٠٤ نتيجة لزيادة مشاركة المزارعين التي بلغت ٧٥,٢٦ % في عام ٢٠٠٥ وقد أوضحت النتائج أن تبطين المراوي الحقلية أدت إلى إضافة ٠,٦ % إلى المساحة المنزرعة.

أوضحت النتائج أن نسبة الفائدة إلى التكاليف عند ١٠% سعر خصم أكثر من واحد صحيح (١,٤) وهذا يوضح أن الفائدة المتوقعة أعلى من التكاليف الأستثمارية على مدى عمر المشروع وأيضا أوضحت البيانات أن القيمة الصافية الحالية موجبة (٥٠٧ جنيه مصري) عند خصم ١٠% مما يدل على أن الأستثمار في أنشطة هذا المشروع مفيدة. وقد أوضحت النتائج أن معدل العائد الداخلي لنشاط تبطين المراوي أعلى من تكاليف الفرص البديلة ١٩% وهذا يعني أنا نحتاج إلى نسبة فائدة عند إدخار هذه الإستثمارات في البنوك تقدر بحوالي ١٩%.