Impact of channel lining on the economic feasibility for the agricultural sector (Case study in Babylon Government)

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Abstract

Periodic maintenance of irrigation projects and the use of modern irrigation methods play a key role in improving irrigation efficiency and have a positive impact on economic factors and improving agricultural productivity. The issue investigated is the low irrigation efficiency and its impact on agricultural productivity. The main objective of the research is to guess the economic benefit of preparing and lining irrigation projects. The agricultural area located within Iskandariya in Babylon Governorate, Iraq, that is irrigated from the branching canal from Iskandariya project was selected as a case study. Hydraulic data of the channel were collected before and after the channel lining, as well as agricultural and economic data of the study area. Initially the Flow Pro 2 model was applied for the purpose of estimating the hydraulic transactions of the channel for the period 2012 and 2018, before and after the lining process. Then, annual productivity and cash revenues were guessed on the basis of the data obtained and applied in economic mathematical equivalents. The results observed a water depth rate before lining of 0.6 m, while increasing by 0.15 m after lining. Also, the value of the water energy line is increased by 0.1 m. Moreover, the area under cultivation was shown to be 112 hectares more than in the past, in addition to the increase in the annual rate of profit being $59,515 compared to cash revenues before channel lining. Hence, an increase occurred in the rate of flow velocity of approximately 22% due to the training of the hydraulic section, which resulted in reducing the area of the hydraulic section of the channel by 33%. In addition, an increase occurred in the rate of flow velocity of approximately 22% due to the training of the hydraulic section, which resulted in reducing the area of the hydraulic section of the channel by 33%. Finally, the study recommended that, in order to optimize the use of water, modern irrigation techniques that improve water efficiency should be used and enhances the cultivation of the crops that need lower consumptive water.

Keywords: lining, Flow pro 2, agricultural productivity, cash revenues, economic benefit.

أثر تبطين قنوات الري على الجدوى الاقتصادية للقطاع الزراعي (دراسة حالة في محافظة بابل)

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الخلاصة

تلعب الصيانة الدورية لمشاريع الري واستخدام أساليب الري الحديثة دورًا رئيسيًا في تحسين كفاءة الري ولها تأثير إيجابي على العوامل الاقتصادية وتحسين الإنتاجية الزراعية. موضوع البحث الذي تمت دراسته هو انخفاض كفاءة الري وتأثيرها على الإنتاجية الزراعية. الهدف الرئيسي من البحث هو تخمين الفائدة الاقتصادية لإعداد وتبطين مشاريع الري. تم اختيار المنطقة الزراعية الواقعة داخل الإسكندرية في محافظة بابل، العراق، والتي يتم ريها من القناة المتفرعة من مشروع الإسكندرية كحالة دراسية. تم جمع البيانات الهيدروليكية للقناة قبل وبعد تبطين القناة، بالإضافة إلى البيانات الزراعية والاقتصادية لمنطقة الدراسة. في البداية تم تطبيق نموذج Flow Pro 2 لغرض تقدير المعاملات الهيدروليكية للقناة للفترة 2012 و 2018، قبل وبعد عملية التبطين. بعد ذلك، تم تخمين الإنتاجية السنوية والإيرادات المالية على أساس البيانات التي تم الحصول عليها وتطبيقها في المعادلات الرياضية الاقتصادية. بينت النتائج معدل عمق المياه قبل التبطين بمقدار 0.6 متر، بينما زاد بمقدار 0.15 متر بعد التبطين. كما زادت قيمة خط الطاقة المائية بمقدار 0.1 متر. علاوة على ذلك، ازدادت المساحة المزروعة بمقدار 112 هكتارًا عن السابق، بالإضافة إلى زيادة معدل الربح السنوي إلى 59,515 دولارًا أمريكيًا مقارنةً بالعوائد المالية قبل تبطين القناة. وبالتالي، ازداد معدل سرعة التدفق بنحو ٢٢٪ نتيجةً لتأهيل المقطع الهيدروليكي، مما أدى إلى تقليل مساحة المقطع الهيدروليكي للقناة بنسبة ٣٣٪. كما ازداد معدل سرعة التدفق بنحو ٢٢٪ نتيجةً لتأهيل المقطع الهيدروليكي، مما أدى إلى تقليل مساحة المقطع الهيدروليكي للقناة بنسبة ٣٣٪. وأخيرًا، أوصت الدراسة بضرورة استخدام تقنيات ري حديثة لتحسين كفاءة استخدام المياه، بما يُعزز زراعة المحاصيل الأقل استهلاكًا للمياه.

الكلمات المفتاحية: التبطين، برنامج Flow pro 2، الإنتاجية الزراعية، الإيرادات المالية، المنفعة الاقتصادية.

Introduction

The challenges that we face due to water scarcity as a result of climatic variability, rising temperatures, and increased water demand due to population growth, which adversely affected the quantities of water duty. It directly contributes to the dispossession of large agricultural areas, adversely affecting the country's economy, as well as the negative effects of environmental pollution. By determining the water consumption, the plant needs within a certain planting season, overall, the water requirement can be estimated. Soil and vegetation are deemed the most important factors influencing the value of water consumption. Improving irrigation efficiency and sustainable water resources ensures long-term durability of agricultural activity (Abidalla, *et al*.2021).

There are several methods to calculate, including mathematical methods, numerical methods, and computer models. Several materials, including concrete, geomembrane, bitumen, and masonry, have been employed to prevent seepage loss in canal lining. Concrete and geomembrane are the most widely utilized types (Soomro.*et al*,2018). Ponding tests on two canals before and after they were coated with concrete for a year showed that seepage loss may be decreased by 52–55% in China (Moataz,2022). For example, **(**Hojyaz. *et al*.2013) indicated that a lined canal's flow velocity is 1.5 to 2 times that of an unlined canal with the same canal bed slope and canal size. This implies that a lined canal's cross-section is smaller to provide the same discharge **(**Jägermeyr, *et al*.2015) simulated combined on-farm water management techniques to investigate how they could lower consumptive water losses and boost world production by 41%.(Rosa, *et al*.2020) discovered that adding supplemental irrigation to currently rainfed crops on a sustainable basis may boost yields enough to feed an extra 840 million people. (Zhang, *et al*.2017) Investigation of irrigation canal seepage losses through use of four different methods in hetao irrigation district.

(Kumari. *et al*,2017) examined water efficiency and agricultural productivity of several crops in different areas of Uttar State based on secondary data collected from different sources. The results provide comprehensive decision-making support to researchers, policymakers, and government development agencies to develop strategies for sustainable and alternative agricultural production systems to improve resource efficiency, particularly water, and maximize net agricultural income .While (Al-Qaisi. *et al*.2018) estimated the integrated actual and maximum water consumption based on field measurements, climate data, and the use of GIS techniques, remote sensitivity, and spatial images of the study area to determine the region's topography and vegetation. hence using a model (SWAT) in water consumption determination and optimal water duty evaluation that contributes to environmental conservation by promoting green spaces and supporting the country's agricultural and economic sector. (Weerahewa, *et al*.2023) demonstrated that the seepage rate for a canal liner with a 1% crack area is 70% higher than that for unlined conditions. The study concluded that the smooth surface and lining of the canal can boost the flow's velocity (Toman Osman Tarsh,2024) Assessment of water transport efficiency in the main channels distributed within the Khajia project in the Wasit governorate. The study also examined the negative impact of significant water resource shortages resulting from population growth and global warming on socio-economic aspects. The study concluded that a large amount of water was lost due to deep penetration and recommended studying the cracks in the lining boards and using modern irrigation methods to reduce water loss. Objective of the current study 1. Estimated hydraulic factors of irrigation channels before and after lining performance. 2. Estimated the agricultural productivity and the rate of interest for cultivated crops irrigated from the sub-channel of Iskandariya Channel in the Babylon governorate.

Study area

Part of Al-Iskandariya region was selected within the Babylon Governorate/Iraq with a total area of 4,000 dunums and irrigated from the IS-05 canal branching from the Ayman Iskandariya Table within the 363772-3630413 longitude and the 439134-441630 latitude as shown in Figure (1).
Through field investigation, the land level and topography and the places of altitudes and lows were identified and shown to range between 35 and 30 m.
The study area includes residential buildings and roads as well as arable agricultural land, where the soil is classified as silty soil .The agricultural lands of the study area have been irrigated by the branch IS-05, which is deemed one of the earth channels fed by the Iskandariya stream. The discharge of the channel was 1 m³/s, controlled by a head regulator with dimensions of 0.8 m * m³ and a length of approximately 8 km as it runs along the Karbala-Baghdad railway. To reduce water losses and deliver water rations to all beneficiaries, they have been lined with concrete with the establishment of regular outlets by the Ministry of Water Resources in stages for the regular distribution of water. All hydraulic details of the channel before lining were shown in Figure**(**2)**.** (MoWR,2022) (Mohamed, *et al*. 2023).

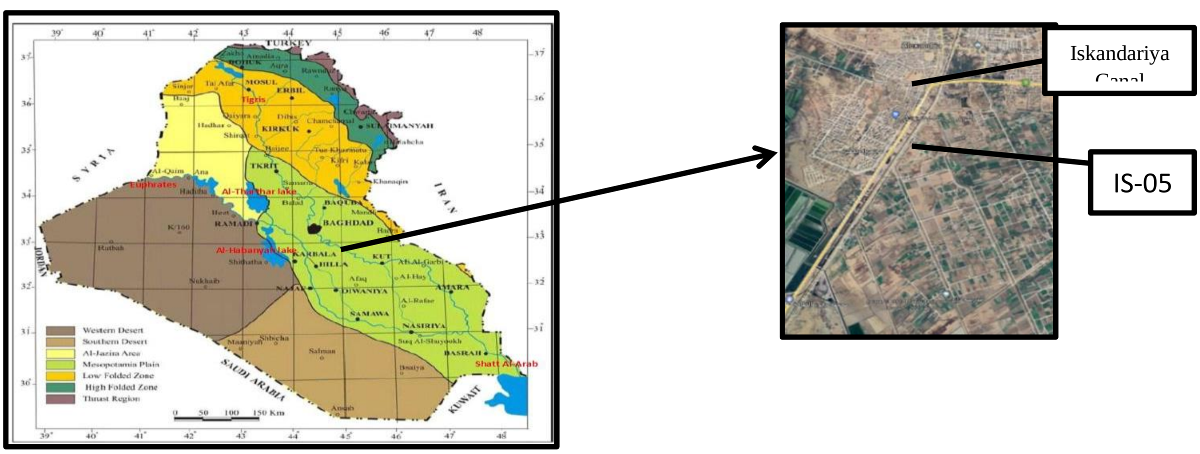

Figure 1 Study area

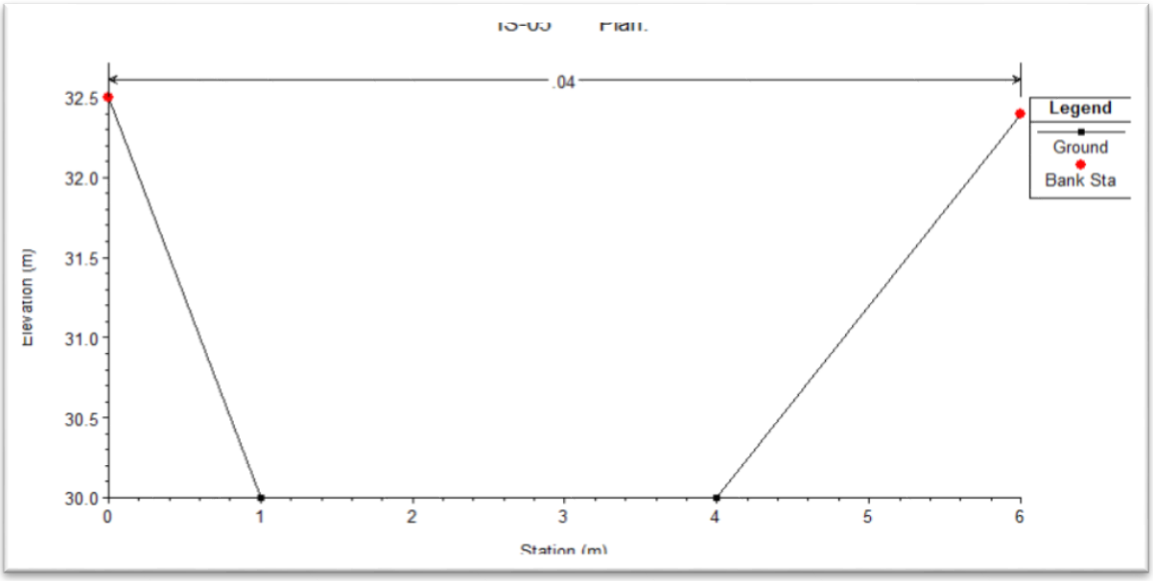

Figure 2 Hydraulic section of the sub- channel before lining

MATERIAL AND METHODS

1. Data gathering

In this study, the field data of the study area have been obtained by the (Department of Agriculture/ Iskandariya.2023**)** (Ministry of Agriculture, 2023) for summer and winter crops (wheat, barley, maize, and other crops), with the value of proceeds and cost before and after lining and for 2012 and 2018 as shown in Table 1 and Table 2. According to data obtained from the study area, 90% was covered by agricultural crops and 10% by trees and orchards.

On the other hand, varying productivity and prices of agricultural crops were investigated when enhanced water quantities after reclamation of the cultivated land.

Table 1. Represents the production cost of before -lining crops 2012

Type of crops	Productivity ton/ ha	Sale price ton /$	Production value (ha/ $)	Cost (ha/ $)	Area cultivated before lining / ha
Wheat	2.8	500	1400	800	175
Barley	2.6	300	780	350	75
Corn	2.6	250	650	250	115
Other crops	3.3	150	495	200	25
Sum					390 (ha)

Table 2. Represents the cost of productivity of crops grown after lining 2018

Type of crops	Productivity ton/ ha	Sale price ton /$	Production value (ha/ $)	Cost (ha/ $)	Area cultivated after lining / ha
Wheat	2.8	500	1400	800	250
Barley	2.6	300	780	350	90
Corn	2.6	250	650	250	130
Other crops	3.3	150	495	200	32
Sum					502(ha)

Mathematical model

A computer model (Flow Pro 2) was used for the purpose of estimating hydraulic parameters after channel qualification (lining), relying on the Manning equation as listed below. (Chow, Ven Te.1988).

$Q= 1/n *(S)^{\wedge 2} *(R)^{\wedge 2/3} *A$ (1)

Where:

Q: discharge (m^3/s)

S: slope of the channel

A : hydraulic area (m^2)

R :hydraulic radius (m)

Many mathematical equations were then applied for the purpose of guessing agricultural productivity before and after lining as well as the value of total and net return before and after qualification as listed below (Vedula. and Mujumdar.,2005)

Production value per hectare/dollar ($) = productivity ton/hectare * Sale price per ton/dollar ($) (2)

Value of return per hectare/dollar ($) = value of production per hectare/$ - value of expenses per hectare/$ (3)

Total Return Value Before Petition/$ = Return Value Per Hectare/$ * Area Grown Before Lining/$ (4)

Total return value after reprieve/$ = return value per hectare/$ * Area grown before lining/$ (5)

Net return per hectare/$ = total return value after reply/$ - total return value before lining /$ (6)

Future worth value = present value * $(1+ \text{interest rate})^n$ (7)

n: Number of years, i: interest rate.

Lining process

Generally, the lining identified as the process of covering the bottom and sides of water channels with impermeable materials to improve their efficiency and durability. It thus helps reduce leakage losses, corrosion, and water saturation, ensuring more water reaches the channel tail. Several advantages were obtained from the lining canal, such as preventing corrosion. protects the channel from deterioration due to water flow, Increased flow efficiency reduces resistance, allowing water to move faster, lower maintenance costs by reducing plant growth and sediment accumulation, preventing floods by strengthening the canal structure, and reducing the risk of breaches (Azzam. Et al.2016) (Elkamhawy. Et al,2021) Common methods were employed for lining (Concrete lining – durable and soft, lining with building materials, Lining with plastic or asphalt materials, lining with clay). Also, geomembranes or geotextiles provide seepage control, which is deemed lightweight and flexible. while HDPE Geomembranes High-density polyethylene (HDPE) geomembranes, which are durable, UV-resistant, and flexible. in which an alternative to concrete in remote areas where transportation and installation of heavy materials are challenging as shown in Figure (3. a, b, c, d)

Results and Discussion

The modeling of the irrigation channel before and after the lining process of the study area was performed by applying the Flow Pro model 2. Through the results of scenarios (before and after lining), the subcritical flow type and M-1 flow curve type were generally observed. There has also been a significant change in hydraulic transaction values (depth, velocity, and water kinetic energy rate). Water depth at station 1000 m before lining is 0.6 m While increasing by 0.15 m after lining. While the increase in water energy is 0.1 m .At the same time, the rate of depth of flow appeared at station 1000 m distance from the head regulator after canal lining was 0.22 m and then increased very slightly until it became constant along the channel section, while the highest value observed for the velocity after lining was 0.43 m, as shown in figure (4) and figure (5). After hydraulic modeling and based on field data of the study area in 2012, the annual pre-lining productivity rate and the cash returns were calculated, which were $1,725 as shown in Table 3. At the same time, the cost of each crop per hectare and the net proceeds before lining were represented. The total annual return of the crops grown in the area, which was 390 hectares before qualification, was determined, as shown in Table 4.

In 2018, after the lining, the annual rate and revenue of the cultivated area, which was 502 hectares, were calculated as shown in Table No. 5. The results show that the increase in the area under cultivation is 112 hectares more than in the past, in addition to the increase in the annual rate of return of $59,515 compared to the revenues before lining the channel. The annual annual interest rate was also estimated on the basis of net returns, as shown in table 6.

Through the results, it was observed that the rate of increase in the depth of water at the lining of the canal is approximately 30% and is also offset by an increase in the amount of energy by 15%. The flow velocity rate before lining was seen at the station 1000m from the head regulator at 0.22m and then increased very slightly until it became constant along the channel section, while the highest value observed for the velocity after lining is 0.43m.

a.

b.

c.

d.

Figure3 Channel lining types

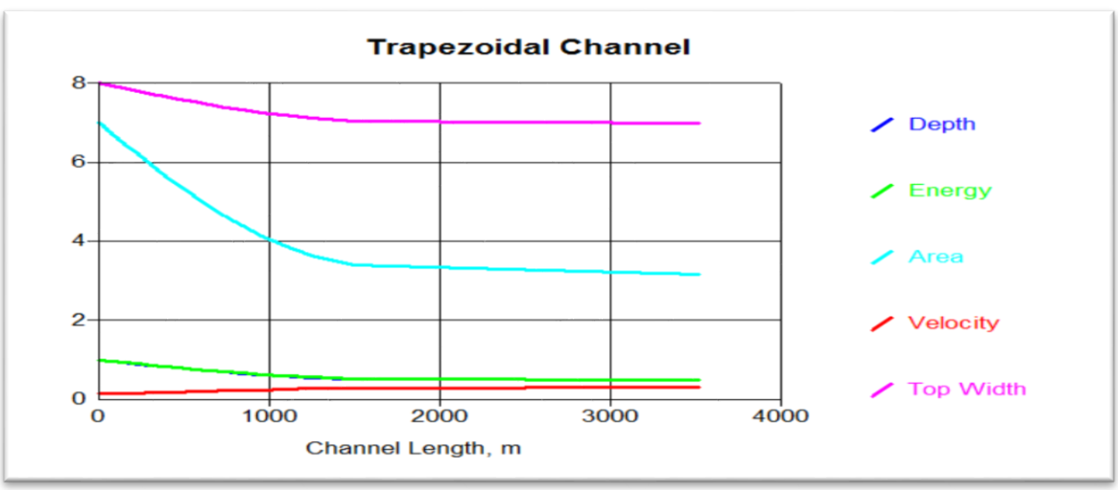

Figure 4 Hydraulic details of the branch channel before lining

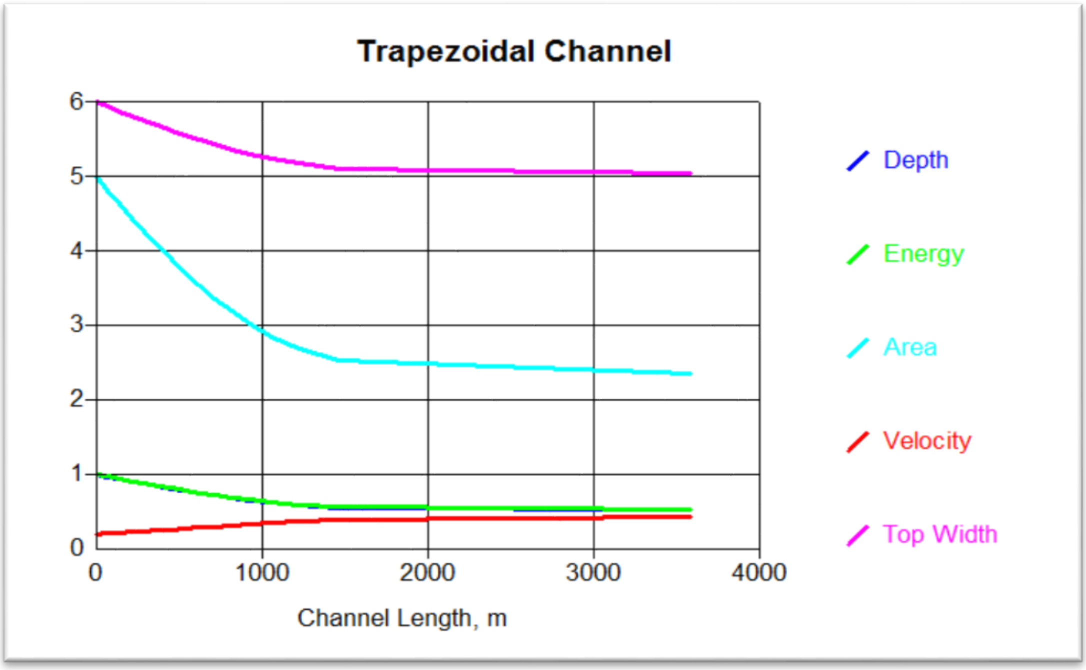

Figure 5: Hydraulic details of the branch channel after lining

Table 3 Represents the annual production value of crops grown per hectare before lining

Type of crops	Productivity ton/ ha	Sale price ton /$	Production value (ha/ $)	Cost (ha/ $)	Revenue (ha/ $)
Wheat	2.8	500	1400	800	600
Barley	2.6	300	780	350	430
Corn	2.6	250	650	250	400
Other crops	3.3	150	495	200	295
Sum					1725($)

Table 4. Represents the annual total revenue of crops grown per area before lining

Type of crops	Revenue (ha /$)	Area cultivated after lining / ha	Total revenue after lining /$
Wheat	600	175	105000
Barley	430	75	32250
Corn	400	115	46000
Other crops	295	25	7375
Sum		390 (ha)	190625 ($)

At the same time, an increase in the rate of flow velocity was apparent by 22%, resulting from the improved of the hydraulic section, reducing the area of the hydraulic section of the channel by 33%, and reducing the roughness coefficient of the channel. Economically, the proportion of area grown after lining increased by 22%, which in turn contributed to an increase in annual productivity by 24% and cash revenues by 17%. In order to optimize the use of water, the use of modern irrigation techniques and the reduction of abuses on river profiles and the selection of low-water crops, while activating the role of water users' associations and effective cooperation between farmers and water management. shown in figures (6), (7), (8), and (9).

Applying the equation no. (7) by adoption net interest rate the future cash value of each crop was guessed as the highest value of future worth yields of the wheat crop was observed as ($200,000).

Finally, (Han. *et al*,2020) examined that the lining process, not used for minimize the seepage only, but it reduced the issues of water logging. this water saved aid and contribution for enhancement the crop types. These water-saving measures help and contribute to the improvement of crop varieties. Consequently, farmers' economic standing improves. Additionally, it supported a water supply for the tail end. (Mistry. *et al*,2023) investigated that a smooth surface rugosity coefficient will be reduced by the lining, resulting in reduced flow resistance and enhanced flow velocity. About 25–30% of water that would otherwise be wasted is saved by canal linings for the different reasons mentioned above.

Water conservation through lining will allow the project to expand irrigation to an additional 2000 ha. In addition to reducing seepage, canal lining will lessen the issue of waterlogging. Water savings of any amount can be applied to better crop patterns.

Table 5. Represents the total revenues of crops grown for each area after lining

Type of crops	Productivity ton/ ha	Sale price ton /$	Production value (ha/ $)	Cost (ha /$)	Revenue (ha/ $)	Area cultivated after lining /ha	total revenue after lining /$
Wheat	2.8	500	1400	800	600	250	150000
Barley	2.6	300	780	350	430	90	38700
Corn	2.6	250	650	250	400	130	52000
Other crops	3.3	150	495	200	295	32	9440
Sum					410$	502(ha)	250140($)

Table 6. Represents annual net revenues and interest rate for crops grown per area after lining

Total revenues after qualification/$	Total revenues before qualification/$	net revenues	Interest Rate (i%)
150000	105000	45000	0.75
38700	32250	6450	0.1
52000	46000	6000	0.09
9440	7375	2065	0.045
250140($)	190625 ($)	59515($)	

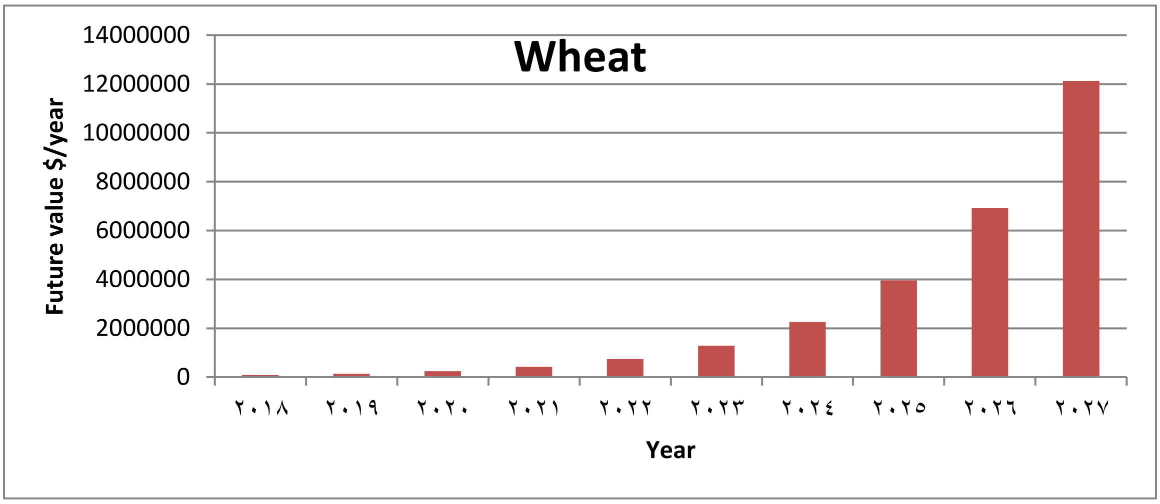

Figure 6 Probable annual future worth for the wheat crop

The rate of increase in the depth of water when lining the canal is approximately 30%. also, corresponding the increase in the amount of energy about 15%.

An increase in the rate of flow velocity by 22% resulting from the trimming of the hydraulic profile and reducing the area of the hydraulic section of the channel by 33% and reducing the roughness coefficient of the channel.

- The proportion of area cultivated after lining increased by 22%, which in turn contributed to an increase in annual productivity by 24% and cash revenues by 17%.

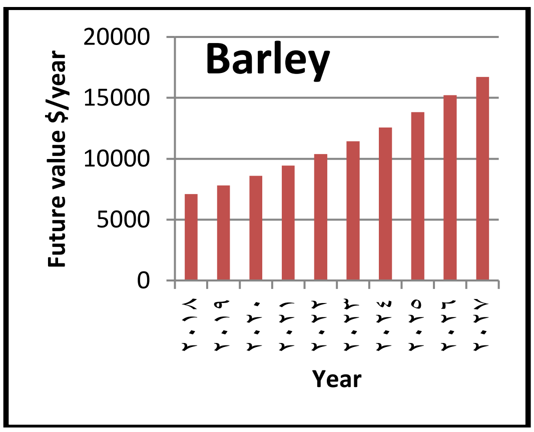

Figure 7: Probable annual future worth of barley crop

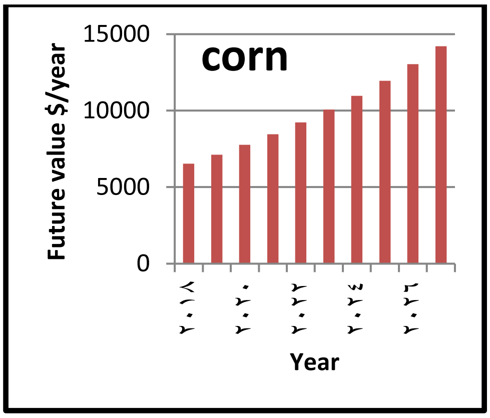

Figure 8 Probable annual future worth of corn crop

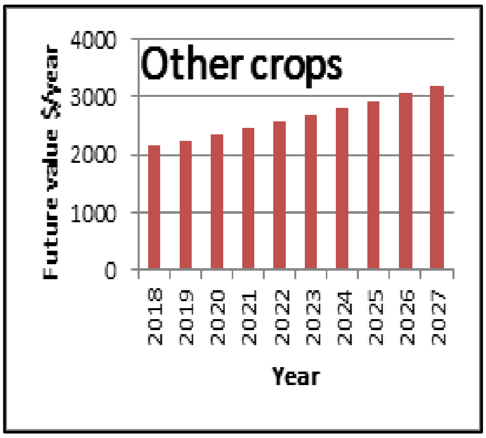

Figure 9 Probable annual future worth of another crop

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