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ADAPTING THE IRRIGATION MANAGEMENT SIMULATION GAME TO THE SURFACE IRRIGATION SYSTEM IN THE NILE DELTA "A CASE STUDY FROM DAKAHLIA GOVERNORATE"

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ABSTRACT

An adapted card-simulated-version of the irrigation management game was developed to conform to the old surface irrigation system in the Nile Delta. This first version was applied and evaluated for a case study from Dakahlia Governorate.

The water supply factor and yield response factor to water deficit were used as indicators for the goodness of water supply and coincided yield. Because of the multidisciplinary factors included in the irrigation management game a computer-based model needs to be developed to determine how best to allocate irrigation water resources among crops and among farms when water supply is limited. It should take into account the socio-economic and technical factors of farm income.
Keywords: Irrigation management game, Surface irrigation, Nile Delta.

INTRODUCTION

Irrigation management especially with the old surface system in the Nile Delta is not an easy job. This is basically due to the inter-relationship between technical and social factors and multidisciplinary nature of the Delta. Farmers lack knowledge on water requirements and misuse fertilizer input levels and they are very keen to override their water rations. On the other hand, irrigation officials most likely misallocate water supplies. Moreover, the inability of neighboring communities to collaborate for more efficient use of resources (Carruthers, 1981).

The irrigation management game (IMG) is a gaming simulation or a Role-playing Game (RPG) which draws together some of the technical and social issues involved in irrigation water management (Burton, 1989 and 1994). In the field of water management, games have been used as training tools for a long time (Lenselink & Jurriens, 1993).The IMG history goes back to 1982 when the first version was developed by Burton of the Institute of Irrigation Studies, Southampton and Carruthers of the Economics School, Wye College, University of London, in collaboration with Sir M. MacDonald & Partners, Consulting Engineers, Cambridge (MacDonald & Partners 1982). The IMG may be considered as a role playing exercise for the training of professionals involved in the management of irrigation schemes. The game places participants in the role of farmers and irrigation officials. The role play develops an understanding of the issues involved in managing an irrigation system and creates an awareness of the importance of human relationships and communication in the management process (Burton and Carruthers, 1984).

The IMG has been developed with the overall goal of demonstrating the significant impact of irrigation water distribution decisions on farmers and farm income. This goal is achieved by structuring the game to feature the relationship of farm unit geographical location within the irrigation system as well as crop growth and yield response to water supply. Farmers within the irrigation scheme are dependent on irrigation supplies from the main canal system and have to schedule irrigation supplies to their field based on the supplies received and crop type. The IMG serves to draw participants' attention to the effect of timeliness of water supplies for different crops, to the effect of water supply on crop yield and to some of the advantages and disadvantages experienced by top and tail-enders in the canal network. It also recognizes the water allocation policy adopted for the irrigation scheme, performance assessment and work done versus results achieved.

The main objective of this paper was to adapt and apply the irrigation management game to the old surface irrigation system in the Nile Delta where a case study from Dakahlia Governorate was initiated. Other objective was to test and evaluate the game simulation on the overall irrigation management process.

MATERIALS AND METHODS

Basics of IMG:

The irrigation system consists of a number of cropping areas each of which is cultivated by farmers from one village. The irrigation water is diverted by means of a masonry weir from the river into the head reach of the irrigation system. The water supply available to the irrigation system varies within and between years depending on the annually joint policy and decision making process between officials from Ministry of Agriculture and Ministry of Irrigation and Water Resources. The Ministry of Agriculture requests the quantity according to the expected cropping patterns and the area cultivated. However, the upper hand is for the officials of the Ministry of Irrigation and Water Resources. Most of the time, farmers are not satisfied with their shares. This is may explained by the fact that the policy of crop rotation became voluntarily. As a result, farmers choose to cultivate crops with high returns regardless it matches their water rations or not. Therefore, water distribution is very difficult to manage. Neither officials nor farmers are pleased though.

The case study from Dakahlia Governorate was chosen from Aga district. Where the main canal (Mansoria) branches from the Nile at Meet Ghamr Weir. Then secondary canals branches from Mansoria to irrigate different areas. The selected studied area (half the distance between Nawasa al Bahr and Nawasa al Ghayt) is located within the circle area of Aga district (Table 1 and Figure 1).

This area is about 179 Feddan and is irrigated via the "OM-Algalagel" secondary canal. This canal as it passes through irrigates two basins in this area (i.e. the eastern coast ≈ 91 Feddan and the western coast ≈ 88 Feddan). The average number of land holders on this water supply is 41. The average holding area is 5 Feddan/holder. Crop pattern consists of a mixture of field crops and vegetables. Between the head reach and the tail end of the secondary canals the allocation of water to each individual landholding is controlled by the Section of the irrigation department. The farmers' main concern is the adequate and reliable water supplies, especially during periods when crop yields are sensitive to the supply of water.

In order to properly organize the distribution of water among landholdings, the farmers have appointed water managers (WM) whom represent a link among farmers and irrigation officials. They also advise farmers on which crops to grow during seasons, familiarize their selves with the crop water requirements and make requests of water supply requirements for the forthcoming season from irrigation officials. Consequently, the irrigation officials consider the requests and calculate the water allocation for the canal accordingly.

Table 1. GPS location of the studied area (Google, 2009)

Region	GPS location			
Nawasa al Bahr	30°	59'	7"	N
	31°	18'	5"	E
Nawasa al Ghayt	30°	58'	29"	N
	31°	19'	19"	E

IMG procedure:

Figure 2 was adapted and developed to represent a flow chart for the IMG steps:

1. The area was divided according to landholdings into blocks (basins) Figure 3. The total area of each block was similar (≈10 Feddan) but not equal. The landholdings' fragmentation may explain the reason. One crop must occupy the whole block to ensure the same amount of crop water requirements for this block. Each block had an intake opening on the canal to control the supply.
2. At the start of the season, the crop pattern was planned. Three field crops were examined; winter potatoes, onions, and maize where one block was specified for each crop.
3. Water requirements (required amount) for each crop were calculated using methods described by Ramadan *et al.* (2005). For each crop, three crop stages were considered; (I) vegetation, (II) flowering and (III) yield formation. For each block (Figure 4) the water required was then calculated considering the average field efficiency factor of 0.6.
4. The canal water supply request was then calculated (Figure 5) based on the sum total of blocks.
5. The irrigation officials decide water allocation based on the available water supply.
6. The water supply factor was recognized according to Table 2 and the following equation:

Figure 1. Arial satellite photo of the studied area (source, Google, 2009)

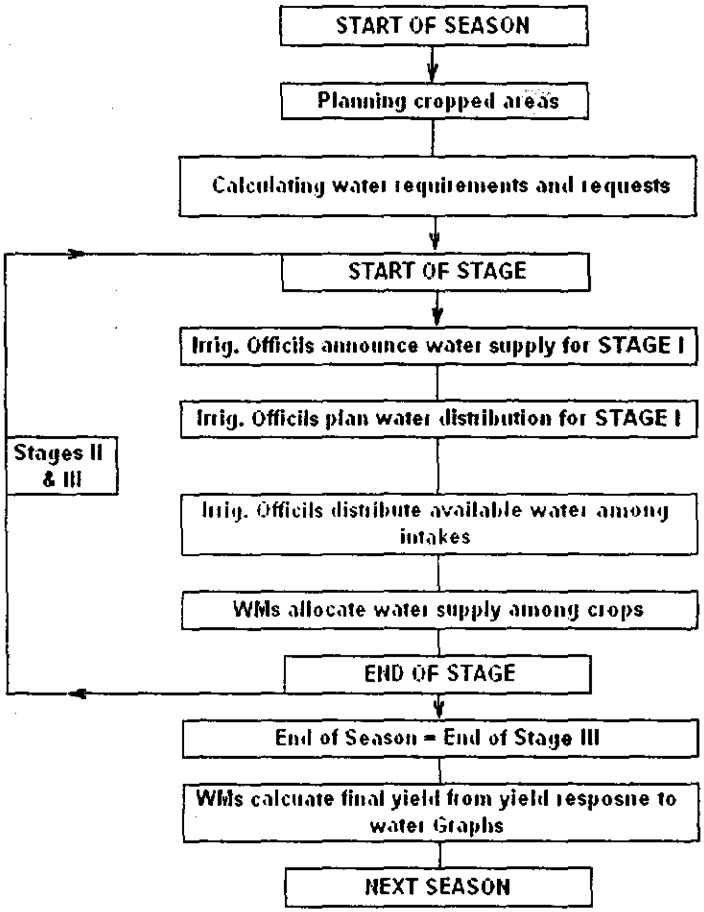

Figure 2: A Flow Chart for the IMG steps

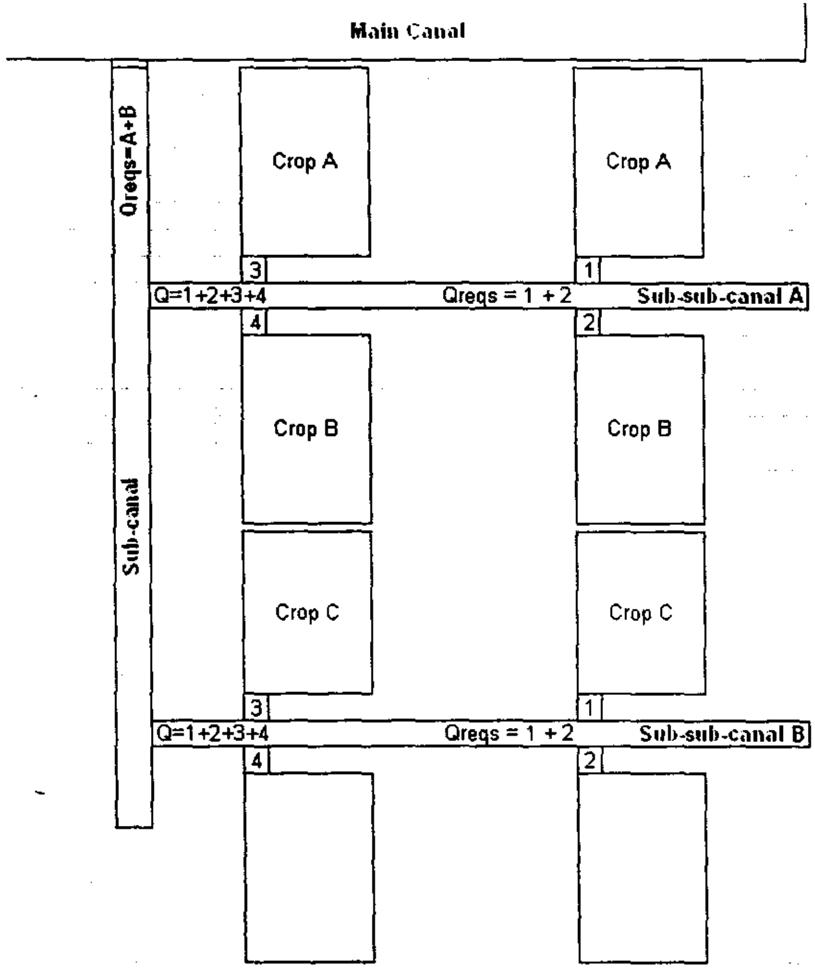

Figure 3. Graphical presentatin of water allocation on field

Block No.				
Crop:		Area: .... F		
Field efficiency factor:				
Stage	Qreq	Qrec	Qreq/Qrec	Yp
I				
II				
III				
Qreq = Quantity required on field				
Qrec = Quantity received on field				
Yp = Potential yield				

Figure 4: The block (crop type) card

Canal degree .... Canal name .....,			
Stage	Qreqst	Qsupp	Bsub
I			
II			
III			
Qreqst = Quantity Requested			
Qsupp = Quantity Supplied			
Bsub = Block sub-total			

Figure 5: The canal intake card

$$Water\ Supply\ Factor\ (WSF) = \frac{Received\ water}{Required\ water} \quad ....(1)$$

Table 2. Evaluation of water supply factor (MacDonald & Partners 1982)

Value of Water Supply Factor	Supply evaluation
Greater than 1.10	Excessive supply due to water logging
0.90 - 1.10	Good
0.50 - 0.89	Medium
0.20 - 0.49	Poor
0.00 - 0.19	No supply

Yield response to water calculation:

The yield of a crop is related to the quantity and timing (scheduling) of the water that it receives. Different cops have different yield responses to water (Doorenbos *et al.* 1979). The yield response to water was calculated according to the following formula:

$$1 - (Y_a / Y_m) = K_y [1 - (ET_a / ET_m) \quad ....(2)$$

where,

Y_a = actual harvested yield

Y_m = maximum harvested yield

K_y = yield response factor

ET_a = actual evapotranspiration

ET_m = maximum evapotranspiration

The maximum evapotranspiration was calculated to equal the potential consumptive water use demanded by the atmosphere at no water shortage (Allen, *et al.* 1998). The maximum harvested yield (Y_m) was based on the maximum yield obtained in the area at no limiting factors of water, fertilizers and crops' diseases. The (Y_m) was considered to be 15, 15 and 4.5 ton/Feddan for winter potatoes, onions, and maize respectively.

RESULTS AND DISCUSSION

Crop water requirements:

Table 3 represents average crop water requirements, m^3/Feddan and as irrigation depth (mm) for maize, potato and onions at the three growth stages. The total irrigation depths were 648.2, 642.6 and 471.6 mm for the maize, potato and onions respectively.

Table 3. Average crop water requirements, m^3/Feddan and as irrigation depth (mm) for maize, potato and onions at the three growth stages

Crop growth stage	Maize	Potato	Onions
Vegetative	1125.0 (267.9)*	719.7 (171.4)	565.7 (134.7)
Flowering	472.5 (112.5)	899.6 (214.2)	685.1 (163.1)
Yield formation	1124.8 (267.8)	1079.6 (257.0)	730.0 (173.8)
Total	2722.3 (648.2)	2698.9 (642.6)	1980.8 (471.6)

*** Values between brackets = irrigation depth, mm**

Yield response factor (Ky):

When water supply does not meet crop water requirements, actual evapotranspiration will fall below maximum evapotranspiration (Thompson *et al.* 1981). Water stress will then develop and adversely affect crop growth and ultimately yield. The effect of water stress on growth and yield depends on crop species and variety on the one hand and the magnitude and the timing of occurrence of water deficit on the other. This is of major importance in scheduling available but limited water supply over the growing periods of the crops and in determining the priority of water supply amongst crops during the growing season.

Figures 6, 7 and 8 show the relationship between relative yield decrease (1- Ya/Ym) and relative evapotranspiration deficit (1 – ETa/ETm) for maize, potato and onions at three crop stages respectively. The relative yield decrease (1- Ya/Ym) was then correlated to the relative evapotranspiration deficit (1 – ETa/ETm) to obtain the yield response factor (Ky). Table 4 represents the values of (Ky) for maize, potato and onions at three crop stages respectively. For the three investigated crops the trend was similar but the magnitudes varied. The coefficient of determination was highly significant (i.e. being 0.99) at 1 % level. The (Ky) represents the slope of the line fitted for the relationships. The higher the line slope the more sensitive the crop stage. For maize crop the flowering stage was the highest sensitive period where (Ky) equaled 5.61. Comes in descending order the vegetative stage having Ky of 1.83 then the yield formation stage at Ky of 1.01 (Table 4). The Tuberization period of potato crop was the highest sensitive stage to water deficit. The onions establishment period was the highest sensitive stage to water shortage.

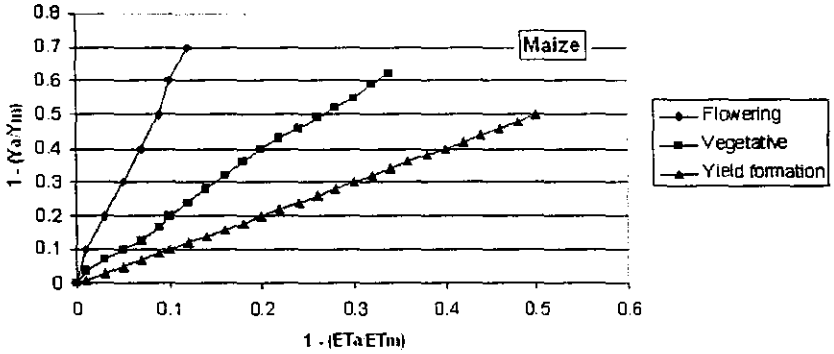

Fig. 6: Relationship between relative yield decrease (1-Ya/Ym) and relative evapotranspiration deficit (1-ETa/ETm) for maize

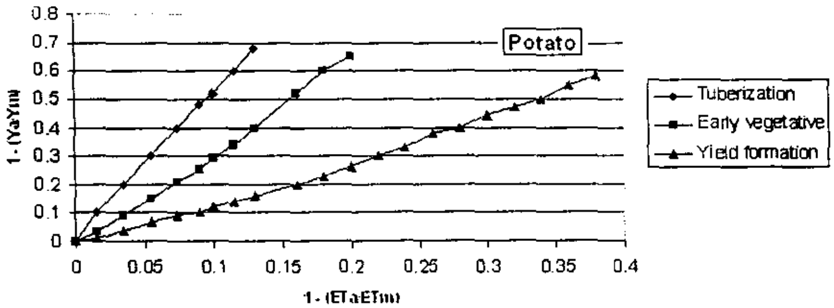

Fig. 7: Relationship between relative yield decrease (1-Ya/Ym) and relative evapotranspiration deficit (1-ETa/ETm) for potato

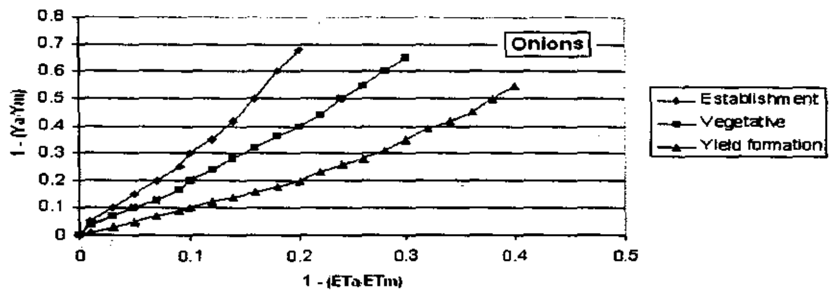

Fig. 8: Relationship between relative yield decrease (1-Ya/Ym) and relative evapotranspiration deficit (1-ETa/ETm) for onions

Table 4. Values of yield response factor (Ky) for maize, potato and onions.

Maize crop stages		
Vegetation	Flowering	Yield formation
1.83	5.61	1.01
Potato crop stages		
Early vegetation	Tuberization	Yield formation
3.35	5.12	1.54
Onions crop stages		
Establishment	Vegetation	Yield formation
3.26	2.12	1.3

Experience with the game:

Experience with applying the irrigation Management simulation game with old irrigation system in the Nile Delta is unique. The participants varied in their education and concepts. This was reflected on their decision making process during the implementation of the game. The need to further improve the on-farm irrigation management process via is though required.

CONCLUSIONS

It may be concluded that:

- The water supply factor and yield response factor to water deficit were used as indicators for the goodness of water supply and coincided yield. For the three investigated crops the trend was similar but the magnitudes varied. The higher the line slope (Ky) the more sensitive the crop stage. For maize crop the flowering stage was the highest sensitive period where (Ky) equaled 5.61. Comes in descending order the vegetative stage having Ky of 1.83 then the yield formation stage at Ky of 1.01. The Tuberization period of potato crop was the highest sensitive stage to water deficit. The onions establishment period was the highest sensitive stage to water shortage.

- Because of the multidisciplinary factors included in the irrigation management game a computer-based model needs to be developed to determine how best to allocate irrigation water resources among crops and among farms when water supply is limited. It should take into account the socio-economic factor of farm income.

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ادخال وتهيئة لعبة محاكاة إدارة المياة لتوافق نظام الري السطحي في دلتا نهر النيل
" دراسة حالة من محافظة الدقهلية "

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تم استنباط نسخة محاكاه للعبة إدارة المياه بوسائل الكروت العادية لتتوافق مع نظام الري السطحي القديم المستخدم في دلتا نهر النيل. وتم تطبيق استخدامها وتقييمها كدراسة حالة من محافظة الدقهلية. تم استخدام عامل اتاحة مصدر المياه ، وعامل استجابة المحصول للنقص في المياه وذلك لبيان مدي جودة المصدر علي الامداد بالمياه وكمية المحصول المتحصل عليه طبقا لحساسية نوع ومرحلة نموالمحصول للنقص في الاحتياجات المائية. وتبين من التطبيق أنه وبسبب العوامل المتعددة والتداخل الحادث بينها في لعبة ادارة مياه الري فالحاجة ماسة لاستنباط نسخة تعتمد علي الحاسب الالكتروني لتحديد جودة توزيع مصادر مياه الري بين انواع المحاصيل وكذلك بين المزارع المختلفة عند محدودية مصادر المياه. ويجب أن تشمل نسخة الحاسب هذه علي اعتبار العامل "اجتماعي- اقتصادي – فني" لدخل المزرعة .