Iraq’s Wheat Production Economics: To what extent it is possible to close the current yield gap? By Dr Fadhel Ridha *

Contents

IEN Policy Papers: Iraq’s Wheat Production Economics

Abstract

The objective of this paper is to raise a question and examine the possibility of revitalizing wheat production and industry in Iraq. To what extent it is possible to close the gap between the actual wheat yield per unit of land and the potential yield in Iraq using the available tools such as high yielding cultivars, optimal use of fertilizers and water application as well as other agronomic practices. The paper is descriptive in nature and intended to invoke discussion on wheat sector. This paper will be followed by technical research study on wheat sector economics.

The papers argues that the strategy of business-as-usual implies exit of millions of productive land and in turn Iraq will run the risk of failing to achieve food security for ever growing population. The adoption of strategy based on an integrated technology packages and developing policy to incentivize startups and young entrepreneurs to operate in the farming sector are key pillars to have a vibrant agricultural sector. Wheat farming can be a candidate sector for economic diversification.

ملخص

تهدف هذه الورقة إلى طرح سؤال ودراسة إمكانية تنشيط إنتاج القمح في العراق. إلى أي مدى يمكن تحقيق نمو مستدام في غلة القمح المنتج في وحدة المساحة المزروعة بالقمح في العراق باستخدام الأدوات المتاحة مثل الأصناف عالية الغلة ، والاستخدام الأمثل للأسمدة والمياه بالإضافة إلى المعاملات الزراعية الأخرى, ولردم الفجوة بين العائد الممكن والغلة الفعلية للقمح. ان هذه الورقة ذات طبيعة وصفية ويقصد بها تفعيل النقاش العلمي حول اساليب السياسات وادارة الانتاج في قطاع القمح. من المؤمل أن نتبع هذه الورقة بدراسة بحثية تتضمن التحليل الفني لاقتصاديات القمح أذا ما توفرت المعطيات المطلوبة لاستخدام المناهج التحليلية للدراسة.

ان المعطيات التي تم بحثها في هذه الدراسة توضح بان غلة القمح المنتجة في وحدة المساحة في العراق متدنية بشكل كبير وهنالك أمكانية لزيادتها. أن قطاع القمح هو احد الفرص المتاحة في ستراتيجيات تنويع الاقتصاد العراقي. كما ان منهج الاستمرار بالسياسات التقليدية في القطاع الزراعي سيفضي الى خروج ملايين الهكتارات من الانتاج وبالتالي زيادة الهجرة من الريف والدخول في مخاطر عدم اليقين في تأمين الامن الغذائي في العراق. ان تبني ستراتيجيات مبنية على حزم تكنولوجية متكاملة وتشجيع فئات الشباب في العمل الزراعي هو احد اسس تنويع الاقتصاد العراقي.

Introduction

Iraq is in a pressing need than ever to diversify its economy and to exit from a situation where the entire economy as being "terminal economy" which it is based on exhaustible resource. While agricultural sector has been neglected for the last 50 years, it is still the candidate domain which can contribute to the strategy of economic diversification. Further, the rate of rural migration is unprecedented and alarming. The societal cohesion and stability of the social structure may be threatened by the rapid increase of urbanization where the government fails to provide jobs and required services in the peripheries of major cities.

Wheat is the major source for calories in Iraq. It is considered one of the strategic crops in food security bundle. While cereals yields in most of the developed and developing world increased steadily during the last 50 years (P. Tittonell, K.E. Giller, 2013), long term average of wheat yield in Iraq per unit of land did not exceed 1 ton/ha^{-1}/year^{-1}. However, the productivity of per unit of land in Iraq is low compared with world yield average per unit of land. However, there has been noticeable increase during the last 10 years as shown in figure.1 and figure 2. which show the total annual wheat production and the yield per hectare for years 1960 to 2019 respectively. There exists large wheat yield potential which can be achieved by adopting high yielding cultivars that can express their potential at low level of N (Monasterio *et al.*, 1997), combined with efficient agronomic practices such as irrigation schedules, optimal application of fertilizers, date of planting and optimal water applications. Understanding differences between the theoretical yield levels and actual farmers' yields define the yield gaps, and the precise spatially explicit knowledge about these yield gaps is essential to guide sustainable intensification of agriculture (van Ittersum *et al.*, 2013). Given the environmental stress every hectare of existing crop land will need to produce yields that are substantially greater than current yield levels. Yield gap analysis should form the foundation to identify the cropping patterns where there is scope for yield improvement and the possibility of improving the agronomic practices to close the gap.

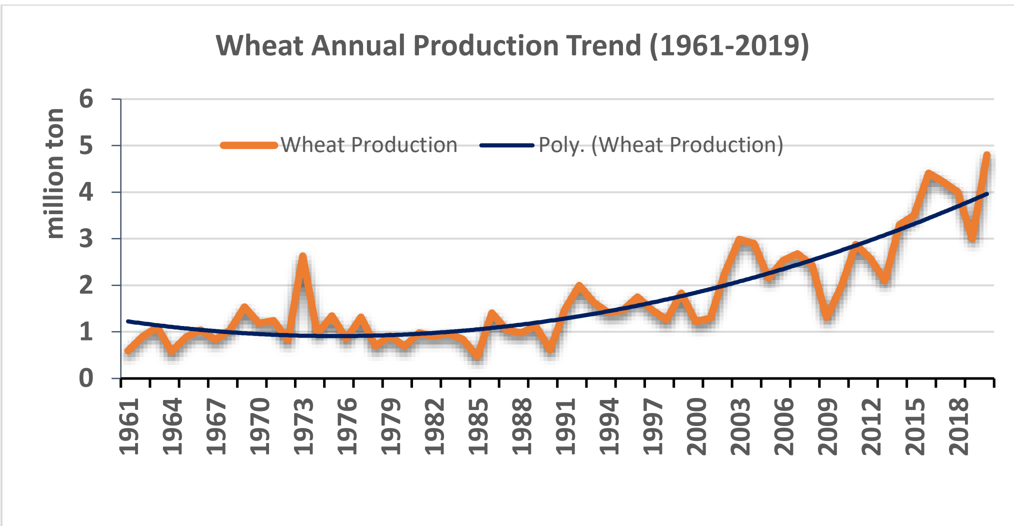

Figure 1. Wheat production Trend for the period 1960-2019 (data source: FAOSTAT, CSO)

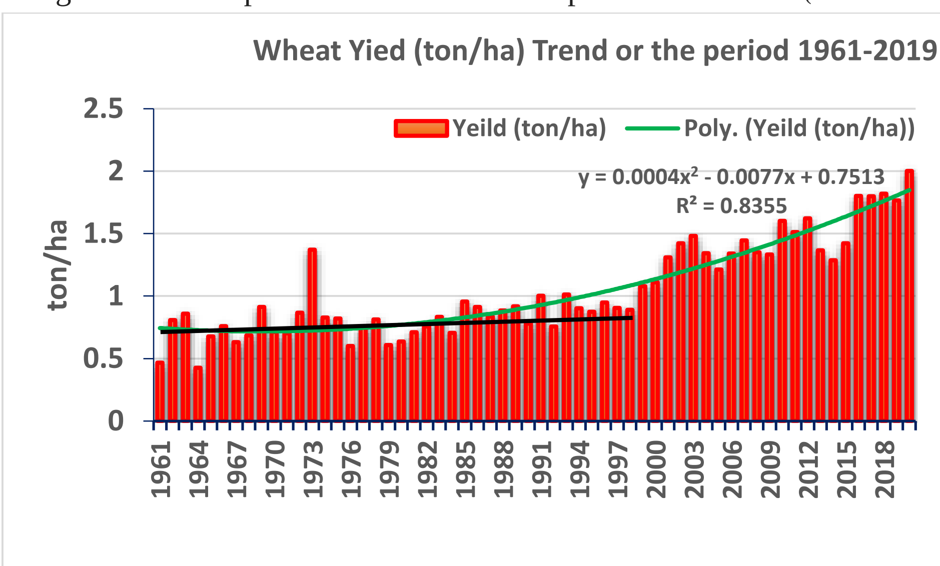

Figure 2. Wheat per hectare yield for the period 1960-2019. (Data source: FAOSTAT, CSO)

Globally, demand for wheat is predicted to increase and it is similarly true for Iraq as its population growth is estimated at 2.6% which is one of the highest growth rates. The challenges to increase production are considerable.

Wheat yield potential: Some comparisons

Wheat yield per unit of land has increased in some countries exponentially for the last 100 years. It has grown from one ton/ha^{-1} to 10 ton/ha^{-1} particularly in Europe during the last century, Yield increase has been based on set of technologies adopted which include genetic improvement, use of fertilizers and herbicides and irrigation technologies. Wheat and other cereals average increase was 98% for the period 1960-1990 and it was about 200% for some countries in Europe (Lucie Michel and David Makowski, 2013).

While per hectare wheat yield was stagnant for long period in Iraq, it has increased noticeably for the last few years. However, there is still large gap in the performance of wheat cropping in Iraq compared with other countries as shown in the figure 3.

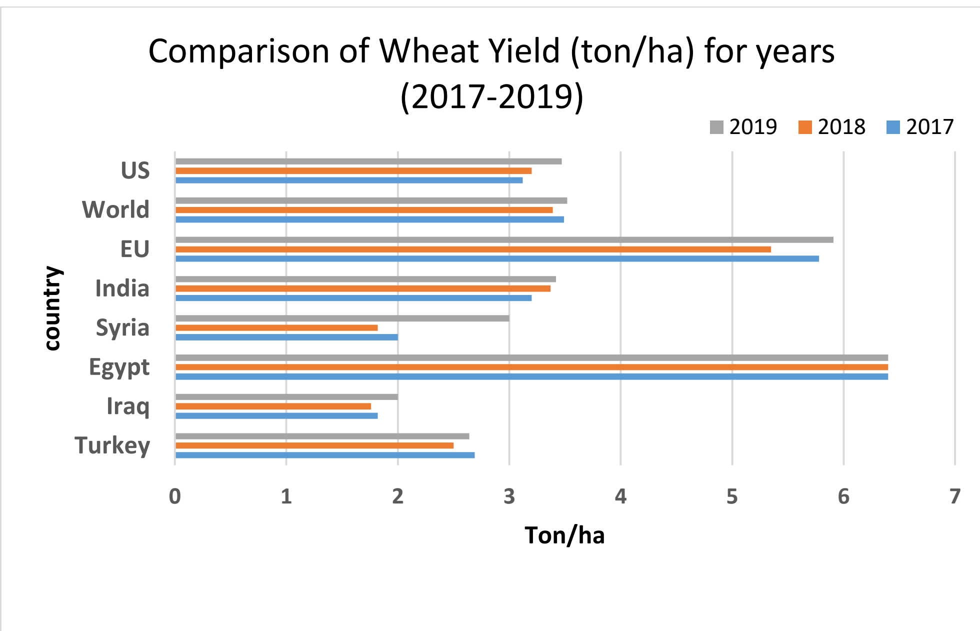

Figure 3. Wheat average per hectare yield for number countries for the years 2017-2019. (Data source FAOSAT)

The performance of wheat yield per unit of land in Egypt is relatively high in comparison with many countries and a study increase of yield has been sustained for long period of time as depicted in figure 4.

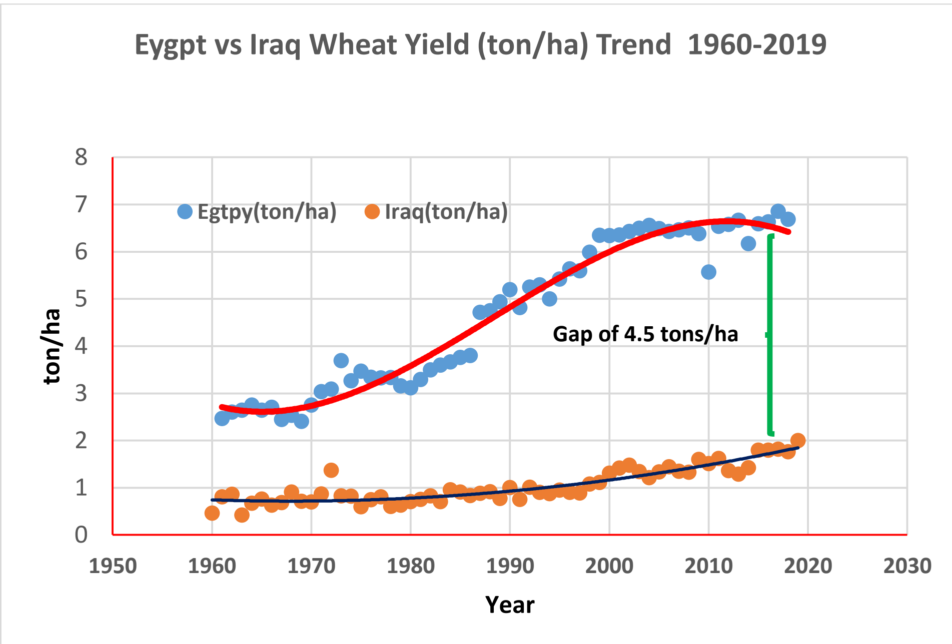

Figure 4. Egypt yield per hectare for Egypt and Iraq the period 1960-2019. (Data source: FAOSTAT, CSO)

In Egypt, wheat yield per unit of land growth most gain was during the seasons 1980-1989 and 1990-1999. It declined form 3.5% annual increase to less than 1% during the period of 2000-2017. The slowdown in land productivity in recent years can be attributed to the degradation of land fertility and water resources (Hamdy and Thilman, 2019), as well as the decline in government spending on agricultural research and development. Expansion of wheat cropping from 559 thousands to 1.36 million hectares during the period 2010 -2017 due to higher procurement prices. The use of new improved varieties, new cultivation techniques, and modern irrigation techniques contributed to 97.0% of the increase in yield per unit area and 1.5% of the increase in yield was due to planting area expansion (Kishk *et al*. 2019).

Wheat yield per unit of land in Iraq has been affected by the level of salinity in the soil. Salinity also affects the efficiency of the use of production inputs such as fertilizers. Farms with low level of soil salinity are more environmentally efficient. Research shows that farmers using reclaimed soil with lower salinity level in the irrigation water more environmentally efficient with higher yield. It was found that wheat yield average was estimated at 3.5 ton/ha^{-1} at 2.5 dS/m-1 irrigation water salinity level , while the yield decreased to 2.4 ton/ha^{-1} when the level of salinity was 2,5-

7.5 dS/m^{-1} and it was only 1.5 ton/ha^{-1} when irrigation salinity level was more than 7.5 dS/m^{-1} (Abdulradh *et al.,* 2018).

The recent increase of wheat per hectare need to be determined through on-farm trials for few years which should identify the physical factors such as cultivars, agronomic management, irrigation methods and socioeconomic factors such as education, extension schemes and policy. Despite the noticeable increase per hectare yield and government support prices, the annual variation of the production carry high risk on farm revenue as depicted in figures 1 and 11.

Since farmers participating in the government agricultural plan receive input subsidies, there is a noticeable increase in the use of fertilizers as shown in figure 6. Studies (Abdulradh *et al.,* 2018) indicates that excessive use of fertilizers will have environmental stress on soil and the increase of fertilizer application will adversely affect crop yield in future planting seasons. The challenge is how to maintain balance between soil quality and yield increase given the deteriorating soil condition all over arable land in Iraq.

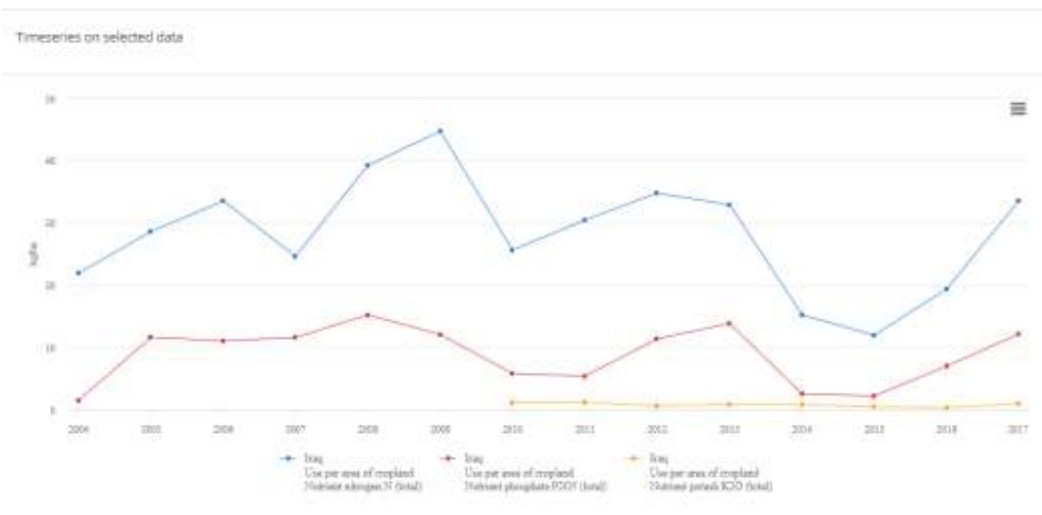

Figure 5. Fertilizer use for wheat production (Adopted form FAOSTAT).

Wheat yield, water and salinity issues

Water-stress evaluation indices for Iraq are alarming, specifically Water Resources Vulnerability Index (WRVI, which measures resource uncertainty, use-to-resource ratio and coping capacity

(Raskin *et al*., 1997). These indicators demonstrate that water scarcity is the biggest future challenge for Iraq economic development and internal stability.

Water demand is a function of population growth, economic development, and use efficiency specifically in agriculture sector and climate change effect. Iraq population is expected to reach 55 million in 2030 while the per capita renewable water resource has declined from 12,000 m^3 in 1962 to 2,450 m^3 in 2014 (FAO, AQUASTAT) which constitute a decline of 3% per annum. In addition, agriculture share in the total water demand is estimated at 79% (FAO, AQUASTAT) where water use efficiency has been as low as 40-50% (MOP), other estimate place the efficiency within the range of 25-35% and the loss would be 33 km^3 annually. The expected high demand for water might lead to a major crisis as the Iraqi ministry of water resource has predicted that the future available renewable water resources will be as low as 20 km^3 in 2025 while the total required withdrawal would be 66 km^3 (Iraq datasheet).

It is well recognized that the future sustainability of irrigated agriculture in Tigers and Euphrates plain is affected by the rising salinity level of the water supply. This is also linked to the reduction in level of stream flow due to the continuous construction of reservoirs along the rivers. Water supply to the agricultural sector constitute about 86% (CSO, 2018).

Further, quality of Tigris and Euphrates water has been deteriorating rapidly due to agricultural and industrial activities in the upper part of the rivers basin where the drainage water is responsible for high salinity level including the contaminating fertilizers and pesticides chemicals released into the river system in additional to the salinity discharge within Iraq. These factors combined with the irrational land management and poor drainage has affected about 60% of the cultivated land and 20-30% of the cultivable land have been abandoned (Wua 2014).

Tigris and Euphrates rivers ecology has been severely affected as salinity level increased from 500 ppm to more than 4500 ppm in the southern part of the rivers (Khayyun and Halihan, 2010) whereby 3000 ppm level would mean water is no longer suitable for most municipal or agricultural uses as shown in table. 1 and table.2. Euphrates water quantity and quality is below the minimum in-stream flow (environmental flow) necessary to sustain the health and biodiversity of the river basin system. Irrigation-induced salinization lead to estimated loss of 300 million USD annually due to salinity effect on per unit of land productivity and the exit of cultivable land (UNWFP, 2018).

Table 1. Water quality for Euphrates form the point of entry to affluent point.

Point of entry	**Total Dissolved Solids (mg/l)**
Station E2 Hsaiba area	441.08
Abu Skhair	868.75
Karma	8,270.09

Table 2. Table 1. Water quality for Tigris river form the point of entry to affluent point.

Point of entry	Total Dissolved Solids (mg/l)
Station T1 Hsaiba area	291
T28 Wasit city	887
Kurna city	1,684

Source: (MoP-SCO)

Water productivity is a key policy element in the consideration to develop viable agricultural sector and it is equally critical for raising the productivity of wheat. While 80% available water resources is allocated to agriculture, the productivity is still very low as shown in Figure 6 and table 3. Hence, Iraq requires a master plan for water resource management which should take into consideration both demand and supply management of water on basin and plot levels.

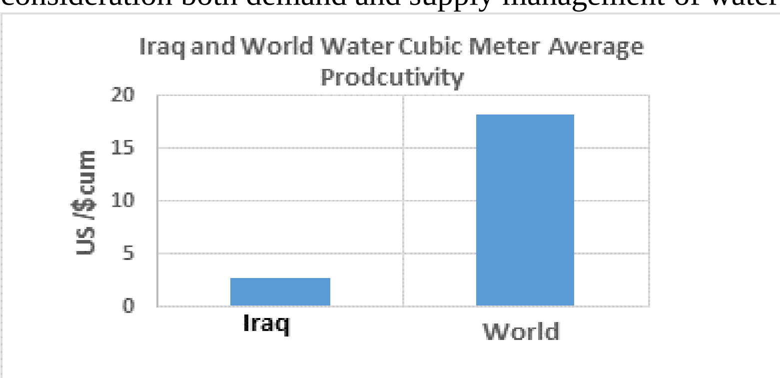

Figure 6. Water Productivity for selected countries. (Data source: Aquastat)..

Table3. Water productivity USD/m^3 for different countries.

Country	Water Productivity USD/m^3	Rank
Singapore	1,480	1
Luxemburg	1,341	2
Denmark	500	4
Germany	110	23
Australia	64	41
Turkey	21	88
China	14	108
Iran	5	146
Iraq	3	159
Senegal	7	138
Egypt	3	156

Data source: Food and Agriculture Organization, AQUASTAT data, and World Bank and OECD GDP estimates.

There is no conclusive evidence related to the relationship between farm size and the technical efficiency, for rain-fed wheat it was found that the technical efficiency was higher for small size farms (Rijib & Jbara , 2016). While other studies for irrigated wheat shows that the small holding less than 8 hectare may not be optimal for wheat farming.

Simulating economic cost of salinity on wheat Production

Salinity in Iraq is more widespread and possibly getting more severe according to previous assessments indicated, with virtually all areas affected by soil salinity (Evans et al., 2013). According to the same source which agrees with many studies, current salinity levels are causing a loss of USD 300 million per year. Farmers in salt-affected areas could only crop 30% of their land and achieve 50% of expected yield. If the status quo continues and the agricultural development will not achieve its objectives the following cost scenario may follow:

Scenario 1:

- Assumption 1.: Business-as-usual with USD 300 million annual loss and 50% yield of expected yield.
- Assumption 2: Crop productivity loss of 50% due to salinity.
- Assumption 3: Cultivable land exit at 70,000 (ha) a year which is at low estimation.

Under this scenario, there will be considerable financial loss for the coming years combined with the exist of thousands of hectares of productive land as depicted in figure 7.

Scenario 2.

- Assumption 1. : Reclamation project will be implemented.
- Assumption 2..: Water management scheme to be adopted.
- Assumption 3..: Agricultural extension program is implemented.

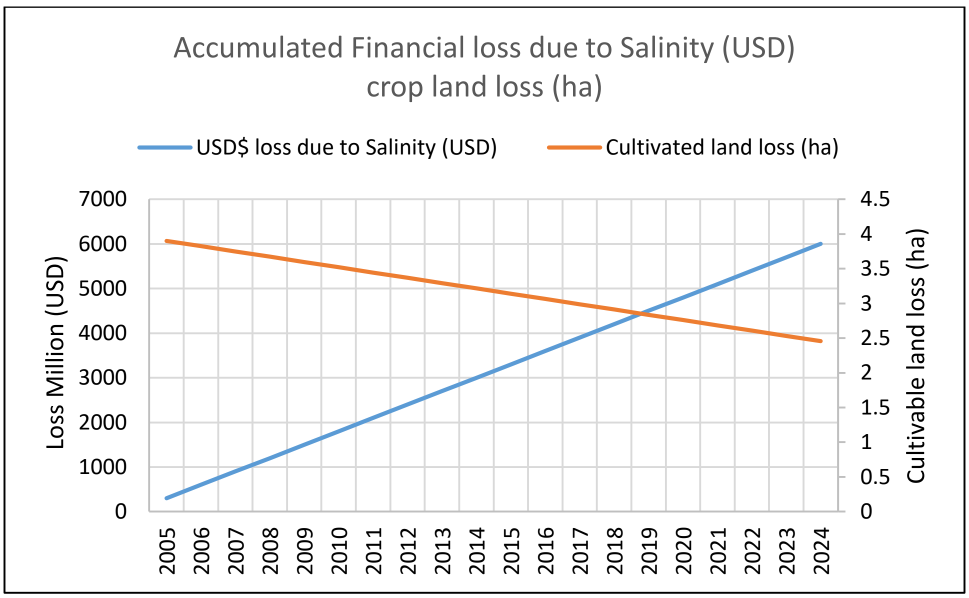

Figure 7. Simulated financial and cultivable land loss based on business-as-usual scenario.

This figure indicates the financial loss due to salinity effect on agriculture production activities. As cereals occupies 50% of the cultivated land, the major loss affect cereal production and hence financial loss. Due to salinity, studies shows that the cereal crop land declined from 3.9 million hectare to 2 million between 2005 and 2012. We tried to assume lower land exit loss at 70,000 ha annually. The cultivated land exit is estimated at 1.4 million hectare for 20 years period.

The second scenario is based on the national development plan which include water management, land reclamation scheme, improved land management, the expected gain would be to level off the loss of USD 300 million for the next five years as well as cropping land production reentry as shown in figure 7.

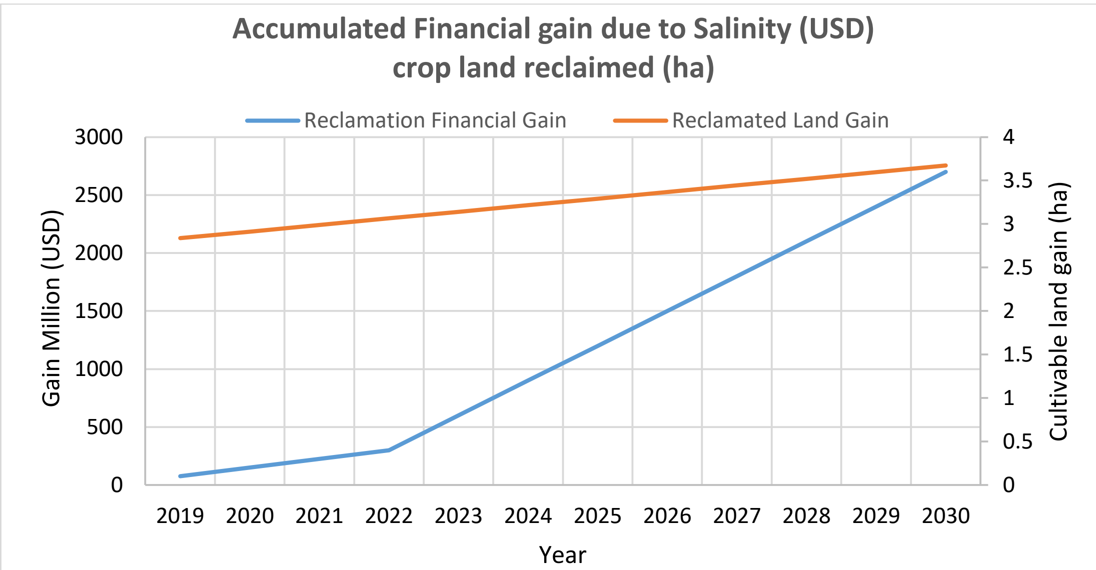

Figure 7. Simulated financial gain and cultivable land entry on national development plan.

Wheat **consumption and** Public Distribution System (PDS)

Iraq is a conflict-affected state with large safety net spending equivalent to 2.6% of its GDP. PDS is a large programme and involves large scale operation for import procurement and tends to be expensive and inefficient (Krishna *et a*l., 2019). It is also politically sensitive as it seen as an entitlement. It is considered as the only programme which covers the poor and the vulnerable in the country as the social security net only serve one fifth of the poor (World Bank 2014).
Oil for food ration began in 1990 and expanded in 1996 under the UN oil for food programme which included the following items:

Table 4. PDS food items and per person quantity.

Item	Ration (person/kg/month^{-1}
Wheat flour	9
Rice	3
Sugar	2
Tea	0.2
oil Cocking	1
Legumes	0.25

Salt	0.15
Milk	0.5
Washing powder	0.3
Baby milk and food	3

It is clear that wheat is the main item in the bundle. The quantities distributed through the PDS is estimated at 435 thousand tons per month. Figure 5 shows the annual quantities of wheat that distributed through PDS. The estimated annual quantity distributed 2019 was 3.4 MMT (USAD-FAS, 2019). Based on the 2019 PSD quantity, it was possible to estimate the annual quantities backward based on 3% annual increase in the distributed quantities.

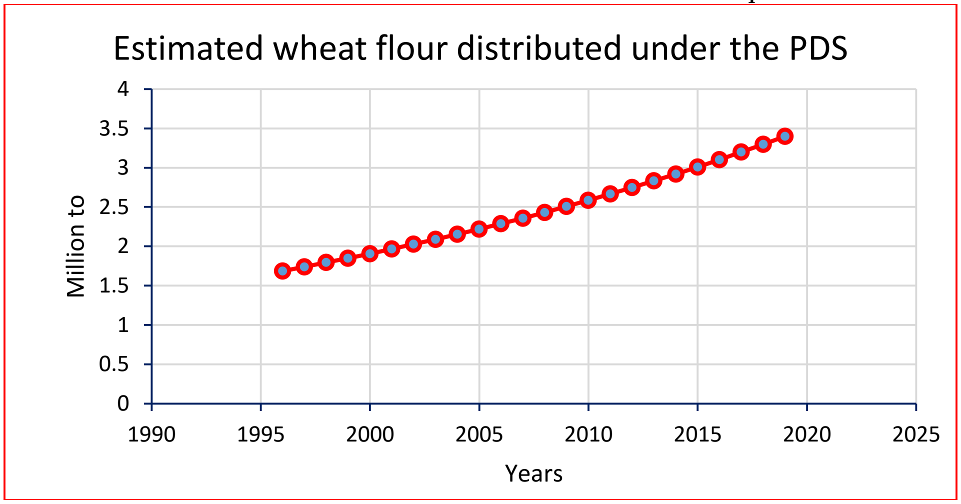

Figure 8. .Estimated Annual quantities for wheat through PDS.

The long term general average annual consumption growth is 7% which is positively correlated with the population growth of 2.6%. With population of 40 million, the consumption is expected to increase and the annual average consumption of wheat is 7 MMT as shown in figure 9. To meet the demand for PDS distribution and the industry, the government has to import, on average 3.5, MMT annually.

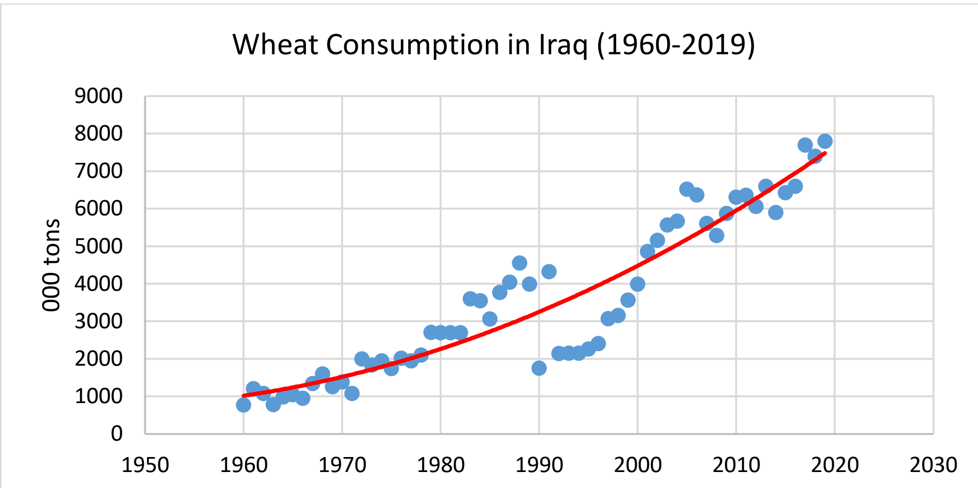

Figure9. Wheat consumption for the period (1960-2019). Data source: (CSO, USDA, FAOSTAT).

Cost of wheat distributed under PSD

One estimate (World Bank, 2007) found that it costs USD 6.30 to transfer USD 1.00 worth of food through the PDS programme, although several national and international studies argue that PDS had become less consistent and efficient due mainly to the 70 percent decrease in its budget and poor management. While the decrease in PDS budget from USD 5.9 billion in 2008 to USD 1.6 billion in 2017 affects its ability to meet its commitment, it may develop a willingness to become more targeted system. Assessment to the PDS is problematic as it distorts domestic food markets, affects national resource allocation and is highly regressive due to a lack of targeting mechanisms. The result is that the PDS system burdens the government budget without contributing to food security. The system should target the poorest among the poorest of the Iraq population.

Government intervenes in the grain market and pays high price for wheat which is higher than the international prices as shown in table 3. The current procurement prices although blow 2016 prices but it is still high and may induce inefficient allocation of resources and hinder competition.

Table 3: Iraqi Wheat Procurement Prices

Grade	Farm-Gate Price (IQD)	Approx./MT (USD)
First Grade Wheat	560,000	466
Second Grade Wheat	480,000	400
Third Grade Wheat	420,000	350

Source: USADFAS.

If the government maintains the same procurement prices and given the current wheat international FOB at USD 200/MT, and adding freight, insurance and other handling charges, wheat social prices still higher than the international prices. The effective protection coefficient (EPC) is estimated at 1.7 for surface irrigation (Duliami, 2012) and it currently greater than 1 which indicates that the policy intervention is carried out through the annual agricultural plan under which farmers receive input subsidies for seeds and fertilizer purchase as well as procurement crop price support.

Potential wheat yield increase

The magnitude and the frequency of wheat yield annual variation (figure 10) is substantial which has implication on the farmer income and on the country food security.

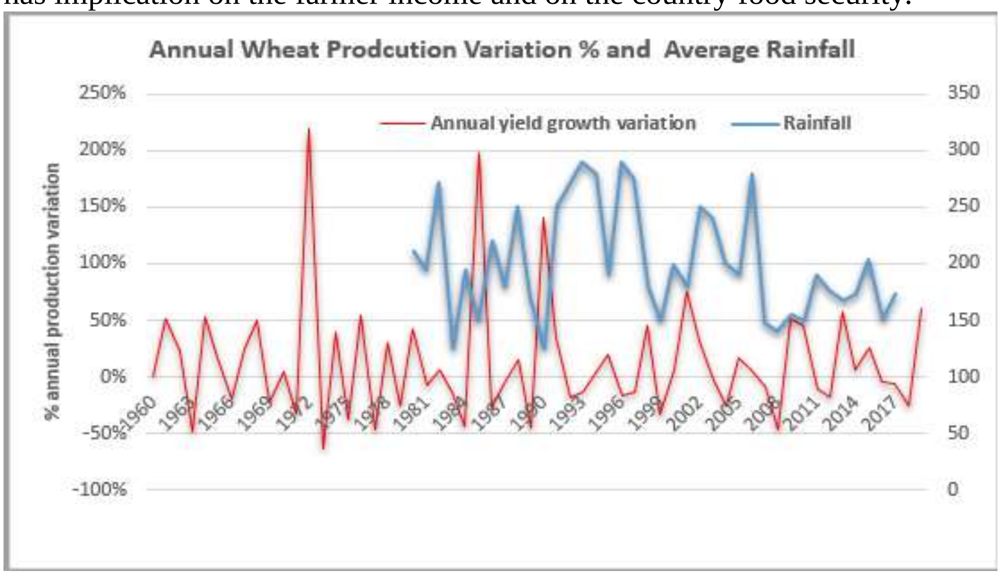

Figure 10. Annual wheat production variation for the period (1960-2019).

Super imposing rainfall level series[1] on the annual total production does not give any indication about the effect of the variability of the annual rainfall level on the annual wheat production. To reduce the risk of crop failure on farm level revenue and the yield variability, supplemental irrigation is necessary at the critical growth stages as well as the seed filling phase of the crop life cycle particularly for rain-fed wheat farming. Irrigation water management is key factor to sustain crop yield growth and should also be complemented by other agronomic management activities.

[1] We tried to double check the accuracy of the rainfall level of the data sets and it was difficult to find data on rainfall level in Iraq.

While fixed procurement prices is a measure to mitigate wheat price volatility, yield variability tends to outweigh the impacts of the price-yield correlation. The relationship between yield variability, price variability, and the price-yield correlation in influencing the effectiveness of risk management tools are important factors affecting producers' choice of risk management strategies. Identifying the main factors of yield variability and formulating plans and strategies to minimize them, is necessary for reducing the related risks. Annual yield variability constitutes yield loss on farm level and on the total yield on the national level. Figure 11 depicts the percentage production annual loss compared with 7-years maximum production. The percentage loss due to annual production variability is substantial and in turn the financial loss is also substantial.

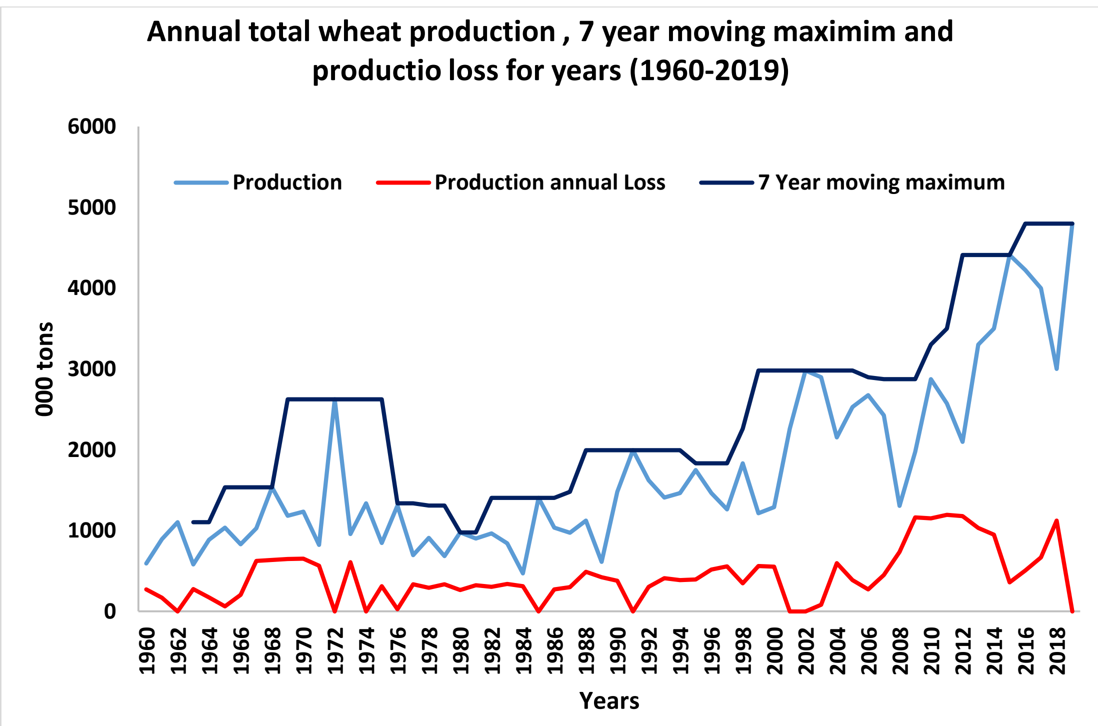

Figure 11. Annual production and production loss as % of 7-years maximum.

The national development plan should make a priority for developing the social infrastructure and human capital to foster the development of vibrant agricultural sector. The adoption of new irrigation methods will serve dual purposes: improving water use efficiency, reducing soil salinity and saving water for expansion for wheat production or to release for other uses. Land reclamation

is another critical factor to minimize the exit of thousands of hectare of agricultural land. The adoption of wheat cultivar with improved genetic materials is necessary to mitigate the effect of climate change and salinity. Encouraging startup entrepreneurs specifically graduate for colleague and technical institutes to develop agricultural small businesses will contribute to the development of the agricultural sector and thus creates job opportunities for the young generations.
It is highly possible to increase the wheat yield per hectare by adopting set of technologies mentioned above with effective extension scheme throughout the country. An increase of 500 kg per hectare yield can have substantial financial again and will enhance the food security and can be depicted in figure.12 and table 4 which summarize the following scenario:

1- Sustainable increase in yield per hectare of 500 from the current 2 tons.
2- Annual sustainable increase by .004 and it is assumed that the yield per hectare will reach 2.9 ton/ha by 2030.
3- The average price per ton is assumed 350 USD. This is based on the cost of imported crops including CIF and other handling charges and the price support paid to farmers.
4- The annual harvested area of wheat is fixed at 2.4 million hectare (2018 harvested area).

Table 4. Scenario for yield per hectare increase from 2 ton/ha to 2.5 with annual increase of .04.

Year	Annual Production (000 tons)	Financial Returns (million USD)	Yield (ton/ha)
2020	6,000	2,100	2.54
2021	6,096	2,134	2.58
2022	6,192	2,167	2.62
2023	6,288	2,201	2.66
2024	6,384	2,234	2.70
2025	6,480	2,268	2.74
2026	6,576	2,302	2.78
2027	6,672	2,335	2.82
2028	6,768	2,369	2.86
2029	6,864	2,402	2.90
2030	6,960	2,436	2.94

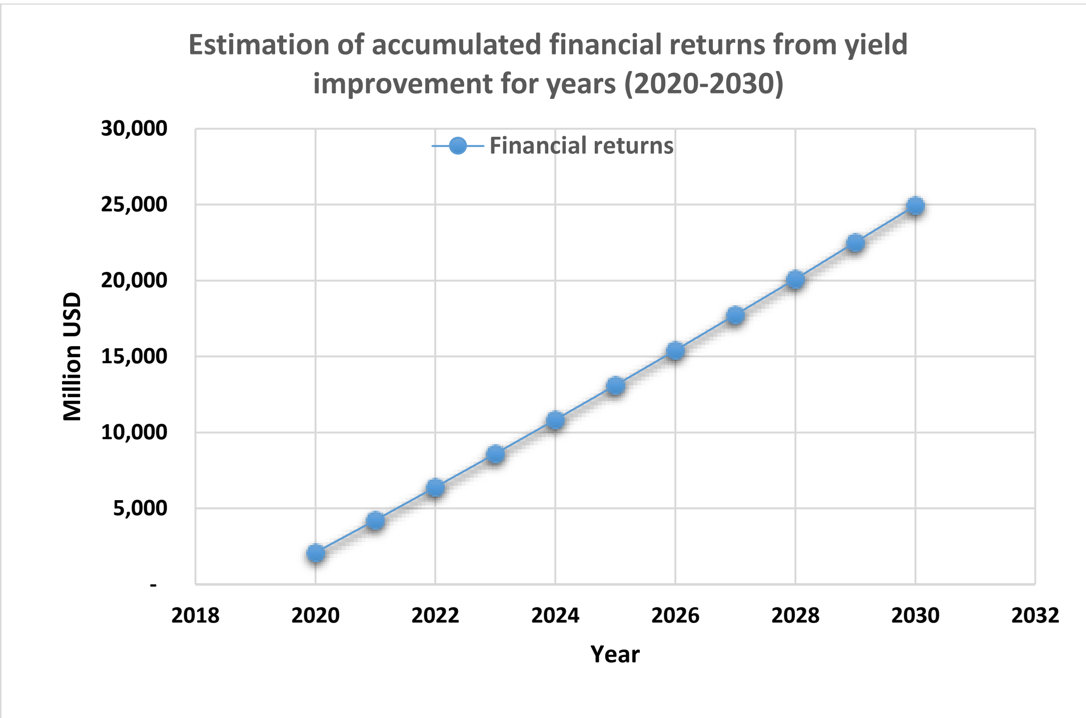

Figure 12. Accumulated financial return of wheat production based on 2.5 ton/ha with sustainable annual increase.

Summary

Cereal cropping particularly what crop is critical sector for food security and foreign exchange earnings diversification in Iraq. Wheat yield per unit of land is considerably low despite the recent improvement. The annual production of wheat is highly variable and the growth is not sustainable and farmers bear high risk and become vulnerable to revenue loss despite the procurement prices support. The vulnerability of crop failure either stems from the lack of water resources or bad agronomic management and specifically irrigation scheduling, date of planting and choice of cultivars.

The potential of closing the yield gap should be part of master agricultural development plan which include adoption of set of technologies to improve wheat farming including the adopting high yielding cultivars with heat and salinity tolerance traits , modern water management, effective extension and education, land reclamation and startup entrepreneurship support.

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Reference

Abdulradh, M.J., Jbara, O.K., Dhehibi, B., 2018. SALINITY IMPACTS ON ENVIRONMENTAL EFFICIENCY OF WHEAT FARMS IN CENTRAL OF IRAQ. Iraqi Journal of Agricultural Sciences. 2018:48(2):288-294.

Central Statistics Organization (CSO), 2018. Annual Abstracts.

Duliami, M. A. K., 20102. Impact of the Agricultural Policies on Wheat Product in the Anbar province, 2010-2012. ANBAR JOURNAL OF AGRICULTURAL SCIENCES. 2012. Vol(10).1:36-47.

Evans, R., Soppe, R., Barrett-Lennard, E. & Saliem, K.A. 2013. An overview of the potential solutions and development of a national framework for the management of soil and water salinity in central and southern Iraq. Project report.

F. H. Nasser and O. K. Jbara, 2012. THE IMPACT OF PARTITIONING FARM SIZE ON COSTS AND PRODUCTIVITY OF WHEAT (BAGHDAD PROVINCE AS A CASE STUDY). Iraqi Journal of Agricultural Science. 43(6).2016:: 114-116 .ISSN: 00750530/24100862.

Food and Agricultural Organization (FAO). 2014. FAOSTAT. http://www.fao.org/faostat/en/#data.

Hamdy Sayed Abdou Abdelaal and Dawn Thilman, 2019. Grains Production Prospects and Long Run Food Security in Egypt. Sustainability 2019, 11, 4457; doi:10.3390/su11164457.

Hamdy Sayed Abdou Abdelaal and Dawn Thilmany, 2019. Grains Production Prospects and Long Run Food Security in Egypt. Sustainability. Sustainability 2019, 11, 4457. doi:10.3390/su11164457.

https://www.sei-international.org/mediamanager/documents/Publications/SEI-Report-WaterFutures-AssessmentOfLongRangePatternsAndProblems-1997.pdf

Khayyun A. Rahi Todd Halihan.2010. Changes in the salinity of the Euphrates River system in Iraq. Regional Environmental Change volume 10:27–35(2010).

Kishk Abdelmageed, Xu-hongCHANG, De-meiWANG, Yan-jieWANG, Yu-shuang YANG, , Zhi-qiang TAO, 2109. Journal of Integrative Agriculture.Volume 18, Issue 3, March 2019, Pages 483-495

Lucie Michel, , David Makowski, 2013. Comparison of Statistical Models for Analyzing Wheat Yield Time Series. POS. October 2013 | Volume 8 | Issue 10.

M.Z. Rijib and O. K.Jbara,2106. MEASURING THE TECHNICAL EFFICIENCY AND THE RATE OF CHANGE IN THE TFP FOR FARMS RAIN-FED WHEAT IN THE REGION IN LIGHT OF DIFFERING SIZE AREA. Iraq Journal for Agricultural Science . 47(6).2016:1475-1485 . https://doi.org/10.36103/ijas.v47i6.477.

Martin K. van Ittersum, Kenneth G. Cassman, Patricio Grassini, Joost Wolf, Pablo Tittonell, Zvi Hochman, 2013. Yield gap analysis with local to global relevance—A review. Field Crops Research 143 (2013) 4–17.

Mohammed J. Abdulradh, Boubaker Dhehibi, Osamah K. Jbara, and Kamel H. Shideed, 2018. Assessing the Impact of Salinity on Resource Use Efficiency in Wheat Production in Central Iraq. ournal of Advanced Agricultural Technologies Vol. 5, No. 1, March 2018.

Nandini Krishnan, Sergio Olivieri , Racha Ramadan, 2019. Estimating the Welfare Costs of Reforming the Iraq Public Distribution System: A Mixed Demand Approach. The Journal of Development Studies.Vol.55, No. S1, 91–106, https://doi.org/ 10.1080/00220388.2019.1687878.

Ortiz-Monasterio R, J.I., K.D. Sayre, S. Rajaram, and M. McMahon. 1997a. Genetic progress in wheat yield and nitrogen use efficiency under four N rates. Crop Sci. 37(3):898-904.

Pablo Tittonellو Ken E. Giller, 2013. When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture. Field Crop Res. 143, 106–118.

Raskin, P., Gleick, P., Kirshen, P., Pontius, G. and Strzepek, K. 1997. Water Futures: Assessment of Long-range Patterns and Problems. StockholmEnvironmentInstitute.

United Nations World Food Programme (WFP), 2018. ational Strategic Review of Food Security and Nutrition in Iraq . Amman.Jordan.

United State Department of Agriculture (USDA)-FAS, 2019. Grain and Feed Annual. Iraqi Grain Production Revives in the Rain. GAIN Report Number: IQ 1900.

Weicheng Wua, Ahmad S. Mhaimeedb, Waleed M. Al-Shafiec, Feras Ziadata, • Boubaker Dhehibia, Vinay Nangiaa, Eddy De Pauwa. 2013. Mapping soil salinity changes using remote sensing in Central Iraq. Geoderma Regional. Volumes 2–3, November–December 2014, Pages 21–31.

World Bank. 2007. Considering the future of the Iraqi Public Distribution System. World Bank, 9p. Available at worldbank.org/content/ dam/Worldbank/document/ MNA/ Iraq_unfulfilled_ promise_report_chap3.pdf. World Bank 2018. Source-WB- https:// data.worldbank.org/ indicator/nv.agr.totl.zs.

World Bank. 2014. IRAQ The Unfulfilled Promise of Oil and Growth Poverty, Inclusion and Welfare in Iraq, 2007-2012. Washington DC.