Chapter 5
Domestic Food Production and Consumption in Saudi Arabia: Status Quo and Future Prospects

Ishtiag Faroug Abdalla

Abstract Nourished communities are recognized as having a productive and sustainable agricultural sector. The Saudi government has shown great concern for food production and availability, which is reflected in the Saudi Arabia Vision 2030 which focuses on both food availability and consumption. The overall objective of this chapter is to evaluate the current and potential status of domestic food production and consumption, as well as forecast patterns and changes in the future. In this chapter, time series secondary data and information gathered by the Food and Agriculture Organization (FAO) were used. The data covers crop and animal products from 1961 to 2021, as well as food supply information from 2010 to 2020. Data were analyzed using descriptive statistics such as averages, graphs, and trend lines. The results revealed that 43% of the land is used for fruit cultivation, 38% for cereals, and 18% for vegetables. The passage of time has had a significant effect on cultivated land and cropping patterns, which have changed significantly due to issues with water and natural resources. While the land and production for cereal crops are decreasing, they are increasing for vegetables. The increase in vegetable production is higher than the increase in land, attributable to advanced production technologies and efficient resource usage. Food supply showed changes over time, with varying self-sufficiency rates for vegetable crops ranging from 4 to 118% and fruits from 60 to 118%. For animal products, it ranged between 43% for red meat and 121% for milk. We conclude that despite the unfavorable climate and natural resource constraints to food production, efforts have been made to enhance production and food security regarding food availability in Saudi Arabia.

Keywords Animal product · Cereals production · Consumption · Food availability · Food security · Production · Saudi Arabia

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1 Introduction

Nourished communities are recognized as having a productive and sustainable agricultural sector. Agricultural activity is essential for every community, where a productive agriculture sector that is ecologically and socially sustainable is crucial for enhancing and improving human health and life (Sobaih 2023; Jones and Ejeta 2016). Saudi Arabia has shown great concern for food production and availability, which is reflected in Saudi Arabia vision 2030 which considers both food availability and consumption (Alnasser and Musallat 2022; Grindle et al. 2015). The growth of population and global climate and environmental changes require the authorities of each country to consider future food availability and accessibility. Haque and Khan (2020) and Pickson et al. (2023) have indicated that food production in Saudi Arabia is constrained by the weather, where temperatures are high and have been increasing over the years. This aligns with Fiaz et al. (2018), who noted that Saudi Arabia is mostly a food importer due to desert domination. Haque and Khan (2020) have also indicated that, despite the limited natural resources, Saudi Arabia is food secure as it is financially able to import food. Food and Agriculture Organization, FAO et al. (2021) refer to Saudi as a net importer of wheat, which is estimated to amount to around 80% of the country's needs. However, despite this, Saudi Arabia ranks among the top food wasters at the retail and household level, with 427 kg of food waste per capita per year (Baig et al.2019; Sobaih 2023). Alshabanat et al. (2021) estimated that food waste and losses in Saudi Arabia amount to about 33.1%. In line with Saudi Arabia vision 2030, which aims to address the issue of food security through four food security pillars, namely food availability, access to food, food utilization, and food stability, as identified by the UN Committee on World Food Security (CFS) (2014). Saudi Arabia's action plan is to enhance the resilience of food production, support food security and production in the country, and reduce dependency on imports. The government has allocated 665 million USD to support farmers (Arab News 2020). Saudi Arabia is also encouraging overseas agricultural investments, with Saudi investors acquiring agricultural land in foreign countries for crop and animal production. The government is supporting and boosting farming abroad in ten countries in Africa, the Black Sea, and Latin America by offering low-interest loans totaling 533 33 million USD to companies that send at least half their harvest to Saudi Arabia (Abu-Nasr and De Sousa 2020; Arab News 2020; FAO et al. 2021).

Economist Impact (2021) with the support of the Fondazione Barilla developed a measurement for the sustainability of food systems in 78 countries using the Food Sustainability Index (FSI). FSI is based on three key pillars mainly are food loss and waste, agriculture, and nutritional challenges. The Index consists of 38 indicators with 95 sub-indicators. The overall score is calculated from the scores of the three pillars. Saudi Arabia in 2021 scored 60 and ranked Medium (48 out of 78 countries), which reflects an average rank in terms of progress towards meeting environmental, societal, and economic indicators of food sustainability (Economist Impact 2021).

The major crops cultivated in Saudi Arabia are wheat, sorghum, barley, millets, dates, vegetables, and citrus fruits (Haque and Khan 2020). The agricultural production heavily relies on irrigation systems, which has a significant impact on freshwater aquifers, resulting in high production costs (Frenken 2009; Procházka et al. 2018). Due to the vast areas and varying climates in Saudi Arabia, cropping systems and patterns vary accordingly. However, climate change, particularly changes in temperature, annual rainfall, and water scarcity, is expected to cause a decline in crop production and alter the crop pattern (Mahmoud and Abdallh 2013). As a result, farmers are advised to shift from water-intensive crops to those with lower water requirements. The objective of this chapter is to evaluate the current and potential status of domestic food production and consumption, as well as forecast patterns and changes in the future.

2 Methodology

This chapter relies on secondary data and information that was gathered and analyzed to achieve the chapter's bjectives. Time series data regarding crop area, production, consumption, and self-sufficiency was collected from various sources, such as the Food and Agriculture Organization (FAO) website (FAOstat.org), the Gerneral Authority for Statistics in Saudi Arabia, the Ministry of Environment, Water, and Agriculture (MEWA), and other related publications. The data collected covered the time period from 1961 to 2021 for cereal crops (sorghum, wheat, barley, maize, and millet), vegetable crops (potatoes, tomatoes, and onions), and fruits (dates, citrus, and watermelon). Animal production data, such as eggs and red and poultry meat, was also gathered. Consumption data for some cereals, vegetables, fruits, and animal products were obtained from the Ministry of Statistics for the year 2021 and from FAO from 2010 to 2020. Simple calculations as simple descriptive and trend line analysis were performed.

3 Findings

3.1 Domestic Food Production: Current Status and Potential

The total area of Saudi Arabia is estimated to be about 2240 thousand km^2, with the agricultural area being about 173.6 thousand km, or about 8.1% of the total area. Crops grown in Saudi Arabia included cereals, vegetables, fruits, and fodder. Adam et al. (2014) reveal that cereals cover about two-third of the cultivated area while vegetable and fruits cover one-third.

Table 1 Area under cultivation, and crop and livestock production in Saudi Arabia for the year 2021

Item	Area (000 ha)	Production (000 mt)	Available for consumption (000 mt)	% of self-sufficiency
Plant product				
Cereals	188.8	881.7	–	–
Fruit	213.1	2474.1	–	–
Vegetable	92.8	2305.4	–	–
Vegetable (greenhouse)	6.0	613.6	–	–
Fodder	210.0	3870.1	–	–
All	*710.8*	*10,144.9*	–	–
Livestock product[a]				
Red meat		178.0	414.0	43
Eggs		359.2	321.0	112
Poultry meat		930.0	1409.0	66
Fish meat		177,264	344,601	51
Milk		2600.0	2149.0	121

[a] Compiled by the author based on the data from MEWA (2021a)

Table 1 displays the cropped areas (000 ha) and production (000 mt) of different crop groups and livestock products in Saudi Arabia in 2021. The total cultivated area is estimated to be approximately 710 thousand ha, used for growing cereals, vegetables, fruits and fodder crops. Fruits and fodder are grown on approximately 30% of this land each. However, domestic production of poultry meat, red meat, and fish falls short of domestic demand. On the other hand, domestic production of eggs and milk exceeds domestic demand.

Figure 1 shows the share of cultivated areas for vegetables, cereals, and fruits in Saudi Arabia in 2021. Fruits cover about 43% of the cultivated area, followed by cereals at 38% and vegetables at 19%.

3.1.1 Cereals Production

Wheat, sorghum, barley, and millet are the main cereals grown in Saudi Arabia. Rice used to be grown in Saudi Arabia from 1961 to 1980, with an average area of about 616 ha producing about 1634 mt, but it was discontinued due to the high water requirements. Figure 2 shows the total cereals area in Saudi Arabia. The area increased during the 1980s and 1990s but later declined. As shown in Fig. 2, the trend line of the area during the time did not explain much, and its contribution to affecting the change in the area is small. This could be explained by climate and resource availability constraints. On the other hand, the effect of time is significant on cereal production ($F = 13.35^{***}$), which could be attributed to advances in agricultural

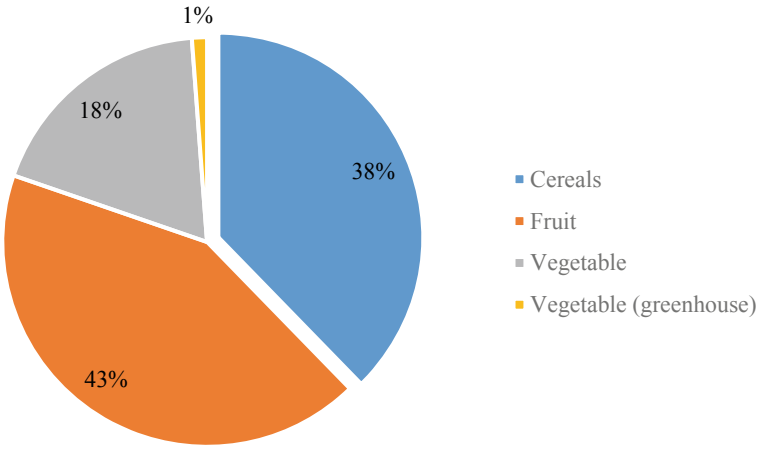

Fig. 1 Shares of the cultivated land in Saudi Arabia for the year 2021. *Source* Prepared by the author based on data from MEWA (2021a)

production technologies. Figures 3, 4, and 5 show wheat, barley, and millet production (in mt) from 1961 to 2021. Production was boosted during the 1980s for cereals due to area expansion and an increase in the average yield. For example, wheat and barley areas were boosted during the 1980s and 1990s, resulting in surpluses and even exports. Later, due to scarce and non-renewable water resources and the need to control water demand, the area declined significantly. These results indicate what Mahmoud and Abdallh (2013) and Haque and Khan (2020) have also observed. FAO et al. (2021) has also specified that intensive wheat farming is depleting freshwater aquifers, highlighting the priorities of resilience policies.

Figure 5 shows millet production, which increased during the 1960s and then decreased after 1972 up to the present day. The production has stayed consistent, ranging from 7 to 12 thousand mt. The trend line shows a decrease of − 1.2 thousand mt annually in millet production.

3.1.2 Vegetable Crops

Many vegetable crops are grown in Saudi Arabia, including potatoes, tomatoes, onions, cucumbers, and gherkins. The area and production from 1961 to 2021 are represented in Table 2 and Figs. 6, 7, 8, 9, 10 and 11. Table 2 shows the equation for the trendline of the areas and production of potatoes, tomatoes, onions, cucumbers and gherkins in Saudi Arabia from 1961 to 2021.

Figures 6 and 7 depict the areas (in thousands of hectares) and production (in thousands of mt) of potatoes and tomatoes between the years 1961 and 2021. The tomato area experienced a surge from the 1970s to the 1990s followed by a decrease, while the potato area has been on the rise since the 1990s. Time appears to have

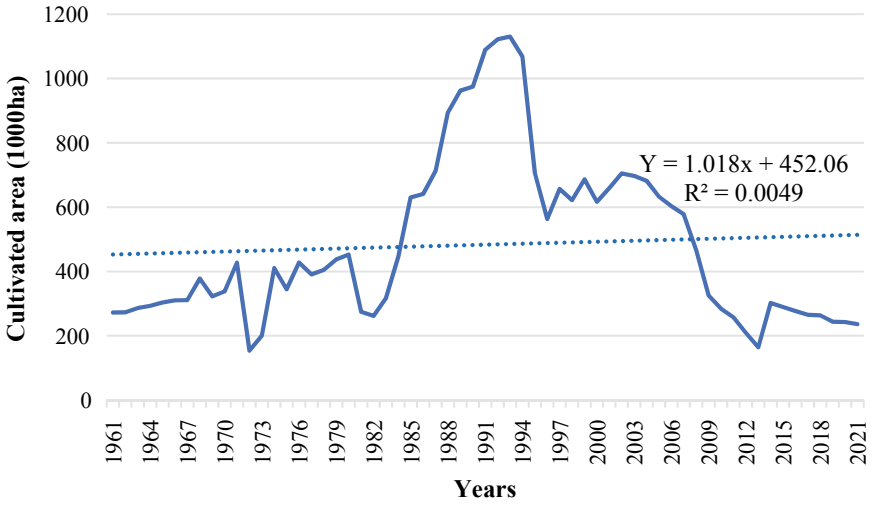

Fig. 2 The cultivated area for cereals in Saudi Arabia between 1961 and 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

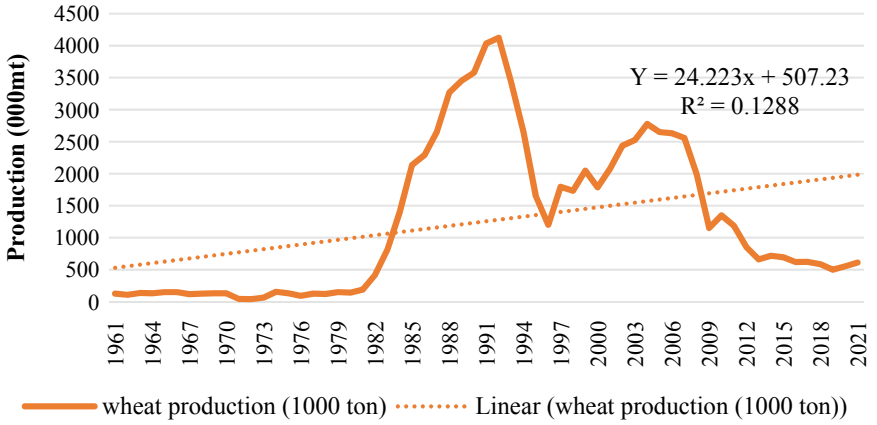

Fig. 3 Wheat production (000 mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

had a significant impact on potato area ($R^2 = 82\%$) compared to tomato area ($R^2 = 11\%$). Figure 7 shows that tomato production increased over time, from 1961 to 2021 ($R^2 = 65\%$). Despite the tomato area declining in the 2020s, the production remained stable, which could be attributed to an increase in yield and the rise of greenhouses production. Potato production has been stable, similarly to the area, which has experienced growth since the 1990s. The effect of time on production changes can be explained by $R^2 = 84\%$. The figures showing the area and production

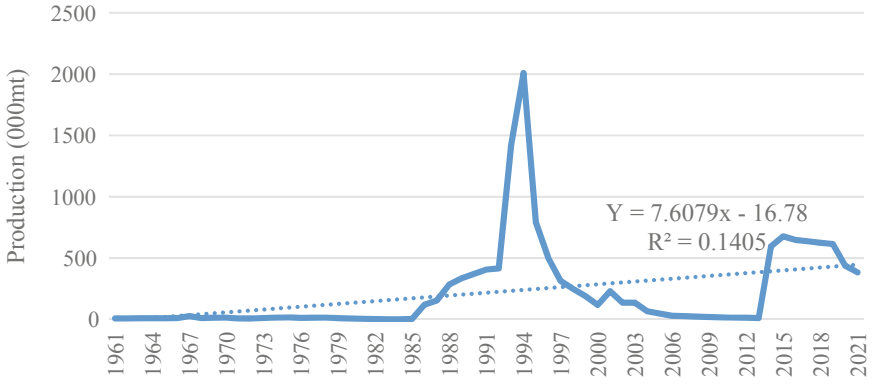

Fig. 4 Barley production (000 mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

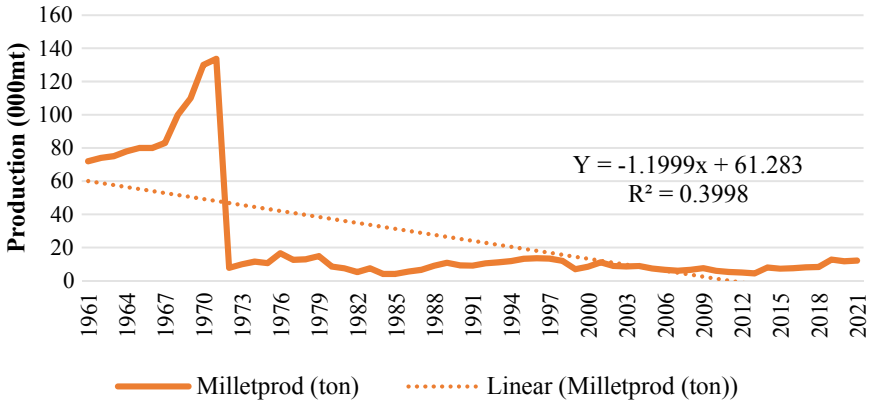

Fig. 5 Millet production (000 mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

Table 2 Equations for the trendlines of the area and production of some vegetable crops

Crop (Y)	Duration	Function	R^2
Tomato area (ha)	1961–2021	123.2x + 12,158	0.106
Tomato production (mt)		7442.6x + 86,454	0.653
Potato area (ha)	1961–2021	423.5x − 4663	0.825
Potato production (mt)		10,508x − 129,413	0.841
Onion and shallots area (ha)	1961–2021	36.263x + 2626.9	0.0384
Onion and shallots production (mt)		1881.3x + 10,732	0.258
Cucumber and gherkins area (ha)	1978–2021	18.183x + 2713.4	0.033
Cucumber and gherkins production (mt)		4184.1x + 39,446	0.427

Source Prepared by the author based on data from FAOstat.org (2021)

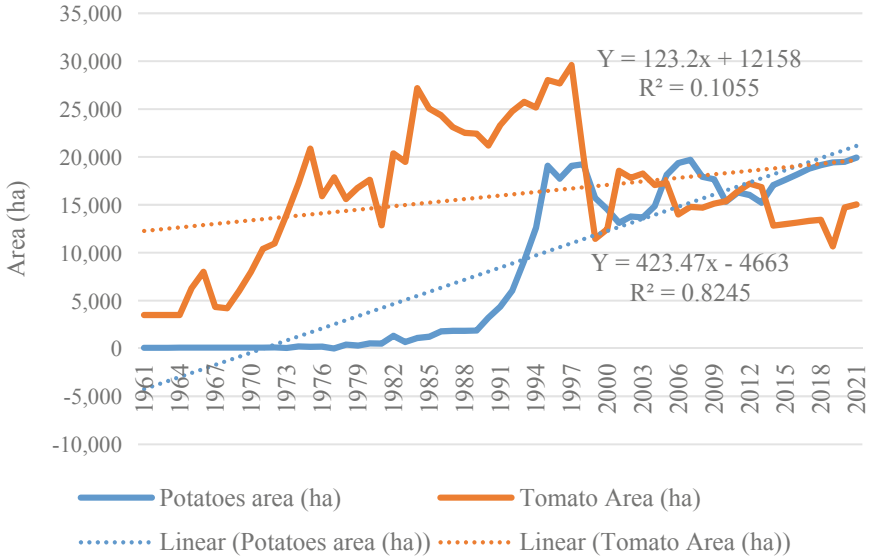

Fig. 6 The cultivated area for tomatoes and potatoes (ha) in Saudi Arabia between 1961 and 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

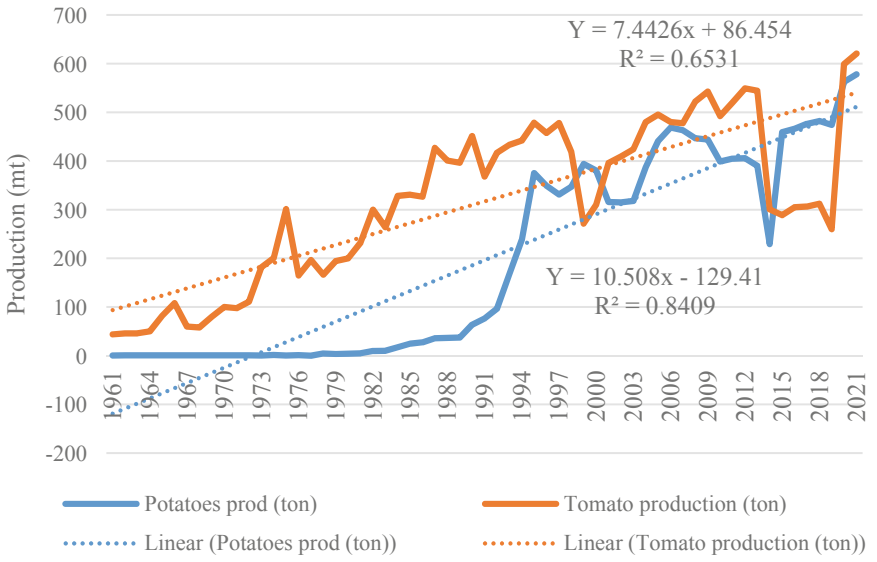

Fig. 7 Tomato and potato production (000 mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

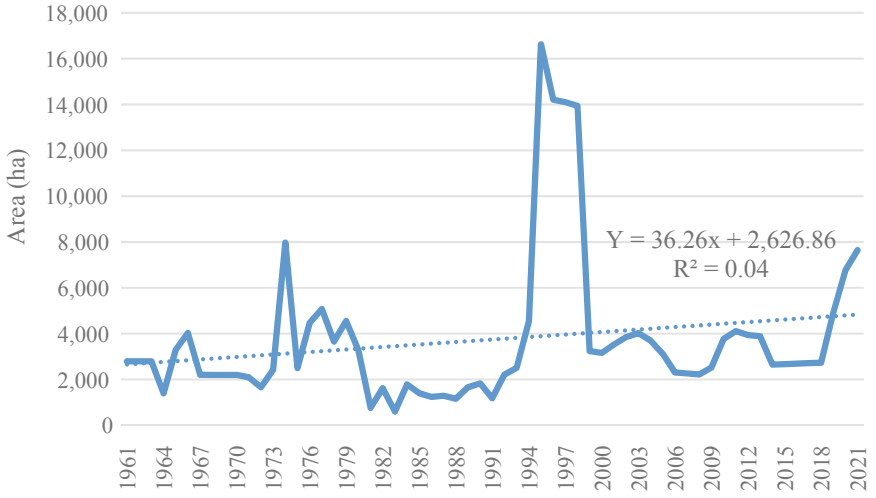

Fig. 8 The cultivated area for onion (ha) in Saudi Arabia between 1961 and 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

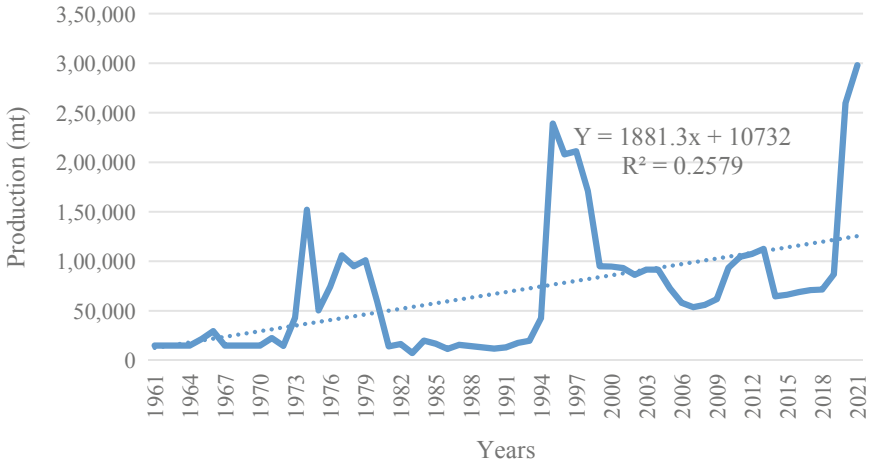

Fig. 9 Onion production (mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

of onions and shallots are presented in Figs. 8 and 9. The area and production of onions experienced a boost during the 1990s, followed by a decline in the early 2000s. However, in the 2020s, the production begins to rise once again. The effect of time on area ($R^2 = 38\%$) is greater than its effect on production ($R^2 = 25\%$). Data on cucumber and gherkins' area and production are available from 1978 to 2021, showing that the increase in production has been more significant than that in area

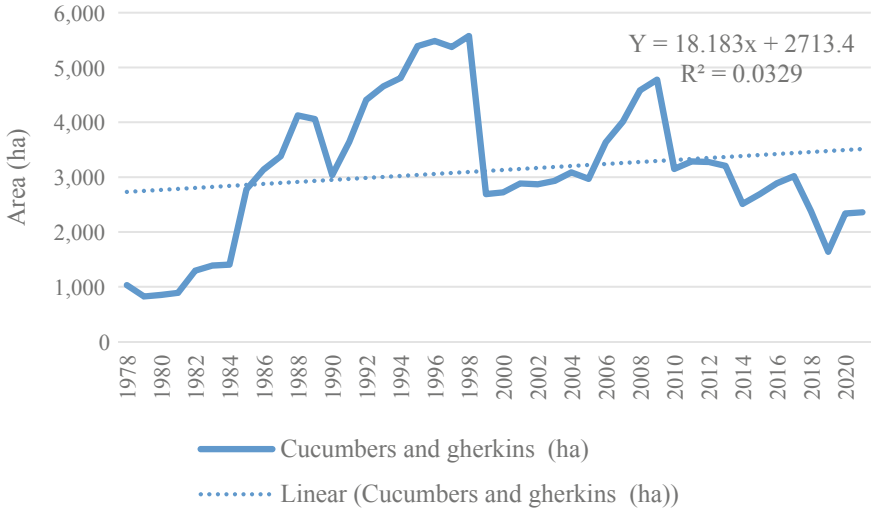

Fig. 10 The cultivated area for cucumber and gherkins (ha) in Saudi Arabia between 1978 and 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

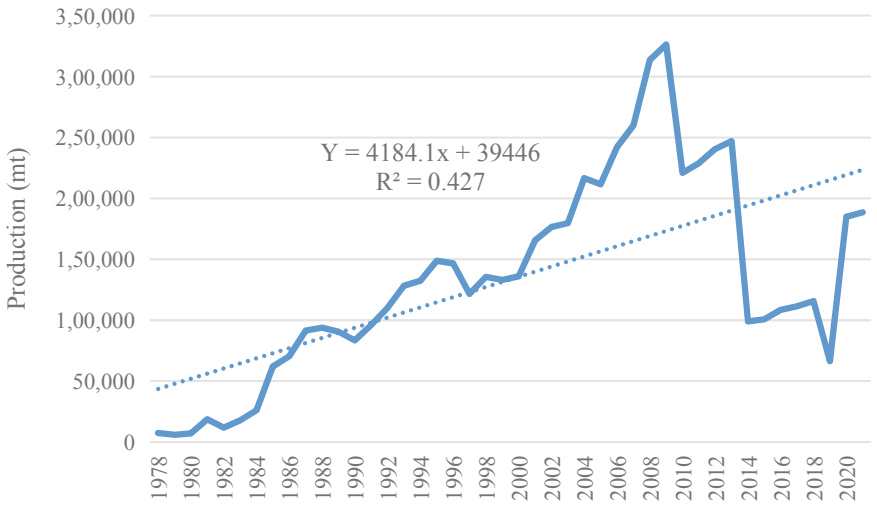

Fig. 11 Cucumber and gherkins production (mt) in Saudi Arabia from 1978 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

(Figs. 10 and 11). The time effect on production was higher ($R^2 = 43\%$) than on the area ($R^2 = 3.3\%$), with the growth partially explained by the adoption of production technologies (Alotaibi and Kassem 2021).

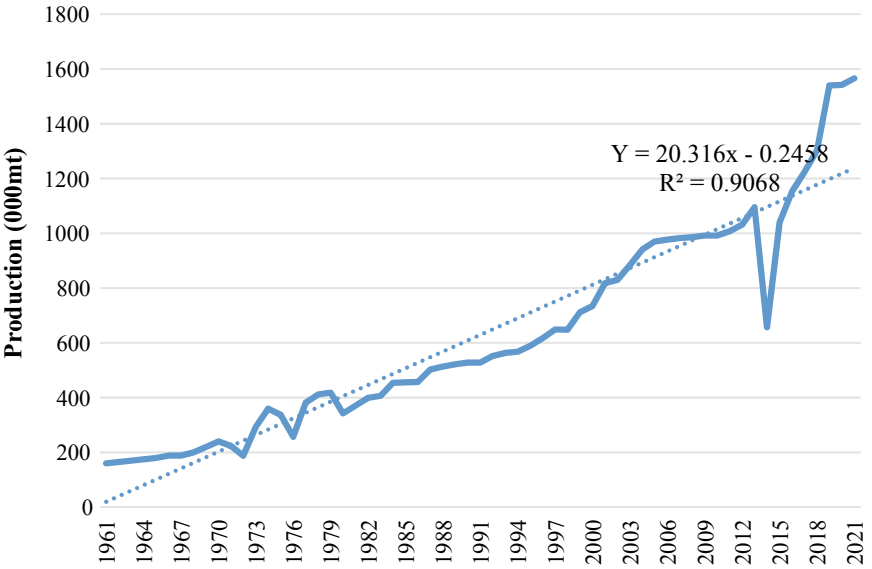

Fig. 12 Date production (000 mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

3.1.3 Fruits Production

Various fruit crops are cultivated in Saudi Arabia, including dates, grapes, citrus, and watermelon. The climate, environment, and culture of the region are favorable for the cultivation and production of dates. Figure 12 shows a significant increase in date production from less than 200 thousand mt in 1961 to 1600 thousand mt in 2021. The time factor alone accounts for 90% of this change. Figures 13 and 14 provide information on the area and production of citrus from 1961 to 2021. Citrus cultivation area and production increased during the 1970s, declined in the 1980s, rose again until 2009, before declining steadily between 2010 and 2015 and stabilizing thereafter. Finally, Figs. 15 and 16 depict the area and production of watermelons in Saudi Arabia over the same period. Both demonstrate an increasing trend over time. The time factor alone explains 52% of the change in area and 27% of the change in production.

3.1.4 Livestock Product

Saudi Arabia, being a desert climate country, primarily raises camels, cattle, sheep, goats, and poultry. Approximately 7.1% of the population works in the agricultural sector. The number of animals is represented in Fig. 17, indicating that goats surpass the others. The growth of animal populations is significantly influenced by time, as indicated by the trend lines in Figs. 15 and 17. The data displays that goats have

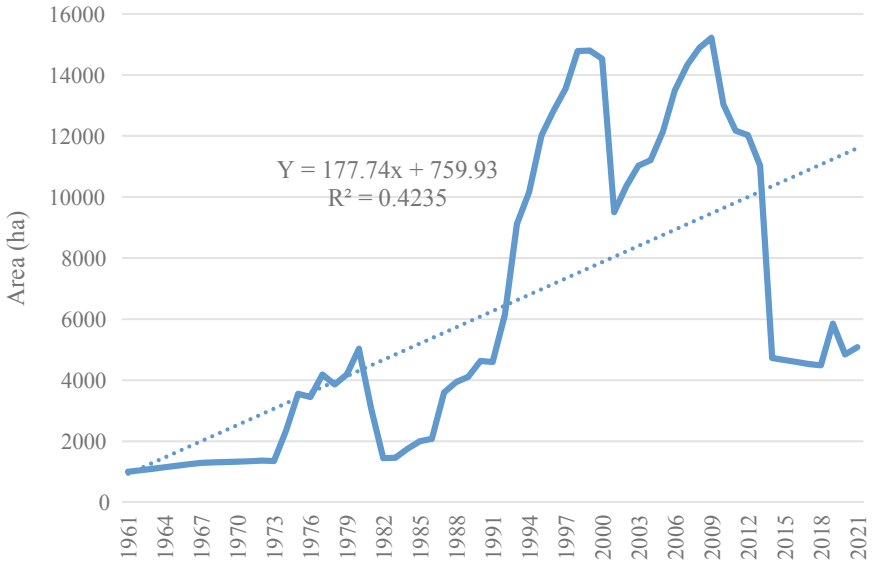

Fig. 13 The cultivated area for citrus (ha) in Saudi Arabia between 1961 and 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

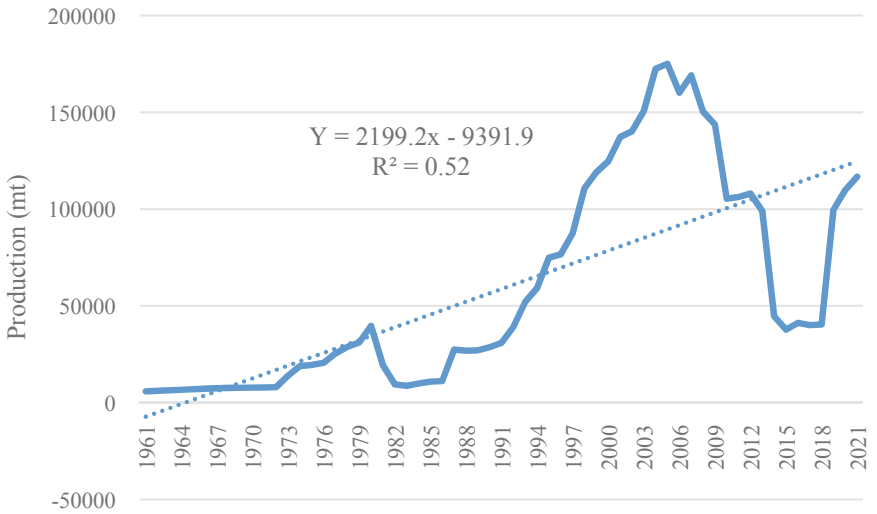

Fig. 14 Citrus production (mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

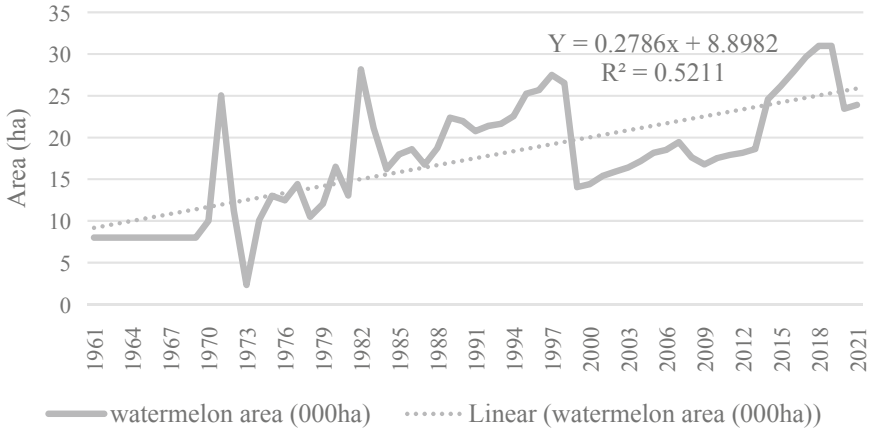

Fig. 15 The cultivated area for watermelon (000 ha) in Saudi Arabia between 1961 and 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

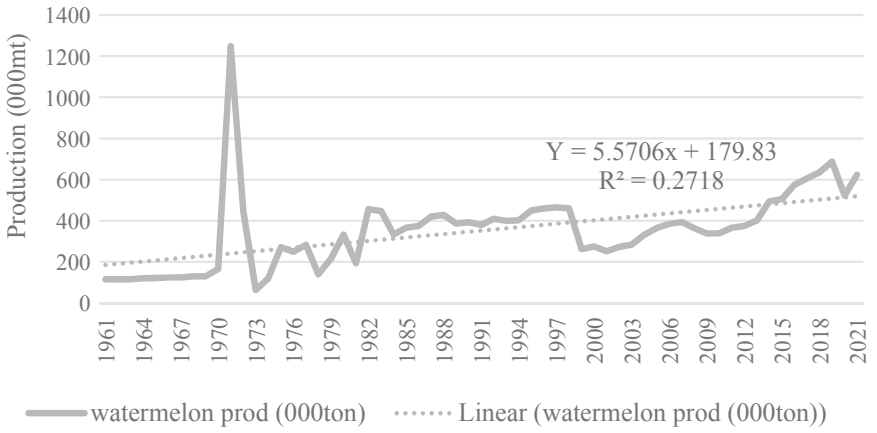

Fig. 16 Watermelon production (000 mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

an R^2 value of 75%, cattle 22%, camels 69%, and chickens 95%. Poultry, red meat, and eggs are the most coveted products in Saudi Arabia. The production of camel, sheep, and chicken meat from 1961 to 2021 is displayed in Figs. 17 and 18. Poultry meat production has witnessed substantial growth over time, which is reflective of high demand. Figure 19 demonstrates the milk production of camels, cattle, and goat animals from 1961 to 2021. Cattle milk production has shown remarkable growth along with a significant impact over time. The R^2 value is 80% for cattle, 82% for camel, and 77% for goat. Figure 20 exhibits an increase in egg production in Saudi

Arabia from 1961 to 2021. The trend line indicates annual growth in production exceeding that of the chicken population.

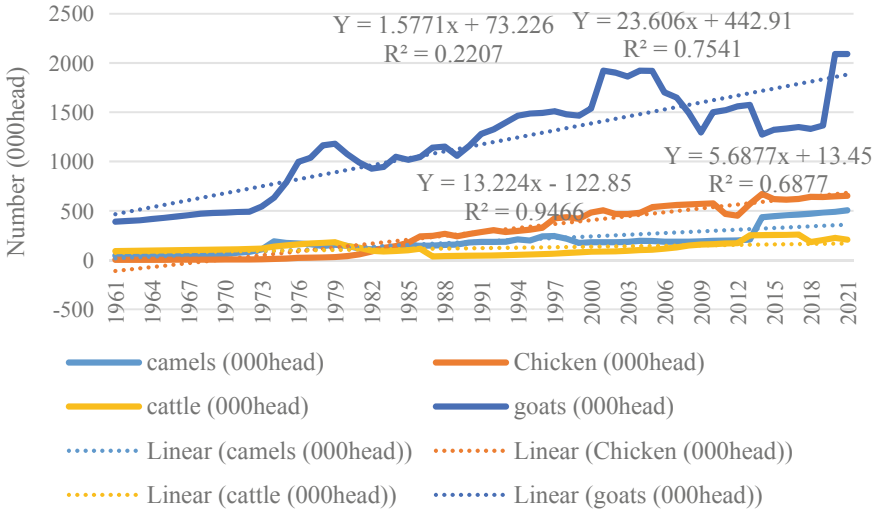

Fig. 17 Camel, cattle, goats and chicken number (000 head) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

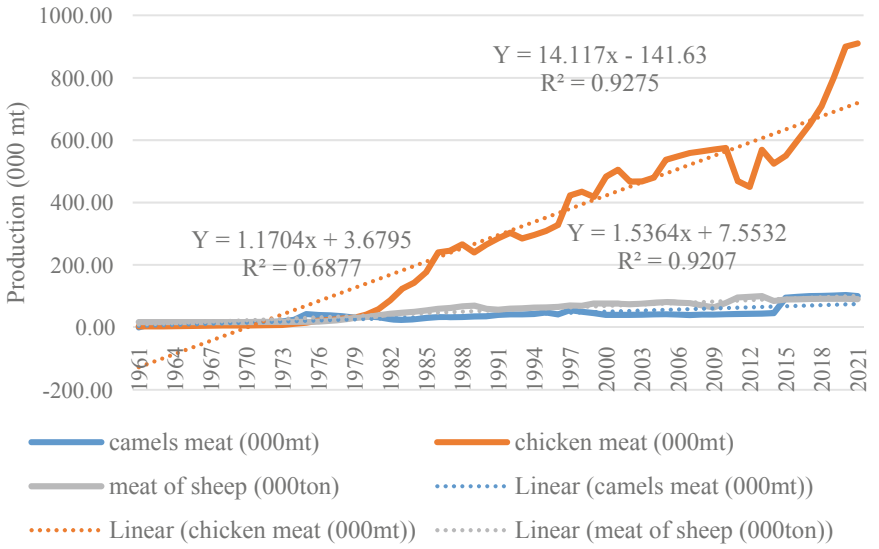

Fig. 18 Camel, sheep, and poultry meat production (000 mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

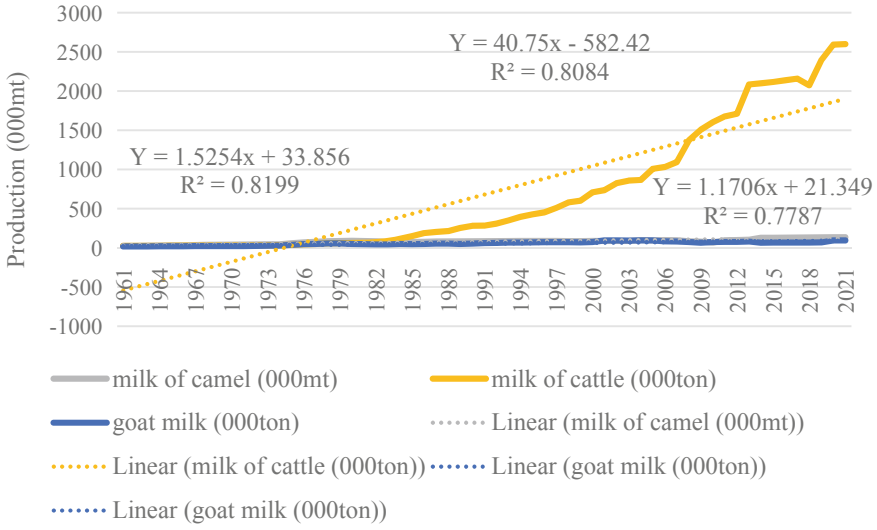

Fig. 19 Milk production of camel, cattle and goats (000 mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

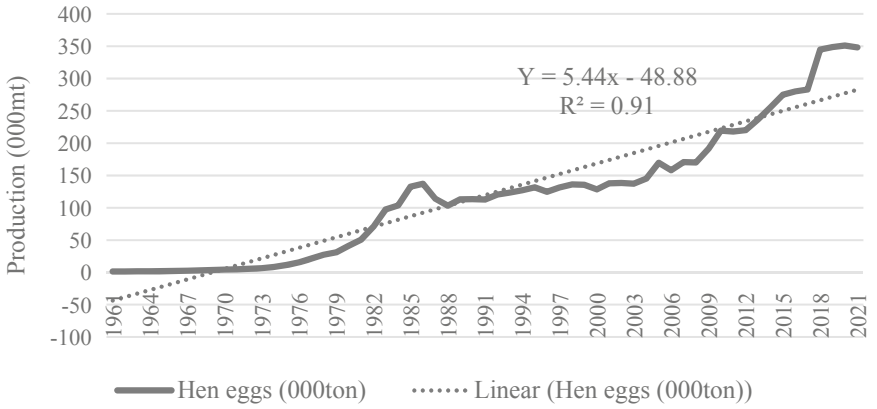

Fig. 20 Eggs production (000 mt) in Saudi Arabia from 1961 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

3.2 Aggregate Domestic Food Consumption

3.2.1 Food Security and Climate Change

Food security and climate change are important issues in the agriculture sector, which is a fast-growing industry in the country. Depending on natural resources and maximizing their efficient use will result in a better quality of life for individuals. The

Saudi Arabia government is committed to diversifying its business away from the sole reliance on oil exports and production. The agriculture sector contributes 54 billion SR annually to the GDP and provides 30% of the food available for consumption, however, the country relies heavily on imports (Haque and Khan 2020).

3.2.2 Food Security in Saudi Arabia

According to Guiné et al. (2021), Saudi Arabia is considered food secure based on the security pillars of food availability, access, utilization, and stability. As an oil-producing country, Saudi Arabia is able to import sufficient food. According to the Human Development Report (2021), Saudi Arabia is ranked 35th among high-income countries (UNDP 2022). However, as noted by Adam in 2014, there are still segments of the population in high-income countries like Saudi Arabia who do not have adequate nourishment. Fiaz et al. (2018) also highlight the obstacles in domestic food production due to limited agricultural resources. Table 3 shows the production, net consumption, and self-sufficiency rates for selected vegetable and fruit crops that were grown in Saudi Arabia in 2021. Taking into account production constraints, imports exceeded exports for all listed crops except for dates. The self-sufficiency rate ranged from 4 to 118%. For vegetable crops, it ranged between 116% for eggplant and 38% for carrots. Onions, tomatoes, and potatoes had self-sufficiency rates of 52%, 77%, and 92%, respectively. Among fruit crops, dates had the highest self-sufficiency rate of 118%, followed by citrus fruits at 99%, and mangoes and grapes at 60% each. Figure 21 represents the cereal dependency ratio from 2000–2002 to 2017–2019, which increased from 73 to 94%. The dependency is significantly related to the time factor. This reflects the increase in cereal imports. Wheat consumption showed highly significant growth ($R^2 = 94\%$) from 1978 to 2021 (Fig. 22). Animal products are the main source of protein globally. Meat production needs to be increased to cover population growth, as recommended by the World Bank (Alsarawi et al. 2022). Alsarawi (2022) revealed that the self-sufficiency ratio for red meat, poultry meat, and fish from 2005 to 2020 is changing with an average of about 57%, 50%, and 42%, respectively. Population growth increases the food gap in meat and animal products.

Table 4 shows the annual supply quantity (in kg) per capita consumption for selected food items. In general, the supply of selected food items changes annually, showing an increase and then a decrease, with the exception of wheat and eggs which are increasing. On average, there is approximately 96 kg of wheat and 55 kg of rice available for consumption. In comparison to the rest of the world, the per capita consumption of wheat and rice is higher, with the world consuming about 67 kg of wheat and 78.4 kg of rice per capita in 2018. The supply of poultry meat is higher than the world consumption. The annual supply of eggs is increasing and is almost near to the world consumption levels. The supply of milk, 47 kg/capita, is far below world (79 kg) and Asia (60 kg). The average per capita supply from fish, tomato and onion is almost equal the world supply and Asia supply per capita Potato annual per capita supply is ar below the world and Asia supply.

Table 3 Production, consumption and self-sufficiency in Saudi Arabia, 2021

Crop	Production (000 mt)	Imports (000 mt)	Exports (000 mt)	Consumption (000 mt)[a]	% of self sufficiency
Potato	578.1	48.3	0.0	626.3	92
Tomato	620.9	186.8	0.6	807.1	77
Onion	298.0	274.5	0.5	572.0	52
Squash	64.7	1.6	1.5	64.7	100
Gherkins	188.6	1.4	3.1	186.8	101
Sweet pepper	108.1	29.5	3.5	134.1	81
Okra	25.3	0.3	0.8	24.9	102
Carrot	24.5	43.7	3.8	64.4	38
Eggplant	112.0	0.8	6.4	106.4	106
Grapes	106.4	71.8	0.5	177.8	60
Dates	1565.8	19.8	258.1	1327.5	118
Watermelon	624.1	7.1	0.1	631.1	99
Citrus	116.8	657.9	10.4	764.3	15
Mango	88.7	60.0	0.9	147.8	60
Banana	22.2	496.7	5.4	513.4	4

Source MEWA statistical book 2021
[a] Author compilation

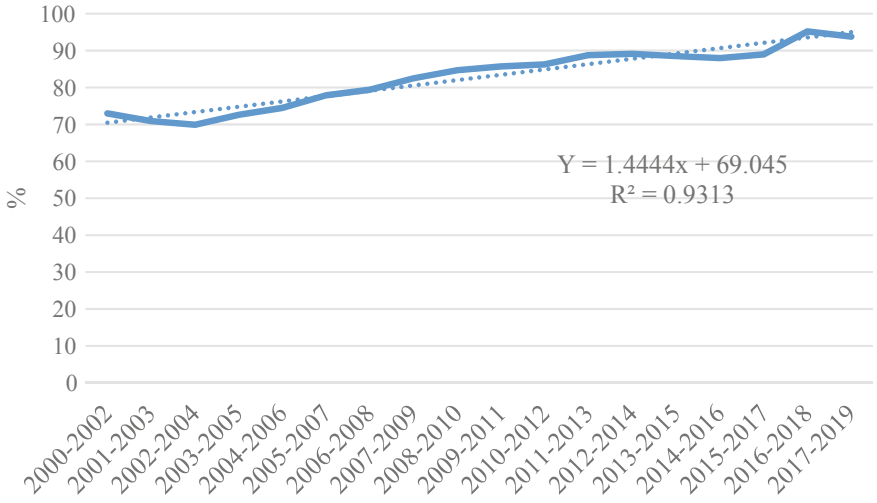

Fig. 21 Cereal imports dependency in Saudi Arabia from 2000–2020 to 2017–2019. *Source* Prepared by the author based on data from FAOstat.org (2021)

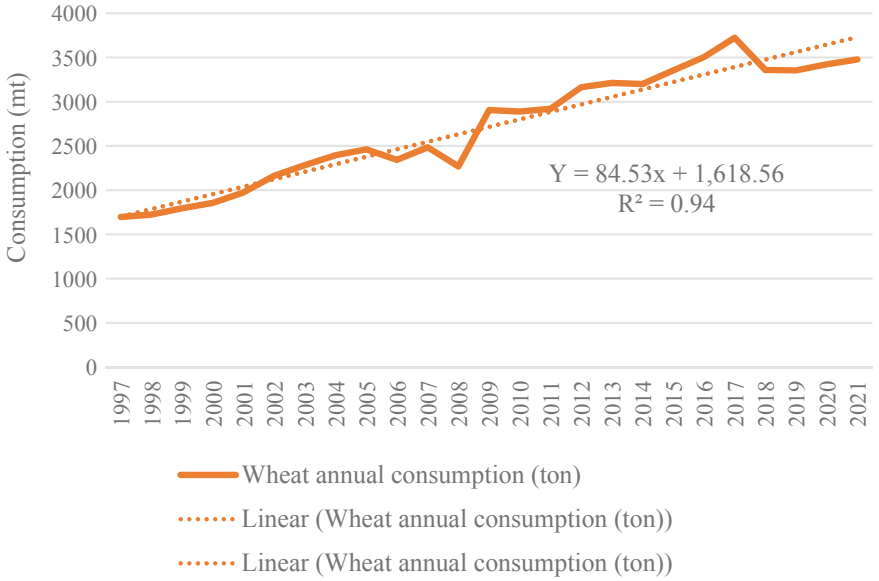

Fig. 22 Wheat consumption (mt) in Saudi Arabia from 1997 to 2021. *Source* Prepared by the author based on data from FAOstat.org (2021)

4 Future Prospects for Production and Consumption of Food Items

The IAEA (2018) reported that Saudi agricultural land is suffering from salinity due to various factors, including the extensive use of underground water, crops grown using chemical fertilizers and pesticides, and farming practices implemented by farmers. Effective farm management can greatly reduce the problem of salinity. Haque and Khan (2020) reported a significant increase in average temperature in the last 50 years, which has led to a significant decrease in crop yields. Fortunately, this has not led to a large change in rainfall. However, Procházka et al. (2018) noted that this has had a less significant effect on agricultural production in Saudi Arabia, which is mainly irrigated. He also projected that water demand will increase by 2030, which will require action. Overall, factors such as climate change, soil problems, chemical use, and water requirements are reducing the production and yield of food crops, which in turn affects the national food supply and security. This conclusion is in line with Avnery et al. (2011) report highlighting the increasing threat to global food security caused by O_3 pollution. Additionally, Fiaz et al. (2018) noted that due to the limitation of agricultural resources such as land and water, Saudi Arabia is expected to import all of its domestic needs by 2050. Al-Shayaa and colleagues (2020) indicated that the initiation of large-scale agriculture in Saudi Arabia requires

Table 4 Food supply quantity (kg/capita/yr) in Saudi Arabia from 2010 to 2020

Year	Wheat and products	Rice and products	Mutton and goat meat	Poultry meat	Bovine meat	Eggs	Milk	Fish	Potatoes and products	Tomato and products	Onions
2010	90.0	55.2	5.7	45.4	5.4	4.8	43.0	20.0	9.0	25.2	11.7
2011	86.5	54.3	6.2	44.2	5.4	4.9	47.2	20.2	10.01	24.6	12.1
2012	89.3	54.8	6.2	43.4	5.7	5.1	53.6	22.9	11.6	26.4	13.3
2013	89.4	53.9	6.5	48.9	5.6	5.2	42.5	22.6	18.0	23.9	12.9
2014	102.7	52.0	6.2	40.4	5.5	5.3	52.1	21.3	13.0	15.6	11.7
2015	98.9	59.0	5.9	43.3	5.4	6.7	43.4	20.4	13.2	16.1	13.1
2016	98.9	53.9	5.0	44.6	4.3	7.1	45.8	17.9	13.0	16.3	12.7
2017	99.9	52.6	4.9	38.0	4.8	6.8	45.0	19.0	16.2	15.3	13.3
2018	98.9	55.6	4.6	35.0	4.6	7.8	44.2	16.9	16.1	15.0	13.1
2019	100.4	53.6	4.3	41.2	4.3	8.7	46.8	15.6	17.1	17.0	10.6
2020	99.2	56.1	4.8	43.0	4.4	10.0	52.1	16.3	19.1	19.6	16.1
Average	95.8	54.6	5.5	42.5	5.0	6.6	46.9	19.4	14.2	19.6	12.8
Per capita consumption 2018[a]											
World	67	78.4	NA	15.6	9.1	9.7	79.3	20.2	32.9	21.2	11.8
Asia	65.2	113	NA	10.1	4.7	10.1	60.2	23.7	29.9	21.4	13.1

Source FAO: https://www.fao.org/faostat/en/#data/FBS
NA not available
[a] https://goodseedventures.com/worldwide-food-consumption-per-capita-2/

the government's continuous search for environmentally friendly farming practices. They also revealed that farmers are aware of these practices, but more effort is needed to encourage them to adopt and stay updated on good practices.

The global community has come up with an initiative called Good Agriculture Practice (GAP) to enhance food safety, as reported by the United Nations in 2019. This initiative aligns with the Sustainable Development Goals (SDGs) related to food safety. According to the United Nations, the aim of GAP is to eliminate food hazards, improve working conditions for farmers, and protect the environment. GAP brings together all parties involved in food production and distribution. Relevant institutions and adopters require certification for GAP. The Arab Organization for Agricultural Development (AOAD) adopted this practice in 2007 through the development of the ArabGAP guide to promote the adoption of GAP in the Arab world. Along with Saudi Vision 2030, which aims to enhance food security, the Saudi government highly prioritizes improving the quantity and quality of available food. In 2017, the MEWA established a plan to implement SaudiGAP, with a unit dedicated to guiding the plan and offering annual certification for those employed in the industry (MEWA 2021b; United Nations 2019).

Organic farming and advanced agricultural technologies are being encouraged in Saudi Arabia to increase food production and efficiently utilize the country's economic resources. MWEA (2021b) reflects a change in food production items for the years 2019–2021 in comparison to 2015. Vegetable production in greenhouses has increased by 127%, and fish from fish farms has increased by around 260% between 2015 and 2021. Saudi GAP has contributed to enhancing production and marketing efficiency in egg, chicken, and cow-raising farms since 2021. GAP in vegetables, field crops, and dates has significantly contributed to increasing production (760%) and the number of certified working farms (29%). Meanwhile, efforts to utilize scarce resources such as water have been emphasized by adopting water harvesting techniques and decreasing fodder land from 640 thousand ha in 2015 to 214 thousand ha in 2021.

Furthermore, it has been reported that efforts to develop food safety and organic farming have resulted in significant achievements such as a decrease in pesticide residuals from 24 to 4%, the incorporation of organic fertilizers in hydroponic farming has increased from 0 to 45%, and there has been a notable increase of approximately 100% in the production of organic food. According to MEWA (2021b), there has been a significant improvement in the services provided to farmers and other parties working in agriculture to enhance the performance of agricultural production, such as crop protection and animal vaccinations.

In regards to the forecasted estimates for crop production in the year 2030, Table 5 outlines select crops such as cereals, vegetables, fruits, and animal products. The results are based on trend lines estimated through Excel. Table 5 displays the production in 2021, the expected production in 2030, and the percentage change. Wheat and barley both show a positive increase of 36% and 34%, respectively, which may be due to intensive production during earlier years. Millet production showed negative production in 2030 which could be due to high decrease in production trend. Date production shows a decrease of 9%. Potato production is expected to increase

by 4% from 2021 to 2030, while onion production is expected to decrease, which could be explained by annual changes in production. The expected animal production in 2030 shows variation. Hen egg and milk production are both expected to decrease by about 5% and 11%, respectively. However, sheep meat production is expected to increase by about 27%, while chicken and camel meat production are expected to increase by about 18% and 7%, respectively. Abdullah et al. (2016) studied the impact of agro-meteorological and socio-economic parameters such as water scarcity, CO_2 fertilization, and climatic change vulnerability on pasture yields and the resulting effects on meat production in 2030. The author revealed that these factors are expected to have a negative effect and could cause a substantial reduction in beef, mutton, and poultry production.

The growing population, changes in taste and preferences, and intensive production will put pressure on resources and the environment. Saudi consumers tend to favor meat due to social and cultural factors. In 2017, the average daily meat consumption among Saudis was 73.3 g. According to Adam et al. (2014), meat supply increased by 435% from 1990 to 2007. Saudi Arabia scored 58 on food loss and waste and ranked 37 out of 78 countries, indicating substantial food losses. The Ministry of Environment, Water, and Agriculture (MEWA) developed a set of initiatives to reduce food waste and promote sustainability, including a national program of food waste reduction (Alshuwaikhat and Mohammed 2017). Sobaih (2023) indicated that food waste in Saudi Arabia holds an economic, social and environmental burden. Alnasser and Musallat (2022) revealed that consuming plant-based diets is more environmentally friendly and enhances the sustainability of the food system compared to meat consumption. Many authors, including Alnasser and Musallat (2022), emphasize the importance of reducing food waste and loss to enhance food

Table 5 Future production forecast for selected food items (in thousand mt)

Food item	2021	2030	% of change
Wheat production[a]	612.6	830.6	+ 35.6
Barley production	383.3	515.8	+ 34.5
Millet production	12.2	– 22.7	
Onion	298.0	142.4	– 50.0
Potato production	578.1	606.1	4.8
Dates	1565.8	1421.9	– 9.2
Citrus	116.8	144.6	23.8
Hen eggs	348.2	331.8	– 4.7
Sheep meat	90.6	115.1	27.1
Camel meat	108.3	89.1	– 17.7
Chicken meat	910.0	846.6	– 7.0
Milk (camel, cattle and goats)	2831.3	2514.0	– 11.2

Source Author compilation based on data from FAOstat.org (2021)

[a] Use an exponential function for prediction

sustainability while Sobaih (2023) reflect on food waste reducction as high strategic priority. On the other hand, increasing consumption of plant-based diets and fish and seafood from sustainable sources will also play a vital role in food sustainability and security.

5 Conclusion and Prospects

Saudi Arabia is determined to be food secure, despite relying heavily on food imports (80%) made possible by returns from oil exports. This determination is driven by factors such as global climate change, resource exploitation and depletion, food shocks and crises, and a growing population, all of which highlight the importance of sustainable food production. In light of this, the Saudi Vision 2030 recognizes the importance of concurrently promoting food security and resource sustainability. Despite challenges such as an unfavorable climate and limited natural resources, Saudi Arabia has made efforts to improve food security and production within the country. The production patterns have changed over the years, adapting to changes in population preferences and modernization. Agricultural production, which is generally irrigated, has historically relied heavily on wheat production, causing strain on underground water and necessitating the exploration of alternative options. Vegetable and fruit production, on the other hand, has expanded mainly through the use of greenhouses. Animal products such as eggs, milk, poultry, and red meat have seen considerable growth. The Saudi government has taken steps to ensure an adequate and varied food supply over time to meet health and nutrition requirements. The high demand for mead among Saudis is due to social and cultural factors, but this increased food supply has led to a high amount of food waste and loss. In fact, Saudi Arabia ranks among the highest countries for food waste and loss, indicating the need for action by the community and government to address this issue. Some solutions to enhance food sustainability in Saudi Arabia include improving resource utilization efficiency through the adoption of improved production technologies like greenhouses, and raising awareness among the populace about increasing consumption of plant-based diets and environmentally friendly products like fish and seafood as alternatives to animal products. Additionally, reducing household and retail waste can significantly improve food sustainability.

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