Situation analysis of watermelon production in the Kingdom of Saudi Arabia CRL/051/2022/1

Strengthening MoEWA's Capacity to implement its Sustainable Rural Agricultural Development Programme (2019-2025) (UTF/SAU/051/SAU)

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1. Introduction.

The FAO technical cooperation in Saudi Arabia provides support to Ministry of Environment, Water and Agriculture (MoEWA) in implementation of the flagship programme through the project "Strengthening MoEWA's Capacity to Implement the Sustainable Rural Agricultural Development Programme (2019-2025)". This project is consistent with the national development goals, fits within the Saudi Vision 2030, contributes directly to achievement of the objectives of the National Agriculture Strategy, the National Environment Strategy and supports fully the achievement of the development goal of the SRAD Programme (2019-2025). The project is being implemented by FAO through direct implementation modalities in full collaboration and partnership with the MoEWA.

The project covers nine components covering commodities, rain-fed cereals, subtropical fruits, rose, fisheries, coffee Arabica, beekeeping and honey, and livestock besides components on natural resource management and enhancing value addition from smallholdings and rural activities. It aims to achieve its six outcomes: 1) technologies and innovative practices to sustainably increase rural agriculture productivity; 2) innovative practices and technologies pilot tested and adopted to restore and conserve natural vegetation; 3) capacity of rural agriculture institutions and small producers enhanced for better access to resources, services and markets; 4) technical capacity of government and stakeholders strengthened to curb land degradation and combat desertification; 5) capacity of public and private sector actors strengthened to develop rural agro-enterprises; and 6) information and knowledge products developed and disseminated.

Rainfed watermelon as a commodity has not been a target in the project document and it was added recently following the official request by MoEWA. Following this, the program component on rainfed cereals was tasked to include watermelon into its portfolio. The watermelon proposed geographic area of intervention is Makkah and Madinah regions. These two regions are characterised by high population in the major cities like Jeddah, Makkah and Madinah and relatively low development of agriculture targeting primarily vegetables and fruits.

The southwestern region`s agro-ecology is very diverse on landscape, elevation, soils, and climate. There are four clearly defined framing systems: rainfed without any irrigation, flood irrigation in lowlands; terrace farming in the highlands and supplementary irrigation in the lowlands. The key to improving crop production is more effective use of the scarce water resources. However, existing rainwater harvest infrastructure requires improvement and irrigation systems efficiency is only 35-40%. For all field crops, the farmers use conventional varieties and extensive cultivation technologies with little if any inputs. The crops suffer from diseases and pests, weeds are common in some areas. However, the farmers seem to be satisfied with the varieties they grow and production technology they apply with exception of the costs of soil preparation and harvesting. Mechanization of the field operation represent one of the major challenges.

The farming community is diverse and dynamic responding to internal and external drivers and challenges. Rainfed crops production is not only important source of income but contributes substantially to the rural livelihood. There is high degree of commitment to rainfed crops production stemming from cultural traditions and rural values. Unfortunately, there is very limited support from adaptive research and extension. Lack of rural support and services as well as the limited capacity to provide the services requires substantial enhancement.

The project interventions, activities and deliverables have been designed to address numerous challenges and build on strengths. These interventions have been aligned with MEWA/SRAD initiatives and prioritized for implementation. The first priority themes include: Water, Mechanization, Demonstration farms, Strengthening of agricultural research and extension. The implementation methodology is based on pilot governorates identified already and demo farms within these governorates. The consultation mechanism with the primary audience stakeholders has been established and assures timely and high-quality implementation of activities. Incorporation of watermelon into project activity will be relatively easy considering the progress made so far with cereals to follow the same model for this new crop.

The objective of this review is preliminary situation analysis of watermelon production in general, and rainfed production in particular in the country with the main focus on the target regions. The review is based on literature, reports, and data study and one visit to the production areas in Makkah region. However, at the time of the visit watermelon was not grown in the field and follow up field missions are needed to complete the analysis and the current review. Therefore, this document represents a short first draft of the

2. Global and national context of watermelon production.

Watermelons, *Citrullus* species (*Cucurbitaceae*), are native to Africa and have been cultivated since ancient times (Paris, 2015). The fruit flesh of wild watermelons is watery, but typically hard-textured, pale-coloured and bland or bitter. The familiar sweet dessert watermelons, *C. lanatus*, featuring non-bitter, tender, well-coloured flesh, have a narrow genetic base, suggesting that they originated from a series of selection events in a single ancestral population. Archaeological remains of watermelons, mostly seeds, that date from 5000 years ago have been found in northeastern Africa. An image of a large, striped, oblong fruit on a tray has been found in an Egyptian tomb that dates to at least 4000 years ago. The Latin literature from the beginning of the sixth century present watermelons together with three sweet fruits: figs, table grapes and pomegranates. Wild and primitive watermelons have been observed repeatedly in Sudan and neighbouring countries of northeastern Africa. *Citrullus colocynthis*, the colocynth, grows wild in the deserts spanning northern Africa to southwestern Asia including Saudi Arabia. Colocynths have small, spherical, and extremely bitter fruits valued for medicinal use of extracts from their dry, spongy pulp or extraction of the oil from their seeds.

Watermelon (*Citrullus lanatus*) is a sweet and refreshing low calorie food. It provides hydration and also essential nutrients, including vitamins, minerals, and antioxidants. Along with melon and cucumber, watermelons are a member of the *Cucurbitaceae* family. There are five common types of watermelon: seeded, seedless, mini, yellow, and orange. Watermelon is around 90% water, which makes it useful for staying hydrated in the summer. Watermelon contains carbohydrates, fiber, calcium, phosphorus, magnesium, potassium, vitamin C, folate, choline, vitamin A, beta carotene, lutein & zeaxanthin, lycopene and phytosterols. Watermelon also contains antioxidants. The daily recommended watermelon consumption is 100-150 gr. Watermelon is highly demanded in the countries with hot climate and, therefore, very popular in Saudi Arabia all year round but especially in summer.

The list of top 20 countries producing watermelon is presented in Table 1. China is a production giant with 60 M tons which is higher than all remaining countries combined. Türkiye, India, Iran, Brazil and Algeria follow China with annual production exceeding 2 Mt. Saudi Arabia produced 0.522 Mt in 2020 (rank 23) from just under 30,000 ha with average yield of 22.3 t/ha. Global watermelon trade amounted to US$1.88 billion in 2020. The main exporters were Spain: (US$508.2 million or 27% of exported fresh watermelons), Mexico ($267.3 M, 14.2%); Morocco ($160.8 M, 8.6%), Italy ($128.3 M, 6.8%) and United States ($126.3 M, 6.7%). Figure 1 demonstrates the main directions of export and import of watermelon between the countries. The nature or watermelon trade is regional and cross border due to the volume and weight of this commodity. For example, Mexico exports to USA while USA exports to Canada. Morocco exports to Spain and it exports the fruits to France, Germany, UK and Scandinavia. Central Asia (Kazakhstan, Tajikistan and Uzbekistan) exports watermelon to Russia. The gulf countries import watermelons from India, Pakistan, Jordan, Myanmar, Egypt, and other countries. Saudi Arabia is essentially self-sufficient in watermelon production and annually exports around 10% of the total product - 4,000-7,000 tons and imports 3,000-5,000 tons (source: FAOSTAT).

Table 1. Watermelon total and per capita production, area, and yield in 2020 (FAOSTAT)

Area	Production, x 1000 t	Rank	Area, x 1000 ha	Rank	Yield, t/ha	Rank	Per capita prod-n, kg	Rank
China	60,083	1	1,397.6	1	43.0	5	42.1	6
Türkiye	3,491	2	78.2	7	44.7	3	42.4	5
India	2,787	3	110.2	2	25.3	13	2.1	21
Iran	2,736	4	100.7	3	27.2	12	33.5	8
Algeria	2,286	5	61	10	37.5	7	53.1	4
Brazil	2,184	6	98.2	5	22.2	17	10.4	19
USA	1,741	7	39.1	13	44.5	4	5.3	20
Senegal	1,677	8	86.6	6	19.3	19	102.9	1
Russia	1,584	9	100.0	4	15.8	20	10.85	16
Egypt	1,491	10	45.0	12	33.1	10	14.9	15
Viet Nam	1,456	11	61.6	9	23.6	15	15.1	14
Mexico	1,362	12	31.1	15	34.8	9	10.7	18
Kazakhstan	1,259	13	50.3	11	25.0	14	73.4	3
Uzbekistan	1,254	14	34.7	14	36.1	8	38.0	7
Spain	1,234	15	21.6	19	57.1	1	26.4	10
Afghanistan	990	16	66.2	8	14.9	21	26.0	11
Tajikistan	752	17	23.3	18	32.3	11	80.7	2
Morocco	677	18	16.8	20	40.2	6	18.6	12
Italy	651	19	13.5	21	48.5	2	10.8	17
Mali	504	20	27.8	16	21.3	18	30.2	9
Saudi Arabia	522	23	23.5	17	22.3	16	15.3	13

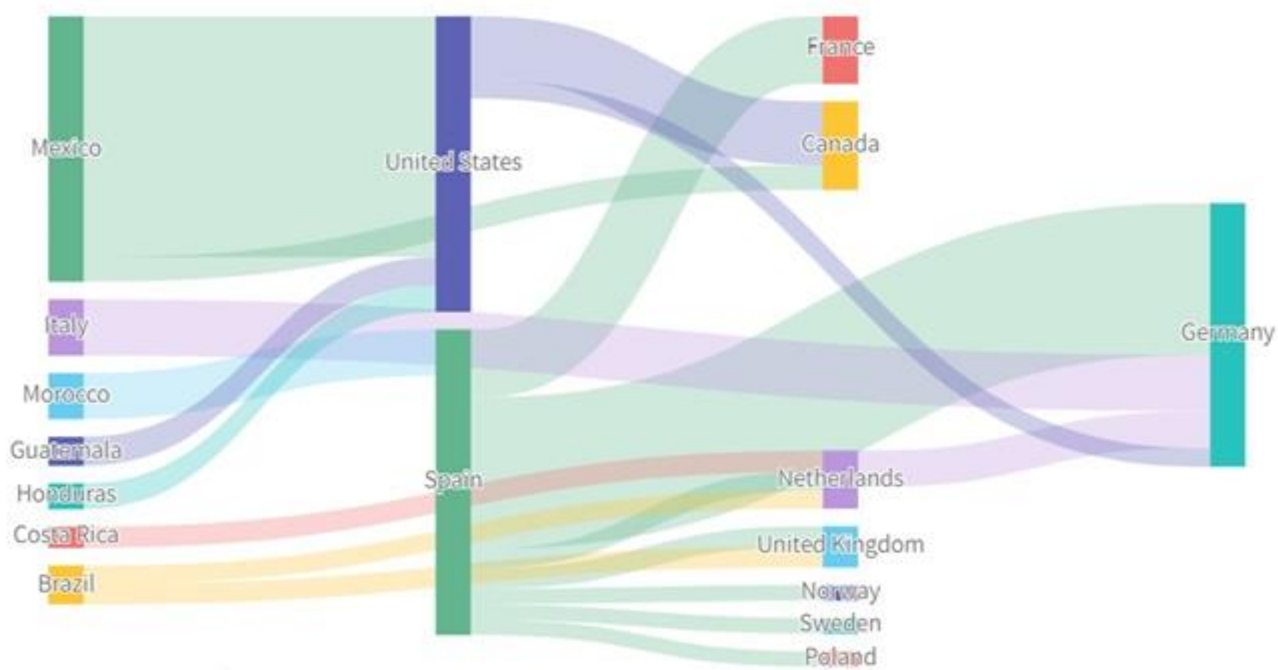

Figure 1. The main directions of export and import of watermelon between the countries (https://www.tridge.com/intelligences/watermelon/import). **China and Hong Kong taken out**

Saudi Arabia watermelon area, production, and yield variation in 2001-2019 is presented in Figure 2 (FAOSTAT data). There is steady increase in area and production since 2011. The production increase is primarily due to area expansion at the backdrop of variable average yield of 19-20 t/ha. Watermelon specific feature as an open field crop is very high-water consumption. Depending on the environment and soil the water needed to grow 1 ha of watermelon varies from 3,000 to 10,000 m^2. Water availability is the main challenge for crops production in KSA. Therefore, the increase in watermelon area can be attributed to expansion of watermelon area under rainfed conditions as well as the favorable prices for the product suggesting its profitability driving area and production increase. According to FAOSTAT watermelon producer price increased from 750USD per ton in 2016 to 850USD per ton in 2019.

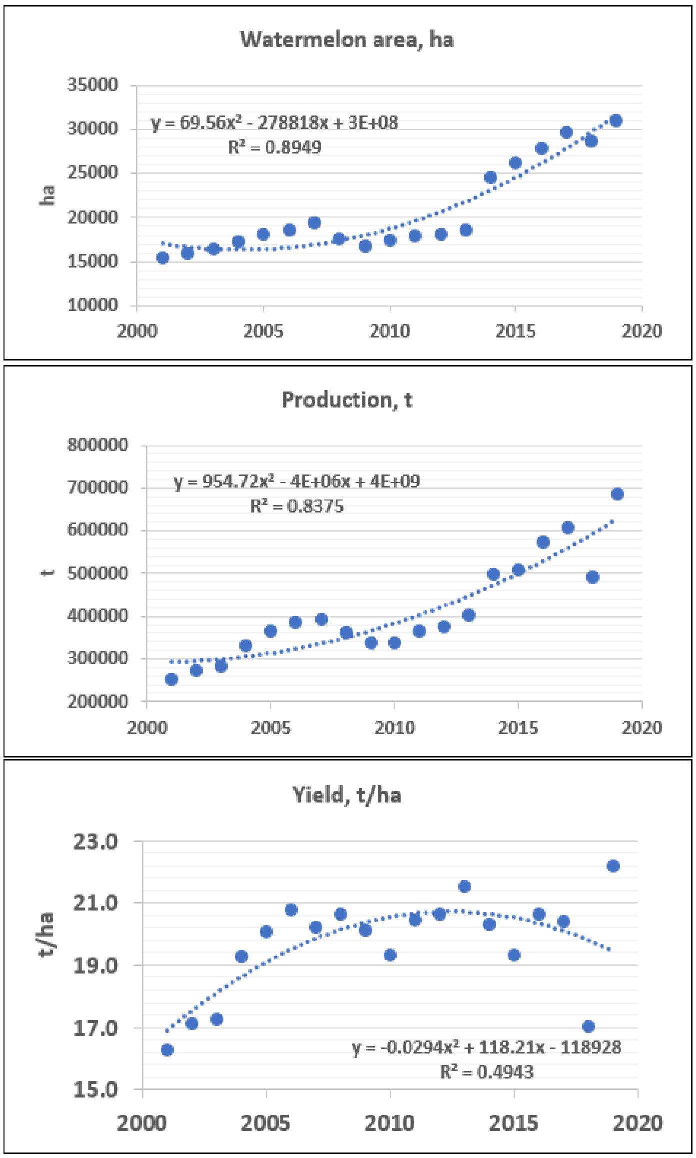

Figure 2. Watermelon area, production and yield in KSA in 2001-2019 (FAOSTAT)

The government of Saudi Arabia and MoEWA regulate the production of the crops under irrigation which uses deep aquifers and non-renewable sources of water. This especially concerns the important food security crops like wheat and fodder crops (barley and alfalfa). The production is regulated through the purchasing prices and subsidies. In the recent past barley was essentially eliminated from irrigated production and alfalfa area is being reduced while favoring increase in wheat acreage. However, vegetables including watermelon are not subject of direct government policy and left for the free markers forces to determine the supply and demand. One important factor favoring watermelon production is consumer's overall love to this fruit as well as high degree of preference of local Saudi grown products.

3. Mapping watermelon production in KSA and selection of priority target areas.

The watermelon area and production in each of the 13 regions of the country is presented in Table 2 and on Figure 3. Makkah region stands out as the main watermelon producer accounting for 80% of domestic production. Riyadh follows with almost 10% and Jazan region produces nearly 5% of country total.

Table 2. Watermelon area, yield and production regions in KSA (2018 GAS data)

Region	Agroclimatic zone	Main cropping system	Harvested area, ha	Yield, t/ha	Production, t
Riyadh	Najd	Irrigated grains, forage, vegetables	3,072	20.9	64,328
Jouf	North Plains	Irrigated forage, vegetables	257	20.0	5,132
Qassim	Najd	Irrigated grains, forage, vegetables	195*	18.4	3,544
Hail	N. Plains, Najd	Irrigated forage, vegetables	52	20.0	1,039
E. Province	Najd, Gulf	Irrigated forage, vegetables	290	20.0	5,794
Makkah	Najd, Aseer, Red Sea coast	Irrigated vegetables, fruits. Rainfed cereals.	24,350	22.8	555,033
Jazan	Red Sea coast, Aseer	Rainfed cereals. Irrigated fruits and vegetables.	1,250	19.7	24,684
Tabuk	North Plains	Irrigated forage, vegetables	184	23.2	3,584
Medina	Hijaz, Najd, Red Sea coast	Irrigated vegetables.	737	22.1	16,075
Asir	Red Sea coast, Aseer	Rainfed cereals. Irrigated fruits and vegetables.	2	16.5	33
Najran	Najd, Aseer,	Irrigated vegetables, fruits.	2	18.4	31
Al Baha	Aseer	Rainfed cereals. Irrigated fruits and vegetables.	589	14.3	8,421
NB	North Plains	Irrigated forage, vegetables	-	-	14
Total			30,980	22.2	687,714

* - Qassim production areas seems too low.

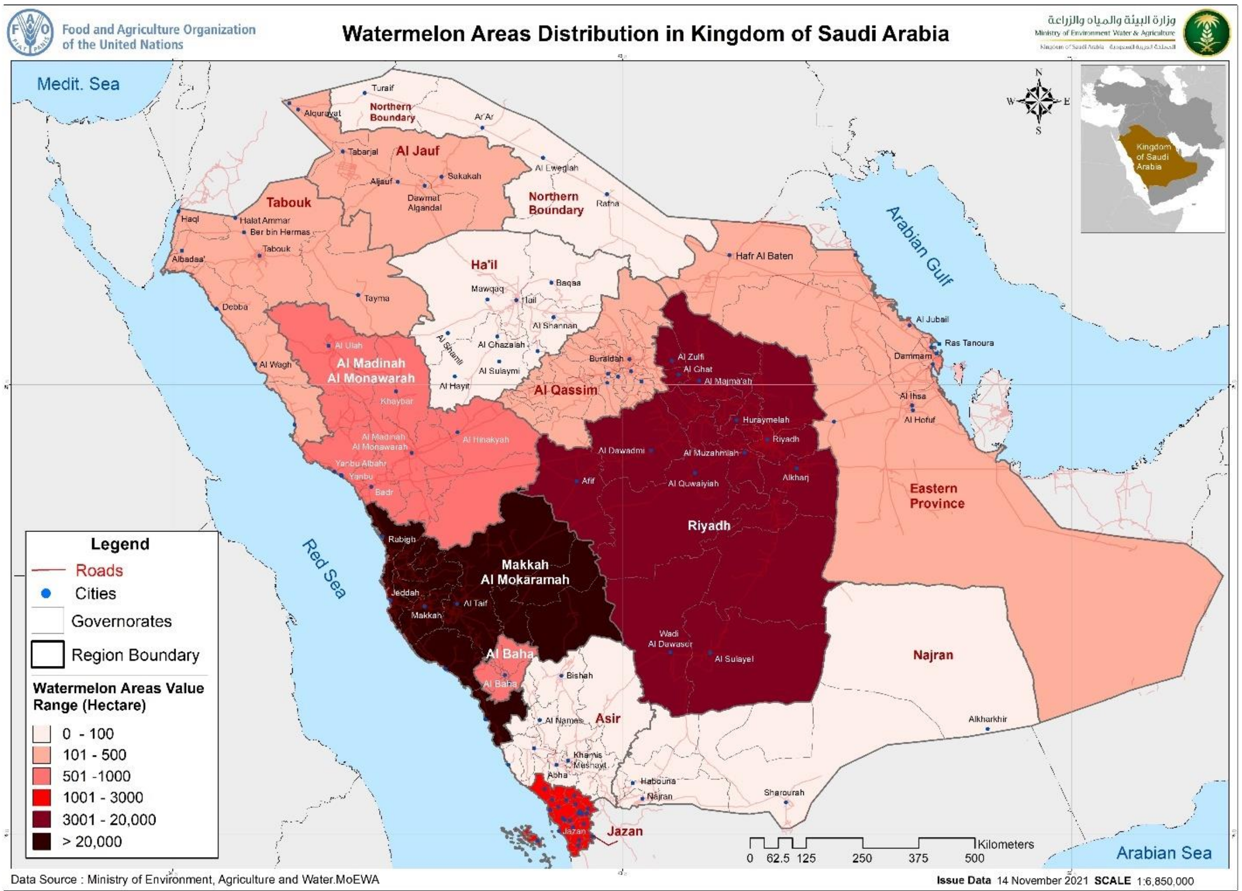

Figure 3. The map of watermelon production in Saudi Arabia (GAS data, 2018).

The data on watermelon area in four project target regions (Al Baha, Aseer, Jazan and Makkah) indicates the dominance of Al Lith governorate in Makkah region which grows around 12,500 ha or 67% of all crop area (Figures 4 and 5). The neighboring Al Qunfudah governorate grows 2,300 ha.

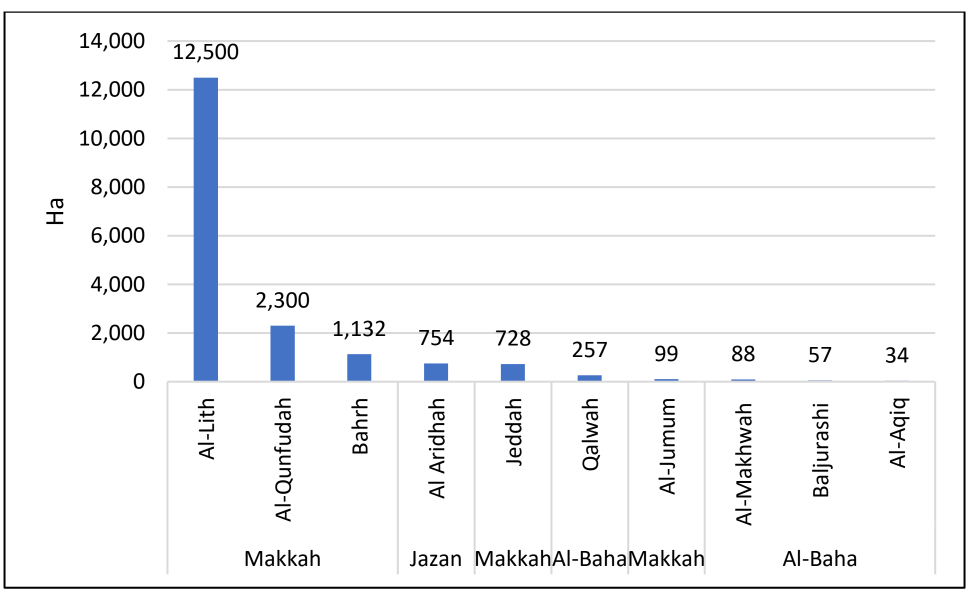

Figure 4. Watermelon area (ha) in the target regions governorates cultivating this crop (2020 MEWA data).

Figure 5. The map of watermelon production in governorates of Al Baha, Aseer, Jazan and Makkah regions (2020 MEWA data).

SRAD project applies pilot area approach in introduction of progressive technologies and practices. Under this approach the initial project activities are focused on selected governorates which meet two important criteria: a) The importance of the target commodity in the governorate as indicated by the area grown and a number of farmers involved; b) Representation of agroclimatic zone and cropping system for wider application of the pilot activities results and outcomes. This approach was successfully used for selection of pilot governorates for establishment of demo farms for rainfed cereals activities. It is anticipated that other (non-pilot) governorates will benefit from the project through conducting activities at a later stage, participation in training events at pilot governorates and through spillover effect. For watermelon, establishment of the demo farms is also planned. The recommendation is to focus on two governorates in Makkah region which produce the bulk of watermelons in the region: Al Lith and Al Qunfudah.

These two governorates are major agricultural areas of Makkah region accounting for 65% of all land used for agricultural production (Table 3). They also account for 90% of all cereals and 88% of all watermelon in the region. However, these two governorates also have clear distinction. Production in Al Lith is totally dominated by watermelon (88% of all planted area) whereas Al Qunfudah has more diverse production with cereals (sorghum and millet) accounting for 44% of the land and fruits – 18%. Thus, watermelon is part of the cropping system with around 30% of the area. The two governorates also differ in production systems where watermelon is grown. Overall, these two pilot governorates have watermelon as an important crop and provide sufficient diversity to develop interventions which may be applicable well beyond to cover other production areas.

Table 3. Population and crops production structure in Al Lith and Al Qunfudah governorates on Makkah region (2020 MEWA data).

Governorate	Popul-ation	Agro-climatic zone	Area, ha					
			Land planted	Grains	Forage	Fruits	Veget-ables	Watermelon
Al Lith	128,529	S.Tihamah Aseer Scarp	14,165	887	57	124	457	12,500
Al Qunfudhah	272,424	S.Tihamah Aseer Scarp	7,322	3,214	52	1,322	430	2,300
Total two governorates			*21,487*	*4,101*	*109*	*1,446*	*887*	*14,800*
Total Makkah region			***33,183***	***4,540***	***1,312***	***6,812***	***3.324***	***16,825***

4. Cropping systems and production technologies applied for watermelon.

Saudi Arabia growing conditions are highly suitable for watermelon as this crop requires warm environment. However, availability of moisture is the main limitation to expand the area and increase productivity. Suitability of the country for watermelon production is also reflected in possibility of growing the crop in two seasons: winter and summer. This provides the opportunity for all year-round supply of the fruits to consumers. There are three main productions systems for watermelon.

- Irrigated summer watermelon in Riyadh and Qassim regions. There is limited information on this system due to the fact that the region was not visited, and it is outside of the SRAD project target areas. However, the production system is fully irrigated from underground water sources and lasts from spring to fall with possibility of more than one growing season. The varieties grown are Sunshade, Diamond, Charleston, Charleston gray, Crimson sweet and Fashion (Alsohim et al. 2014).
- Wadi spate irrigation system during winter season in southern Tihamah plain (Jazan and Makkah). The production is based in river valleys being irrigated by flash floods from the rainfalls in the mountains, The fields are flooded for several days and then cultivated and planted after water recedes. The crops are grown using residual moisture from September-December till March-April. The main crop in this system is sorghum widely used for forage and grain. However, watermelon may constitute up to 30% of the farm area as a cash crop. Several watermelon varieties are grown in this system originating from USA, Holland, and France. The planting density is 1.5-2 m apart with 2-3 seeds later thinned to one seedling. No fertilizers are applied on watermelon.
- Entirely rainfed production system focusing primarily on watermelon. This unique system is also situated in South Tihamah region in the desert along the Red Sea coast especially in Al Lith governorate of Makkah region. Watermelon in the system is grown on the best soil in the country according to general soil map produced in 1986. The plan density is lower compared to wadi system with 3-4 m between the plants to allow higher moisture availability. Thinning is applied the same

way as for wadi system. Charleston Grey is the main variety grown in this system and can reach 60-80 cm in length. The soil preparation is limited to cultivation of the area where the watermelon is planted.

The main challenge of watermelon production uniformly mentioned by MEWA and farmers is diseases. This is also proved by the number of scientific publications on this subject coming from Saudi Arabia universities. Back in 1990s Abu Salih (1992) described drastic watermelon production in Gazan due to a severe disease called locally watermelon yellowing. It is characterized by leaf mottling followed by general chlorosis of large areas of the leaves which may result in complete loss of yield. The results indicated that the disease is transmitted by the whitefly *Bemisia tabaci* but not mechanically or by aphids. None of the 17 watermelon cultivars tested proved to be resistant or tolerant to the disease. Incidence of the disease was markedly affected by sowing dates with June and July sowings showing the lowest incidence of the disease. Chemical control of the vector by soil incorporation of carbofuran at planting and 2 and 3 weeks later, coupled by weekly insecticide sprays gave a marked reduction in disease incidence.

The more recent studies using molecular tools demonstrated that this disease is caused by several viruses. During the spring season of 2014, watermelon leaves were exhibiting yellowing, mottling and stunting symptoms in Western and Southwestern regions (Jeddah, Al-Lith, Jezan, Asfan, Ghonfada, Tofeel, Wadi Baish, Abu Arish) of Saudi Arabia (Ahmad et al. 2020). Samples (139) were collected from symptomatic and asymptomatic watermelon plants. DASELISA was performed to detect Cucurbit yellow stunting disorder virus (CYSDV) and other suspected cucurbit viruses. Out of 139 watermelon samples, nine and 98 samples were found to be positive with CYSDV and Watermelon chlorotic stunt virus (WmCSV), respectively and 22 samples were found to have mixed infection for both viruses. Saudi Arabian CYSDV virus isolates separated into distinct eastern subpopulation due to its survival in the harsh weather conditions with very high temperature and low humidity Phylogenetic position of four CYSDV isolates identified depicts that the virus is endemic to the region and has no evolutionary relationship to isolates reported from other countries. The same group studied incidence of viruses during the spring season of 2014 using a total of 148 melon and watermelon leaf samples collected from symptomatic and asymptomatic plants in the western and southwestern regions of Saudi Arabia (Ahmed et al. 2018). WmCSV and CYSDV were detected in majority of the samples. Host range experiments revealed that eight out of fourteen tested plant species were susceptible to WmCSV. Coat protein gene sequences from eleven WmCSV isolates indicated that the highest identity was between the 104WMA-SA isolate from the Wadi Baish location and a previously reported isolate from the AL-Lith location in Saudi Arabia. The lowest identity was observed between the 42WMA-SA isolate and an isolate from Palestine.

Rezk et al (2019) identified watermelon chlorotic stunt virus (WmCSV) symptomatic and non-symptomatic leaf samples of cucumber, zucchini, melon and watermelon plants collected from three locations (Al-Ahsa in the East, Jazan in the South and Tabuk in the North) during 2013–2014. The detection of begomovirus infection was commenced with serological assay, rolling circle amplification and PCR amplification with universal begomovirus primers. The zucchini and watermelon samples tested positive for the presence of WmCSV infection in 39.6%, and 41.5% samples using serological and PCR-based detection, respectively. The phylogenetic dendrogram grouped two DNA-A clones into separate sub-groups, suggesting that both isolates were introduced separately into Saudi Arabia. The identification of WmCSV from zucchini in Saudi Arabia and other hosts in the neighbouring countries suggests that this virus is becoming an emerging threat to cucurbits in this region.

Santosa et al (2018) studied severe virus disease-like symptoms on watermelon in Al-Ammariyah area of Riyadh region. The virus was transmitted by *Aphis gossypii* and *A. craccivora*. ELISA revealed positive results only to Watermelon mosaic virus (WMV). The homology tree that was constructed from multiple sequence alignments of the detected Saudi Arabian isolate of WMV (WMV-SA) with 18 other isolates of WMV from nine different countries indicated close relationships between them. Two isolates from Spain and two other isolates from Iran were more closely related to the WMV-SA whereas the isolate from Poland was the least. Seven watermelon cultivars were screened for their reactions to a severe Saudi Arabian isolate of Watermelon mosaic virus (WMV-SA) that induced a severe disease in watermelon in Riyadh region (Al-Shahwan et al. 2018). All of them were found to be susceptible and showed different virus-like symptoms upon mechanical inoculation. Sugar Baby, Crimson Sweet 1 and Crimson Sweet 2 cultivars showed milder symptoms and, therefore, got lower grand mean of weekly symptom ratings than Charleston Gray No. 502, Jubilee, Black Diamond, and Charleston Gray No. 133. Artificial inoculation with this isolate significantly reduced the plant height, fresh and dry weights of the tested cultivars. The reduction in percentages of fresh weights of Sugar Baby, Crimson Sweet 2 and Jubilee were significantly lower than reduction percentages of Crimson Sweet 1, Black Diamond and Charleston Gray No. 133. No correlation existed between the virus titer in the infected cultivars and their performances. In general, Sugar Baby and Crimson Sweet 2 performed better than the other cultivars as they had the lowest symptom severity ratings, the lowest percentages of plant height, fresh and dry weight reductions compared to the other tested cultivars.

The viruses affecting watermelon belong to the group of Begomoviruses, family *Geminiviridae* and are single-stranded circular DNA viruses with either monopartite (DNA-A genome of about 2.7 kb), encoding six open reading frames or bipartite genomes (DNA-A and DNA-B genomes of 2.5–2.6 kb) encapsulated in twinned particles (Sohrab, 2020). They are efficiently transmitted by the vector whitefly (*Bemisia tabaci*) to dicotyledonous plants. The DNA-A component of the bipartite begomoviruses is involved in replication and production of virions but requires the DNA-B component for nuclear localization, systemic infection, host-range determination, and symptom expression. Begomoviruses are known to have satellite molecules known as betasatellites and alphasatellites. Plant virology in Saudi Arabia is in its infancy and very little information is available about the plant viruses causing diseases in important crops. The review chapter summarizes the major developments and current status of begomovirus research and future prospects in Saudi Arabia.

Watermelon fungi diseases were studied in different fields in Abu-Arish governorate, Jazan region (Alharbi, 2014). Incidence of damping off disease in watermelon root samples which naturally infected with *Fusarium solani* and *Rhizoctoina solani* were 43.2 and 50.5%, respectively. *F. solani* and *R. solani* were the most prevalent fungi with 48.4 and 52.6 F%, respectively. Two *Trichoderma* species (*T. harzianum* & *T. viride*), three *Pseudomonas* species (*P. chlororaphis*, *P. eruginosa*, *P. florescence*) beside the fungicide Rizolex were used to study their effect on the root rot fungi *F. solani* and *R. solani* under laboratory and greenhouse conditions. *In-vitro* experiment showed that treatment with Rizolex-T resulted in great inhibitions on growth of *F. solani* and *R.solani* followed by treatments with *P. florescence*, *P. chlororaphis*, *P. eruginosa*, *T. harzianum* and *T. viride*. Also, same treatments showed significant decrease in disease incidence (pre & post-emergence damping-off) followed by treatments with *T. harzianum*, *T. viride*, *P. chlororaphis* and *P. eruginosa* under laboratory and greenhouse conditions. All treatments enhance dry weight of shoot and root systems and showed a significant increase in total chlorophyll content compared with control. This is an important study outcome outlining the IPM options for watermelon root rot. It also demonstrates the research and development capacity of Jazan University to attend important agricultural challenges.

The situation with insect pests is much less clear compared to diseases. The farmers mentioned the insect which penetrates the fruits and spoils them completely. In the literature Aljedani (2020) from Jeddah describes the control of black watermelon bug (*Cordius viduatus*) as the biggest potential threat to production on a huge scale which deteriorates the quality and results in low yield. Imidacloprid is a synthetic chemical insecticide, which is extensively employed for controlling insect pests. However, it is used less often due to its highly negative impacts on non-target organisms. Moreover, these organophosphates also possess poor environmental and toxicological profiles. The issue stimulated the application of natural products as a substitute pest control strategy. Plant-based insecticides like Neem (*Azadirachtin Indica*) are effective and show good efficiency against more than 400 insect species. Moreover, neem oil can be used potentially against insects as well as mites and to manage phytopathogens. Considering these facts, researchers carried out a new experiment to calculate the effects of imidacloprid as well as azadirachtin on the black watermelon bug, especially evaluating the acute toxicity, mortality and sublethal effects while determining the lethal concentration and lethal time. The study exhibited that the imidacloprid possess a stronger effect on the elimination and mortality of the black watermelon bug as compared to azadirachtin. Also, the imidacloprid pesticide requires less time in the elimination and death of the black bug population by employing half-lethal concentration. Conclusively, the imidacloprid was found very toxic against the black bugs regarding both mortality and longevity. Furthermore, the botanical insecticide group such as azadirachtin showed a moderate toxic impact on the population density of the black bug than imidacloprid but this approach is environment friendly and reduces environmental pollution.

So there are important diseases and pests of watermelon affecting the production. However, there is also a capacity for their identification and development of control measures. Several watermelon production guides have been published and are useful resource for improvement of production.

A farmers' guide to growing watermelons. http://www.free-ebooks.net/tos.html.

Watermelon production in California. vric.ucdavis.edu.

https://www.fao.org/land-water/databases-and-software/crop-information/watermelon/en/

5. Production support services and value chain.

Watermelon production support services we appraised through the interviews with governorate MoEWA offices and farmers in Al Lith and Al Qunfudah. Seeds are normally purchased from the agricultural inputs shops which offer fertilzers, vegetables seeds and crop protection chemicals. There are 1-2 shops in each town and farmers also have option of buying the seeds from bigger shops in Jeddah. No fertilizer is used for watermelon production. The crop protection chemicals are used but it was not clear from the interviews about specific product and event its function – to protect against diseases or pests. Though the farmers realize that pesticides protect against the losses. The services of establishing irrigation are available in both governorates from commercial companies which can make design, drill wells, install the pumps and water distribution system of any complexity. However, the prices may be high as the irrigation we saw was simple pumps with flood irrigation. There is no dedicated extension service. It would only help in the case of locusts attach by spraying the crops. There is not applied agricultural research located in Al Lith and Al Qunfudah. There are no cooperatives of any kind targeting agricultural production.

Marketing of watermelon takes place through local market along the main road when the fruits are sold by pick-up trucks (Figure 6). The pick-up rack can accommodate 60-80 fruits and can be sold from over 2,000SAR early in the season for large fruits to 700-800SAR later in the season for smaller fruits. There is seasonal variation depending on the area planted, losses due to diseases, rainfall and season duration and other factors. The watermelons purchased from the markets by pickup trucks are taken to Jeddah for reselling to vegetables shops or directly to consumers. There is no local cold storage capacity for watermelons which could extend the storage period and sell the fruits at higher prices. In general, there is a need for more detailed and focused study to understand the marketing system.

Figure 6. Watermelon market in Al Lith, Makkah region.

The survey and interviews did not identify any value addition for watermelon practiced by farmers or other actors in value chain. However, watermelon jam is sold in the shops though may not represent a large-scale utilization of the fruits. The recent publications from Saudi Arabia scientists draws attention to processing of watermelon rinds which are rich in a number of compounds with positive effect on human health.

Fadimu et al (2020) used ultrasound-assisted extraction (UAE) for the collection of phenolic compounds and determination of antioxidant activity of watermelon peel (WMP) and watermelon seed (WMS). UAE process variables (sonication temperature, sonication time, and ethanol concentration) had a significant impact on the total phenolic content (TPC) and antiradical activity of WMP and WMS. The optimum conditions for WMP extraction (sonication temperature = 47.82 °C, sonication time = 31.63 min, and ethanol concentration = 42.84%) yielded maximum TPC (7.944 mg GAE/100 mL) and antiradical activity (85.150%) while UAE at 50.32 °C, 37.60 min, and 39.18% ethanol yielded maximum TPC (32.152 mg GAE/100 mL) and antiradical activity (85.947%) for WMS. There is potential in using watermelon for extraction of phenolic compounds.

Microbial lipids namely single cell oils (SCOs) are one of the microbial products that considered as a multi applications product that involved in nutraceutical, pharmaceutical and industrial fields (Hashem et al. 2020). Watermelon peel waste (WPW) was used for first time in single cell oils production via a promising oleaginous fungus *Lichtheimia corymbifera* which was isolated from Egyptian ecosystem. Pretreatments of WPW were carried out by mechanical, physical, and chemical methods; the most potent pretreatment was selected according to total reducing sugar and total lipid production. Accordingly, the mechanical ptetreatment of WPW was distinctly the best pretreatment method for SCOs production from L. corymbifera. The study showed that WPW was used as a natural, effective, economic, ecofriendly and integrated substrate without adding any outsource nutrients to produce sustainable SCOs with low-cost production.

6. SWOT analysis.

Preliminary analysis of strengths, weaknesses, opportunities, and threats of watermelon production is presented in Table 4. Their consideration is important for designing the interventions to enhance watermelon production.

Table 4. Analysis of strengths, weaknesses, opportunities, and threats for watermelon production in southwestern part of KSA

Strengths	**Weaknesses**
- Long history and tradition of watermelon cultivation in the South-West of the country - Farmers experience and commitment to cultivating watermelon - Availability of rainfed land for cultivation and expansion - Availability of adapted varieties accepted by consumers - Consumption of watermelon contribute to human health and considered healthy functional food - Research work at universities targeting different aspects of watermelon production - Established value chain system	- Inadequate applied research support - Lack of adopted improved varieties and technologies - Poor extension and technical support services to watermelon producers - Limited water availability and inadequate use of rainfall catchments and water harvesting - Poor finance services for small-scale watermelon growers - Inadequate storage and marketing infrastructure - Limited watermelon market promotion - Lack of effective agricultural cooperatives for rainfed watermelon - Absence of effective market integration and sales platform for watermelon.
Opportunities	**Threats**
- MoEWA interest and support to develop watermelon sector - Watermelon has high domestic demand as healthy food - Strong research and seed production in advanced countries - Consumer driven demand for healthy food - New SRAD subsidy scheme supporting rainfed production - Presence of capable research groups in Universities (King Saud, Jazan, KAUST) able to work on watermelon.	- Uncertain labor availability during harvesting seasons - Lack of market information to farmers - Arbitrary setting of the prices - Small farm sizes limit application of modern technologies, income and livelihood for farmer families - Faster climate change pace resulting in drier and hotter weather, weather extremes - Slow transformation of research and extension service limiting provision of products and services to producers.

7. Watermelon production enhancement directions and next steps.

The preliminary situation analysis identified the following topics which shall be addressed to develop interventions to enhance watermelon production:

- Evaluation of watermelon cultivars under different ecologies and moisture conditions and selection of the most suitable
- Study of the varieties and seed market and its optimization
- Development of Good Agricultural Practices for the main watermelon production systems
- Detailed analysis of the value chain, support services including extension and development of recommendations for their improvement
- Detailed study of the watermelon market and value addition for the target governorates.

The current situation report is based on a limited surveys and interviews conducted during a single mission of FAOSA cereals staff to the target region. The staff involved are not experts on watermelon production and the project needs input from an expert with profound knowledge of the subject. TORs have to be developed for hiring the expert and conducting more detailed analysis with solid technical recommendations. FAOSA cross-cutting experts need to tasked to incorporate watermelon into their respective activities with clearly defines work plan and outcomes. FAOSA cereals staff will continue to be involved in watermelon activities in leading and coordinating role until the detailed interventions work plan is developed and provided to the management. The timeframe for development of the interventions activities and work plan is first half of 2022.

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9. Annex. Watermelon production photos.


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مسابقة أكبر حبحبة في الموسم
المجيرمة 2021

برنامج التعاون الفني بين وزارة البيئة والمياه والزراعة ومنظمة الأغذية
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