



TONY BLAIR
INSTITUTE
FOR GLOBAL
CHANGE

How Israel became a world leader in agriculture and water

Insights for today's developing countries

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SEPTEMBER 2019

In collaboration with:



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Acknowledgements

The authors would like to thank all of our interviewees, who embraced our mission of sharing Israel's agricultural journey for the benefit of other countries and who so generously gave of their time. Without their stories, experience and insights this paper would not have been possible.

We are also grateful to Melissa Pickard for assistance with the design and to Mairav Zonszein for the copy editing.

Last but by no means least, we would like to express our great appreciation to Prof. Edo Chalutz, Prof. Uri Mingelgrin, Prof. Yoram Kapulnik and Prof. Itamar Glazer for working with us to identify the interviewees, providing guidance throughout the course of this research and reviewing the paper.

This paper was supported by the Alliance for a Green Revolution in Africa, Volcani International Partnerships and the Tony Blair Institute for Global Change.

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Tony Blair

HOW ISRAEL BECAME A WORLD LEADER IN AGRICULTURE AND WATER MANAGEMENT

For many in the world, Israel is most often discussed in the context of the Israel/Palestine dispute and hopes for its peaceful conclusion. But alongside this long running political question, has been the emergence of Israel as a successful, modern and innovative nation.

In fact, Israel has overcome overwhelming challenges such as water scarcity and poor land conditions to emerge as a world leader in agriculture and water management technologies - spanning the spectrum of low to high-tech solutions for smallholder farmers and large conglomerates.

In recent years, arising out of my intensive engagement with Israel and in Africa, I have been approached by numerous African leaders seeking to connect to and learn from Israel's agricultural miracle. Through these various interactions I have come to see first-hand just how much Israel has to offer others from its experience in "making the desert bloom" - building a thriving agriculture sector under conditions of considerable adversity.

Africa is on the rise. With a predicted four billion people in just eighty years' time, and half its territory as yet uncultivated, Africa has the potential not only to feed itself, but to be the primary exporter of food products to a hungry world.

We are already witnessing varied signs of development and economic transformation across the African continent, and yet the scope for further and faster growth is immense.

This is where learning from the lessons from a country like Israel will be so valuable and is precisely why the Institute has produced this report.

It identifies how Israel developed its current capabilities from its starting point- when agricultural and institutional capacity and its GDP per capita were at similar levels to those of many developing countries today.

Every country is unique and each has to chart its own course, and yet certain principles and insights are universal. The lessons one can draw from the way Israel structured itself from the early years are relevant for governments, farmers, markets, and development partners.

The Institute's report examines the drivers behind Israel's agricultural success, highlighting the key principles that should be applied across Africa, and providing insights for developing countries seeking to drive and implement a transformative agenda in their respective agricultural sectors.

These examples of best practice include being market-led, focusing on education for farmers, aggregation of farming units, developing a research capability and targeting government infrastructure spending to drive economic transformation.

A striking example is the way in which Israel overcame acute water shortages with the dramatic decision to build a national water carrier to transport water from the Sea of Galilee in the north to the Negev desert in the south, a decision that revolutionised Israel's water distribution network and enabled Israel to farm the desert.

From my conversations with many world leaders I know the demand for agricultural solutions to revolutionise the sector is great and hope the lessons of this report for both governments and development partners can be an important step in meeting that demand.

I am passionate about the work my Institute does to equip Africa's leaders to drive practical change to benefit their people. Agriculture is a critical area within this work and I believe Israel's agriculture experience is an invaluable tool in furthering our shared ambition for Africa's future.



Tony Blair

Executive Chairman of the Tony Blair Institute for Global Change

Former Prime Minister of Great Britain and Northern Ireland

Introduction

Israel is not a natural
nor sensible place
for agriculture.

Two thirds of the land is semi-arid or arid and much of the soil is of poor quality. There is a shortage of natural water resources, a scarcity of precipitation and Israel is far from key export markets. Most early immigrants tasked with developing the land had no prior farming experience and on arrival faced a desertified, barren and swampy landscape.

Despite such overwhelming challenges, in its short history Israel not only managed to create a remarkable agricultural transformation, securing national food security and establishing thriving export industries, but also emerged as a global leader in agriculture and water management. How did it succeed?

Unsurprisingly, Israel's agricultural success against all reasonable odds has generated great interest. Many government representatives of developing countries visit Israel in search of advice and support, asking, "what can we learn from Israel's story and what can Israel offer?" This report provides a response, with insight into how Israel developed its world class agriculture and water management sectors, with an emphasis on the roles of government, markets and innovation.

Israel is a unique country whose history, politics and geography shaped the mindset of its people and its leaders. Nonetheless it offers many valuable insights and practical lessons. This report extracts such lessons for today's developing countries. Many African nations, in particular, are still awaiting an agricultural revolution that historically has proved crucial for the development, food security and large-scale poverty reduction of advanced and fast-developing countries across the world.

This report presents the main building blocks of the agriculture sector – and to a lesser degree the water management sector – through a historical lens that demonstrates how they came to be. It identifies how Israel developed its capabilities when its agricultural capacity, its institutional capacity and its Gross Domestic Product (GDP) per capita were at similar levels to where many developing countries are today. The paper's primary target audiences are policymakers in developing countries, their development partners and the Israeli community engaged with developing countries

Israel's Agriculture Sector

Israel is a world leader in agriculture and water management, as reflected in key statistics.

PRODUCTION ACHIEVEMENTS

Israel records the highest productivity of cow milk in the world at 13,000 litres per cow compared to 10,000 litres in North America and 6,000 litres in Europe.¹ It produces 262 tonnes of citrus fruit per hectare, compared to 243 tonnes in North America and 211 tonnes in Europe.² Israel's tomato yield is 300 tonnes per hectare, compared to an average of 50 tonnes per hectare worldwide.³ And it is a world leader in the production of fruit such as pomelits, pomegranates, nectarines, plums, dates, strawberries and avocados. The country also leads in post-harvest handling: it records 0.5 per cent of grain storage loss, compared to 20 per cent worldwide.⁴

1 Faostat.org

2 ibid.

3 Interview with Volcani Research.

4 Ministry of Agriculture, Israel.

EXPORT STANDING

In 2018 Israel exported \$350 million worth of vegetables, \$250 million worth of dates, avocados and mangoes, \$215 million worth of fruit juices, \$193 million worth of citrus fruits, \$188 million worth of processed food and \$151 million worth of seeds.⁵ These agricultural exports alone equate to three quarters of the entirety of the non-fuel and non-ship goods exports of Nigeria – Africa's largest economy. And this from a country that only has 295,000 hectares of arable land, less than the 315,000 hectares that make up Rhode Island - the United States' smallest state.⁶

SEMI-ARID AND ARID AGRICULTURE

Realising a flourishing agricultural sector in desert conditions and reversing trends of desertification is one of Israel's greatest agricultural achievements. More than 40 per cent of the country's vegetables and field crops are grown in the desert.⁷ The vast majority of exported melons – some 90 per cent – are grown in the Arava (the Jordan Valley desert).⁸ The desert is also home to fish farms, olive groves, vineyards, date palms and crops for alternative industries. One such example is jojoba. Israel's desert is now the biggest producer and distributor of jojoba, a crop that produces oil for the cosmetic market. With an average harvest of 4,500kg of seeds per hectare, Israel's jojoba accounts for nearly 50 per cent of overall global production.⁹

OVERCOMING WATER SHORTAGES

Israel has only 90 cubic metres of internal renewable water per capita annually, compared to 1,300 in Germany, 2,200 in the United Kingdom and 8,700 in the United States.¹⁰ However, Israel is now a world leader in water management for domestic, agricultural and industrial purposes.¹¹

Mekorot, Israel's national water utility company, uses desalinated sea water to provide between 60 and 85 per cent of water for domestic and industrial uses. Indeed, some 40 per cent of Israel's drinking water comes from desalinated water from the Mediterranean Sea.¹² Furthermore, Mekorot registers a world record three per cent water loss across its water distribution system, compared to 15 per cent in developed countries and 35 per cent in developing countries.¹³

Another notable achievement has been Israel's ability to maximise water use efficiency and utilise different sources of water for agriculture. Between 1950 and 2006 agricultural water usage in Israel rose only fourfold, whereas agricultural output increased 21.2 times.¹⁴ Figure 1 below shows how agricultural water use in 2008 was the same as in 1986, despite the quantity of crop production increasing by 40 per cent.

Recycling wastewater is another unique example of Israel's innovative water management. Israel was the first country to make effluent recycling a central component of its water management strategy.¹⁵ As a result, Israel has seen a dramatic increase in the use of marginal water and purified wastewater for agriculture. Israel treats 93 per cent of its wastewater, such that 86 per cent of sewage water is reused for agriculture purposes as effluent water. This compares with just 34 per cent in Singapore, 18 per cent in Australia, and nine per cent in the United States.¹⁶

This efficiency allows 52 per cent of total water produced in Israel to be allocated to agriculture and 200,000 hectares of arable land to be irrigated. Approximately 55 per cent of the water used in Israeli agriculture is marginal water and 80 per cent of the orchards in the Negev desert in the south are irrigated using recycled water.¹⁷

⁵ www.trademap.org

⁶ *ibid.*

⁷ Interview with Volcani Research.

⁸ *Ibid.*

⁹ Interview with Head of Moshavim Movement.

¹⁰ Aquastat, FAO.

¹¹ *ibid.*

¹² *ibid.*

¹³ *ibid.*

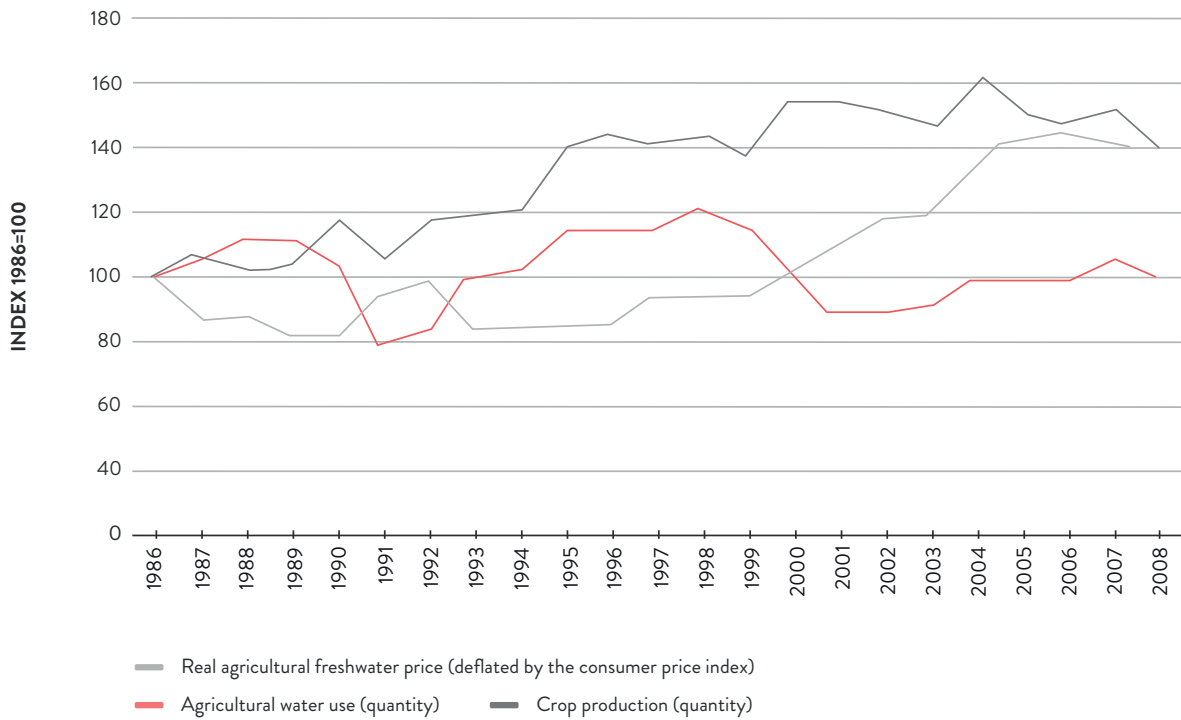
¹⁴ https://www.moag.gov.il/en/Subjects/Green_Agriculture/agricultural_water_use/Pages/default.aspx

¹⁵ Tal A., 'To a Make a Desert Bloom: The Israeli Agricultural Adventure and the Quest for Sustainability', 2007

¹⁶ Mekorot (Israeli Water Company).

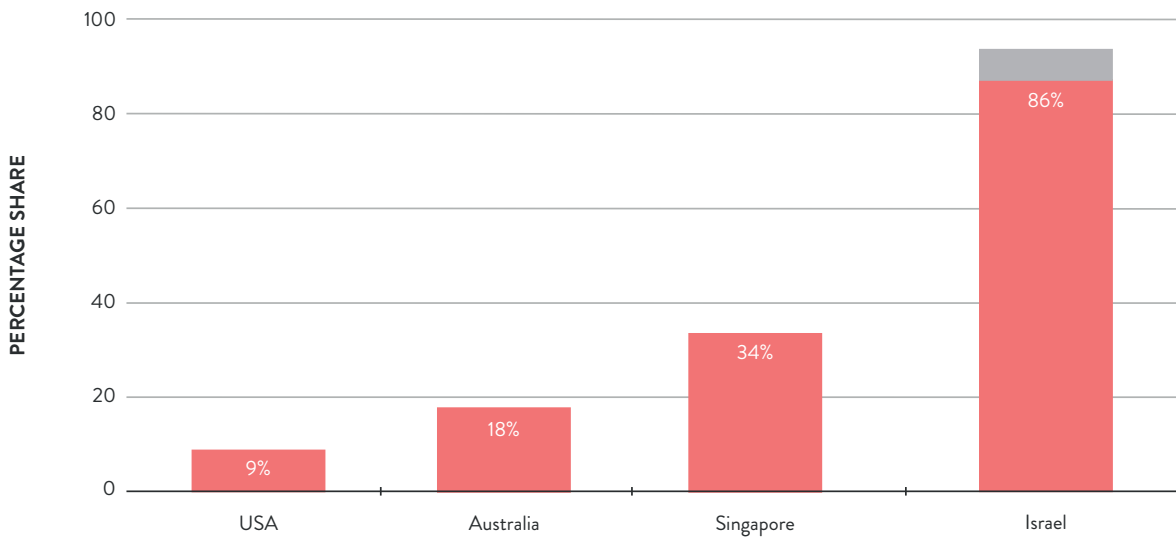
¹⁷ Interview with Mekorot.

FIGURE 1 Israel agriculture production, water usage and water price, 1986-2008



Source: Volcani Center

FIGURE 2 Share of effluent water reclaimed for agriculture and irrigation



Source: Mekorot via BlueTech Research, 2017

History and Context

Prior to delving into how Israel developed such successful agriculture and water sectors, it is essential to understand the unique heritage and historical context that shaped Israel's agricultural transformation. It was this context that provided the relentless drive of its agricultural pioneers, engendered the commitment of its political leaders and influenced the decisions that were taken.

Three underlying elements laid the foundations for Israel's agricultural transformation:

1. Ideology and Consequent Embrace of Agriculture as a National Mission
2. Israeli Pioneer Mindset
3. Historical Inheritance

IDEOLOGY AND THE EMBRACE OF AGRICULTURE AS AN IDEOLOGICAL MISSION

The Jewish people were originally farmers. The Bible and Jewish calendar reveal how Jewish theology is tied inextricably to agriculture and the land; from Biblical farmers Cain and Abel, to the Jewish holidays that celebrate the first fruits and agricultural harvests of each season. However, after centuries in the diaspora, working in a variety of professions unrelated to agriculture, both the world and Jewish community itself had long ceased to perceive Jews and farmers as synonymous.¹⁸

In the latter stages of the 19th century, the emergence of the modern Zionist movement in Central and Eastern Europe reignited the connection to the land and to agriculture. Inspired by strong socialist impulses from Russia, they sought to reestablish the Jewish nation in the Land of Israel and most importantly, to reclaim the status of the Jewish farmer by embracing agriculture as a national mission. So strong was this philosophy that it galvanised an intellectual cadre of young European immigrants with no prior farming experience to immigrate to the harshest of environments and develop the land. They believed there was no higher aspiration.

This goes a long way to explain the perseverance displayed by the early pioneers, the overwhelming commitment of Israel's political leaders to agricultural development and the socialist elements of Israel's nascent population. Specifically, it also explains two key aspects of Israeli agriculture: collective farms – the kibbutzim¹⁹ and the institutional effort to study agricultural development.

PIONEER MINDSET

As the pioneering immigrants arrived in Palestine they were met by harsh and unfamiliar conditions. Parts of Israel's coastal plain and the upper Jordan Valley were swampy, the Judaeen mountains were rocky and the south was arid at best, desert at

worst. Diseases like malaria, typhoid and cholera were rampant.

Establishing farms across the territory was a capital-intensive project requiring collective resources. In response and inspired by the socialist Zionist vision, Israel's pioneers established farming cooperatives – the kibbutzim.

The kibbutzim were based on egalitarian and communal principles, and the aspiration was to be self-sufficient. All revenue generated by kibbutz members went into a common pool to be managed by a central committee, and all members received an equal budget regardless of their job. Due to the socialist approach, as well as the scarce resources at the time, a forward planning system was established to overcome obstacles and to maximise resources. In agriculture, this led to a strong, centralised planning system where each farmer was instructed which crop to grow and in what quantity.

HISTORICAL INHERITANCE

It is important to also acknowledge the advantages that Israel enjoyed on becoming independent. The British left behind major infrastructural assets, such as a railway system and good roads across what is a small country. They also provided certain platforms which supported the development of Israeli agriculture. In 1925 the British established the Empire Marketing Board to promote the marketing of produce across the empire. These included India's potato board, Canada's wheat board, New Zealand's kiwi board, Ghana's cocoa board, Congo's palm oil board and importantly, Israel's citrus board, established in 1929 as the Jaffa Citrus Exchange. This board encouraged the expansion of citrus fruit agriculture through irrigated orchards and grower cooperatives who would sell to the board. In turn, the board would export to the UK and beyond, making the Jewish population in Palestine the fourth largest global exporter of citrus in the 1930s.

Another advantage was Israel's human capital. Whilst many of the immigrants had minimal agricultural experience, the population at large was highly educated. Life expectancy of Jews in Palestine in the 1920s and 1930s was 20 years more than that of

¹⁸ Tal A., 'To a Make a Desert Bloom: The Israeli Agricultural Adventure and the Quest for Sustainability', 2007

¹⁹ Kibbutz is singular, kibbutzim is plural.

THE BEGINNING OF ISRAELI AGRICULTURE AND KEY FOUNDATIONAL LEADERS

In 1908 the Jewish Agency was established under the original name, 'Palestine Office of the Zionist Organization'. This led to an institutional effort to promote Jewish immigration to modern day Israel and in recognition of the importance of developing the land, dedicated efforts to study the best agricultural development methods. Several figures and approaches emerged as pivotal.

In 1908 Yitzhak Elazar Vilkansky, an agronomist from Lithuania, immigrated to Palestine to assist with agricultural development. He worked to implement his vision, inspired by his time in the United States engaged in its land-grant university system. He believed that farmers must dedicate their time to cultivating crops, while scientists should provide solutions to the challenges they face. He set up the first agricultural research station and his legacy was the Volcani Center

– now Israel's national Agricultural Research Organisation - which was established in 1921, 27 years before the State of Israel was founded.

Akiva Ettinger, who became head of the Jewish Agency's Settlement Division in 1921, studied German and Russian strategies on how to develop settlements and agriculture in new areas. He believed that extension was critical to teach farmers how to farm properly. Going against the wishes of the head of the Jewish Agency, he secured a budget to support the kibbutzim and provided extension services.

Moshe Smilansky noted that individual farmers and the kibbutzim were not organised into a farmers' association. He highlighted the need to be coordinated in order to convey challenges and issues to the British Mandate, which was governing Israel at the time. He thus established the Farmer's Federation of Israel in 1920 and served as the representative of farmers until 1948.

Arabs, and by 1950 literacy among Jewish people in Israel was 100 per cent compared to just three per cent among Arab women.

Yet despite these colonial advantages, the huge investment and the dedication of Israel's early pioneers, Israel started from a difficult place. When Israel declared independence in 1948, it was still a poor country and became a recipient of aid. Its GDP per capita was \$1,000, similar to where many least developed countries are today, and it faced large waves of immigration and with it, concerns of food security, which led to rationing.

These underlying elements of Israeli agriculture set the foundations for the six key factors that enabled Israel to succeed:

1. Strong leadership and government commitment to agriculture
2. Effective government
3. Innovation: approach to problem solving
4. Farmer organisation
5. Market-led approach
6. Support from abroad

The remainder of this report focuses on each of these in turn.

Strong leadership and government commitment to agriculture

The first factor of Israel's success was the government's total commitment to agricultural development and strong leadership on the issue. Without it there would have been no agriculture in the Jordan Valley desert, where the only available water is one kilometre below the ground, or in the Negev desert. There would also have been little productive agriculture south of Tel Aviv.

The unwavering commitment of government to agriculture emerged due to the ideology driving the embrace of agriculture as a national mission and the composition of the government. In Israel's initial decades, around a third of its parliament members came from the kibbutzim and moshavim (a cooperative model that allows individual land ownership). Between 1948 and 1977, Israel was led by the Labour Party, the party of workers and farmers. Not only was it made up of the children of the first settlers and of the Kibbutz Movement, but most importantly, its leader and Israel's first prime minister, David Ben-Gurion was a farmer and so was half of his cabinet.

Such strong government leadership and commitment to agricultural development led to:

1. Strong leadership in owning the national mission and key decisions
2. Clear policies and programmes to support the farmer
3. Policy consistency and continuity
4. Effective prioritisation, planning and coordination

STRONG LEADERSHIP IN OWNING THE NATIONAL MISSION AND PUSHING THROUGH KEY DECISIONS

Zvi Alon, Chairman of the Israel Plants Production and Marketing Board says, *“Everything comes and goes with government, policies and people. The government was key to teach the people to understand the importance of rural development; and to ensure a strong rural economy. Governments need to start by setting rural development as a national mission; and they need to decide this in parallel to the people.”*

In the 1950s and 1960s the government spent approximately a third of the national budget on agriculture and water infrastructure, an additional 30 per cent was spent on education and another 30 per cent on security.²⁰ It was a political decision by Ben-Gurion and his cabinet to allocate the budget in this way, a clear hallmark of strong political leadership that helped Israel develop its agriculture sector.

One of the greatest products of such leadership and key decisions is Israel’s water system. Large parts of Israel were semi-arid or arid with scarce water sources. This impeded settlement growth in the south. In the early 1950s Ben-Gurion and his agriculture minister – a powerful senior cabinet role at the time – decided to build water pipes to transport water from the Sea of Galilee in the north to the Negev desert in the south, a distance of 250 kilometres. The engineers at the time told Ben-Gurion ‘it cannot be done’, yet in 1964 Israel’s National Water Carrier began operating.

The decision to build this water system was a major political decision at the time, requiring a disproportionately large investment. It was essential to Israel’s success and it only happened because of

Ben-Gurion’s political leadership and the political dominance of people with an agricultural background, such as Levi Eshkol and Yitzhak Rabin, Israel’s third and fifth prime ministers, respectively.

The political determination to create agriculture in Israel’s deserts, even at a time when no one would have said it was possible, led to additional key decisions. Israel’s government decided to invest a disproportionate amount of funds into the farms, agricultural research and extension system. It was this dedicated R&D and training that enabled the transformation of the desert into agricultural lands in the south of Israel. These areas were dry and arid with little agriculture. Today they look like a breadbasket.

Another outcome of Israel’s early political vision and leadership was the decision by Ben-Gurion to keep and institutionalise through law the citrus board that Britain had established. This was not an easy thing to do politically as it forced everyone in the industry to be licensed by the board and to sell its produce through the board. The law empowered the citrus board with its own police. However, it proved successful: citrus production rose from 18,000 hectares in 1948 to a peak of 1 million tonnes of export in 1967, covering 42,000 hectares. Citrus fruits rose to account for 95 per cent of Israel’s goods exports.

The importance of political leadership also manifested itself in more recent history. In the 1990s, when Shimon Peres was prime minister, the cabinet made him the main advocate for agriculture such that wherever he went in the world he bore the same message, promoting Israeli agriculture. Then in 2001 Israel faced years of drought and water shortages. Prime Minister Ariel Sharon, originally a farmer too, recognised the importance of increasing government resources allocated to the water sector. The minister of agriculture at the time said that while most ministers did not understand why such an investment was essential, the prime minister did. In April 2001 the government therefore decided to change its water strategy and committed to invest in water desalination plants, aquifers and recycling for water agriculture. Israel’s water sector today depends largely on these reforms.

²⁰ Interviews conducted for this case study.

FIGURE 3 Map of Israel's National Water Carrier built in the 1950s and early 1960s



All of these functions are the role of government. This is what helped Israel in the early stages. Farmers did not have to worry about who's going to buy their chickens. They could focus on growing them as best they can. The farmer was not responsible for the entire value chain."

Throughout the 1950s and 1960s the Ministry of Agriculture managed a program of grants for agriculture investments, such as farms, packing houses, greenhouses, land preparation and electricity. Up to 30 per cent of farmer investments were covered by these grants. Grants were also provided to farmers for operating farms and these grants were tied to certain crops and crop products, depending on the region.

POLICY CONSISTENCY AND CONTINUITY

The government's commitment to agriculture was strengthened through coherent policies. In the 1950s and 1960s the governing Labour Party ensured a consistent national mission: the government invested – in the same geographies and the same crops – in logistics, electricity, roads, water, agriculture financing and crop insurance, while ensuring that trade policy for those agricultural products was aligned. Israeli agriculture would not have been successful had the government not built reservoirs and roads connecting key farmers.

CLEAR POLICIES AND PROGRAMS TO SUPPORT FARMERS

The government took great responsibility to establish policies and programmes to ensure that farmers received all the support they needed to succeed. In the words of Shalom Simhon, a former minister of agriculture: *"Israel had three factors of success: farmers, endowments and the government. Agriculture is composed of water, soil, labour and money. The government has a key role to play. It needs to supply farmers with technology, infrastructure, advanced irrigation, fertilisers and training so that farmers can grow better crops. Regional centres for training, farmer extension, technology and infrastructure hubs are essential. The government is also important for ensuring aggregating, sorting and marketing and distribution, especially exports."*

PRIORITISATION, PLANNING AND COORDINATION

The government also played a critical role in prioritising the allocation of limited resources. For example, the government decided to invest a large part of the budget (up to 30 per cent) in water, infrastructure and agriculture and they prioritised in which crop products to invest. In the 1970s the government made the decision to assign a region of Israel to grow vegetables. The minister of trade and the minister of agriculture together convinced the minister of finance to invest in this crop family, based on a market assessment of vegetable export potential to Europe. This was a big boost to Israel's vegetable sector. Later, in the 1990s, when the local floriculture industry started to lose out to places like Kenya, where labour was cheaper, the government decided

to shift extension workers and researchers who were working on floriculture to work on vegetables and tree crops. Volcani stopped funding floriculture job positions. Likewise, when the price of melons declined, the government stopped funding melon investment in the Jordan Valley desert and shifted this money first to sweet peppers and then to dates.

We conclude this section with the words of Shalom Simhon: *“As minister of agriculture I learnt one rule: don’t play victim in Cabinet. If you act like a victim you will be treated like a victim. It is important to be strong and talk positively about agriculture. Villages are always poor around the world. But the Israeli model is different because our economic base is the village.”*

LEADERSHIP

“Historically, leading figures of the kibbutzim were very talented people who would normally have gone on to become famous or wealthy, but they were so ideologically driven that they found themselves on a farm”. Prof. Alon Tal, Tel Aviv University

Strong leadership stood at the heart of Israel’s agriculture and water success, and is a common factor that transcended all aspects of the Israeli system - from community management, to farming cooperatives, to private business and to government. Such leadership is supported by a long tradition of motivating storytelling and narratives. One example of a narrative that empowered leaders over the years is the story of David and Goliath and its message: although you may be small, you can still thrive and win by using your wits.

Yossi Vardi, one of Israel’s first high-tech entrepreneurs, says that the cultivation of leaders across society is essential: *“You need to find the rough diamonds – the most enthusiastic, passionate and charismatic people - and empower them to take over the challenge. We need to look for those that are deemed crazy, for they will eventually be the champions of change. Ambition, drive and commitment are the fuel that makes people do amazing things and inspire others. In the kibbutz, though everyone was equal, it was the young men and women with the exceptional merits that rose to leadership positions in their communities and later throughout the country. The early private firms and kibbutzim were effectively all terrific start-ups by young people in their teens and twenties. This entrepreneurship was embedded in the culture and what we see today is a continuation of this culture.”*

Effective Government

Beyond the importance of government leadership, the institutional set up was also key. This chapter explores the key structures of government and how they were empowered to advance Israel's agricultural and water development. The key government structures were:

- Crop Production and Marketing Boards
- Agriculture Trade Services in Ministry of Agriculture
- Agriculture Research, with Volcani at its core
- Chief Scientist of Agriculture
- Extension Services
- Water Authority and Water Management Company (Mekorot)
- Ministry of Economy and Innovation Authority
- Department of Planning, Economy and Strategy in Ministry of Agriculture

We present the role of each of these in turn.

CROP PRODUCTION AND MARKETING BOARDS

Although the agriculture sector follows a market-based approach, the government has always been the locus of coordination and joint public-private decision making. This mainly happens through the Crop Production and Marketing Boards. Israel inherited the Citrus Board from the British. Due to the proven efficacy of this approach and the rapid development of agriculture, throughout the 1950s the government decided to add other boards to support additional crop products.

These boards, which are crop specific, are deemed an essential part of the system with a mandate to safeguard the entire value chain. Crop chains like dates, citrus, dairy and beef, which have conglomerate firms operating in them, all have dedicated production and market boards. They are a parallel but complementary body to the Ministry of Agriculture, although they are chaired by the minister of agriculture. The boards serve two key functions. First, as an essential connector of farmers to markets, allowing the two-way flow on information on price, quantity and quality. Second, as a mechanism for identifying, defining and prioritising problems that need to be solved, so that a solution with suitable resourcing can then be designed and implemented. Every year they bring together their own staff, lead farmers, extension agents and researchers to run a budgeting exercise and set priorities, including priority crops. For example, off the back of such an exercise, the cotton board provided credit to farmers and supported kibbutzim to build ginning capacity, while providing the offtake to ensure ginned cotton was marketed and sold.

The boards collect a small proportion of levies from farmers and deals with the specific problems faced by that value chain. In this way farmers can focus on farming, while the board can focus on broad issues, from inputs and research through to extension and market access. The funds raised from farmers are important in order to give farmers a say - and a majority vote - and allow them to collaborate and brainstorm with research, extension workers and marketers. The government also provides the boards with financial support. For example, it funds pest control for the Citrus Board. Other revenue sources include royalties from brand licenses and sales commission.

The head of the Citrus Board said: *“If the board didn’t exist, citrus would have remained a small sector because the cost of production is high here. Israel has to compete with countries with a low cost of production. We probably would not have been able to export. The organisation of the sector and research into new varieties gave us the advantage we needed to compete in niche markets.”*

AGRICULTURE TRADE SERVICES

Unlike many developing countries, the Ministry of Agriculture has a unit dedicated to agriculture trade services that is well-resourced. This unit provides input on agriculture trade policy to the Ministry of Economy, to allow for a coordinated approach. It also lobbies on custom duties. But most importantly, it ensures farmers have quick access to the market. This is crucial in an industry with perishable products. The unit focuses on wholesale markets and since the 1950s has had the role of ensuring physical markets are suitable for exports. According to the Ministry of Agriculture, it has been essential to have had this function, as the Foreign Trade Administration at the Ministry of Economy is not specific to sectors and sub-sectors and has only been interested in generic trade rules.

AGRICULTURAL RESEARCH AND DEVELOPMENT (R&D)

One of the most important functions was agricultural R&D and this was led by the government’s Agricultural Research Organisation – the Volcani Center. Dedicated R&D is what enabled Israel to grow crops in the desert, to develop one in every two varieties of tomato in the world and one in every three varieties of watermelon. It enabled Israel to develop a comparative advantage and is now driving the emergence of Israel’s agri-tech sector. When Volcani was established it was fully funded by the government.²¹

The funding commitment also extended to salary levels. Researcher salaries have always been above average and this has helped Israel avoid issues of perverse incentives. This reflects the strong government commitment and great understanding

²¹ Today the government funds 60 per cent of its costs and it is required to raise 40 per cent of its funding from competitive grants and royalties.

of the role and importance of R&D. This funding situation contrasts with many developing countries in Africa where agriculture research funding is limited and often stagnant: in 2011, 19 of the 40 countries for which data were available spent less than \$10 million on agricultural R&D.²²

The Volcani Center's overriding mission has been to serve the needs of the Israeli farmer and Israeli agriculture. This is built into the promotion structure and Volcani's scientists are not only evaluated on the quality of their research but also how applicable their results are, and the extent to which they contribute to agriculture development. For example, researchers are measured based on variables such as how many varieties are given to farmers; how much they contribute to protect plants from diseases and gains from increased water efficiency. As a result, there is an overwhelming focus on applied research and scientists commonly respond to specific demands from farmers.

One example emerged out of Israel's annual conference for olive growers. At one such event recently, farmers presented a problem they faced with growing jojoba. Jojoba is a relatively new crop in Israel and the farmers explained how their crops faced certain diseases and they did not know the optimal protocols for pruning, fertilising and irrigating. Triggered by that event, Volcani formed a multidisciplinary consortium of ten researchers to study the crop. It presented a research proposal to the chief scientist, who funded a programme worth \$0.5 million for three years to develop a suitable growing protocol. This programme is now in its third year, and many of the experiments are taking place in the growers' fields, as is the norm in Israel.

Another example, which demonstrates how the applied research addresses market needs and ensures Israel's farmers can keep ahead of competitors can be seen in the date market. The head of the Beit Shean regional R&D station says that *'there are 12 different varieties of dates. Since Israel's goal is to maximise markets, and you don't argue with taste, you need to maximise the varieties*

you have to access more markets. Hence, we are currently researching a new variety of date with less sweetness as we recently received feedback that our Medjool date is too sweet.'

A critical element which enabled Volcani's success in pursuing applied agriculture is what Israelis commonly call the golden triangle – the system formed by the interaction of research, extension and farmers; many now in Israel also add a fourth, the private sector. One of the reasons this system works so well is because of Israel's flat hierarchy and educational level of the farmers.

Israel in general is marked by a flat hierarchy between citizens and this extends to the agricultural community too. There is little separation, even socially, between Volcani's top researchers and the farmers. To the extent that farmers in Israel feel free to discuss their problems directly with researchers by phoning, texting and sending in photos of their pests or problems. In most cases, farmers and researchers lived together in the kibbutz and served together in the army. It is not uncommon to find researchers out in the field with the farmers where they engage on an equal footing. There is no sense of inferiority among farmers. This can be attributed to the fact that very often the farmers and researchers studied together at university – but also to the idealisation of the farmer in Israel and the respect given to those working the land. This connection is also facilitated by the fact that the majority of farmers in Israel are well educated.

The Volcani Center comprises one main campus and two regional research centers – one in the north and one in the south. Today there are 200 scientists working in a system built around six research disciplines: plant sciences, soil and water, post-harvest, plant protection, animal sciences and agricultural engineering. This structure is important and enables Volcani to take a multidisciplinary approach to solve problems (more on this in the next chapter). This agricultural research system is also supported by eight local R&D centers whose role is to take the innovations from Volcani and adapt them for the local context. These local centers are run by the regional councils as part of the local authority, but Volcani appoints a lead scientist to oversee each center. Volcani also has a dedicated unit for royalties and technology transfer.

²² Gert-Jan Stads, 'Investment in agricultural research and development: an account of two-speed growth, underinvestment, and volatility', in Lynam J et al, 'Agricultural Research in Africa. Investing in Future Harvests'. 2016. IFPRI, Washington DC.

CHIEF SCIENTIST OF AGRICULTURE

The Chief Scientist Office - which is comprised of ten staff members and has a budget of \$37 million per year - plays a key role in the Israeli agriculture system. The Office was established in the 1950s and was run by the same person who headed Volcani. The role was split in the 1990s to elevate standards, although in the early stages of development it was essential to have these roles merged so that the research that was conducted was strongly anchored in the government's mission and strategy. Since the role was split, Volcani must compete on the calls for research proposals published by the Chief Scientist.

The concept behind the Chief Scientist's role is to serve as a security net for risk. As the Ministry of Agriculture rolls out its five-year plans, it often encounters bottlenecks in implementation. Some of these bottlenecks need scientific solutions. The Chief Scientist is a problem-solving tool for the Ministry. For example, if you want to ensure people can access tomatoes at reasonable prices, and you know that tomato harvest suffers when temperatures are too hot, you need to invest in greenhouses or else import more. What's the relative cost and could the cost effectiveness of greenhouse tomato production be improved and by how much? These are the types of problems the Chief Scientist takes on.

Many research projects funded by this Office need to be based on a partnership between academia and the private sector, and in one funding stream, firms need to invest at least 30 per cent of the cost of the project. The Chief Scientist only invests 50 per cent of the cost of the project. According to the Chief Scientist, pure academic research does not lead to implementation and the way to apply technological innovation is through business collaboration, not through researchers.

The Office also leads research planning. It runs a committee that includes extension, researchers and farmers. These set research priorities based on assessment of farm issues and whether they merit Ministry of Agriculture support. These are done in collaboration with local and regional councils, providing a feedback mechanism from farmers to the minister.

EXTENSION SERVICES

Recognition of the important role of extension services began before Israel's independence, when such services were provided by the Jewish Agency. Israel's extension service was officially established as a professional service in 1955. There was a clear understanding that to achieve Israel's mission things had to be done differently. The government knew that the pioneers needed training and support, otherwise they would likely leave the settlements due to the harsh conditions and the Israeli project would fail. So the best performing farmers were engaged as extension workers to teach others. Ben-Gurion encouraged the second generation of the pioneers of moshavim to become counselors to new communities.

The government made extension a priority and committed the funding. The deputy director of Israel's Extension Service explained why this is so important: *"extension has to be public, provided by the government. If it is private the advice won't be objective and impartial. In the private sector there is always a vested interest and farmers cannot survive by paying for extension services. It must be provided by government. Agriculture must be seen as a natural resource, and land is worth money."*

As a result of such strong government support, Israel has a relatively high number of extension workers. In the 1950s and 1960s Israel had one extension worker for every 50 to 80 farmers. Today, this ratio is lower: Israel's Extension Service is comprised of 136 people, with two to five consultant specialists per crop, serving approximately 15,000 farmers, a ratio of around one worker for every 110 farmers. By comparison, in many African countries this ratio stands at one per 3,000 farmers.²³

In Israel, central planning was a key feature of the Extension Service. Since the early days, extension workers operated under the Ministry of Agriculture's crop planning framework. The government was able to plan the number of extension workers around production needs.

²³ AGRA via 'The Smart Way to help African Farmers target Climate Change', 20 January 2017 <http://www.thenewhumanitarian.org/feature/2017/01/20/smart-way-help-african-farmers-tackle-climate-change>

For example, if there was a need to produce a certain quantity of eggs per year, they would calculate how many extension workers are needed. The service was so dependent on this plan that the deputy director of the Extension Service said that if they had not had a plan, they would not have had an extension service.

Israel's Extension Service had several other characteristics that fostered its success:

- **Specialisation** – the extension workers specialised in and were organised by crop or crop family. There was a clear understanding that farmers cannot be a master of all crops; one needs to specialise in a few crops.
- **Empowered Extension Workers** – extension workers were provided with the tools they needed to be out in the field with farmers, not sitting in their office.
- **Close Contact with Farmers** – an extension worker would meet each farmer every other day and the worker would closely inspect progress in the growth of the crops.
- **Collaboration and Messaging** – a common message of farmer collaboration was provided to farmers: they were told that they were not competing against their neighbours. Rather they were competing together with their neighbours against Spain and Turkey to access the market in France and so on. This promoted a sense of collaboration among farmers. Extension workers were also required to promote the social aspect of community living - it was not just about agriculture support.
- **Connection to Research** – extension services worked hand in hand with agricultural research from the outset. Today the headquarters of the extension service is adjacent to the headquarters of Volcani. Extension workers were also required to spend 30 per cent of their time on research, such that they spent a lot of time in research centres. They became closely affiliated with their local regional centres.

WATER MANAGEMENT

Another critical role the government plays is water management. While Ben-Gurion initiated major investment in the water sector in 1952, another major reform he introduced was the Water Law of 1959. This defined water resources - including drainage water - and made them public. It also created the role of Water Governor, which today is the Water Authority - a role and agency that were never politicised. This system centralised the management of the sector, such that the Water Authority could see the whole picture, including political considerations, and drive one holistic development plan for the sector. Another law that same decade introduced water meters to allow user charges. These reforms were crucial to allow Israel to develop one of the most advanced water management sectors in the world.

Beyond the National Water Carrier – and a related pipeline, called the Yarkon-Negev pipeline – investments in water infrastructure continued through Israel's history. In the 1970s the largest wastewater plant in the Middle East was opened and in 1989 a third pipeline to the Negev desert was opened. In 2005, driven by drought, Israel expanded its water system by introducing five desalination plants for seawater which today contribute 95 per cent of household and industry water needs. These are all privately run, with Mekorot - the national water company - responsible for water transmission.

Crucially, although Mekorot is a state-owned enterprise, it is well managed and is an AAA-rated company. It reports to the Water Authority; its CEO changes every two years and it is measured by financial results. Over the decades water has not been politicised, so it has a history of being run by management professionals. The government ensures it remains profitable, promotes water education and through the Water Authority - the regulator - sets the strategic direction and provides a road map for the sector. This has proved essential in distributing water resources efficiently across sectors.

This has been the key to success in Israel's water sector and allowed for long-term strategic decisions to be taken over the years. For example, farmers in the desert region had started to use saline water for their cotton and vegetables. They had no alternative. Therefore, the government took the decision to set up a special budget to research how crops could use effluent water. Today most of Israel's agriculture uses effluent water and Israel is a world leader in its use.

Avrum Ben Yosef, Vice President at Mekorot said: *"It is only the government that can drive such big picture thinking. And sometimes politicians have better decisions than professionals. Because their considerations are broader, beyond purely technical things like water costs."*

MINISTRY OF THE ECONOMY AND THE INNOVATION AUTHORITY

Another critical function played by the government and which underpins the agriculture sector is the investment in industry. The private sector is a key element of the success of Israel's agriculture sector. For example, many kibbutzim invested in the plastics and packaging industry in order to supply their packing houses. A suitable packaging industry was a crucial element in the success of Israel's agriculture sector because without it, it could not deliver its produce - whether fresh or not - in good quality to its targeted markets, both export and domestic. This is one of many examples that reflect the importance of the link between agriculture and industry in Israel.

The Ministry of Economy is key to ensuring a suitable enabling environment for agribusiness. One way it does this is through the Innovation Authority which runs some 30 programmes that channel R&D financing into different stages of micro, small and medium enterprises, including start-ups. A major element is focused on technology development, so that innovative technological solutions can be diffused through a viable business. It runs various incubators and accelerators, and the Authority is obliged by law to respond to proposals within 60 days. A sister office is the Chief Scientist for the Economy.

DEPARTMENT OF PLANNING, ECONOMY AND STRATEGY, MINISTRY OF AGRICULTURE

Although set up in 2012, it's worth flagging that the Ministry of Agriculture - like most other ministries - now includes a dedicated department for planning, economy and strategy. These departments are mandated to manage the government's strategy for each sector. It has three long-term targets for agriculture:

1. Keep fresh agricultural produce share in line with population growth
2. Maximise efficiency
3. Keep Israel as a lead agtech nation.

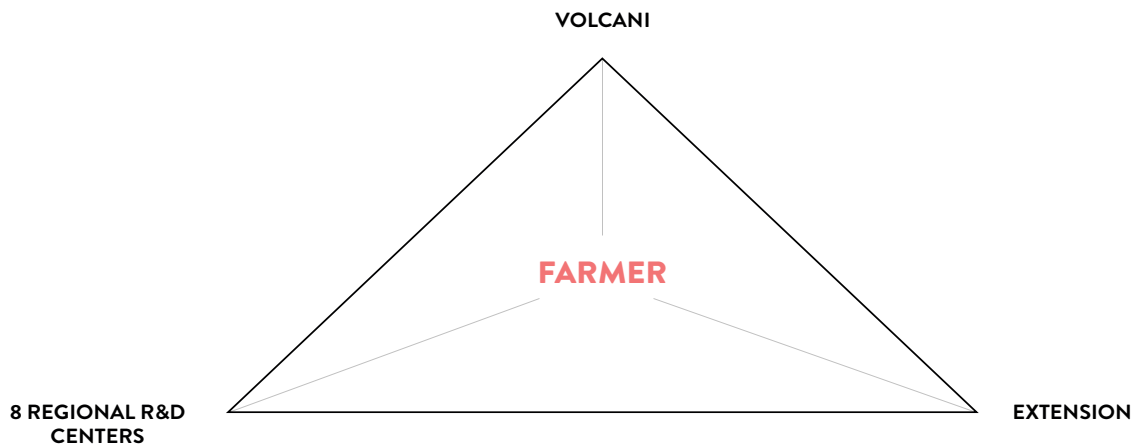
This department also provides oversight to state owned enterprises in the sector and to the production and marketing boards, while also running an information centre. Such departments from different ministries get together regularly in a forum to share ministry strategies, coordinate and share tips and insights.

Innovation: Approach to Problem Solving

Israel's innovation ecosystem was central to its success in agriculture and water management. It provides solutions to problems faced by farmers and private actors along the value chain and continually develops new opportunities for the sector.

The innovation approach is rooted in Israel's agricultural research and extension system, which is the focus of this chapter. The institutional set up of the government in this area – the golden triangle plus private industry – serves as heart of the Israeli agricultural innovation ecosystem. Figure 5 below presents the golden triangle.

FIGURE 4 Israeli agricultural innovation system



Source: Authors

This model illustrates how the needs of the farmer are the focus of all the players. It shows how challenges, ideas, knowledge and solutions are constantly communicated between all players.

Moreover, given Volcani's connection to the Ministry of Agriculture, it also shows how the farmer has direct access to the government. Volcani is a core government agency as an arm of the Ministry of Agriculture and Volcani's researchers lead the way working hand-in-hand with extension workers, farmers and the private sector.

This structure and interaction enable four key elements of the agricultural innovation system. First, it ensures that the innovation system works on the right problem. Farmers can communicate their problems directly to all parties. Second, it enables the development of an appropriate solution. Volcani researchers and regional R&D centers work together on the solution, hand in hand with extension workers and farmers. Third, the model contains a built-in adaptation function through the regional R&D centers. Spread across a small, but ecologically diverse country, the regional R&D centers adapt solutions to local conditions. Fourth, the structure and interaction lay the foundation for effective dissemination and high adoption of the new innovation. Many developing nations often ask, 'how do you convince the Israeli farmer to try a new innovation?' In Israel the researchers face the opposite dilemma and often feel that the farmers are too keen to adopt

a new solution even before the research trial has finished. This is because farmers trust the researchers and extension agents and view them as critical partners for their success. They follow the progress of the research from the beginning, they are keen for the field trials and experiments to take place, and as soon as they see results they are ready for them to be applied.

This allows the innovation system to undertake four essential tasks.

The first task is **effective problem solving**, ensured by the system's holistic and multidisciplinary value-chain approach. When facing an agricultural challenge, it is rare that the most effective solution can be devised by experts from one discipline alone, focusing on just one part of an agriculture sub-sector. Thus, when faced with a problem, Volcani convenes scientists from across its multidisciplinary structure to study the problem, brainstorm and work together - literally around the large conference table in the Volcani office - on creating the most effective solution for the target crop and its products.

For example, in the 2000s, the production of pomegranates in Israel was low and it lacked downstream products. In order to compete with imports, yields needed to rise by some ten per cent while the quality also needed to improve. Volcani studied the crop. Its agro-engineering

scientists developed a machine to automatically peel pomegranates. This made the entire value chain cost-effective and led to a surge in pomegranate tree planting, from 300 hectares to 2,000 hectares in Israel. This machine was patented and sold around the world. In California it led to a tripling of planted pomegranates. Then the plant-breeding scientists studied its breeding patterns to search for new varieties. A third group of scientists worked on fertilisation and irrigation, while another group worked on downstream products. This opened a new strand of the value chain: pomegranate juice. They also found that potential was high in antioxidants and could be used as cow feed. A fifth group of scientists studied pomegranate diseases. And a sixth studied post-harvest shipping to Europe. This group of researchers worked with export organisations who conducted market development. Their research helped to extend the shelf life through suitable cold storage for this fruit.

A similar approach was applied to other crops like avocado, tomato, pepper and mango in the 1970s. Among other things, this led to the development of a system to treat mangoes to extend their shelf-life by two weeks. This was critical for ship-based exports. Experimentation was carried out in a farmer's own packing house and the researcher also went to Europe to see what mangoes shipped from Israel looked like when they arrived. This shows that Israeli researchers follow the whole value chain.

The second task of the innovation system is to **lead out-of-the-box creative thinking**. In Israel this is done by bringing a range of players to the table, believing that 'nothing is impossible until we prove it is impossible',²⁴ and working from the basis that no idea is too ridiculous to try. The way Israel handled the red palm weevil - a tree-killing beetle - is exemplary of such problem-centered innovation that stands at the heart of Israeli agriculture success.

The red palm weevil, which can fly ten kilometres in a day, can infest palm trees and hollow them out from the inside, while leaving the tree looking healthy from the outside. It is thus almost impossible to detect infested trees until it is too late and the tree collapses. Some four years ago this was leading to the sudden

collapse of many palm trees across the country. Farmers went to the regional research station to ask for help. Together with Volcani, a multidisciplinary team was assembled to assess the problem. Three different innovative solutions were proposed.

One suggestion was to use a drone with a thermal imaging camera to assess the temperature of the tree. When trees are sick, their temperature rises like that of humans. Another researcher, inspired by the work of army dogs who sniff out explosives, suggested using dogs to sniff out weevil larvae. With help from the army dog unit, a research exercise was set up to train five dogs to detect the larvae. Finally, a third suggestion came from an army engineer who had been working on tunnel detection in southern Israel. He heard of the problem through a country-wide television campaign and approached the regional R&D center directly to suggest his idea. He asked for a room with some trees and weevils to try it out. He developed a sensor that was screwed on to the tree and connected to a phone. The sensor picks up if there is any movement in the tree and notifies researchers through a phone application. This idea has since evolved into a commercial start-up and is the most widely used method for detecting red palm weevil in Israel today.

Another challenge arose in basil. The market for basil is strong in winter, but low temperatures are problematic for the crop, causing lower yield and quality. One solution is to heat the growing environment, but this leads to high energy costs. Farmers went to the local research center and requested they provide a simple, cost-effective solution which would enable them to compete. Through numerous trials and adaptations over the course of four years, the research station developed an effective solution. It introduced vertical sleeves filled with water that ran parallel to the crop rows. The water heats during the day and cools during the night, serving as a regulator of the air temperature in the greenhouse. This allowed the temperature to increase by 20 degrees Celsius - enough for a cost-effective energy solution that allows Israel to produce basil in the winter and supply the lucrative winter market. When the idea for the solution was presented to growers they thought the research station was crazy, and it was not until they saw it for themselves with a thermal camera in the middle of the night that they were finally convinced.

²⁴ Quote from interview with – as per the words of Zion Deko Director of R&D at Eden Farm Agricultural Research Station.

The third task of the innovation ecosystem is to **introduce new opportunities to the sector**. The approach of government agriculture research is *“if you are growing tomatoes, let me help you expand the range of products possible with tomatoes”* says the director of one of Israel’s regional research stations. *“Maybe we can develop new varieties for cherry, plum, vine, mini and maxi tomatoes to help you expand your market. If you specialise in basil, you should have many varieties of basil: there are four or five types of basil. All the varieties are brought to the research centre and their ability to grow in the local conditions is assessed. If growers say a specific variety grown abroad is of interest, we will research it and aim to copy it to their fields. We then accompany these farmers for two years.”*

The government’s role is key for providing new business opportunities. Such a research-based approach contains inherent risk and this is where the government plays a critical role with funding and an attitude that embraces failures as an opportunity to learn. Israel’s institutions and its system learnt from numerous stories of failure, not just success. One such failure was biodiesel.

In 2005 the demand for alternative energy sources to oil was high. Volcani had never dealt with energy related crops before, but because of high market demand, Volcani’s directors decided to research plant crops for biodiesel. A multidisciplinary team was assembled comprised of breeders to develop improved varieties, fertilisation and irrigation experts, plant protection, post-harvest and agro-engineering

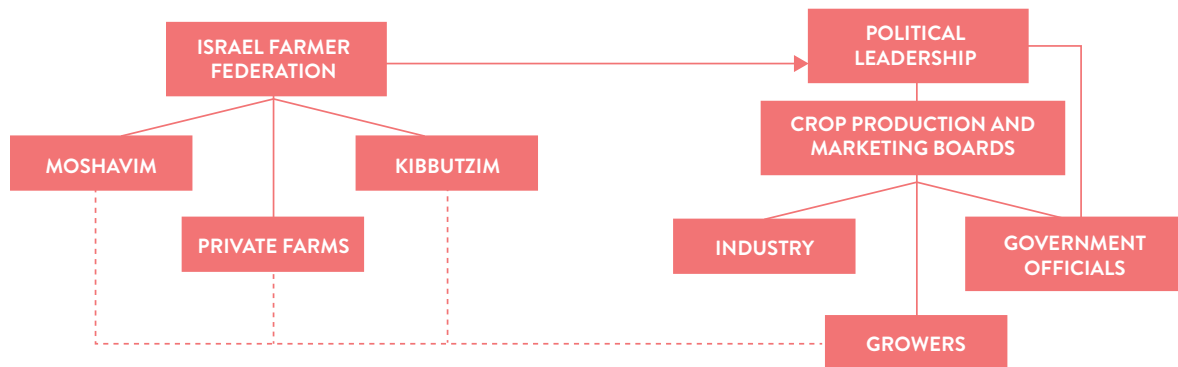
specialists. A coordination project was established and funding was secured from the government’s Innovation Authority and from private companies investing in crops like castor beans and jatropha. A connection was also set up with Brazilian research agencies for field trials in Bahia. This multidisciplinary research led to an increase in the yield of castor bean from two tonnes per hectare to 12 tonnes per hectare in five years. However, prices and demand subsequently fell and the project failed. This shows the importance of using public sector support to take calculated risks.

Finally, the fourth task of the innovation system is to **provide support for risk taking** and *ad hoc* funding to address emerging challenges. At one stage, a new bacteria started killing tomatoes in Israel’s greenhouses and the farmers and extension workers did not know what to do. Tomato is a major crop in Israel and it is important for the inflation index. If the supply of tomatoes declines, inflation will rise. A multidisciplinary team was assembled, and a four-year project was funded by the government to study the problem and provide a solution. After only a year and a half, the research team solved the problem and returned the rest of the money. The team tracked the behaviour of workers in the greenhouses and recognised that morning dew droplets were accumulating bacteria that were then being inadvertently distributed by workers on the morning shift. They suggested that workers start their shift later, once the dew had dried and this solved the problem. A protocol was then developed and the message was easily transmitted to the farmers who eagerly followed the progress of the research.

Farmer Organisation

A further factor of Israel's success is the organisation of farmers into larger units from the outset. Most Israeli agriculture was organised through farmer cooperatives - either via the kibbutzim, the moshavim or private farmers under the Farmer's Federation of Israel. In the 1940s and 1950s approximately 40 per cent of agriculture was through kibbutzim, 40 per cent through moshavim and 20 per cent through private agriculture. This is different in many developing countries, particularly in Africa, where few farmers are organised and even fewer in well-managed farmer organisations.

FIGURE 5 Israel's farmer system



Source: Israel Farmer Federation

Israeli economist Shaul Zaban explained why farmer cooperatives are important: *“If you have many small farms growing grains, they will be in poverty all their lives. Staple food must be grown in big farms. Small holders cannot survive, unless they are focused on income and are connected to big units of production. In addition, if farmers don’t control the value chain, they will miss out on technological improvements because the traders will push their price down as far as it can go. It is important to be able to move up in the value chain and for this, the bargaining power of farmers is essential. The question is then how do you increase farmer bargaining power: you need to be in a bigger unit of activity.”*

The kibbutz is the most extreme form of cooperative. There are 284 kibbutzim in Israel today. They were funded and supported by the government who provided land, water and basic infrastructure. An equal proportion of land plots of around 3 to 6 hectares were allocated to each family, and each kibbutz had around 150 families. The land was not owned by the families, but by the kibbutz. In the early stages, each family was told what to grow and in what quantity, and each family’s produce was aggregated for the kibbutz members to sell. The income belonged to the kibbutz, as did all the assets and possessions of the families living on the cooperative. In the early stages, it was an extreme social experiment. Today, families own their possessions, but the land remains communal.

Historically the kibbutzim were perceived to be larger and more productive than the moshavim because in the economically-difficult years there were always people available to work the land; in the moshavim

there were more freedoms and many of the children did not want to stay on the farm to work the land. The unit of production in the moshav is the family, not the cooperative as in the case of the kibbutz - and this often led to land sewn with the same crop being less congruous. So the kibbutzim benefited from larger-scale agriculture of the same crop. The kibbutzim also proved better at investing in alternate sources of revenue beyond agriculture, such as fuel trading, manufacturing, mining, hotels and car leasing - allowing a diversified source of revenue during a tough period. The moshavim tend to be focused solely on agriculture. During the 1970s and 1980s the Kibbutz Movement struggled with debt because there was a policy whereby if one kibbutz was struggling financially, another kibbutz would guarantee it. This worked well for banks who promoted and encouraged debt.

On the plus side, this led to a big investment in factories in the 1960s – and successful companies like Netafim - a world leader in drip irrigation equipment - emerged out of this era. Indeed, Israel used to have 15 vegetable processing factories, which is a lot for a small country, and these were owned and supplied by the kibbutzim.

The moshavim differ from kibbutzim in that the plots of land in it are privately owned by each family and each family can decide what to grow and how much. Land plots are equal, and aggregation, processing, packaging, marketing and distribution is centralised, although not all moshavim have shared marketing and distribution. So the farming is independent but the post-harvest is collective. Farming equipment is

owned by the cooperative and members can lease it. The land can only be sold to other farmers who are members of the moshav. Each moshav has a board, a general assembly and a chief executive officer, who is elected. This is the only paid position on the board. The moshav then hires staff such as an accountant, a water manager, a packing house manager, a teacher, a landscaper and so on. The marketing and distribution are done by a separate not-for-profit entity with its own staff, that is owned by the moshav. It operates as a commercial entity with its own chief executive, chief finance officer and so on.

There are 440 moshavim in Israel today, and the proportion of non-cooperative farmers is small because many non-cooperative farms have been sold for real estate. Israel is a densely populated country and real estate prices are high. Over the years there has been a lot of land consolidation through a mix of the land market and policy incentives. The average farm size is now 16 hectares.

In the 1970s planning quotas ended and the kibbutz movement set up eight regional cooperative bodies. These are supported by joint assets such as regional packing houses, marketers and distributors. These regional bodies also provided financing. They fed into a national representative kibbutz entity that carried out

functions such as purchasing fuel and car leasing for all the kibbutzim. This was essential to step up exports.

There are two nationwide farmer associations in Israel. The Israel Farmers Federation Association is the umbrella organisation primarily for farmers that includes kibbutzim and moshavim; while the Farmer's Federation of Israel represents non-cooperative private farmers. The cooperatives are also part of farmer associations for key crops, such as dairy, dates and apples - and these report to the umbrella organisation (FFI).

To some extent the cooperatives suffered from issues of trust, and wherever issues arose, it was success through profit and money - and the link to markets - that united members of the cooperative. But trust and corruption issues were typically limited because of the inherent transparency of kibbutzim. Farmers were also educated, talented and driven. The general mindset was one of cooperation and learning. Many children who grew up in the cooperatives were in youth movements that focused on problem solving, collaboration and developing an ideological mindset: a mindset derived from the principles of the settlers, among them a focus on entrepreneurship and learning-by-doing, as many of the farmers did not have a tradition of farming, and were essentially learning an entirely new profession.

Market-Led Approach

A market-oriented approach was critical to Israel's agriculture sector from the beginning. The market served as the northern star for Israel's farmers and government. Targeted markets were not only the local market for food self-sufficiency; it was also the international market for economic growth. The parallel development of domestic and export markets was essential. The domestic focus worked because Israel's population was growing rapidly - it ballooned from 600,000 people to 3 million in just 20 years. This allowed the rapid expansion of agriculture. At the same time the government recognised it needed to create jobs and generate more income. Exports, mostly to Europe were essential for this because the local market was a small one, despite rapid population growth. Zvi Alon, head of the Crop Production and Marketing boards said, *"it is essential to focus on where you have a market and where you can make money; if you don't have money you (can't) do (anything)."*

The market hence served as the guiding star for government policy prioritisation and coordination. For example, at one stage Israeli peppers were rejected by the European Union because of high residues. This forced the Israeli government, exporters and farmers to rethink and up their game. The export orientation was also important to allow the flexibility of the Israeli system as it developed, as well as for research and innovation and for institutional development.

Israel's market-led approach started with citrus, a fruit group that was introduced in the 1850s when the first citrus grove was planted in Jaffa. The fruit proved so productive and lucrative that the British Mandate established the Jaffa Citrus Exchange in 1929 to validate quality for export. The Citrus Board was a key source of market-orientation for Israel. It developed the capacity to conduct numerous essential functions such as plant protection, licensing, exporter coordination, sales, managing Israel's Jaffa Orange trademark, competition management, research and development, crop insurance for the industry and international liaison with other producers. Israel believed that farmers could not and should not conduct these functions, and hence a centralised institution was needed to undertake them - institutions that could not have developed without the market-led approach.

"Smallholder farmers cannot go to Covent Garden to sell their produce. They need an organisation on top of them," says the head of Israel's Citrus Board. And each value chain has its own demand, requirements and standards - which are dictated by the market. Smallholder farmers do not have such information and an individual smallholder farmer has no mechanism to enter global value chains. It is only the traders that have full view of the value chain, not farmers. Israel could not have transformed its agriculture without a fit-for-purpose organisation on top of farmers to serve as a mechanism for them to be constantly informed about market requirements.

On the back of this mentality, in 1956 the government and farmers recognised they needed to set up an export entity, and so Agrexco was established, initially as a state-owned enterprise. Agrexco developed the branding of Israel's produce under the Carmel brand. This expanded Israel's export potential to include crops - particularly fruit and vegetables.

"Agrexco helped a lot. Since it focused on exports, every farmer wanted to help his neighbour to compete in the global market rather than with each other. Agrexco had bargaining power as it could aggregate different crops together in their marketing. In niche agriculture such bargaining power is lost. Agrexco also used to protect farmers from the challenging market. For example, smallholder farmers cannot bargain with Tesco on whether a box of strawberries should have five or six strawberries in it. Agrexco could," said Prof. Yoram Kapulnik, former Director of Volcani.

The market-led approach was also key for government policy learning. In the 1970s citrus came to be seen as consuming too much water and labour. An American investor convinced the Ministry of Agriculture to increase investment in cotton due to market potential, and so it did. However, the climate proved unsuitable for good quality and this was reflected in poor prices. The government realised it needed to veer away from cotton. It turned to cut flowers - and, like with cotton, government resources were invested to develop the crop and its products and enable farmers and processors to produce and access markets. Israel exported flowers to the Netherlands for a number of years, although in the end it could not compete with other producers due to its high cost of labour. But Israel let the market lead and accordingly shifted to pomegranates, mangoes, avocados, almonds and peppers in the 1990s - and more recently to dates. Each of these phases of crop switching and expansion had a big government investment and a lot of public research and development focused on improving varieties to better compete in target markets. This market-led, government steered approach also helped Israel to drive innovation, for example by finding a commercial opportunity for every part of a crop or animal.

The Ministry of Agriculture was key in this process. Historically, it has been export-oriented, and in the 1980s it established a market research and information centre to conduct market analysis on key value chains. This was used for sector planning and as an information service to farmers. The market research department would also work with the Ministry's Chief Scientist to assess markets for new varieties. It was essential to conduct such market research and it proved indispensable for citrus and fruits and later for other crops. The long-standing relations with farmers made these market reports *"much better than what consultants produce - much more focused and practical"*, said an official at the Ministry of Agriculture. A good example was when Israel began exporting pomegranates in 2008: the Ministry conducted desk research on the crop and sent researchers to Europe with the exporters. They took samples of the new varieties to importers. The Ministry asked those importers to try the varieties and provide feedback. *"This feedback was invaluable"*, says the same official at the Ministry of Agriculture.

Another major advantage of Israel’s early stage market-led approach was the role of industry. *“Industry takes knowledge and commercialises it. When you discover new varieties and technologies, you must collaborate with industry. For example, when Volcani developed a prototype machine to peel pomegranates, it was industry that scaled it up to sell it and market it. This is essential irrespective of the size of the innovation,”* said Zvi Alon at the Ministry of Agriculture.

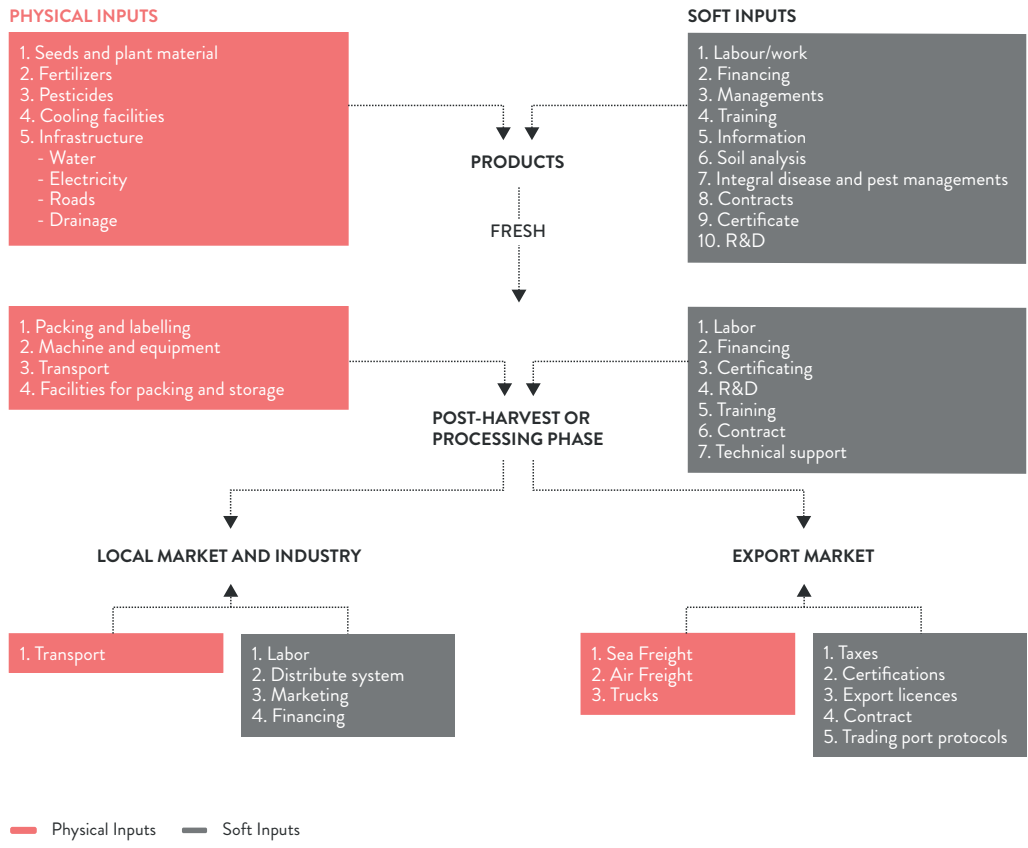
Strong ties between market needs and research are another advantage, that in Israel’s case, led it to become a leading player in the global agritech sector today. Research and development were critical to extend the shelf life of crops that needed to be exported. It was essential to improve packing houses and cold storage, and in general it was central for improving the entire value chain; from inputs and farmers through to the market.

Volcani’s research also led to the establishment of commercial companies that today sell advanced greenhouses, seeds, irrigation systems and agriculture

equipment globally. Moreover, 85 per cent of the patents held by Volcani are currently commercialised or in the process of commercialising. This shows the extent to which Israeli scientists are connected to the market through research on the one hand, and by the commercialisation of their innovations on the other.

Today Israel still uses the market-led approach. Its government and the agriculture sector at large is planning ahead based on market potential. It currently sees two big areas of potential; aquaculture because land sources of protein are disappearing globally, and medical cannabis. Five years’ ago, the government identified medical cannabis as a priority for Israel and it is now working with farmers to research and grow it. Although the pharmaceutical industry is sceptical, Israel believes that through its research it can commercialise it. Israel already has 300 growers of medical cannabis as a result of allowing research and development to start five years ago, before any regulation was ready. The market-led, government-driven approach – which is built around marketable products, as per Figure 7 – is key for this.

FIGURE 6 Israel’s market-led agriculture system, with marketable products as the core



Source: Shaul Zaban

Support from Abroad

The final driver behind Israeli success was its external support. The Jewish National Fund (JNF) was key to Israel's success. It raised funds from Jewish families all over the world. It was established in 1901 to buy and develop land in Ottoman-ruled Palestine. The JNF is a not-for-profit organisation and quasi-governmental agency and in 2007 owned 13 per cent of Israeli land. It has planted over 240 million trees (the majority of trees in Israel) and has built some 180 dams and reservoirs, developed 250,000 acres of land and established over 1,000 parks. It invested in roads, greenhouses and land preparation. It also provided new settlements with tractors, cows, piping and chickens to get them going. It was a major funder of early Israeli agriculture, as were Baron Maurice de Hirsch and Baron Edmond de Rothschild - who tried to reproduce what they saw in Europe.

Together these reflect the key role the Jewish diaspora played in Israel's agriculture and water success story. Another example came about more recently. In 1970 the United States and Israel set up a joint agriculture research programme with an endowment of \$110 million (in 1970 prices). This is called the US-Israel Binational Agriculture Research and Development Fund (BARD). It earns seven 7 per cent per year and has invested some \$300 million into Israeli agriculture research, with estimated returns in the region of \$2.6 billion.²⁵

²⁵ Interviews with BARD and Shaul Zaban.

Conclusion: Lessons for Developing Countries

The key elements of Israel's success in becoming a global leader in agriculture and water management were the mindset of farmers, its nation-building approach, the vision of its leaders and the combined role of government, market-orientation and a focus on problem-solving. Its success was the result of necessity, survival and vision. While Israel's context is unique and its approach is not replicable, it nonetheless holds a treasure trove of lessons and insights for today's developing countries that are looking to it, in part as a role model. In this final chapter we summarise these, while recognising that if and how these can be applied varies by country.

The importance of establishing an innovation system focused on problem solving

- **Structure of the innovation system:** The Golden Triangle – the close relationship and mutual accessibility between researchers, extension agents and farmers – has been key in Israel. Other elements are the multi-disciplinary approach to solving agricultural challenges; the local research stations that serve the needs of the farmers in their region and adapt innovations from the central research facility to local conditions; and the involvement of the private sector – particularly in problem definition and in the commercialisation of solutions. The private sector anchoring has also been explicitly encouraged by the Chief Scientist Office in the Ministry of Agriculture, in order to ensure the applicability of the research. Israel had a strong reliance on markets and industry also to diffuse technological gains.
- **Focus of the system:** The Israeli innovation system focused on local problem solving and on providing new opportunities to farmers and value chain actors through a strong market orientation.
- **Support to the system:** In Israel there has always been high government investment in agricultural research, backed by international partners and diaspora.

The importance of a market-led and value-chain development approach, from the outset

- **Market structuring:** Israel's experience shows the importance of organising the value-chain, for example through well-run, dedicated marketing boards for each crop and its downstream products. These have proved critical to ensure farmers could focus on farming and not need to go to 'Covent Garden' to sell their produce. The Ministry of Agriculture has served as another key element of Israel's market-oriented strategy. Its internal trade department has proved particularly essential to ensure a strong trade link with the Ministry of Economy.

- **Targeting food security and exports simultaneously:** From the beginning, Israel balanced domestic food and export market targeting, and had a deliberate focus on value addition. Furthermore, because of its small size – and relatively smaller farms – Israel did not target cereals as much as it did other crop groups such as horticulture. It recognized that the economics of cereal markets meant they're best suited for large farms.
- **Reliance of markets on government:** Israel's private industry and farmers had a strong reliance on the government to unlock profit-making opportunities in target markets.

The importance of organised farming

- **Farmer cooperatives:** Such bodies – with good management – have proved essential to empower farmers through economies of scale, a strong link to the market and strong bargaining power in both farm input and produce markets.
- **Different models:** From the outset, Israel's agriculture system allowed for three main models of farmer organisation: the kibbutz socialist cooperative, the moshav cooperative, which allowed private land ownership, and private farms that were jointly represented through a strong farmer association.

The crucial role of government and leadership

- **Owning national vision:** Israeli political leadership – at the highest levels of government – owned the vision from the outset and the agriculture focus of this vision survived various prime ministers, particularly in Israel's first 30 years of independence. Israel's story also shows the dependence of the agriculture sector on the nature of local politics and the benefit of not politicising strategic sectors, such as water management – a result of the strong national vision.

- **Clear policies and programs to support the farmer:** The government took key strategic decisions – particularly on the enabling infrastructure for farmers – with a long-term view and clear economic plan in mind. Israel's story also shows that sometimes political leaders take better decisions than technicians, because they have a fuller picture and perspective. It also shows the importance of the government having the policy space to take the lead and chart its own course, while going through a process of institutional mistakes, learning, adjusting and retrying.
- **Policy consistency and continuity:** The strong vision owned by the centre of government served as the anchor for both policy consistency across Ministries – such as seen in the coordination between ministries of agriculture, trade, finance and the prime minister's office – and policy continuity over time. The agricultural vision – embedded in the core national development vision – served as the northern star, allowing policy to transverse political transitions.
- **Effective prioritisation, planning and coordination:** Israel achieved a mechanism of ministerial coordination and joint prioritisation through an anchoring of the planning process in the centre of government. Israel's story also shows that policymaking and implementation need to evolve in parallel and constantly inform each other.
- **Value of the diaspora:** Israel's success in agriculture and water management also shows the potential contribution international diaspora can play if they have a mechanism for channeling capital and resource to the national vision.
- **Treating local leaders with agency:** Finally, Israel also shows the importance of external players treating local leaders across government, private sector and farmers with agency – including freedom by the government to direct how international support is prioritised and spent.

Israel's story provides useful insights and pointers for agriculture and water management in developing countries. Although it is essential to account for contextual differences, it is nonetheless important for these lessons to be applied. This report calls for action by three stakeholder groups.

First it calls on policymakers in developing countries to apply these lessons to their context. Such policymakers – together with local research organisations and private sector – know their country context best and are best positioned to decipher which lessons can be feasibly applied and how. Yet a number of the underlying principles – such as setting up an innovation system and pursuing a market-oriented approach – are universal principles that apply in all contexts. In addition, Israel provides useful specific insights, such as the value of investing in strong management of boards for priority crops and their downstream products, and considering a dedicated trade unit within the Ministry of Agriculture.

Second it calls on the agriculture development community to consider how insight from Israel's story can strengthen their approach to supporting developing countries, such that it may better account for likely factors of success, it may treat local leaders with agency and it may suitably invest in the capacity of all local players – from government, to industry, to farmer organisations, to extension and to research. It may also consider it might better follow the government's lead, recognising that it is the government and local politicians who ultimately own the local vision and nation-building mission and who can see the full picture and spectrum of constraints - from political, institutional, scientific or economic.

The importance of an international community that backs the local vision and development agenda

- **Long-term flexible external support:** Israel's story shows the importance of long-term development partners who stay the course – over decades, as the United States and others did – bringing in capital, expertise and markets where local actors run short, particularly in helping to shape the vision and translate it into reality.

Finally this report should help Israel itself to not only articulate the lessons it has to offer, but to find more practical, structured and long-term ways to contribute to African agricultural development.

In particular Israel should consider how its innovation ecosystem, agricultural experts and private sector can better support and invest in Africa's agricultural transformation and we conclude by presenting a few concrete ideas on this:

- Establishing a partnership hub which will act as a coordinating support facility that can match requests for support with Israeli expertise.
- Utilising Israel's agricultural innovation ecosystem to provide new opportunities to African agriculture and support locally-led problem solving.
- Establishing an agricultural leadership academy for African agricultural political leaders.

Annex – List of Interviewees

This case study is based on interviews with 25 experts all held in Israel between 3 and 6 June 2019. The experts interviewed are:

1. Yitzhak Abt, Former Director of CINADCO
2. Zvi Alon, Chairman of The Plants Production and Marketing Board
3. Tal Amit, Director of Citrus Production and Marketing Board
4. Dubi Amitai, President of Farmers' Federation of Israel
5. Menachem (Mena) Davidson, Former Director of Citrus Production and Marketing Board
6. Dr. Arnon Dag, Volcani Researcher and Former Extension Agent
7. Zion Deko, Director of R&D at Eden Farm Agricultural Research Station
8. Prof. Eli Feinerman, Director General of Volcani Center
9. Prof. Itamar Glazer, Head of Research and Development, Volcani Center
10. Dr. Shmuel Gross, Deputy Director of Israeli Agriculture Extension Services
11. Haim Hevlin, Chairman of the Kibbutzim Movement
12. Dr. Yael Kahal, Manager of Research, Economy and Strategy, Minister of Agriculture of Israel
13. Prof. Yoram Kapulnik, Head of United States-Israel Binational Agriculture Research Fund
14. Prof. Uri Mingelgrin, Chairman of the Board, Volcani International Partnerships
15. Prof. Avi Perl, Chief Scientist, Ministry of Agriculture of Israel
16. Galit Sasson, Senior Water Treatment Engineer, Mekorot
17. Shirley Shahar, Former Head of Marketing, Agrexco and Advisor to Meir Tzur
18. Dr. Orit Shmueli, Office of the Chief Scientist, Ministry of Agriculture of Israel
19. Shalom Simhon, Former Minister of Agriculture
20. Prof. Alon Tal, Professor at Tel Aviv University and Environmental Activist
21. Dr. Shaul Zaban, Managing Director and Partner at Zenovar and Economist
22. Meir Tzur, Head of the Moshavim Movement
23. Dr. Yossi Vardi, Israeli Hi-tech Entrepreneur and Investor
24. Dr. Uri Yermiyahu, Head of Gilat, Volcani's Southern Research Station
25. Avrum Ben Yosef, Vice President of System Integration Engineering, Mekorot

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