# *Barriers Preventing Food Security in Israel, 2050*

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The article highlights the benefits of adopting the practice of long-term planning with the aim of helping decision makers and politicians to include scenario thinking in the process of determining food security in Israel, 2050. This study addresses the question of food security, a step that is in contrast with agricultural planning considerations of the past that have mainly focused on maximizing profits or relied on a closed mathematical model. Two teams of experts identified production limitations affecting long-term planning and the ability to ensure food security under these conditions. It was found that there are five key factors important for the decision process: population, land, water, technology and international trade. The data show that today Israel imports a very large scale of virtual land and virtual water in terms of agricultural products. This means that the attention of the decision makers must be diverted from considerations of short-term profit to long-term food security.

*Key Words:* long-term planning; agriculture policy; food security
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## Introduction

The article deals with the attempt to understand the implications of future calorie supply subject to the terms of the restrictions on the factors of production in agriculture. The largely prevailing view among policy makers in various countries was that lack of food could be supplemented with imports. However, in fact in many countries today it is expected that the issue of food security may be a global problem and imports should not be taken for granted. Agriculture in Israel is expected to face heavy pressure from increasingly restricted water (Hadas and Gal 2014) and land resources (Gal and Hadas 2013) and from a considerable increase in the population (Central Bureau of Statistics 2012). As a result, the Israeli economy is expected to face food supply difficulties in the long run.

Because the State of Israel is a sort of 'Island,' it allows us to examine the question of lack of resources, population growth and the need to understand the importance of long-term planning in some degree of laboratory conditions. The article examines the question of food security and the issue is being discussed as a framework for policy planning in agriculture.

## THE FUTURE IS NOT GOING TO BE WHAT IT USED TO BE

The first decade of the 21st century has seen several indications of a troubled future for global food security. The food price spike of 2008, with its consequent food riots and resulting political changes in several countries, the excessive heat and drought in Russia that led to the 2010 wildfires and grain export embargo, as well as the unprecedented floods in Pakistan, signal more trouble ahead. The warning signs could already be seen in the 1990s, as the long-term decline in the number of the world's poor and hungry stalled, and those numbers began to rise. Population numbers continue their march towards a likely 9 billion by 2050, while higher incomes in until now poor countries will lead to increased demand, which in turn puts additional pressures on sustainable food production. To those already daunting challenges, farmers everywhere will need to adapt to climate change. The agricultural system as a whole will have difficulty supplying adequate quantities of food to maintain constant real prices. The challenges extend further: to national governments, to provide the supporting policy and infrastructure environment and to the global trading regime to balance world supply and demand (Nelson et al. 2010).

Evans (2009) argues that the following trends represent a major challenge for global food security: climate change, energy security, water scarcity, competition for land and demand for food. In another study, Sage (2012) suggests that the global food system will be dominated by: (a) rising energy costs given the anticipated decline in conventional oil supplies which will affect land-use and food security, (b) climate change scenarios that anticipate rates of warming and drying in large areas of the tropics that will also have huge implications for food security in those areas, and (c) a global food system that delivers poor quality nutrition with significant dietary health consequences.

Indeed, there are varying degrees of recognition of the challenges that intersect with food production such as freshwater depletion, biodiversity losses, etc., let alone matters of livelihood security and improved access to food. For most, the central solution is to develop and apply new agricultural technologies in order to increase food production. Only one recent report of international significance comes to a different conclusion (International Assessment of Agricultural Knowledge, Science and Technology for Development 2009), and was clear in its advocacy for a new direction in public policy for food and livelihood security under increasingly constrained environmental conditions. As this report states: 'the current agricultural knowledge, science and technology model requires revision. Business as usual is no longer an option.'

The twentieth century has witnessed extraordinary population growth and the world's population had increased to over 7 billion by 2012. Overall, food production per capita has remained stable during the twentieth century, largely due to technological advances. As the dominant source of human food supply, the per capita availability of world cropland decreased during the twentieth century and will continue to decrease in the foreseeable future. Moreover, the productive capacity of cropland is currently being degraded at an unprecedented rate. Worldwide, nearly one-third of cropland has been lost due to erosion during the past 40 years, it continues to be lost at a rate of more than 10 million hectares per annum and the impact of soil degradation on productivity is indisputable. On the other hand, the demand for cereals will probably continue to grow over the next 20 years, and even larger harvests will be needed if more grain is diverted to produce bio fuels. A higher rate of food production will have to be achieved through agricultural intensification in order to feed additional billions people over the next 50 years (Ye and Van-Ranst 2009).

Historically, Israel's agriculture management policies did not give sufficient consideration for the rapidly growing urban population with its growing demands for the urban, commercial, tourist and industrial sectors (Gal, Gal, and Hadas 2010). Similarly, the planners were overly optimistic concerning the rapidly approaching total exploitation of Israel's limited natural resources. Part of this optimistic point of view stems from the fact that over the last 50 years, even though the role of agriculture in the Israeli economy has been declining, agricultural production grew continuously without additional allocations of water and/or land (Gal and Hadas 2013; Ministry of Agriculture and Rural Development of Israel 2008; 2007; Boroshak 2008; Bank of Israel 2008; Kislev 2002). Even though the importance of agriculture has decreased and an economic cost/benefit analysis might ignore the holistic importance of the sector, there are externalities that decision makers should add to the overall long-term considerations.

Despite its declining importance, the effects of agriculture on the environment are significant and complex. Closer examination of the dynamics underlying the global food system reveals a range of possible factors. Even though declining population in some major countries with high consumption per capita levels may contribute to slowdown the growth of aggregate demand, total consumption of agricultural goods will depend, however on the extent to which non-food uses, such as bio fuels, take up the slack (Alexandratos and Bruinsma 2012).

During this period, Israel's rural areas are expected to witness massive and rapid changes in land use due to changes in demography, trade, technology and urban development. Changes in demand for agricultural products and agrarian production structure are likely to have a large impact on landscape quality and the value of natural areas. Key factors that have driven this change include: structural shifts in the economy between manufacturing and services, rising demand for rural leisure and an increasing preference for rural living. The extent of these changes and their likely impact on environment, landscapes and rural livelihoods are largely unknown. Therefore, policy makers need to act in an anticipative or proactive manner, they need to be informed in a timely way what will or could happen and what can be done to lessen risks and stimulate promising developments. With the structural changes of the agricultural sector and the increase in the importance of the domestic-urban sector because of population growth, how will Israel be able to manage to provide food for its population? The notion that Israel's food supply in the long run depends on local agriculture is a mistaken one (Gal and Hadas 2013; Hadas and Gal 2014). For many years now, the vast majority of the caloric value of Israel's food supply has been based on imports, and almost all of the products are imported calories not grown by Israeli agriculture. Since Israel's food security can be based on local agriculture to only a very limited extent, plans must be developed to improve long-term food storage technology and facilities for imported food staples.

## Combined Use of Professional Expert Knowledge and Public Participation

Scenarios of future thinking contain stories, from the expected to the wildcard, in forms that are analytically coherent. Within the framework of this article, scenario is concerned with creating actual story about the future. In fact, very little is said about the actual creation of stories in most methods. More attention is paid to generating the scenario essence or logic, which can be done by any number of methods (Bishop, Hines and

Collins 2007). Above all, the Long-Term Planner's goal is to map uncertainty. Saffo (2007) suggested that for effective future thinking the planner should define a cone of uncertainty that delineates the possibilities that extend out from a particular moment or event. The most important factor in mapping a cone is defining its breadth, which is a measure of overall uncertainty. In other words, the Long-Term Planner determines what range of events or products the cone should encompass.

Scenarios can identify long-term risk and potential opportunity. They encourage strategic thinking about long-term futures and potential discontinuities in a world that obsesses about the short-term. Many statistical and economic models actually work quite well. However, they are best used in situations where there is a consistency of business phenomena, data are extensive and accurate, relationships among variables remain largely constant and the time frame is relatively short. These are situations where there is not much uncertainty and risk. Scenarios are appropriate in any situation where the data are incomplete or unreliable, the relationships among variables are continually changing and the timeframe is sufficiently long to allow disruptive events to occur. Although there may be numerous advantages to long-term thinking, especially in situations where there may be long-term risk, it has not comely naturally to most enterprises, organizations or business people (Millett 2013).

This article uses scenarios to deal with the above questions because they are popular in assessing environmental impact at the large-scale level (Verburg, Eickhout, and Van-Meijl 2008; Jacobs and Statler 2006) and hence are useful tools for long-term planning. Scenarios are a means to portray what could happen, assuming changes in preconditions that differ in nature, course, rate, duration or place (Rotmans et al. 2000; Peterson et al. 2003; Xiang and Clarke 2003; Wester-Herber 2004).

The underlying philosophy of future thinking, that the future is uncertain and cannot be predicted, is often difficult for decision makers and politicians to accept and have not generally become a widely used technique (Verity 2003). While it is a common experience that plans go unrealized or need to be altered because of changing external events, confidence in forecasting is believed to improve over time with better models and tools. Because it is difficult to accept that uncertainty and risk cannot be planned for the future, long-term planning methods have usually been based on mathematical models. However, environments and futures are increasingly turbulent, uncertain and complex. More than any other strategy tool, scenarios engage with these characteristics rather than ignore them.

There is also antagonism to the idea of relying on experts and Tetlock for example claims that he found little support for the usual hypotheses about factors often believed to influence the accuracy of experts' predictions (Tetlock 1999; 2005; 2007). Predictions of experts made on the political and economic futures found no difference in the accuracy of forecasts from: (1) experts versus dilettantes; (2) those with more experience and those with less; (3) experts from different disciplines (e. g., economists, political scientists); (4) those with access to classified information and those without; (5) those with prestigious institutional affiliations and those without; (6) those who had lived for lengthy periods in the relevant country and those who had not; (7) those with and without relevant language skills; (8) those who identified their ideology as liberal versus those who considered themselves to be conservative; (9) those who classified themselves as realists (who believe that in world politics, the strong do what they will and the weak accept what they must) versus those who classified themselves as institutionalists (who believe that international institutions have some normative force not reducible to power politics); and (10) those whose temperamental self-identification was boomster-optimist versus doomster-Malthusian. Tetlock's conclusion was that in a complex, probabilistic world, we reach the point of diminishing marginal predictive returns for knowledge considerably more quickly than most experts and most users of expertise appreciate. However, it should be emphasized that when the debate rests on technical limitations, the limitations of production factors, or scientific feasibility, relying on experts allows for identifying the boundaries of possibilities. Although experts are not immune to error, knowledge and professional experience in the field has meaning that cannot be ignored. Under certain conditions diversity and the 'wisdom of crowds' may be better than experts' wisdom, but this principle does not eliminate the role of the experts.

Public decision-making is inherently exposed to a high conflict potential. The necessity to capture the complex context has led to an increasing request for decision analytic techniques as support for the decision process (Gamper and Turcanu 2007). Scenarios such as multi criteria analysis are deemed to overcome the shortcomings of traditional decision support tools used in economics, such as cost-benefit or cost-effectiveness analysis. This is due, among other things, t o its ability of dealing with qualitative criteria, as well as with uncertainties about current or future impacts. One of the reasons for the use of future scenarios within the framework of this article is based on the claim that Israel can survive only as a high-tech urban/industrial society and will have to reallocate most of its high quality drinking water from agriculture to the domestic/urban/tourist/industrial sectors. Agriculture can no longer be viewed as a high priority food production branch when it comes to the allocation of fresh water (Shuval 2011). However, this argument is based on the reasoning in static and linear systems. The underlying premise of the argument is that in the future, decisions will have to be made where to import the necessary nutrients from. However, what if that is not possible? If we accept the argument of linearity, it is necessary to reduce the importance of the agricultural sector. What if one examines a different story for the future? This completely changes the rules of the game.

The historic question that is raised by Israel's need to reduce its fresh water allocations to agriculture is how will it be able to manage to provide food for its population? For many years now, the vast majority of the caloric value of Israel's food supply has been based on imports and some 80% of Israel's caloric intake is imported (Buchwald and Shuval 2003). The amount of water required by a country to produce the full 'food basket' from local agriculture varies from about 1,000–2,000 $m^3$/person/year (Gleick 2000). It is obvious that countries like Israel with a total water resource potential of significantly less than 1,000 $m^3$/person/year can never approach total food self-sufficiency based solely on locally grown food. Israel can at best grow only 10–20% of its food needs locally and like many other countries with serious water shortages, solves its food security problem by the import of staple food products from the world market. Therefore, the decision makers must face several key questions: what if the world market is not stable? Not sure? What if trade barriers prevent the free movement of goods? Will the decision makers of tomorrow be able to blame the mathematical model? What exactly will feed the population? Will it be new mathematical recipes? Because of the difficulties that are raised by these questions and others like them, the need to examine several future scenarios becomes of vital significance for the decision making of today.

## Method

This article focuses on the ability of a small country like Israel to produce all its food needs under conditions of severe land shortage and water availability for agriculture, population growth and worsening climate conditions.

Long-term agricultural planning in Israel today (2014) relies on two components: planning at the regional level and the overall policy of the Ministry of Agriculture on the national level. The strategy used for planning agricultural development (Ministry of Agriculture and Rural Development of Israel 2010) is based on public participation through various regional systems. Public participation in planning processes is a prerequisite for the support of the Ministry of Agriculture and the approval of the regional programs. Within the framework of this study, teams of experts were established to assist placement of boundaries for question answering capability of food security in the long run. The experts included researchers from the Department of Economics of the Faculty of Agriculture of the Hebrew University, experts of the Planning Authority within the Ministry of Agriculture and Rural Development, experts of the Extension Service, and experts in the International Trade Department of the Ministry of Agriculture and Rural Development. A total of 28 experts participated in the study.

In this article, forecasting long-term trends will be based on the following:

1. *Identifying and extrapolating megatrends in the past.* Although long-term economic trends can change, these trends can be extrapolated with a reasonable degree of certainty. Unless of course, we have reason to believe that the present economic system will change in some fundamental manner in the future.
2. *Constructing scenarios by experts to consider future possibilities.* It is difficult to define what an expert is because we actually talk about degrees or levels of expertise. Thus, maybe the real question is how much expertise a person should possess before qualifying as an expert? As the future is not predetermined, scenarios by experts are attempts to visualize a number of possible future schemes and consider their implications. Scenarios are based in part on extrapolating megatrends, and in part on subjective interpretation and specific assumptions about critical aspects of the future. A major purpose of scenarios is to avoid extrapolating into the future in a linear fashion.

Although innumerable forecasts are made every day, little effort is spent in evaluating them, because often, we do not want to be held responsible if our forecasts go wrong. However, judgmental forecasts are much more common than statistical ones in our decision-making processes. We must accept that errors cannot be entirely avoided and that accuracy of judgmental forecasts is, on average, inferior to statistical ones. This is because our judgment is often characterized by having considerable biases and limitations. The entire subject of judgmental biases could take many volumes to treat thoroughly and cannot, therefore, be covered in this article. However, inconsistency can be avoided by formalizing the decision-making process. This would require deciding, first, which factors are important to consider? Second, how such factors should be weighted? Third, what objective should be optimized? The usefulness of decision rules is derived from the fact that several people can be involved in determining them and make it possible to select the best factors, an optimal weighting scheme, and the most viable objectives.

The main steps in drawing up scenarios of possible land allocation in Israel in the decades to come are as follows:

1. Identification of the key forces that are to be included. These agricultural needs are required in order to supply fresh produce to the population and on the other hand the growing demand of land for urban use.
2. Israel's 'food-basket' consumption per capita will remain at more or less the same level in terms of kg per capita. It is assumed that the main factor affecting the demand for food is the size of the population. In addition, it is assumed that an increase in income level will not significantly affect per capita consumption of food.
3. Israel has a developed an agricultural research infrastructure, so the assumption in this study is that the overall rate of technological improvement in production of the agricultural sector in Israel will be at the rate of one percent per annum (Hadas and Gal 2014).
4. Identification of the key factors. These factors are restricted and the number of key factors was kept to a minimum since the complexity in drawing up a scenario rises dramatically in proportion to the number of factors included.
5. Constructing scenarios from the particular factors identified.

Identification of critical factors that might influence long-term planning of the agricultural sector in Israel was carried out by a team of eight experts, Team #1. The team included: an Agricultural Economics expert, an Environmental Science expert, Soil and Water Science experts, an Agricultural Engineering expert and Agricultural Planning experts.

Team #1 established the starting point of the study based on the Israeli agriculture system at present. There are some influencing factors that together shape the strategic options: What are the main emphases of agricultural production management for maximum food safety? Are there other influential factors essential to long-term planning of agriculture in addition to land, water and population size? This set of influences should be analyzed and understood as part of a detailed strategic analysis.

Team #2 consisted of twenty experts. Some were professional advisors of the Extension Service at the Ministry of Agriculture and Rural Development, while others were active farmers who also function as coordinators of various agricultural associations. Within the framework of this article, schematic constraints were chosen for the experts' scenarios. This was based on the assumption that a judgmental opinion is an assessment given by an expert, and it can have significant value in forecasting key policy variables.

The following are the schematic constraints:

- Level of pressure on agricultural water reserves.
- Level of pressure on agricultural land reserves.
- Level of pressure on agricultural technology.
- Level of pressure on agricultural international trade.

### THE EXPERTS' EVALUATION PROCEDURE

Based on some elements of the expectancy value theory (Fishbein and Ajzen 1975) the evaluation procedure took place in three stages:

1. In addition to the list of factors created by experts of Team #1, Team#2 analyzed what they thought might be of importance in establishing a long-term policy for agricultural production in Israel. Each one of the experts designated their highest priority and could add new factors that did not already appear on the list.
2. Team #1 discussed agricultural production factors, while Team #2 discussed agricultural outputs.
3. All the factors were scored according to their importance and ability to provide local food demand. The experts assigned a value to each factor in a subjective way and the final list of factors was ranked accordingly.

There is a temptation to look for a neat and tidy way of formulating strategy. Such a method may appear to be achievable by analyzing the environment and the extent to which resources are matched with the environment. However, this approach may fail to recognize the complex role that people play in the formulation of strategy. Strategy formulation is about objectives, what decision makers want and how political and cultural context play a role (Johnson and Scholes 1999). The fundamental questions that need to be asked are: who should be the authority to determine policy, and how should the direction and objectives of that policy be determined? This question relates not only to the ability to influence objectives but also to the process of supervising executive decisions and actions. This subject, though very intriguing, is beyond the scope of this paper.

## Discussion

### SCENARIOS OF TEAM #1

Team #1 selected five key factors for the long-term planning process in the agricultural sector of Israel: Population growth, land shortage, water shortage, technological developments, and international trade. The land factor is affected by limited supply due to urban pressure and limited soil fertility. The water factor is affected by the capital structure of desalination, as well as availability of land for facilities and environmental impact. The technology factor is affected by the need for streamlining production, reducing the use of production inputs, the development of storage conditions for fresh produce and finding alternatives to the food basket that rely on large-scale use of land and water. The international trade factor is affected by the possible future existence of limitations and restrictions on free trade due to global shortages.

Of these five factors, three are basic and significant factors: population, land, and water. Based on the assumption that per capita consumption in 2050 will remain similar to that of 2010, the demand for land and water will depend on the size of the population (table 1). The population forecast for 2050 is 15 million people (Central Bureau of Statistics 2012). Therefore, future land requirements are expected to be 594,000 Ha and future water requirements will be 1,890 million cubic meters per year. Both requirements are unachievable in Israel. Further details of the cal-

TABLE 1 2050 Planning Data According to the Data of 2010 (Without Import or Export)

| Year | Population | Land* | Water** |
|---|---|---|---|
| 2010 | 7.600,000 | 301,000 | 957 |
| 2050 | 15.000,000 | 594,000 | 1,890 |

NOTES * Hectares. ** Million $m^3$/year.

TABLE 2 2010 Data to Calculate Per Capita Water Consumption (Without Import or Export)

| Branch | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Vegetables | 143.8 | 0.048 | 0.0069 | 274.7 | 39.5 |
| Orchard | 155.5 | 0.052 | 0.0081 | 312.5 | 48.6 |
| Fodder crops | 81.4 | 0.151 | 0.0123 | 119.8 | 9.7 |
| Animal | — | — | 0.0002 | — | 14.5 |
| Fish | 2.80 | 0.105 | 0.0003 | 1,047.6 | 2.9 |
| Field crops, not irrigated | 15.40 | 0.574 | 0.0088 | — | |
| Field crops, irrigated | 41.8 | 0.054 | 0.0023 | 108.1 | 4.5 |
| Other | 0.33 | — | 0.0006 | — | 6.2 |
| Total | | | 0.0396 | | 126.0 |

NOTES Colummn headings are as follows: (1) kg/capita, (2) ha/mt, (3) ha/capita, (4) millions $m^3$/MT, (5) $m^3$/capita.

culation method for the 2050 forecasts are detailed below. This forecast assumes that technology is based on existing knowledge and that population is an independent factor.

Table 2 shows the 2010 data that were used for the calculation of the per capita water consumption (Central Bureau of Statistics 2011). It is important to note that the data of the animal branch mainly include production of milk and eggs and very little meat, which mostly comes from imports.

The experts of Team #1 selected two other factors in addition to the three basic factors. These factors are technological improvements and foreign trade. Assuming that the needed GDP growth in agriculture in 2050 is due to the increase in population, the required rate of technological improvements is therefore 1.72%. This rate reflects the growth of the population from 7.6 million to 15 million people, assuming that the other production factors remain constant. That is, the land for agricultural production and the amount of water required will not grow despite the 2050 forecast data presented in table 1. This of course is a calculated number and still we have to find a professional justification how to achieve this while historical rate is only 1% per annum.

## SCENARIOS OF TEAM #2

The experts of Team #2 think that due to severe resource limitations, there will be a need in the future for a fundamental change in the food basket composition. An example of the type of change that will be necessary

TABLE 3 The Scores of the Experts Team#2 for the Ability to Deliver the Food Security for the Domestic Market

| Branch | Relative weight | Limitations of | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Water | | Land | | Techn. | | Exp./Imp. | |
| | | (1) | (2) | (1) | (2) | (1) | (2) | (1) | (2) |
| Vegetables | 23.5% | 90 | 21.15 | 93 | 21.74 | 88 | 20.56 | 79 | 18.45 |
| Orchard | 25.5% | 83 | 21.17 | 89 | 22.70 | 86 | 21.80 | 78 | 19.76 |
| Fodder crops | 1.4% | 59 | 0.83 | 68 | 0.95 | 73 | 1.02 | 68 | 0.95 |
| Animal | 33.1% | 66 | 21.79 | 67 | 22.07 | 89 | 29.35 | 65 | 21.52 |
| Fish | 1.3% | 57 | 0.74 | 67 | 0.87 | 67 | 0.87 | 77 | 1.00 |
| Field crops, not irr. | 0.4% | 59 | 0.24 | 68 | 0.27 | 73 | 0.29 | 68 | 0.27 |
| Field crops, irrigated | 4.9% | 59 | 2.89 | 68 | 3.33 | 73 | 3.58 | 68 | 3.33 |
| Total | | | 69.00 | | 72.00 | | 77.00 | | 65.00 |

NOTES Column headings are as follows: (1) score, (2) weighted score.

would be a shift from beef consumption to fish, because of water and land limitations required for animal feed. Despite these changes that will be required due to resource limitations, the experts still believe that there will be a problem related to food security. National planning will be required to guide policy makers how to manage the state's inability to satisfy full domestic demand. Food security parameters were ranked by the experts as seen in table 3. Each expert gave a score for the ability to meet any of the four limits set by Team #1 and for each one independently: Water, Land, Technology and Export/Import. The limit scored with the relative weight of the branch allowed for producing a weighted average score of the team to the specific branch. The experts' opinion suggests that Israeli agriculture will not be able to supply local demand when considering each of the four main limitations prescribed by Team #1.

Although it will be impossible to fully meet the demand, there is a consensus that it is important to maintain mixed farming, even if there are no comparative advantages in production.

According to the experts, technology is the simplest limitation to handle, receiving the highest score of 77 out of 100. It is believed that through technology it will be possible to find partial solutions also for the other limitations. The most important technologies relate to efficient methods for water desalination at different quality levels. Other important technologies are growing methods that maintain soil fertility, prevention of food loss through the development of storage methods and post harvest

TABLE 4 The Balance of Israel's Food Production 2010

| Branch | Balance of virtual trade | | | |
|---|---|---|---|---|
| | Water (millions m³/year) | | Land (1000 ha) | |
| | Export | Import | Export | Import |
| Vegetables | 95 | 0 | 16,725 | 0 |
| Orchard | 83 | 0 | 13,796 | 0 |
| Fodder crops | 0 | 224 | 0 | 283,288 |
| Animal | 0 | 7 | 0 | 73 |
| Fish | 0 | 170 | 0 | 5,690 |
| Field crops, not irrigated | 0 | 0 | 0 | 62 |
| Field crops, irrigated | 0 | 102 | 0 | 51,029 |
| Total | 178 | 503 | 30,521 | 340,142 |

techniques, increasing harvesting duration, the development of efficient methods for growing fish intensively in cages and automation that reduces labour costs. In addition, the experts believe that there is great importance in developing a central information infrastructure that includes: research, information systems and a central training centre. All of these technologies are interrelated and should play a role in achieving the ultimate goal of providing food security.

The balance of Israel's food production shows a net export for fruits and vegetables and import for grains (table 4). Translating this trade balance into terms of land and water use shows a virtual importing of land and water through grains, and exporting virtual land and water through fruits and vegetables. The virtual importing and exporting balance sheet for land and water must take into account where the crops are produced. For instance, import data are based on the production function of agricultural technology in Israel. This means that if it was required to fully produce the imported products locally, the calculations would be based on the requirements to do that in Israel.

From the data above it turns out that Israel exports virtual water of 178 millions $^3$/year and virtual land totalling 30.5 thousand hectares per annum. The importing of virtual water is 503 millions $m^3$/year and virtual land totalling 340 thousand hectares per annum. The importing of virtual land is greater than the total cultivated agricultural land of Israel, while the importing of virtual water is equal to the volume of all fresh water allocated for Israeli agriculture. These are the data for the year 2010, hence under conditions that are planned for 2050 with a population twice the size, the situation will only get worse. It should be noted that not only because of the different composition of export crops compared to imports, that even if all the exports were completely stopped, importing virtual land and water would still be required. The agricultural trade structure today is based on the principle of free competition in international markets. However, global warming, global water shortages and reduced arable land per capita might place barriers to free trade. This means that Israel's national planners must confront a strategic problem of food shortages that cannot be taken care of based on a locally produced food basket. This problem will only get worse as the years pass and the population continues to grow.

## Findings and Conclusions

This article is a chapter in a series that deals with the barriers preventing food security in Israel over the next 40 years and with fundamental issues of long-term planning in agriculture in Israel. The article discusses the basic assumptions of food security from the perspective of the quantity required for the anticipated population. The purpose of the article was to outline the difficulties facing the Israel national planner. This is not a forecast, but rather a discussion that deals with the question of the possible limits on long-term food security. Even though the direct importance of agriculture has decreased in the GDP and an economic cost/benefit analysis might ignore the holistic importance of the sector, there are externalities that decision makers should add to overall long-term considerations. This is indeed a very central issue in any discussion of substantive policy of food security.

In Israel, there is a distinction between grain and meat production and the production of fresh fruits, vegetables, milk and eggs. Grains and meat are mostly imported while the latter are often produced by the domestic market. The role of domestic agricultural production is presented in tables 2 and 3 in a focused manner. Breakdown by sub-items of the industry is largely methodological and is not possible within the limits of this article.

Israel's population is expected to grow from 8 million (in 2013) to an estimated 15 million people in forty years, a fact which inevitably will lead to a significant increase in the quantity of food consumed by any method of calculation. This assessment does not even consider the Palestinian Authority's population that relies heavily on Israeli agriculture and is expected to grow as well. Unlike the rest of the world, Israel's population component is a dominant factor with critical significance. The other factors are limitations and barriers that limit the ability to find a solution. Therefore, the different use of these restrictions was the basis for the different scenarios. It is important to remember that Israel is a very small country and most of the area is desert. The intention of the article was to deal with stresses and to outline limitations. It was not meant to be a single parametric forecast.

Israel is characterized by limited land area, built-in water scarcity, a semi-arid climate and a growing population. Global warming will not change materially the desert character of the country. In addition, the natural water sources without desalination are not expected to change significantly. The population issue is a factor that will require increasing the share of urban water and land resources at the expense of agriculture, while requiring a significant increase in food production. This topic is covered in detail in previous articles. Agriculture in Israel is expected to face heavy pressure from increasingly restricted water (Hadas and Gal 2014) and land resources (Gal and Hadas 2013) and from a considerable increase in the population (Central Bureau of Statistics 2012). As a result, the Israeli economy is expected to face food supply difficulties in the long run.

Long-term planning of agriculture in Israel today (2014) relies on two components: planning at the regional level and the overall policy of the Ministry of Agriculture. For this study, teams of experts were established to assist in setting boundaries for answering the question of how to maintain food security in the long run. Agriculture in Israel is characterized by its high level of technology and very advanced research. All of the advanced growth techniques such as hydroponics, etc., are already used in agricultural production in Israel. However, these methods are suitable for limited production systems and do not provide a response to the overwhelming majority of production which is based on land use, such as grains. Reliance on the opinion of experts was designed precisely to address these possibilities. Israel today is a member of the OECD. This means that the average food basket is balanced and in accordance with the standards of developed countries. This is at a time when most assessments of changes in world's food intake are attributed to developing countries. Therefore, the premise of the article was a stable food basket. The only possible fundamental change in that basket would be a transition to artificial food but this topic is beyond the limits of this article.

The development strategy for agriculture in Israel (Ministry of Agriculture and Rural Development of Israel 2010) is based on the concept of maximum independence for the supply of fresh produce while most grains are imported. As a result of the Paris 2011 (FAO/OECD Expert Meeting on Greening the Economy with Agriculture, 5–7 September) conference on food security, food security policy in Israel today (2014) is based on the assumption that the effort should be focused on domestic production as much as possible. The national planner must take into account in particular the question of the future food security of the country. These externalities should take into account such items as environmental aspects related to the rural landscape, maintenance of drainage systems, prevention of soil erosion, refilling of aquifers etc. However, the question that must be raised is what variables should be examined and subject to what considerations? There are so many constraints with different levels of influence, which one should know in order to make the right decisions, which of course is very difficult to achieve.

So far, agricultural planning considerations have mainly focused on maximizing profits. Israel domestic production today supplies mainly the domestic market and export accounts for only about 20% of total production. Still, Israel imports on a very large scale in terms of virtual land and virtual water. This means that the attention of the decision makers must be diverted from consideration of short-term profit to considerations of long-term food security. Relying on the opinion of the experts, there are five key factors for the long-term planning process in the agricultural sector of Israel: population growth, land shortage, water shortage, technology development, and international trade. However, the issues discussed should not be limited only to the restriction of production factors. Other questions are: What other factors that are required today that takes a long time to develop? What should be done in the case that change is not possible? Is there a need for additional budgets to develop advanced technologies for saving manpower, improving storage, raising crops etc.? Other questions might be: What is the most suitable R&D structure? What information systems are needed? What should be the role of the extension services? All of these technologies are interrelated and should play a role in achieving the ultimate goal of providing food security.

In conclusion, the small relative weight of agriculture in the national economy should not be the decisive factor in allocating land and water resources, but rather the strategic issue of the ability to produce food for the domestic market.

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