1. Introduction

Israel is a densely populated country on the eastern shore of the Mediterranean Sea. Science and technology are a major part of Israel's economy and ranks as the fifth most innovative country by the Bloomberg Innovation Index [1]. Despite technological successes, it faces environmental issues of chronic water scarcity and increased air pollution, which threaten the wider societal and economic health of Israel [2] [3]. This essay will focus address the root causes of these issues and how to overcome them through environmental policy.

2. Analysis of Environmental Issues

2.1 Water scarcity

Water is a quasi-non-renewable resource, it is ecologically replenishable, however the rate of consumptive demand often exceeds the rate of natural recharge, leading to persistent reduction in quantity. Israel's climatic profile alongside an inherently low freshwater resource results in high vulnerability to water shortages and demand regularly exceeds the total freshwater supply [4]. This has long been the case and over-abstraction has significantly diminished the availability of the freshwater resource [4] [5]. This has resulted in agglomeration of negative externalities such as deterioration of water quality and lowering of the water table, which contribute to water scarcity today.

Over-pumping has led to to adverse environmental effects such as, seawater intrusion into over pumped aquifers, groundwater nitrification from fertilisers and sewage and contamination from industrial pollutants. While [4] attributes these to a growing population and agriculture sector, [5] holds that the root cause is historical state over-reliance on agriculture. During the period of 1980 and 1990, the government heavily subsidised agricultural water use, which stimulated "an artificial demand in excess of the available water" leading to a yearly water deficit [4]. Socially, this can be explained by the ideological importance of agriculture in the Zionist movement's beginnings at the end of the nineteenth-century, which considers agricultural transformation of land as an index for success in establishing a Jewish nation state [4]. From a supply and demand viewpoint, the reduced price led to greater agricultural supply and resulted in consumption inefficiencies without any additional benefit to the economy. At present, the state continues to subsidise agricultural demand through preferential pricing.

The issue of over-abstraction in underpinned by economic inefficiencies in allocation and sub-optimal extraction paths. Israeli water law and regulation adopts a 'use-it or lose-it' strategy for agriculture based on a block-rate pricing mechanism, whereby supply quotas are based on the previous year's water use [6]. Figure 1 illustrates how this process works in practice for two farmers, each with an annual water supply quota of w1 and w2, where w1 < w2. Pricing blocks vary with respect to the proportion of the quota required (0.5, 0.8, 1) and Farmers 1 and 2 possess different marginal valuations for water (MV_1 and MV_2). However, the delivered outcome is that Farmer 2 is able to obtain a greater volume of water for a lower price (point B) than Farmer 1, despite Farmer 1 holding a higher willingness to pay and utility (point A). This does not satisfy Pareto optimality as net benefits summed over all users is not maximised as Farmer 1 could still be better off, and as such, the market operates inefficiently as it advantages inefficient water users more than the efficient users [7]. Additionally, historical basis of quota allotment creates inflexibility to climate dynamics and the allocation can easily cause over-supply or shortage. Despite this, block-rate pricing has been as preferable pricing mechanism for policy-makers, [7] show that it creates a lower aggregate demand without raising the overall cost of water.

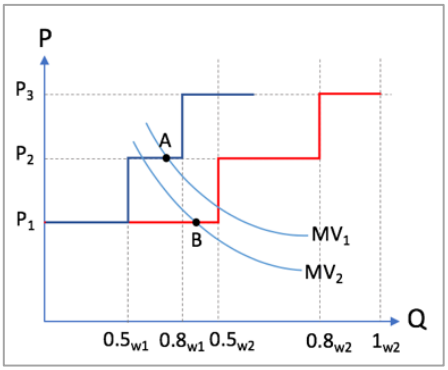

Figure 1: Welfare effect from block-rate pricing

In order to deal with such water pressures, Israel invested heavily in supply enhancement measures by constructing four desalination plants along the Mediterranean coastline. This investment in new technology gave rise to the utility of coastal saltwater, thereby turning a reserve into a useable resource. The new facilities now provide 50% of Israel's annual freshwater supply and virtually all of its drinking water [6]. However, desalination is an energy intensive process meaning that Israel's cost of water production is linked closely to global energy markets. In addition, loss of public coastal open spaces and discharge of concentrated brine into the sea are examples of negative externalities [5], highlighting that this is a short-term solution to a long-term environmental problem.

As purported by [4], population growth has further accelerated the burden on conventional water resources, as domestic and agricultural demand for water is inelastic. Between 1988 and 2018, Israel has seen a population growth of 49%, representing populations of 5.97 million and 8.89 million respectively [8]. In parallel, there has been improvements to quality of life and life expectancy increased from 74.4 to 82.6 in the same timeframe [8]. Israel has seen improvement on the human development index, which aggregates Gross National Income (GNI), life expectancy and education. This ranks Israel as 22nd in the world and since 2010, Israel has been a member of the Organisation for Economic Co-operation and Development (OECD) [9]. Whilst population growth, will increase aggregate demand, improvements to quality of life will drive up demand on a per capita basis. Further growth of Israeli settlements and expansion of Israel's sovereignty in the region will also act to drive up demand, whilst urbanisation may further inhibit aquifer recharge [10]. The consequence of these factors will be an exponential growth water demand, unless technological developments permit efficiency gains. Water scarcity in Israel is driven by a history of water resource over-abstraction and the persistent challenge of rapid population growth, therefore it is a long-term environmental issue.

2.2 Air pollution

Air pollution is defined by a combination of atmospheric nitrous oxides (NO_x) and fine particulate matter (PM_{25}). In Israel, underlying factors are an emission-intensive industrial sector and improper urban waste management [11]. Israel's total primary energy supply is heavily fossil fuel dependent, in 2018, it consisted of 38.7% natural gas, 38.2% oil and 20.5% coal [12], demonstrating a causal link between GDP growth and air pollution. From a demand-side perspective, increases in GNI per capita has increased consumer budget constraints, leading to greater consumption of emission-intensive energy services and proliferation of atmospheric pollutants. In addition, the lack of adequate processing technology for municipal waste has further accelerated abundance of fine particulate matter due to the adoption of environmentally aggressive waste incineration processes [3].

The root cause behind this environmental challenge is that in all of these processes, the externality of air pollution does not appear in the cost of production. Despite, burdening society with the environmental cost, the financial cost of this is not translated to either production or consumption, leading to social welfare loss. Moreover, the atmosphere is a pure public good and due to the lack of property rights, the damage imparted through air pollution does not carry a monetary cost in the market. Fundamental microeconomic theory indicates that the ultimate production level will depend on the level of technology and the lack thereof for waste management results in inefficient outcomes, which propagate air pollution [13].

Israel's geopolitical situation creates additional challenges for state-pollution management. Israel and Palestinian territories are intertwined, which creates difficulty to regulate and control shared environmental impacts, leading to damage of interdependent environmental resources [11]. It highlights the transboundary character of environmental pollution and that environmental law cannot extend beyond individual legal systems and jurisdictions [13]. This atmosphere is an indivisible public good, which makes development of trans-boundary environmental management a significant challenge, but one, which is important to overcome for the preservation of mutual social welfare.

Population increase, greater urbanisation and change in land use will result in persistent air pollution challenges. With Israel's recent discovery of substantial natural gas reserves, leaders consistently perceive fossil fuels as the best means for energy security [14], therefore, endemic air pollution will be reflective of economic growth, and a persistent environmental issue. Although, short-term pollution reduction may be achieved through the relatively low-hanging fruit of improving waste management, the longer-term issue will be regional pollution and particulate concentration in urban hubs, for which there are already a number of precedents from cities around the world in developed countries.

On a fundamental level, air pollution poses high health and wellbeing risk to citizens, damages ecosystems and reduces overall social welfare. With increasing atmospheric pollution, the marginal abatement cost will always be increasing in parallel; therefore, policy changes need to address this before abatement cost outweighs the cost to society. The difficulty in quantifying the environmental impact in a financial sense and in determining the optimum level of pollution reduction.

3. **Management of Environmental Problems**

3.1 Water Scarcity Policy Solutions

The primary objective of proposed policy to reduce water demand from the agricultural sector, which currently constitutes about 70% of total annual supply [4]. This will be achieved by abolishing subsidies for the agricultural sector whilst maintaining the block-pricing system. In doing so, this will reduce overall agriculture demand by increasing costs for farmers and reduce negative externalities of over-abstraction. Maintaining the block-pricing system is advantageous for reducing overall demand, which [7] evaluates as a 7% reduction in comparison to a single price regime [7]. The secondary function of ending subsidies is to tackle agricultural water inefficiency by forcing higher productivity and to encourage a shift away from agriculture-dominance, which is more in line with Israel's current industrial trends of a service-based economy. A formal water trading system is proposed to curtail inter-farm allocation inefficiencies and the principle is based on a balancing market for agricultural consumers for smoothing regional over-supply or shortages. It would also enable the state regulator to be more agile in dealing with climatic factors and by default, re-allocate water resources into the most economically productive activities. This would ensure that water would carries an economic value beyond the point of quota delivery to farmers and would drive up productivity in agriculture as a whole. The risk of this policy will be an increase in food prices, which may result in greater levels of inequality and poverty overall. However, a balance of imported and domestic produce may be a viable option to overcome this. Alternatively, subsidies could be applied at the consumer-side in order to avoid this scenario.

At the production-side, a payment for ecosystem services (PES) policy should be adopted to improve privately owned water resource management. This seeks to internalise the negative externalities of over-abstraction by paying owners to engage in environmentally protective acts. The long-term impact of this will result in a rehabilitation of overall quality and quantity of groundwater resources through incentivised resource management. This policy would avoid a 'tragedy of the commons' scenario, whereby the marginal cost for access is below the marginal benefit obtained from the resource. The PES aims to increase the marginal cost for access, as using the resource would forego the protection payment, thereby reducing over-exploitation. The challenge for establishing this policy is determining an appropriate incentive level such that there is still an economic advantage to abstract water when needed and to avert 'gaming' or exploiting the policy. A means for overcoming this may to introduce a PES threshold for water volume abstracted, but in practice, this would require a high level of regulation and uncertainty in understanding the environmental impact of abstracting different volumes from every aquifer. Despite this, the principle represents a beneficial way of incentivising the protection of the environment, without undermining existing Israeli law, which allows private ownership of water resources through 'ancient rights' [4].

In light of expected population growth, soft 'suasive' mechanisms by educational information campaigns should be used for the wider public, in order to drive up the efficiency of water consumption per capita. It is important that the population is aware of how high consumption causes the negative externality of water scarcity, so that individual actors can take account of this in their utility of water. It may overcome the market failure of 'lack of information', which unknowingly leads to the generation of negative externalities from transactions. This should focus particularly on the residential sector, which will be increasing its demand most considerably due to urbanisation.

3.2 Air Pollution Policy Solutions

The issue of air pollution is particularly difficult due to the lack of well-defined property rights and immateriality of the atmosphere, therefore a policy approach based on the 'Coase Theorem' would not be suitable for this application. Coase holds that optimal resource allocation will take place when transaction costs are zero, regardless of the original property rights allocation [14]. Despite the advantage of re-allocating rights to the party that is has the most cost effective means of pollution reduction, it is not well-suited to deal with air pollution for a number of reasons. Principally, this is due to a high number of victims, and for them to act with a unified strategy is highly unrealistic. In addition, the cost and solution to 'cure' pollution is difficult to quantify and may even be financially prohibitive for any of the parties to address.

Conversely, a Pigouvian tax applied to the waste incineration aims to internalise the negative costs incurred to society through a well-understood source of pollution, and to generate income for investment in cleaner technologies. The tax serves as a means to minimise pollution at source by causing a reduction in production quantity, which is easy to regulate from a point of source. Furthermore, there are continuous incentives for companies to reduce air pollution, unlike emission standards policy, in which there are no further incentives to do so beyond achievement of the standard [14]. The appeal of the tax is that it will discourage high emission-intensity waste disposal, encourage innovation and deliver an immediate short-term impact on local air quality. In order to operate effectively, the marginal private cost through taxation should be equivalent to the marginal social cost through pollution. However, the difficulty arises in quantifying the tax rate and deducing an equivalent monetary value for environmental damage. In the short-term, this would carry the risk of not achieving an adequate level of emission reduction in the absence of historical data. The optimum level of taxation would be when marginal abatement costs of pollution are equal to marginal damages, as this is the socially optimum scenario as the last unit reduction costs the same as the benefit to society.

Alongside the short-term reduction of air pollution from waste incineration, an environmental permit-trading scheme is proposed in order to decouple air pollution from economic growth and deliver a longer-term solution to the issue. Marketable emissions permits present several advantages for Israel. The permits are effectively 'rights to pollute' and they enable the designation of a maximum emission threshold through state control. Beyond defining the allocation, state intervention is not required as the market regulates itself and adjusts for inflation, which is not the case for Pigouvian tax. However, the lack of state intervention can also lead to undesirable consequences such as, uncertainty regarding the cost to the economy, which may be higher or lower than anticipated. Nevertheless, within the context of addressing Israel's environmental challenge of air pollution, the permit-trading scheme offers the distinct advantage of offering guaranteed emission reductions. The main hurdle for an effective emissions trading scheme is the notion of 'grandfathering'. This is when permits are allocated free of charge based on past emissions records and can lead to a number of downstream issues. It implies that the highest polluters are rewarded through gaining the greater right to pollute and can lead to regionalisation of pollution which may compound negative air pollution impacts. In addition, volatility of permit pricing increases risk and may stifle investment opportunities in industry and in principle, it enables polluters continue to make profit from causing environmental harm. A way to mitigate these risks would be to introduce auctioning, however, this wold require state intervention to regulate and ensure that hoarding does not occur to create entry barriers or other perverse incentives.

4. Conclusions

This essay has analysed two key environmental problems in Israel, water scarcity and air pollution. Water scarcity is driven by climatic factors, a historical over-reliance on agriculture and demand increase due to increases in population and quality of life. A combination of agricultural price restructuring, development of water capacity markets and suasive market tools have been proposed in order to reduce demand, whilst a PES policy is proposed to protect the quality and quantity of freshwater resources from over-abstraction. In contrast, air pollution is linked to inadequate waste management due to transboundary limitations, greater urbanisation and a reliance on fossil fuels. A hybrid policy approach is suggested via introduction of a Pigouvian tax and introduction of an environment permit-trading scheme for industry. In conclusion, these challenges are multi-faceted and highly complex, therefore hybrid policy approaches have been adopted in order to maximise upon the advantages of each policy and overcome the shortcomings of others.

References

[1] Bloomberg.com. (2019). Bloomberg Innovation Index. Available at: https://www.bloomberg.com/news/articles/2019-01-22/germany-nearly-catches-korea-as-innovation-champ-u-s-rebounds.

[2] "Israel to top up Sea of Galilee after years of drought", the Guardian, 2018. [Online]. Available: https://www.theguardian.com/world/2018/jun/12/israel-to-top-up-sea-of-galiliee-after-years-of-drought.

[3] "Israel's air pollution among OECD highest: How do we reduce exposure?", Ynetnews.com, 2019. [Online]. Available: https://www.ynetnews.com/articles/0,7340,L-5563669,00.html. [Accessed: 28- Nov- 2019].

[4] Kartin, Amnon. “Water Scarcity Problems in Israel.” GeoJournal, vol. 53, no. 3, 2001, pp. 273–282. JSTOR, www.jstor.org/stable/41147613.

[5] Tal, Alon. “Seeking Sustainability: Israel's Evolving Water Management Strategy.” Science, vol. 313, no. 5790, 2006, pp. 1081–1084. JSTOR, www.jstor.org/stable/3847073.

[6] Kislev, Yoav. “Water Policy In Israel: Water In Agriculture”. Vol. 4. Global Issues in Water Policy. Dordrecht: Springer Netherlands; 2013, pp. 51–64.

[7] Bar-Shira, Ziv, et al. “Block-Rate versus Uniform Water Pricing in Agriculture: An Empirical Analysis.” American Journal of Agricultural Economics, vol. 88, no. 4, 2006, pp. 986–999. JSTOR, www.jstor.org/stable/4123541.

[8] "Israel | Data", Data.worldbank.org, 2019. [Online]. Available: https://data.worldbank.org/country/israel.

[9] "OECD Better Life Index | Israel", Oecdbetterlifeindex.org, 2019. [Online]. Available: http://www.oecdbetterlifeindex.org/countries/israel/. [Accessed: 28- Nov- 2019].

[10] S. Foster, U. Shamir and N. Carmon, Impacts of urban growth on surface water and groundwater quality. Wallingford: IAHS, 1999, p. 409.

[11] I. Alleson, J. Levin, S. Brenner and M. Al Hmaidi, "Peace and Pollution: An Examination of Palestinian—Israeli Trans-Boundary Hazardous Waste Management 20 Years after the Oslo Peace Accords", Journal of Peacebuilding & Development, vol. 8, no. 1, pp. 15-29, 2013. Available: 10.1080/15423166.2013.785651.

[12] International Energy Agency World Energy Statistics 2018. Paris: OECD Publishing; 2018.

[13] Pepermans G, Morbee J, Ovaere M, Proost S. Energy Economics, Leuven: Acco; 2019.

[14] M. G. Faure and R. A. Partain, Environmental Law and Economics: Theory and Practice. Cambridge: Cambridge University Press, 2019.

[15] L. Michaels and A. Tal, "Convergence and conflict with the ‘National Interest’: Why Israel abandoned its climate policy", Energy Policy, vol. 87, pp. 480-485, 2015. Available: 10.1016/j.enpol.2015.09.040.