

# SINGAPORE WATER FOOTPRINT

*A report that focuses on Singapore's beverage and food consumption*



## ABOUT WWF - SINGAPORE

World Wide Fund for Nature (WWF) is one of the largest environmental organisations in the world, with more than 5 million supporters worldwide; and presence in more than 100 countries.

WWF started its Singapore office in March 2006 to engage individuals and organisations towards making a positive change in their lives and business operations.

Through awareness campaigns and outreach activities, WWF aims to educate individuals from all walks of life on how a simple action can add up to make a big difference to the environment and safeguard the world's biodiversity.

## ABOUT THE HSBC WATER PROGRAMME:

Water is vital to building healthy communities and developing national economies. That's why the HSBC Water Programme, which aims to provide and protect water sources, inform and educate communities in need, and enable people to prosper and drive economic development across the world, is so important.

To learn more details about the impact of the Programme, please go to <https://www.hsbc.com/our-approach/building-a-sustainable-future/community-investment>.

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*WWF Singapore Head Of Conservation and Science*

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### 3. EXECUTIVE SUMMARY

Our planet increasingly faces the triple challenges of increasing climate instability, ecosystems operating at or beyond their ecological thresholds and at risk of experiencing rapid and possibly irreversible decline, and a growing urban population that is consuming more resources than before. At the heart of these challenges are the challenges surrounding freshwater consumption, ninety percent of which goes to growing crops. Hence, water resource management is central to the debate on the production of sustainable food and energy, as well as biodiversity loss. Adequate and good quality water resources are not only prerequisites for the development of human societies, they also form the foundation of the natural ecosystems on which human societies and all life on earth depend on. One useful indicator to explore food-water impacts is water footprint, which explores the total volume of freshwater used in the production of a certain product. This concept brings to the fore the often unseen water component embedded in our consumption and highlights the dependence of a country on regional and global resources. In doing so, it raises awareness of the impacts that national consumption can have on water resources in other locations, and the need to understand regional-to-global water dependency for cities and states.

This report is part of an effort to improve the awareness of water resource management among Singapore's residents and aims to develop a quantitative understanding of the water footprint of Singapore's consumption of food and beverages. It provides facts and figures about Singapore residents' attitudes towards water scarcity and conservation and estimates the weekly food and beverage water footprint of individuals. The findings highlight potential local and regional impacts of individuals' water consumption and serve to form the basis of policy formulation to encourage consumption practices that use water resources more sustainably.



### FINDINGS

The study found that water scarcity in Singapore appears to be a distant concept among many residents. Although most residents felt that water conservation is important, only about half saw water scarcity as a problem that Singapore currently faces. This attitude could have stemmed from Singapore's success in water supply management, as well as Singapore's relatively wet, tropical climate. The country's small size and relatively small overall water footprint may also cause people to perceive their contribution as individuals as negligible and consequently, reject culpability for environmental problems elsewhere.

The average weekly water footprint of food and beverages consumed by Singapore residents were 19586 litres and 1312 litres respectively. Among vegetables, leafy greens were the most widely-consumed (68%). Poultry was the most widely-consumed meat (46%) while beef and mutton were the least widely-consumed (5% and 2%, respectively). Local coffee was the most-frequently purchased beverage (5.6 cups/week).

### LOCAL APPETITES, GLOBAL IMPACTS

As Singapore imports 90% of the food consumed locally, these consumption patterns may have far-reaching environmental impacts, and require Singaporeans to pay much greater attention to their imported water risks. Much of the food consumed in Singapore is produced under moderate to severe water scarcity settings in countries such as Australia, China, India, Malaysia, Thailand, the USA and Vietnam. By outsourcing the environmental impacts of crop and animal production from Singapore to foreign soil, Singaporeans leave their water footprint on the already-stressed water basins around the world. These impacts range from reduced water flows and the lowering of groundwater tables, to pollution of freshwater bodies and increased salt intrusion in coastal areas.



As climate change instability increases, many of these places face less predictable rainfall patterns, and increasing competition for water, resulting in a greater potential for food-energy-water insecurity, and ongoing freshwater biodiversity loss. This could, in turn, compromise the standards of living of populations who may already be economically-marginalised - both in countries of production, as well as in Singapore where food prices may increase. Hence, future episodes of water-scarcity, no matter how frequent or severe, will amplify the negative externalities of Singapore's food consumption.

## RETHINKING FOOD FOR WATER: A ONE PLANET DIET

The consumption patterns found in this study highlight the urgency required for Singapore residents to shift towards diets with lower water footprint along with the need to consider sourcing from regions with fewer water challenges. Following the guidelines of the 'planetary health diet'<sup>1</sup>, a diet that the EAT-Lancet Commission regards as being able to improve health while ensuring sustainable food production to reduce environmental degradation, the current local consumption of fruits and vegetables should be increased from 32% to 50% while the consumption of meat and drinks with high sugar content should be reduced by over 50%. In addition to reduced water demands on the environment, a reduction in the consumption of meat and drinks with high sugar content will also benefit individuals' health as such diets are linked to health problems such as diabetes and heart disease. Doing so would require the commitment of every sector of society, from the government, to businesses and to individuals.

- At the school and community level, as evidenced in this report, there is a need to continue to expand Singaporeans' understanding of their water footprint, their food dependency upon (at times water-stressed) regional food-sheds, and their global responsibilities.
- The government can also lead the way in funding and supporting the local agriculture sector to increase sustainably yield (ensuring resource efficiency) while also ensuring rivers and wetlands have sufficient allocations from the savings gained.
- Businesses can take the lead in influencing consumption patterns through labelling and price mechanisms to reflect the social and environmental costs of products.

They can also better understand the water risks in their own value chains through tools like WWF's Water Risk Filter.

- Singapore's investors and financial institutions can understand the water footprints and risks of their portfolios. By encouraging companies to prioritise good water stewardship on their corporate agendas, they can nudge companies towards sustainable practices. They can also begin to see water as an opportunity to create profitable solutions through initiatives like WWF's Bankable Water Solutions.
- Finally, individuals can reduce their consumption of meat and sugar, and also ask questions about sourcing and production. They can also opt for seasonal products that are grown in accordance to water availability of the producing area to avoid increasing water stress during dry periods. Lastly, they can also reduce their use of disposables when doing takeaways and minimize plastic waste, benefitting both rivers and the ocean as well.

This report has created a base to support further work on the impact of Singaporeans' freshwater dependencies. Looking forward, there are opportunities to explore further the water footprint of other consumer or energy products or analyse in greater depth how exposed Singapore's food system is to water risks, including under different projected climatic conditions, trade regimes or national policies. By characterising the actual water footprint of food and beverages consumed in Singapore, this report sheds light on the globalised nature of Singapore's local consumption of one of the world's most valuable natural resources. In doing so, it aims to chart a path for governments, businesses and individuals to work together towards a more sustainable use of local and global freshwater resources.



## 4. GLOBAL WATER PERSPECTIVE

### Water, biodiversity, ecosystem services and Sustainable Development Goals (SDGs)

Although 70% of Earth's surface is covered by water, only 2.5% of this is freshwater<sup>1</sup>. Of this small percentage, about 79% is trapped as ice caps and glaciers and 20% is stored as groundwater. Lakes, reservoirs, rivers and wetlands represent under 1% of Earth's available surface freshwater<sup>2</sup>. Despite making up a tiny fraction of the global water resource pool, freshwater supports approximately 100,000 species, or 6% of all described species in the world<sup>3</sup>. Freshwater bodies and their biodiversity provide vital ecosystem services and constitute valuable economic, cultural, aesthetic, educational and scientific resources. By providing supporting services to freshwater-dependent ecosystems such as rivers, lakes, mangroves and estuaries in the form of nutrient cycling and primary production, freshwater provides provisioning services to humans, including food, medicines and water for human consumption. Regulating services include the buffering of floods, erosion control, carbon storage and sequestration while cultural services include tourism, recreation and spiritual values.

Threatening the viability of these ecosystem services are challenges posed by climate change and the associated precipitation distribution and variability, population growth and human activities. It is estimated that the amount of freshwater withdrawn from inland water systems has increased by at least 15 times over the past two centuries<sup>4</sup>. The number of freshwater habitats and the quantity of freshwater have been reduced by land conversion and infrastructure development, resulting in an 83% decline in freshwater biodiversity since 1970<sup>5</sup>. To meet human food demands, ground and surface



*In 2017, 5 billion people were estimated to be living in areas where freshwater is already or is fast becoming, a scarce and overexploited natural resource.*

water withdrawal has changed river flow patterns, led to the degradation of water quality due to contamination by fertilisers and pesticides and consequently, reduced species abundance and diversity. The poor quality and scarcity of water have in turn given rise to an increasing incidence of waterborne diseases, the loss of livelihoods and hampered socioeconomic development, especially in lower-income countries. In 2017, 5 billion people were estimated to be living in areas where freshwater is already, or is fast becoming, a scarce and overexploited natural resource<sup>6</sup>. Already, despite being a basic requirement for human health, over a quarter of the world's population, or 2.1 billion, lack access to safe and readily available drinking water<sup>7</sup>. Sustainable management of freshwater resources is thus ranked highly among the list of key environmental challenges of the 21st century. Its importance is reflected in the targets of SDG 6 (Clean Water and Sanitation), one of which is the universal and equitable access to safe and affordable drinking water for all by 2030<sup>8</sup>.

### WATER SCARCITY AND THE PLANETARY HEALTH DIET

Planetary boundaries are defined as thresholds within which humans can operate safely with respect to the various functions of the Earth System<sup>9</sup>. The planetary boundary for freshwater use, proposed as 4000 km<sup>3</sup> yr<sup>-1</sup> in the study, was already reached in 2010<sup>10</sup>. Hence, in addition to ensuring access to clean and affordable drinking water, providing a growing population with healthy diets from sustainable food systems

against the backdrop of freshwater scarcity is a large and growing challenge. There are currently about 821 million hungry people in the world. More alarmingly, hunger trends have reversed in progress over the past three years and have returned to levels from a decade ago<sup>11</sup>, rendering SDG 2 of ensuring zero hunger by 2030 a greater challenge<sup>12</sup>. To address SDG Target 2.4 – the need to ensure a more sustainable food system, including resilient agriculture practices, the world needs to find ways to produce and consume healthier diets without compromising the targets for SDG 12, sustainable consumption and production patterns. A large part of this involves preserving the quantity and quality of freshwater<sup>13</sup>.

The World Economic Forum suggests that the global food system is extracting more than can be sustained. Unless we take concerted action, the environmental impact of the already strained system could rise by a further 50-90% by 2050<sup>14</sup>. Globally, the stress that irrigated agriculture puts on water resources is increasing. Both the scarcity of water in the Murray-Darling basin in Australia and the depletion of the Ogallala Aquifer in the American Midwest can be attributed to water abstractions for the irrigation of crops such as corn and wheat<sup>15</sup>. Yet, much of the grain cultivated in the world is not for human consumption but for animal consumption. Of the 92% of the freshwater footprint of humans that is attributed to agriculture, animal products account for almost a third<sup>16</sup>. With an increase in purchasing power that usually accompanies economic development, the demand for animal products such as meat, eggs and dairy products has grown due to a shift towards more affluent food consumption patterns. Accordingly, water demands for food production has increased. In addition to water needs for drinking, water is also needed for growing and preparing animal feed (especially if the animals are grain-fed) and for the cleaning of livestock farms and the associated wastes<sup>16</sup>. Recognising that the link between human health and environmental sustainability is inextricable, the EAT-Lancet Commission compiled findings and recommendations of 37 scientists

and academics from 16 countries to develop global scientific targets around food production and consumption. These targets attempt to define boundaries for a safe operating space for food production practices that can help to achieve both the UN SDGs. The commission presents a ‘planetary health diet’ that recommends a dietary change towards diets lower in animal products<sup>1</sup>. This proposal is also supported by the WWF’s Future 50 Foods report that recommends diet diversity to improve human health while ensuring a more sustainable use of resources<sup>17</sup>. Additionally, a recent study on water footprint and nutrient of crops details the contribution of dozens of crops to micronutrient availability in diets, whilst at the same time assessing the water demands of each crop<sup>13</sup>.

Despite the numerous social and environmental benefits that can follow the consumption of a ‘planetary health diet’, successful global transformation may be a far-fetched ideal unless there is widespread awareness of how food is produced<sup>1</sup>. The growth of international trade has blurred the boundaries between global and local consumption of products and services and complicated our understanding of water resource use, making it evident that the management of freshwater resources in one country or basin cannot be understood in isolation of other countries<sup>18</sup>. Although water resources are an intrinsic element in the international economy, challenges relating to their quality and quantity are rarely translated into costs to either producers or consumers, often resulting in both parties along the supply chain enjoying the benefits at the expense of local communities and ecosystems<sup>15</sup>. Hence, knowledge of water consumption is vital for governments to strategise for and make assessments of their environmental policy and food and nutrition security roadmaps<sup>19</sup>.



## 5. WATER FOOTPRINT

The growing international food trade has resulted in consumers becoming increasingly spatially and emotionally disconnected from the use of water resources. As the various production stages are often located in one or more different locations, all of which may be different from the final place of consumption, the impacts of consuming a certain food on the world’s water resources can only be fully appreciated by tracing the supply chain of the product. An understanding of the links between food production and consumption thus holds great potential for consumers to be potential ‘change agents’ by taking concerted action or making conscious decisions to influence their direct and indirect uses of water<sup>20</sup>.

The water footprint of a product is the volume of freshwater used in its production over the entire supply chain. It is the sum of three components, the blue, green and grey water footprint.



Blue water footprint

Refers to the consumption of surface (rivers, lakes, estuaries etc.) and groundwater resources such that the water is displaced from its catchment area.



Green water footprint

Refers to the consumption of rainwater that does not become surface runoff; it is the water that infiltrates soils and is taken up by plants.



Grey water footprint

Refers to the volume of water needed to assimilate load of pollutants generated in the production processes to their natural background concentrations and local water quality standards.

When considering agricultural products, water footprint is typically expressed in terms of m<sup>3</sup>/ton or litres/kg. For animal products, the water footprint consists of the direct water footprint related to the drinking and service water consumed by the animal and the indirect water footprint of the feed. **Appendix A** lists the global average water footprint of selected feed components. Crop water footprint is the sum of blue, green and grey water used<sup>21</sup>. The water footprint of some food products from animal and crop origin are shown in **Appendix B**.

## 6. THE SINGAPORE FOOD AND WATER STORY

As a highly-urbanised city-state with a population density of 7,796 persons per km<sup>2</sup><sup>22</sup> that lacks freshwater lakes or aquifers, Singapore’s water demand greatly exceeds its naturally occurring supply<sup>23</sup>. To ensure the quality of local catchment runoff water, polluting industries were resettled away from catchment areas, resulting in the gradual phasing out of farms<sup>24</sup>. The proportion of agricultural land in Singapore over its total land area has decreased from over 20% in 1961 to less than 1% today<sup>25</sup>. Consequently, over 90% of the food consumed locally is imported<sup>26</sup>. Despite these challenges, Singapore has enjoyed a high level of food security, coming out top as the most food secure country in 2018 on the Global Food Security Index formulated by the Economist Intelligence Unit<sup>27</sup>.

Diversifying Singapore’s food supply allows the country to avoid over-reliance on a single country and thus reduces the risk of potential food shortages. Malaysia, Indonesia, Australia, Brazil, New Zealand, the USA, China and Thailand are the main exporters of meat and vegetables to Singapore (**Figure 1A and 1B**). Despite this diversification, Singapore has strong dependence on specific countries for individual food imports.

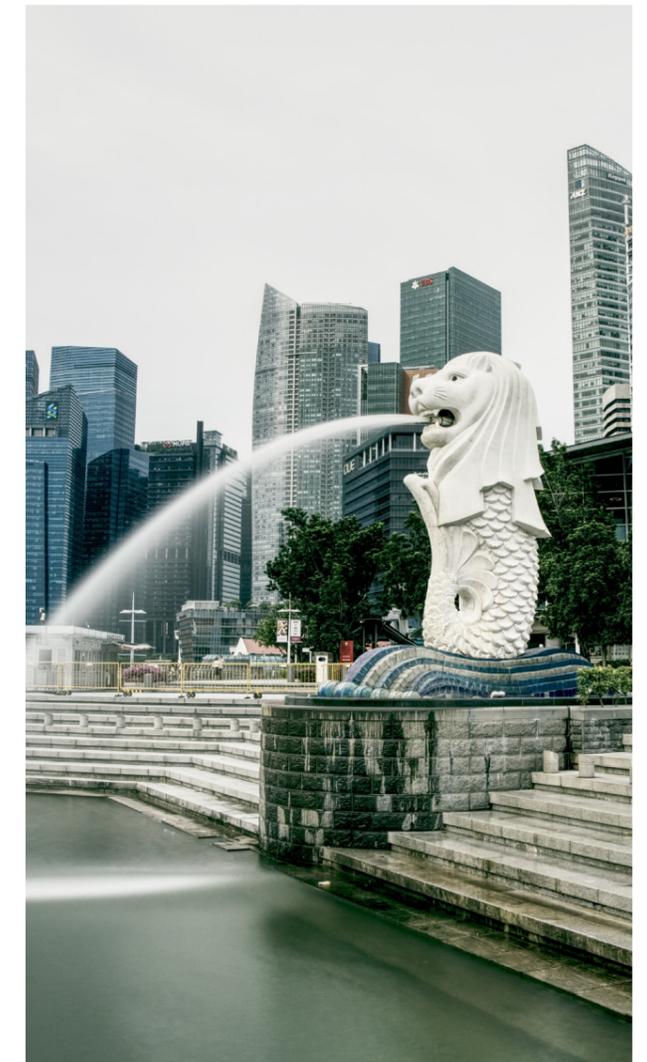
These include the dependence on China for 70.1% of cabbage and kale imports, Malaysia for 69.6% of leguminous vegetables and 85.6% of melons and papayas and India, Thailand and Vietnam for 41.0%, 30.4% and 21.7% of the country’s rice imports, respectively<sup>28</sup>. Around 35% of Singapore’s poultry comes from Malaysia<sup>29</sup>. Food security in Singapore is broadly defined as “access to safe and nutritious food, for all Singapore citizens and residents, at affordable prices, in the short and long run”<sup>24</sup>. As the availability, accessibility, and consequently, the affordability of food resources in Singapore is largely determined by the state of food production in other countries, Singapore remains susceptible to decreases in regional and global food supply due to the impacts of climate change, conflicting demands on land use and declines or variability in production yields of crops and animal products. Higher temperatures and increased frequency of precipitation extremes that have been projected for the Southeast Asian region could lead to an increase in the frequency and intensity of drought and reduce water resource availability, thereby increasing the region’s vulnerability to water scarcity<sup>30</sup>. In recent years, supplies of fruits and vegetables have dropped by as much as 30% during periods of hot and dry weather, triggering price increases of up to 8.4%<sup>31,32</sup>. Locally, the threat of Singapore’s water supply being reduced by a meteorological drought has been actualised in the last few years. In 2015, the Johor River’s Linggiu reservoir saw its water level fall by 54.5%<sup>33</sup>. Later, in 2016, the capacity of the reservoir dipped to a historic low of 25%<sup>34</sup>.

Against this backdrop, the newly formed Singapore Food Agency has set an ambitious target of achieving “30 by 30”, involving the production of 30% of the country’s nutritional needs locally by 2030<sup>35</sup>. This may be especially challenging, given that the consumption of food has increased over the years. For example, the per capita consumption of pork, beef, non-leafy vegetables and eggs in Singapore increased by 2 kg, 1 kg, 2 kg and 26 pieces respectively from 2016 to 2018<sup>36</sup>. Singapore residents are also consuming three to five times more meat and eggs than recommended by the ‘planetary health

diet’<sup>37</sup>. Hence, there is an urgent need to increase awareness of the water footprint inherent in individuals’ consumption of food and beverages as a starting point to change consumption patterns to reduce the environmental impacts of food production to meet Singapore’s demand.



*Over 90% of the food consumed in Singapore is imported. Hence, the country may be adversely affected by decreases in regional and global food supply due to the impacts of climate change.*



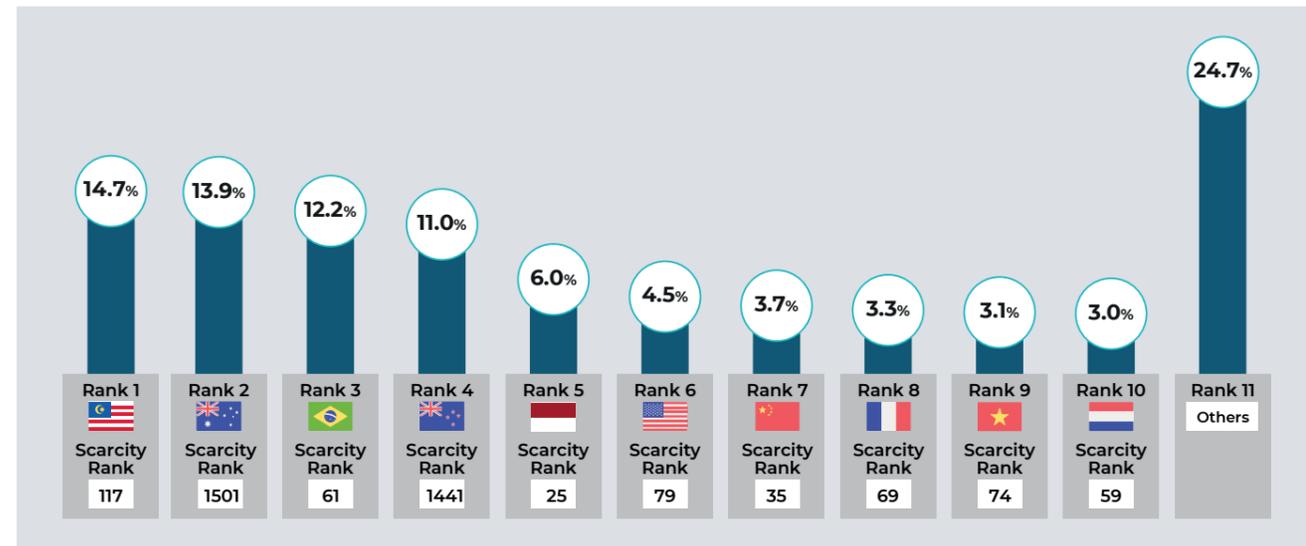


Figure 1A. Singapore animal imports by country, 2017<sup>25</sup>. Scarcity ranking from WWF’s Water Risk Filter<sup>38</sup>.

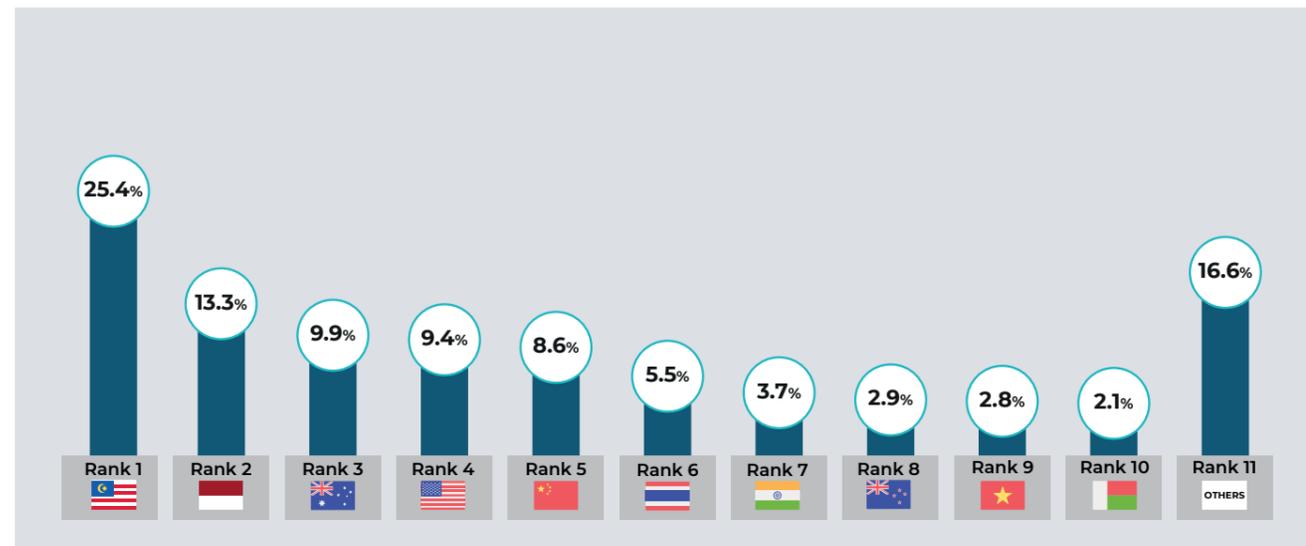
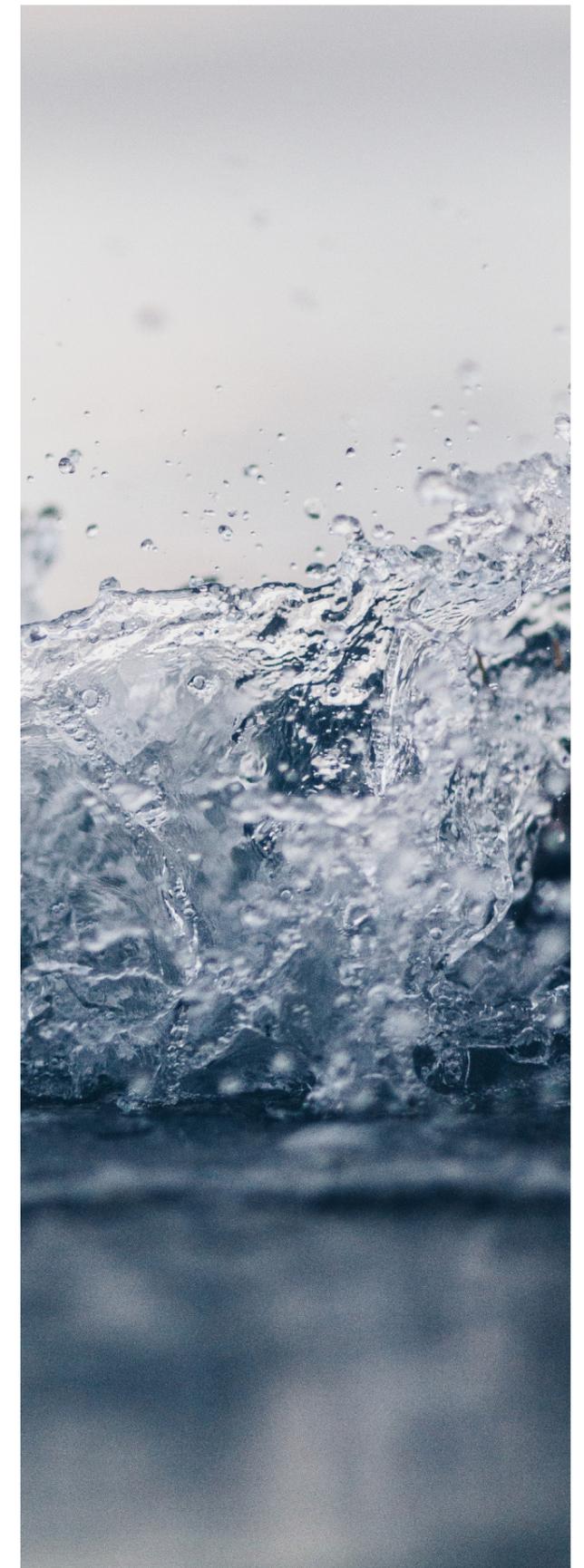


Figure 1B. Singapore vegetable imports by country, 2017<sup>25</sup>.

## 7. AIMS AND OBJECTIVES

Reflecting on the intricate linkages between food, water, environmental sustainability and the SDGs, this report aims to develop a quantitative understanding of the water footprint of food and beverages consumed in Singapore. By supplementing the literature gap in quantifying the true amount of water needed to support the food and beverage consumption habits of people in Singapore, it aspires to encourage more prudent decision-making in consumption and inform strategy implementation. To achieve these aims, the report strives towards the following objectives:

1. To assess the attitude that people in Singapore have towards water scarcity and water conservation.
2. To determine their extent of awareness of water footprint as a concept.
3. To quantify the weekly food and beverage water footprint of individuals in Singapore.
4. To outline the local and regional impacts of this water footprint.
5. To recommend strategies to encourage consumption practices with lower water footprint.



# 8. METHODS

To develop a water footprint database of the food and beverages that Singapore residents typically consume in a week, a five-minute quantitative survey was conducted over a span of three months (16 July 2018 to 15 October 2018) through face-to-face street interviews and online platforms. Two focus group discussions were conducted to collect qualitative data on water consumption habits of Singapore residents, their perceptions of local and regional water scarcity and their knowledge of water footprint as a concept. The first focus group discussion was conducted with eight WWF volunteers and interviewers who conducted the face-to-face interviews to understand their insights and observations in the field. The second focus group discussion was conducted with six respondents of the quantitative survey. Respondents were selected based on their level of awareness of water footprint as indicated in the survey.

To come up with a more accurate estimation of an individual's food and beverage water footprint in a typical week based on their consumption habits, the following factors were taken into account while assumptions made are detailed in **Appendix C**.

### Water footprint of beverages:

- Type and volume of beverages purchased and consumed
- Frequency of consumption
- Toppings added to the relevant drinks
- Container used (Mug/Disposable cup)



The formula for calculating the water footprint of beverages consumed in a week is shown in **Figure 2A**.

### Water footprint of beverages consumed (Up to 3 beverages/pax)



**Figure 2A.** Formula for calculating the water footprint of beverages consumed in a week.

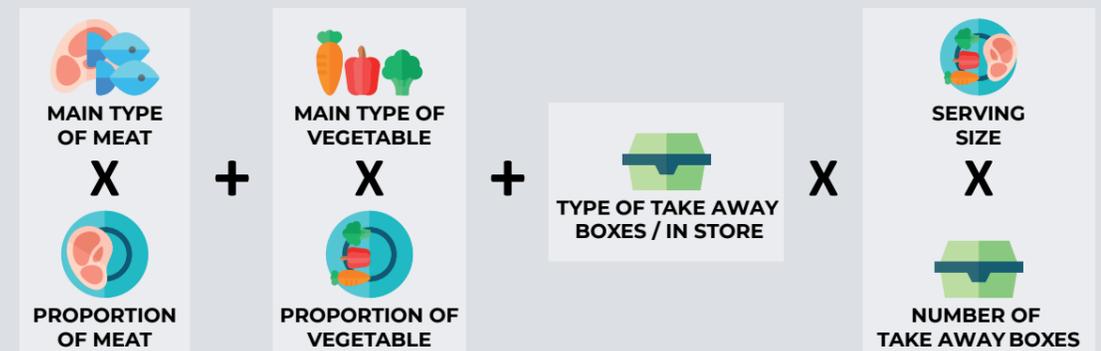
### Water footprint of food:

- Type and amount of meat and vegetables consumed
- The proportion of food categories (carbohydrates, meats and vegetables) consumed
- Container used in take-away

Serving sizes of meat and vegetables in a typical meal were estimated to be about 300 g and 150 g respectively while take-away boxes are gauged to be around 20 g. To ensure ease of understanding among respondents, polystyrene containers were referred to as 'styrofoam boxes' while polypropylene containers were referred to as 'plastic boxes'. The formula for calculating the water footprint of food consumed in a week is shown in **Figure 2B**.



### Water footprint of a meal consumed



**Figure 2B.** Formula for calculating the water footprint of food consumed in a week.

# 9. RESULTS AND DISCUSSION

Of the 5,644 responses garnered, face-to-face interviews and online surveys made up 84% and 16%, respectively. **Figure 3** provides information on the survey respondents' demographics.

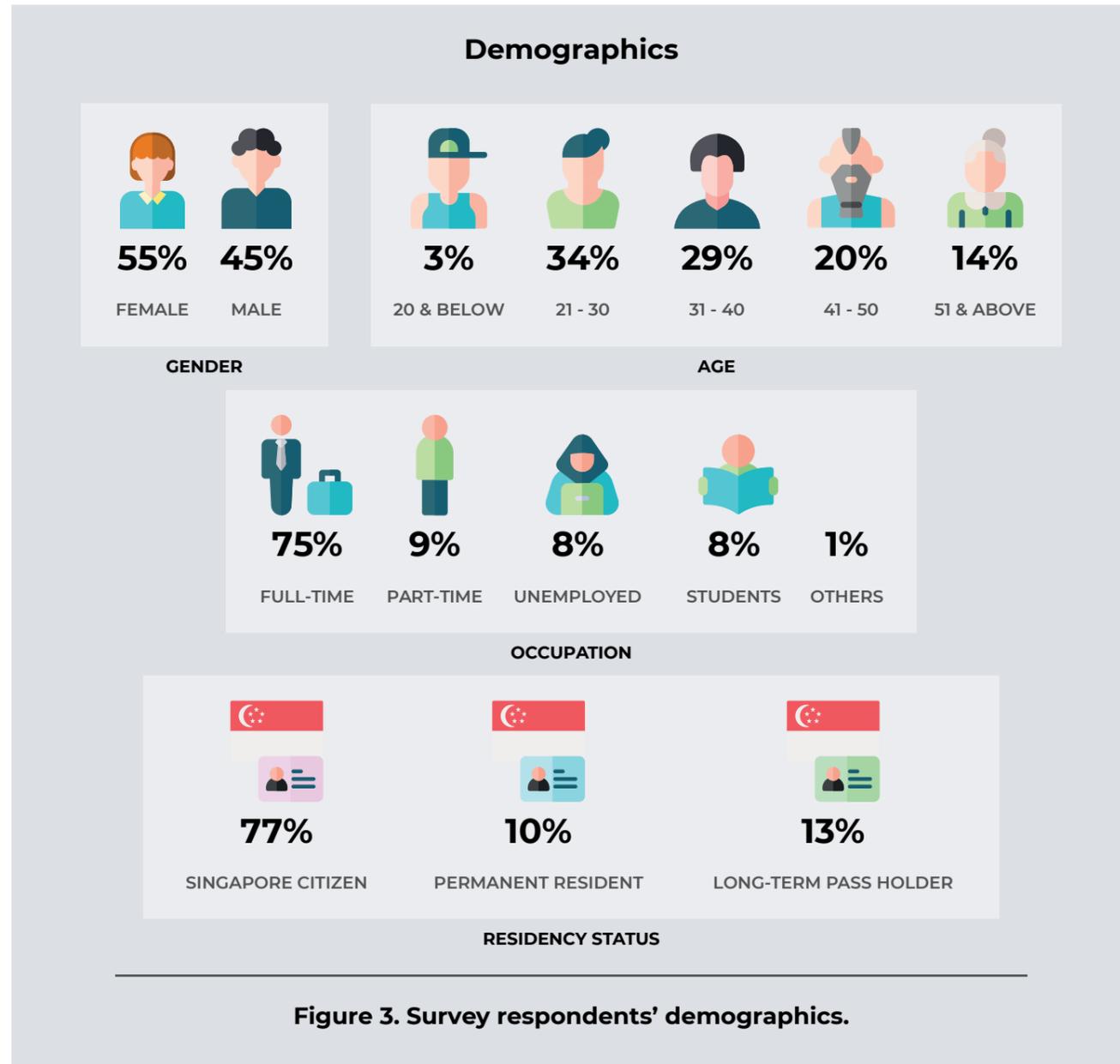


Figure 3. Survey respondents' demographics.

## A. ATTITUDES TOWARDS WATER CONSERVATION AND AWARENESS OF WATER FOOTPRINT

**Figure 4A** shows the attitudes of Singapore residents towards water conservation. The survey found that while an overwhelming majority of residents (99%) felt that water conservation is important, only about half (51%) saw water scarcity as a problem that Singapore currently faces. For at least 17%, water scarcity in Singapore appeared to be a distant concept. The results also indicate that the attitudes of residents towards water conservation behaviours were contingent on the general behaviour of society at-large, with 77% indicating that they will attempt to conserve water if others took the lead despite 89% agreeing on the need to be more active in conserving water.

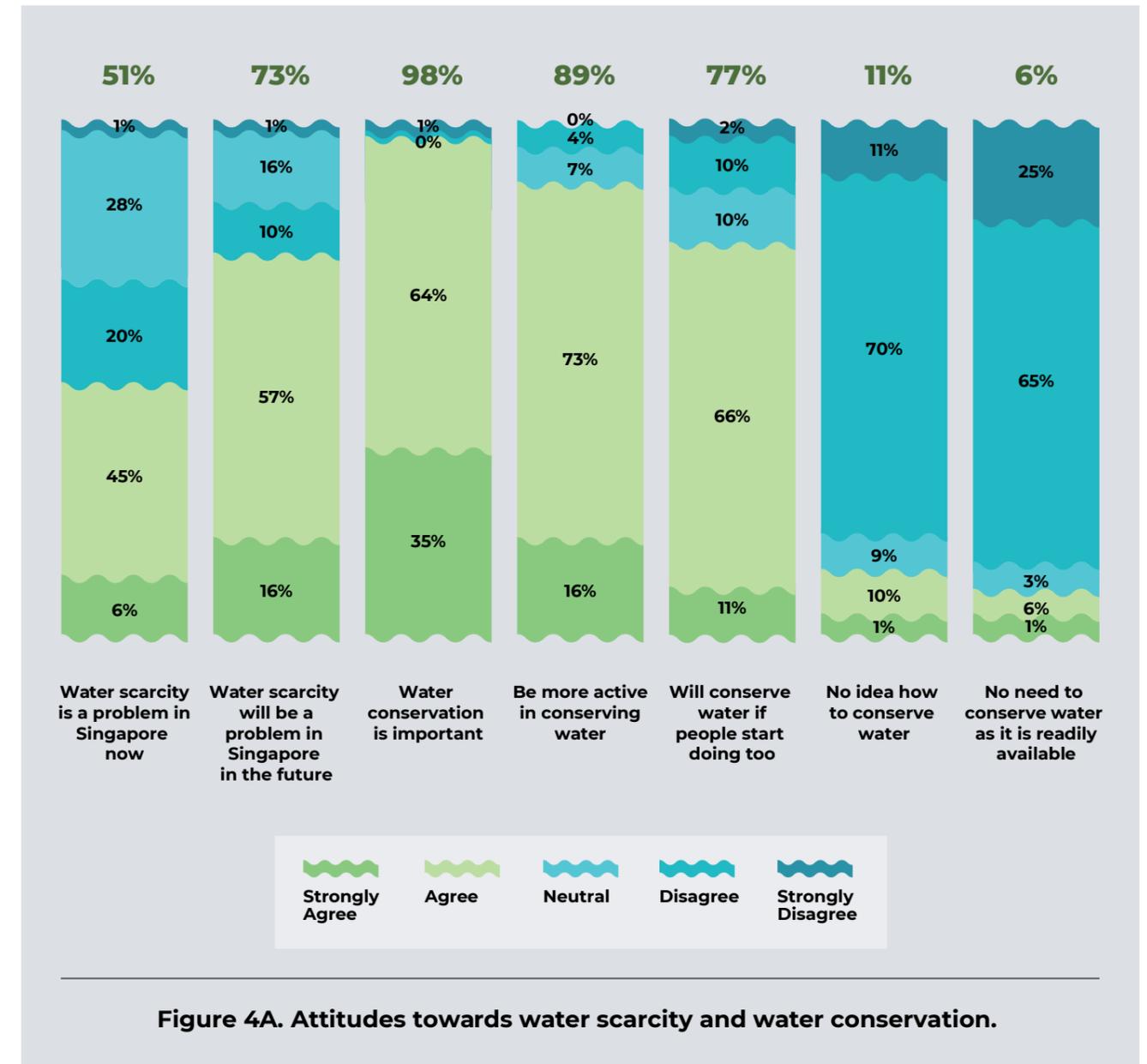


Figure 4A. Attitudes towards water scarcity and water conservation.

Singapore’s small size relative to other countries portrays the country as having little or no impact on a global resource such as water. Hence, there is a tendency for people in Singapore to feel detached from the responsibility of water conservation and the reduction of their water footprint. For example, participants from the focus group discussion made the following comments:



*Is there really a need to conserve water? Singapore has such a low impact globally. If the other countries are not doing anything about it, then why do we need to (do it)?*

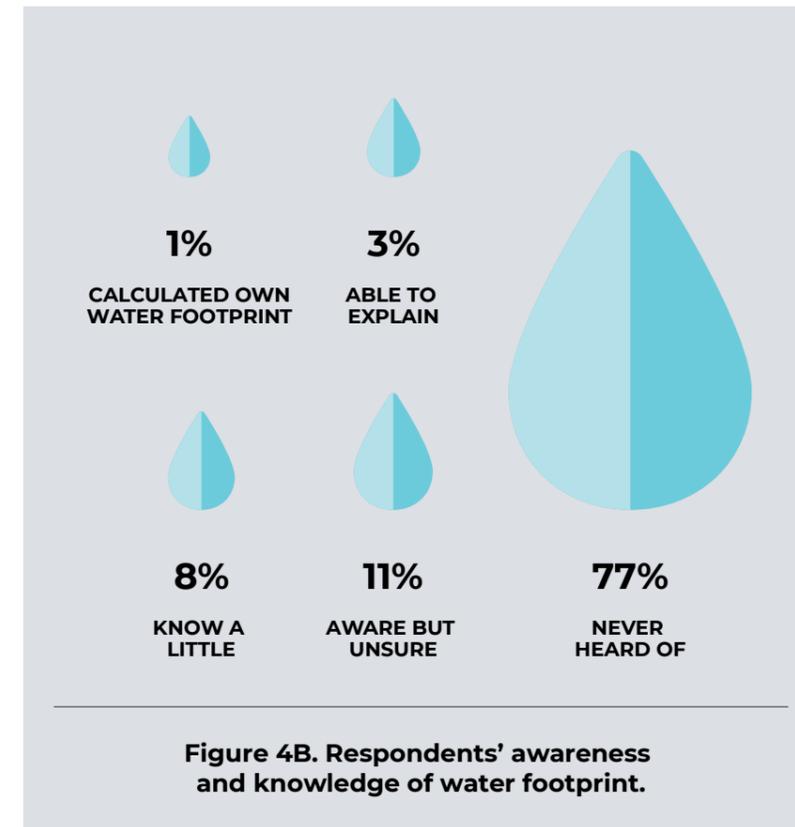
- Participant 1



*A lot of government campaigns are not (for water) ‘beyond the tap’, but are (for water) ‘from the tap’. For them to reach beyond the tap, I think (the responsibility) is not on us. So the government should reach out to the manufacturers to reduce the water footprint. Anyway we buy from the manufacturers, so indirectly, we are reducing the water footprint if the manufacturers reduce the water footprint.*

- Participant 2

The lack of urgency towards water conservation could have stemmed from the success that Singapore has had in catchment management, diversifying its water supply and being a forerunner in the innovation and adoption of water purification and efficiency technologies. While the effectiveness of these strategies has provided people with a high level of confidence in the ability of the government to ensure reliable water supply, they run the risk of rendering the reality of water scarcity on a local, regional and global scale invisible and may reduce stimulus for individuals to modify their water consumption habits.



**Figure 4B. Respondents’ awareness and knowledge of water footprint.**

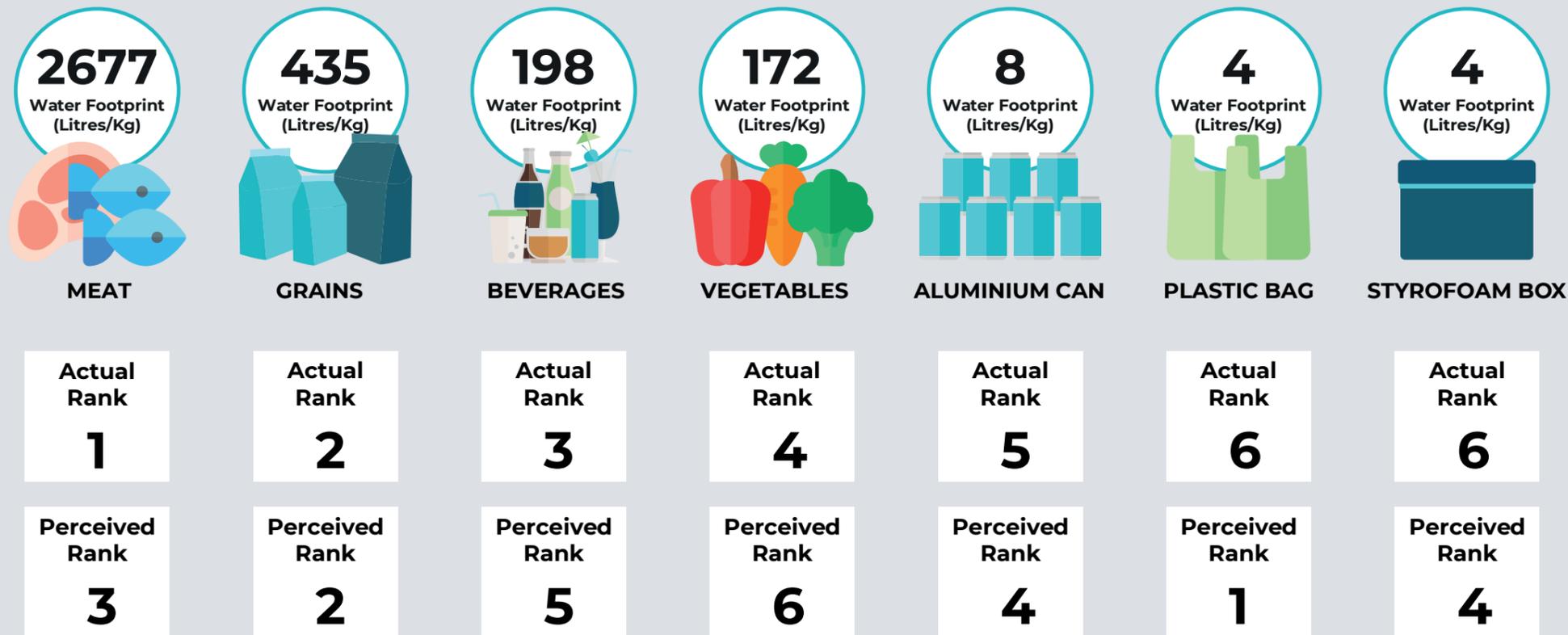
There is an important distinction between water abstraction (water drawn from the tap in the case of Singapore) and water consumption (consumptive water use). While most respondents understood the importance of water conservation, their knowledge was largely limited to that surrounding water abstraction. Conversely, the study found that the awareness and knowledge of overall water consumption, or water footprint as a concept, is low among residents. 88% of the respondents had little or no knowledge of the concept while only 4% felt that they were able to explain or calculate their water footprint (Figure 4B). Of the 12% who indicated having some knowledge of water footprint, few had good understanding of the relative water footprint of various products (Figure 5 and 6). Despite plastic bags having a smaller water footprint relative to meat and grains, it was commonly thought of as having the largest water footprint. Similarly, although vegetables and beverages have a far larger water footprint than aluminium cans and styrofoam boxes, both were perceived to have smaller water footprints.

In Singapore, water conservation education has the goal of engaging the people–public–private (3P) sectors to use water wisely. Community-driven public education programmes include the '10-Litre Challenge' that encourages individuals to reduce their daily water consumption by 10 litres through practices such as limiting showers to five minutes<sup>39</sup>. Strong emphasis is also placed on educating future generations on issues relating to water and the environment through both the school curriculum and non-formal education programmes offered by the Public Utility Board (PUB)<sup>40</sup>. For example, the Ministry of Education has included the topic of water conservation in the Social Studies syllabus for Primary 3 students and in the Lower Secondary Geography

curriculum. Sub-topics include content on global water shortage and the effectiveness and sustainability of various solutions. By providing people with the knowledge of water-conservation behaviours, the PUB hopes to tap into the collective strength of the people to reduce water demand. While these educational strategies have contributed to the gradual decrease in the domestic consumption of water from 165 litres per person per day (pp/day) in 2003 to 143 litres pp/day in 2017<sup>41</sup>, it does little to help Singapore residents understand that water scarcity is an issue that has a local footprint and global reach. This is compounded by the lack of awareness of the concept of water footprint.



*Few people in Singapore are aware of the Water Footprint concept. Many perceive Singapore to have little or no impact on global freshwater resources due to the country's small physical size.*



However, results from the study suggest that it may be difficult for people in Singapore to take concerted action to lower their water footprint, even if measures are put in place to raise awareness. The results indicate that having awareness of an environmental problem may not translate to action to address the problem (Figure 7). More than half of those who felt that plastic bags had the largest water footprint indicated their use of plastic boxes in food takeaways. Likewise, a perception or awareness of the relative water footprint of meat and store-bought beverages was not always found to translate to behaviour to reduce water footprint. Among those who perceived meat to have a large water footprint, 39% indicated their tendency to reduce their consumption of meat. About half of those who felt that store-bought beverages had a large water footprint expressed their attempts to minimise purchasing such beverages.

Figure 5. Actual and perceived size of the water footprint of various products.

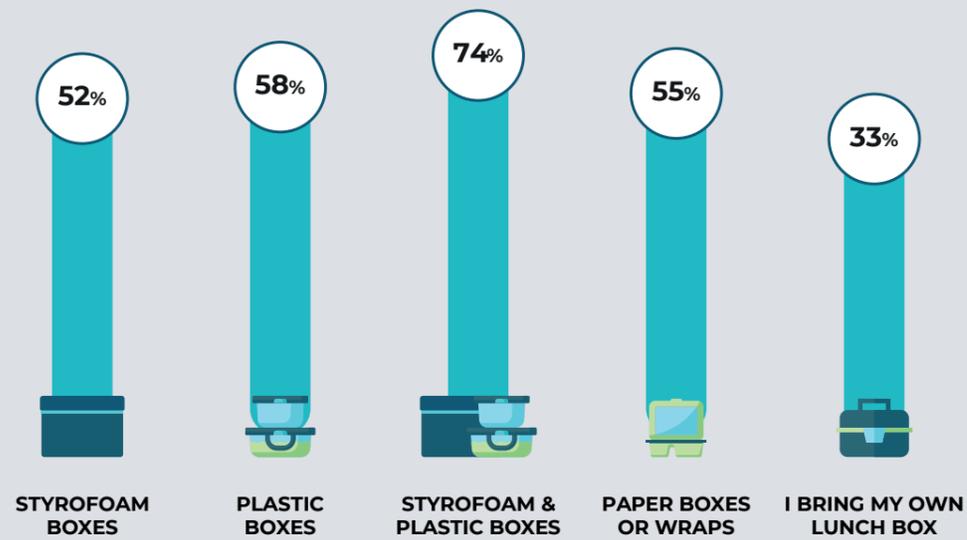


Figure 6. Type of takeaway packaging used by respondents who felt that plastic bags had the largest water footprint.

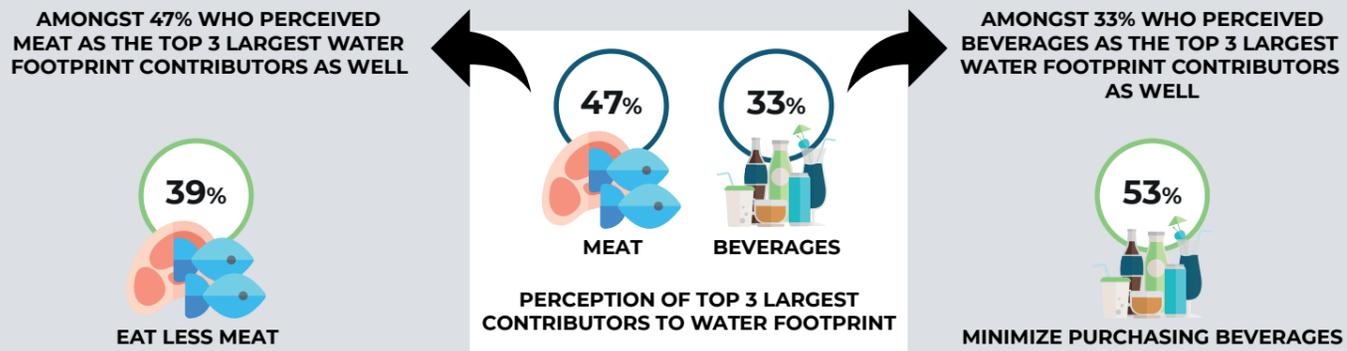


Figure 7. Actions taken by respondents who perceive meat or beverages to be the largest contributors to water footprint.

The imparting of information about environmental issues does not naturally correlate with changes in attitude as individuals may not believe that their actions are sufficient to make a difference<sup>42</sup>. For example, a study on food security and environmental impacts of Singapore’s pork supply found that Singapore consumers are “relatively less concerned about (environmental and animal welfare) issues” when making purchasing decisions due to their lack of awareness of such issues as Singapore “is not a country where agriculture plays a big part in the economy”<sup>43</sup>. Hence, Singapore’s small size and relatively small overall water footprint may cause people to perceive their contribution as individuals as negligible and consequently, reject culpability for environmental problems elsewhere.

## B. WATER FOOTPRINT OF FOOD AND BEVERAGES CONSUMED IN SINGAPORE

The typical water footprint of the average male and female resident in Singapore is shown in **Figure 8**. The beverage and food water footprints for men were approximately 53% and 19% higher respectively than that for women. Across the age groups, those aged 51 and above had the largest beverage water footprint (1,640 litres/week) but the smallest food water footprint (11,323 litres/week). Those between 21 and 30 years of age had the largest food water footprint (21,660 litres/week). On average, the respondents had a weekly beverage and food water footprint of 1,312 litres and 19,586 litres respectively.

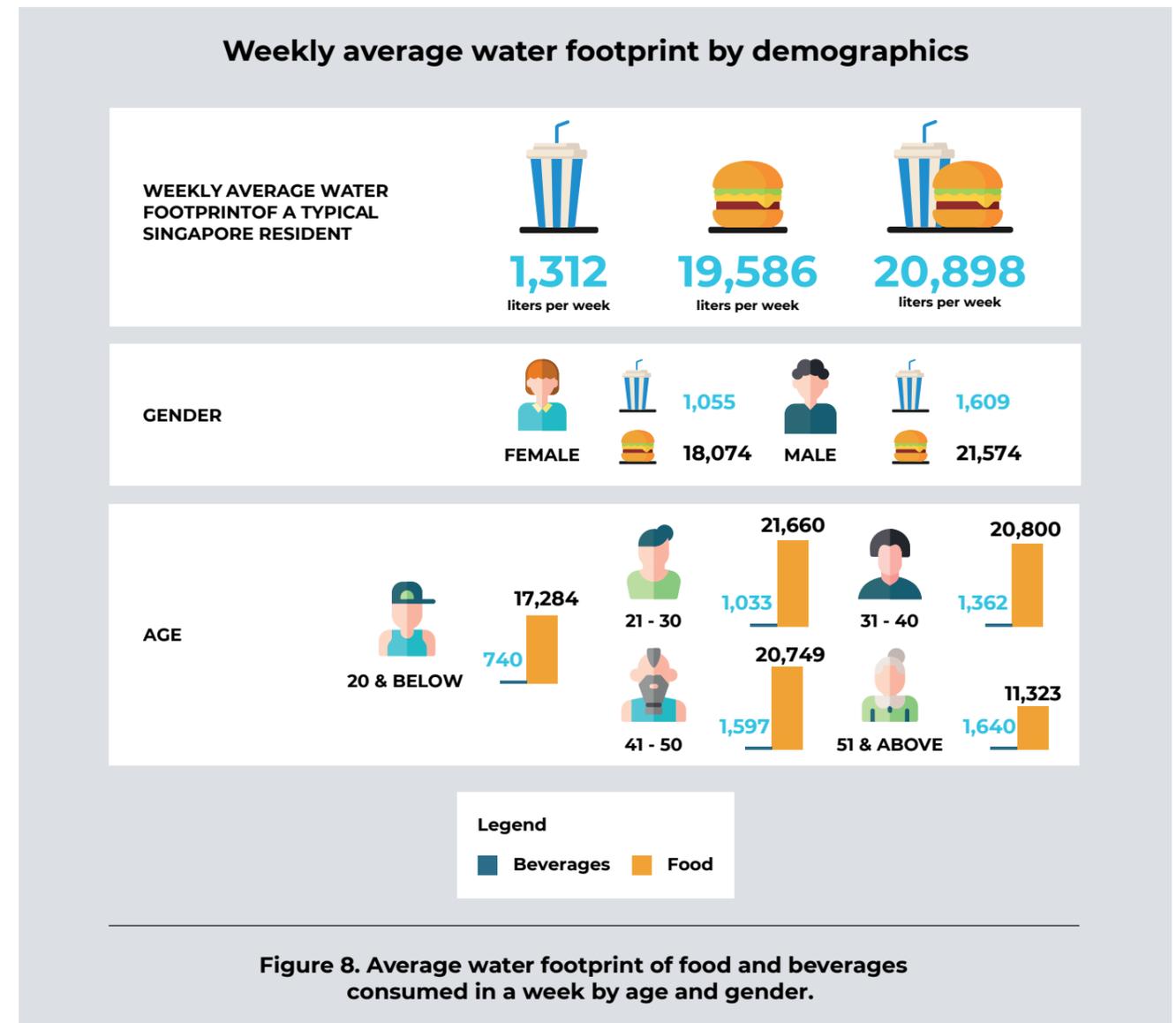
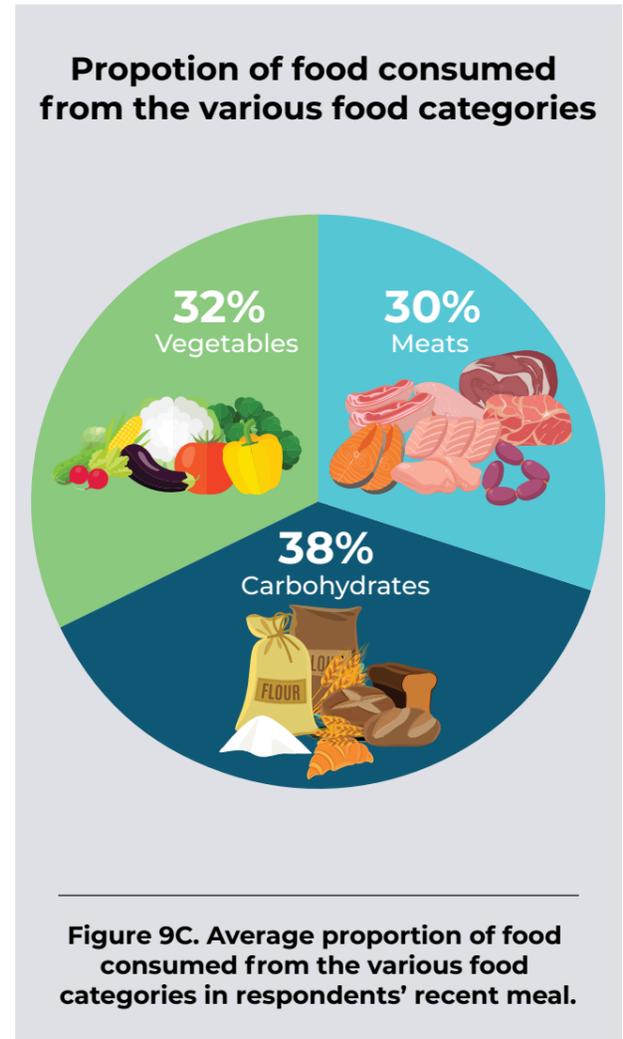
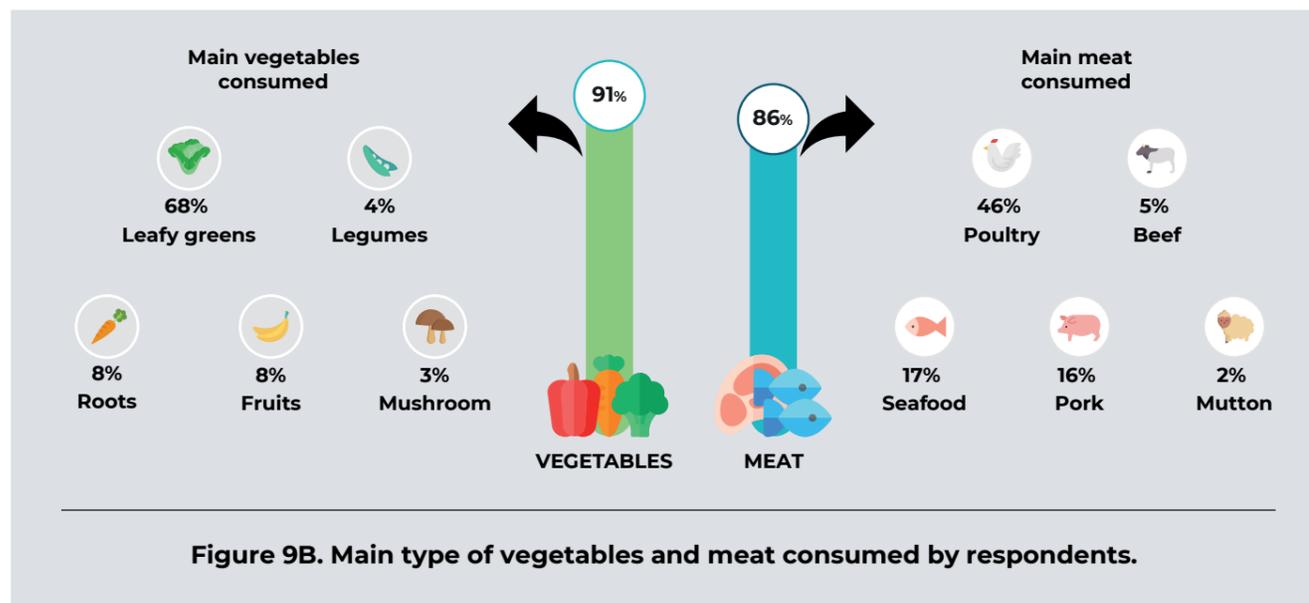
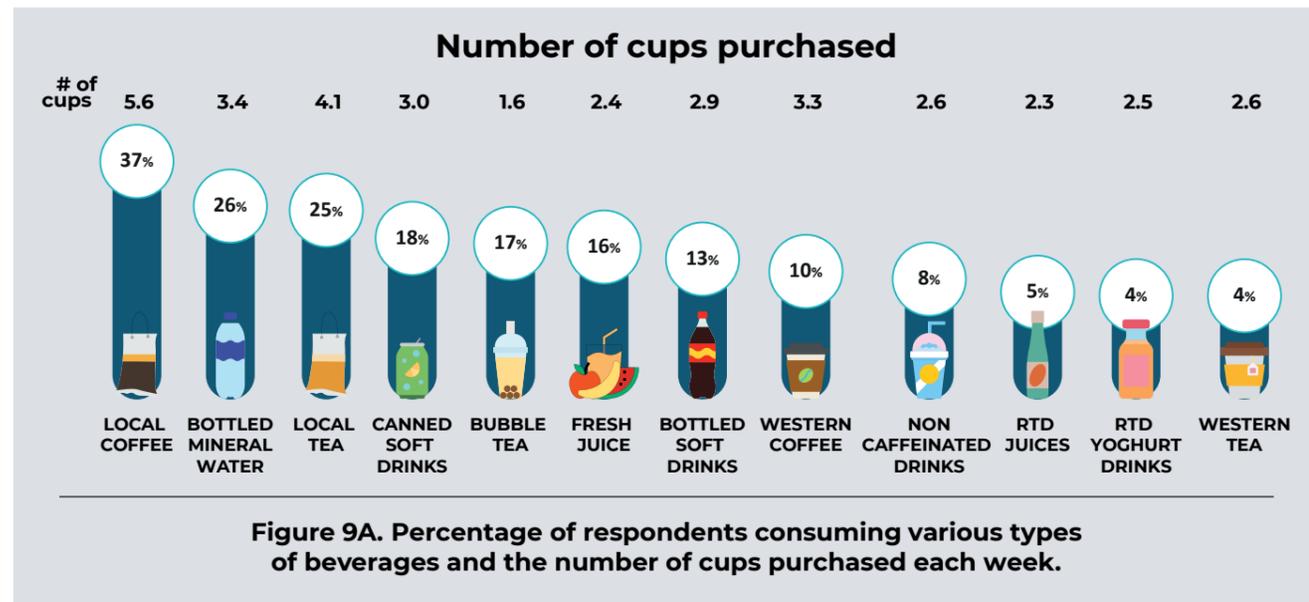


Figure 8. Average water footprint of food and beverages consumed in a week by age and gender.

An analysis of the types of beverage and food consumed (Figures 9A, 9B and 9C) helped to shed light on the contributors to the average water footprint of individuals in Singapore. In addition to being the most widely-consumed beverage (37%), local coffee was also the most-frequently purchased (5.6 cups/week). Bottled mineral water and local tea were the next most widely-consumed (26% and 25%, respectively) and most-frequently purchased (3.4 and 4.1 cups/week,

respectively). Among vegetables, leafy greens were most widely-consumed (68%). Poultry was the most widely-consumed meat (46%) while beef and mutton were the least widely-consumed (5% and 2%, respectively). About a third (36%) of the respondents indicated consuming less than the typical serving portion and 4% had a tendency to not finish their beverages, indicating the possibility of food wastage.



The results are a clear demonstration that the average domestic water withdrawal of 143 litres pp/day in Singapore represents a minor fraction of an individual's total water footprint. Although poultry has the smallest water footprint among the various meats by weight (4,325 litres/kg), its prominent feature in the diets of many people in Singapore amplifies its overall contribution to the country's water footprint. More importantly, the relatively low proportion of beef consumed should not be taken to represent a low or insignificant overall water footprint. With a large water footprint of 15,415 litres/kg, the total water footprint of a beef consumption level of 5% in the population could represent a similar water footprint to a pork consumption level of 16%. The consumption of animal products has a large water footprint due to the water needed for drinking (blue water footprint), to produce feed (green and blue water footprint) and to maintain cleanliness of production areas (grey water footprint). This is especially so for meat produced in industrial systems. Unlike in grazing systems where a large proportion of feed is provided by green water from pastures, industrial systems have a higher blue water footprint as irrigation water is needed to grow feed<sup>15</sup>. Hence, meat produced in regions with surface freshwater scarcity may place additional stress on local water resources.

To move towards a food system that produces nutritious food with as low a water footprint as possible, the intake of food from the vegetables and fruit product groups should increase. For example, leafy vegetables, consumed by 68% of the respondents in a typical meal, have a water footprint of 322 litres/kg. Of this category, crops like spinach and lettuce stand out for their high nutrient density relative to their water footprint<sup>13</sup>. However, when considering a shift to a diet with a larger proportion of vegetables, it is important to consider the different components of water footprint that are associated with specific crops. For example, greenhouse crops like tomatoes tend to require large amounts of pesticides to maintain their quality<sup>44</sup>. This may increase the grey water footprint to reduce the occurrence of water pollution.

Beyond the visible water used in the production of beverages, water used in the production of ingredients such as sugar, cocoa and caffeine can drive up the overall water footprint of the product<sup>45</sup>. For example, as one of the main water-consuming ingredients in beverages, sugar requires an average of 142 litres/litre<sup>45</sup>. Depending on the source, this figure can go as high as 334 litres/litre. Other ingredients with a high water footprint include caffeine (106 litres/litre) and vanilla extract (160 litres/litre). In addition to blue water needed to grow the specific crops, these ingredients tend to have a large grey water footprint as fertilisers and pesticides used can contaminate natural freshwater sources. Hence, the consumption of the greatest number of cups of caffeinated drinks by those above 51 years of age (Figure 10) could have contributed to this group having the largest water footprint.

From both an environmental and public health perspective, the trends in food and beverage consumption in Singapore show large potential for a shift towards a more sustainable and healthy diet. As the study found that meat comprises approximately 30% of an individual's meal, reducing meat consumption holds large potential for reducing water footprint. Although respondents who indicated having an their awareness of the large water footprint of meat products stated that they would opt to consume more seafood, such a modification may not necessarily bring about positive environmental impacts as a shift from terrestrial systems to aquatic and marine systems could exacerbate the situation in another already stressed ecosystems<sup>46</sup>.

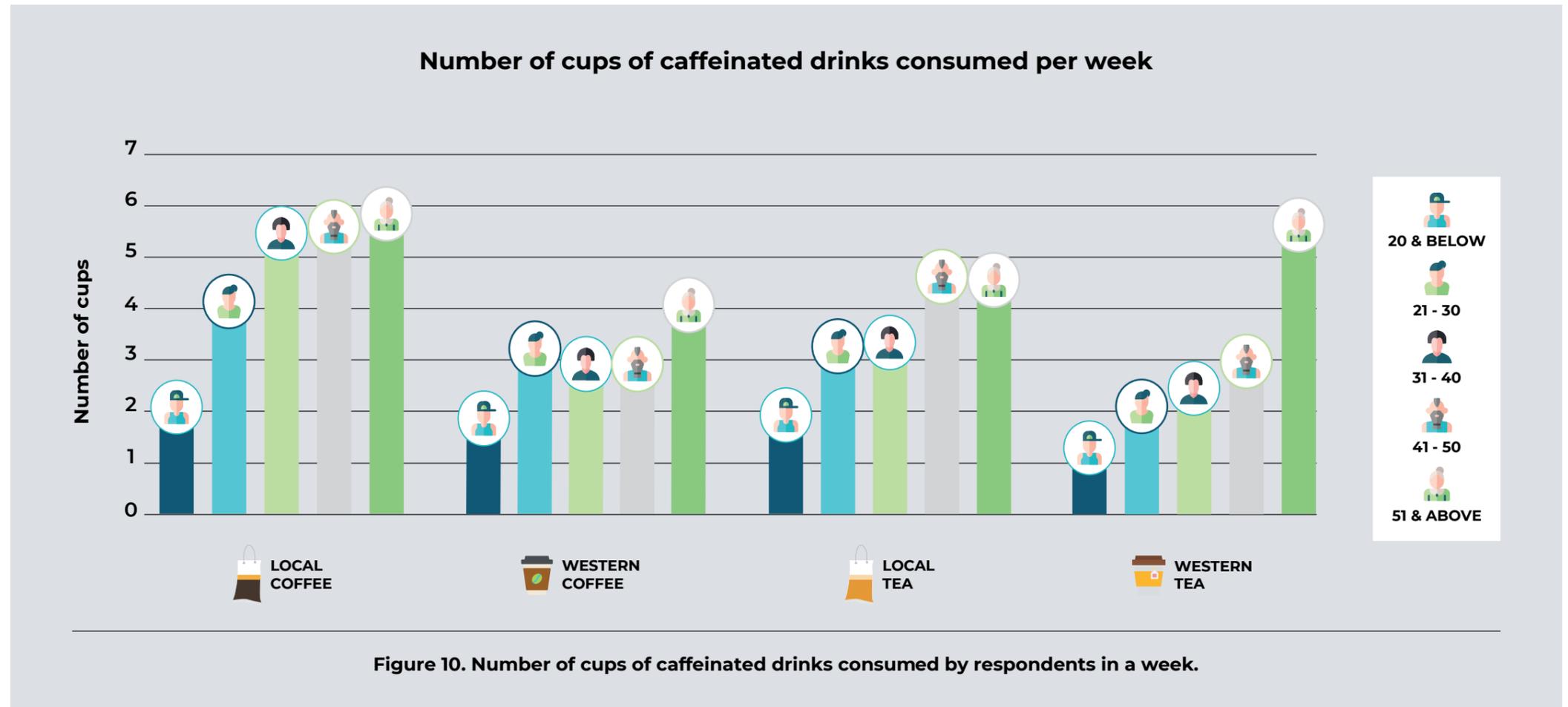


Figure 10. Number of cups of caffeinated drinks consumed by respondents in a week.



Following the guidelines of the ‘planetary health diet’, the current local consumption of fruits and vegetables should be increased from 32% of a meal to 50% while the consumption of meat<sup>55</sup> and drinks with high sugar content should be reduced by over 50%<sup>1</sup>. The findings suggest that the largest potential for this reduction lies with those below the age of 30. The larger food water footprint among those in this age group is indicative of the consumption of a higher-calorie diet and/or one with more meat. Respondents

from 21-30 age group were also the least likely to make a conscious decision to consume less meat (Figure 11A) and consumed a larger proportion of meat relative to the other food groups in their most recent meal (Figure 11B). In addition to reducing water demands on the environment, a reduction in the consumption of drinks with high sugar content will also benefit individuals’ health as such diets are linked to health problems such as diabetes and heart disease.

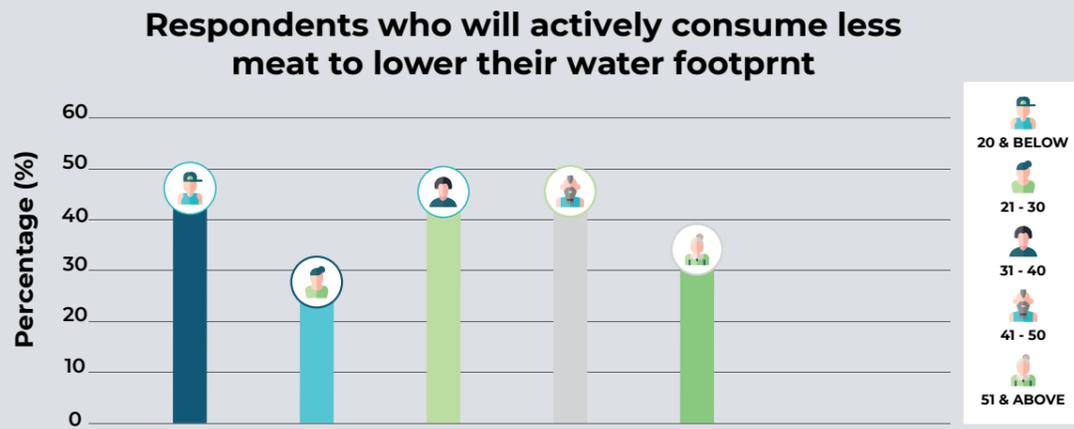


Figure 11A. Percentage of respondents who will actively consume less meat to lower their water footprint.

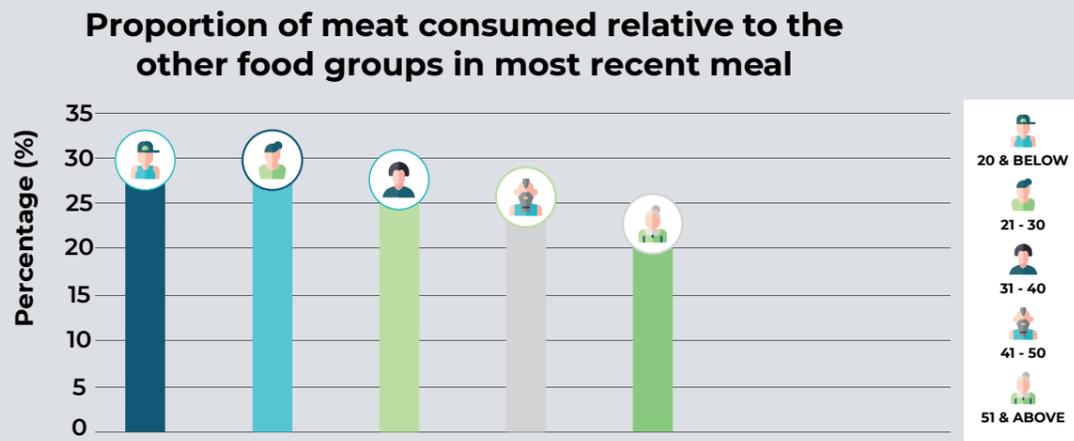


Figure 11B. Proportion of meat consumed relative to the other food groups in respondents’ most recent meal.

Finally, the reduction of food waste would also help to lower the food and beverage water footprint of Singapore. Wasting food means wasting all the resources it took to produce that food. While it was not possible to quantify the amount of food wasted, the results indicate a possibility of this trend in Singapore. This is line with the findings from the National Environment Agency (NEA), which estimated that Singapore generated approximately 763,100 tonnes of food waste, or about 140 kg per capita<sup>47</sup>. The impacts on blue water brought about by the wastage of food, especially cereal, fruit and meat, represent an opportunity cost for the livelihoods of locals and the improvement of global food security, as well as negative externalities for biodiversity<sup>48</sup>. Hence, a reduction in food waste in Singapore would help to reduce pressure on scarce natural resources such as water and minimise the need to increase food production in the region and beyond in order to meet the population’s growing food demand.

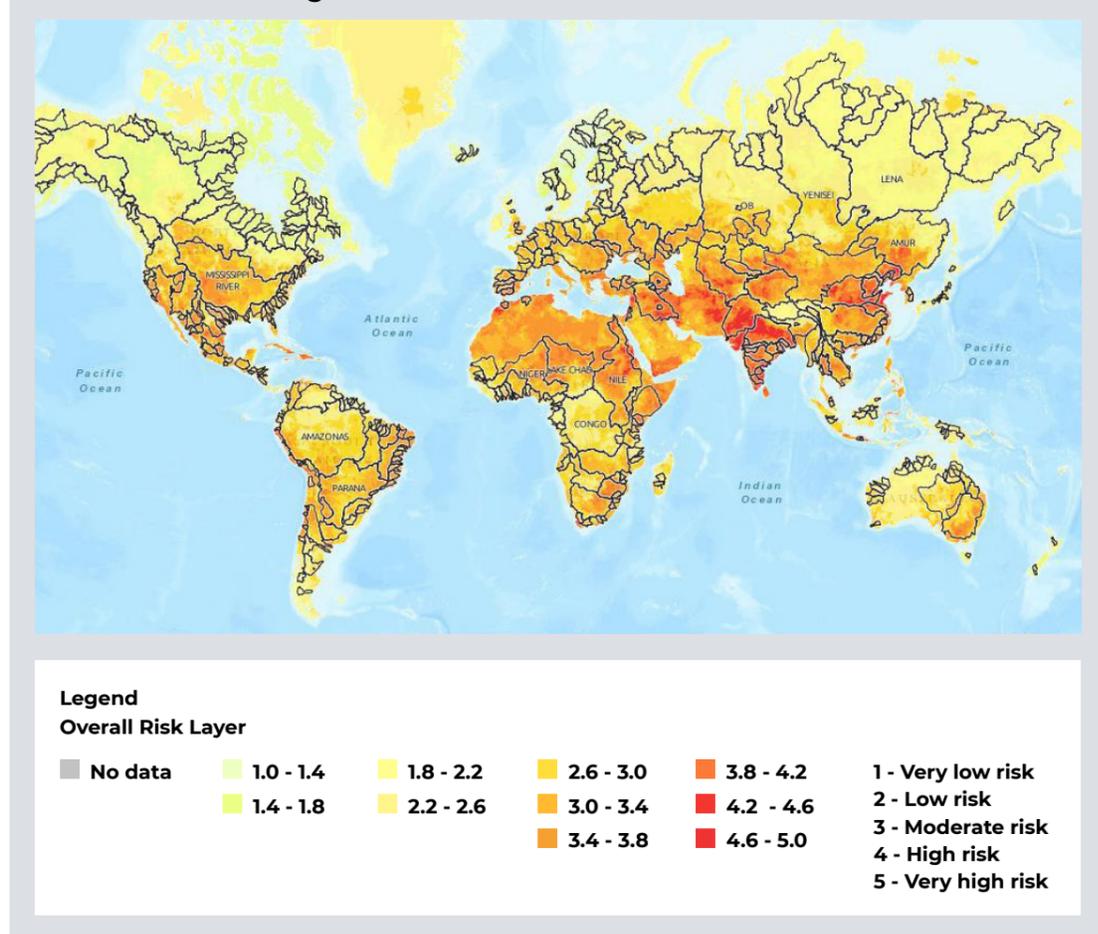


*Following the guidelines of the ‘planetary health diet’, the current local consumption of fruits and vegetables should be increased from 32% of a meal to 50% while the consumption of sugar and meat should be lowered by over 50%.*

### C. LOCAL AND REGIONAL IMPACT OF SINGAPORE'S FOOD AND BEVERAGE WATER FOOTPRINT

Water-intensive agriculture production processes bring about impacts on the water systems at the various locations where production takes place. The impacts vary from reduced water flows, the lowering of groundwater tables, pollution of freshwater bodies and increased salt intrusion in coastal areas<sup>49</sup>. Therefore, food consumption in Singapore has the potential to contribute to water scarcity in other countries, especially when sourced from areas experiencing high water stress. Often, the geographical distribution of food production and its impacts are uneven. For example, Cameron Highlands' farms supply over half of Malaysia's vegetable needs, of which a large proportion is exported to Singapore. In Cameron Highlands, expansion and intensification of farming has resulted in streams being polluted with sediment from soil erosion, manure-enriched runoff and agrochemicals<sup>50</sup>. Pollution from pesticides tends to occur as farmers use more pesticides, sometimes in excess of the maximum residue limits (MRL) established by the European Union, to maintain the quality of leafy vegetables such as lettuce, mustard, spinach and cabbage under tropical conditions<sup>51</sup>. Stream discharge has also been reported to become more erratic, with higher peak and reduced low flows<sup>50</sup>. These changes have serious implications on padi rice irrigation in lowland areas and downstream fisheries and domestic water quality and supply. In 2016, a dry spell resulted in a 20% decline in vegetable output from Cameron Highlands<sup>52</sup>. Adverse weather conditions have on multiple occasions cause vegetable prices in Singapore to rise by as much as 20%<sup>53</sup>.

Figure 12A. Overall water risk of countries.

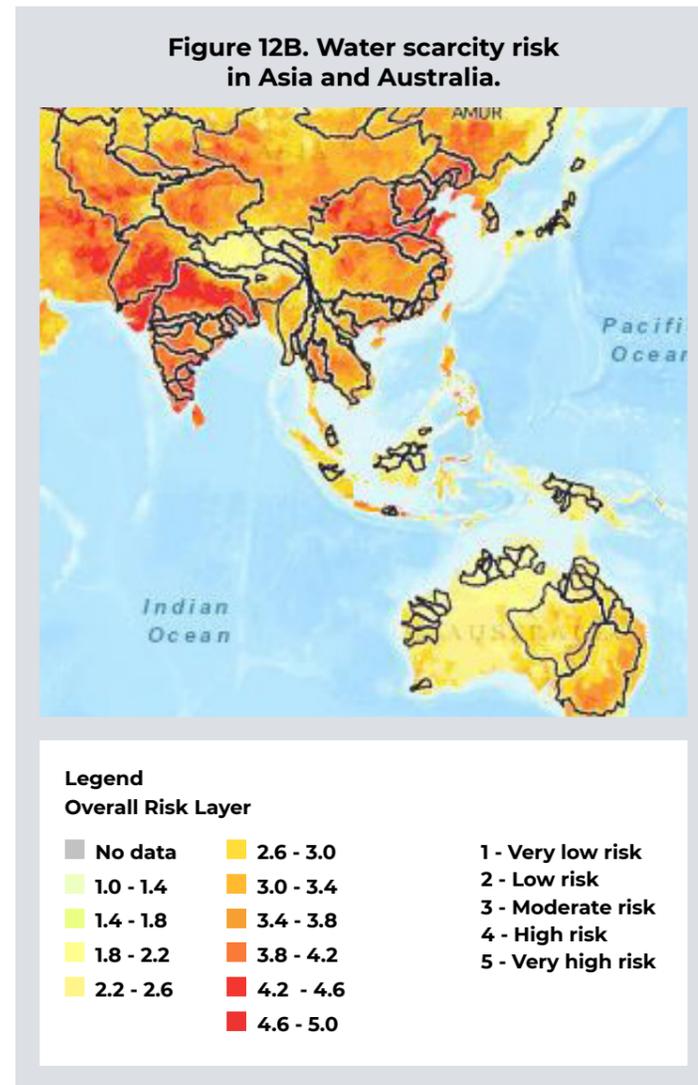


With Malaysian climate change projections being characterised by higher temperature and less predictable rainfall patterns<sup>54</sup>, increasing demand for water-intensive agriculture will increase stress on local water resources. Although Malaysia is Singapore's main source of meat and vegetables, Singapore's diversification strategy ensures that the country's food is also imported from alternate locations including Thailand, China and Indonesia. Nevertheless, with climate-change induced periodic water stress in the region increasing in frequency and extent, pressure to keep food production in sync with demand will inadvertently worsen situations of water stress and compromise the standards of living of already economically-marginalised populations. **Figure 12A** shows the overall water risk of countries. The red and orange areas identified in the map are hotspots with moderate to severe water scarcity. It is without doubt that agriculture has the largest burden on water resources in major rice-producing countries. In line with being the largest exporters of rice to the world, Thailand and Vietnam are major sources of rice for Singapore, supplying about half of the rice consumed here. In Thailand, major rice, or rice grown during the wet season, is classified as having the highest water deprivation among other locally-grown crops, suggesting the large impact it has on local water resources<sup>55</sup>.



In 2015, the Northeastern region where the largest major rice plantation areas are found bore the brunt of the worst drought Thailand faced in 15 years<sup>56</sup>. Similar situations have also been observed in Vietnam. The Mekong Delta suffered from its worst drought in nearly a century in 2016, resulting in nearly half of the delta's arable land being affected by salinization due to freshwater scarcity<sup>57</sup>. With dry spells coming earlier and ending later, local farmers in Central Vietnam have already stopped the production of at least one harvest a year<sup>58</sup>. With only an estimated 58.3% in the Vietnam Mekong Delta having access to improved water and sanitation, strong competition for freshwater by agriculture will serve to hamper the region's progress to achieve the SDGs by 2030<sup>59</sup>.

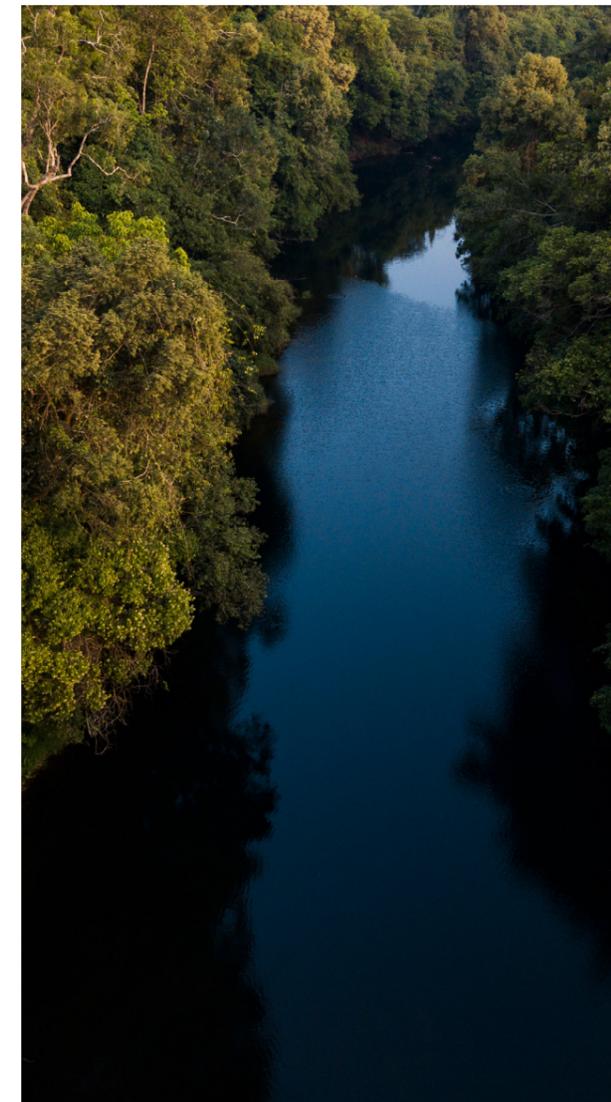
The poultry and pig meat sector are the largest livestock sub-sectors in the world, with outputs of 121 and 119 million tonnes respectively in 2016<sup>60</sup>. As the red meat of choice for many Singapore residents, about 117,000 tonnes of pork were imported in 2016<sup>61</sup>. An increase in pork production, when paired with the geographical concentration of farms, can contribute to local water pollution from excessive manure. For example, a study found strong correlation between livestock density and nitrogen surplus per hectare<sup>62</sup>. Such impacts prompted a complete ban of pig farming in Singapore in 1985. However, this resulted in the shifting of the environmental impacts of producing pork from Singapore to foreign soil, to countries such as Brazil, the Netherlands, Spain, Australia and Indonesia<sup>43</sup>. The largest single source of pork to Singapore is Indonesia, making up 17% of the country's total pork import<sup>61</sup>. As a key export market, Singapore's import of fresh/chilled pork from Australia makes up more than 50% of Australia's total pork export<sup>43</sup>. The water consumption needs of livestock in these areas may thus impact the supply of blue water, especially during dry periods, and increase the requirements of grey water needed to mitigate water pollution.



As both Indonesia and Australia have been identified as regions with a water scarcity risk (Figure 12B), Singapore's external water footprint in meat production may place these countries at the forefront of the repercussions of climate change. In addition to affecting the production of crops needed for animal feed, drier conditions in Australia may also subject the pigs to diseases and/or make it more challenging to maintain a hygienic production environment. Although some of Singapore's other meat-import partners like New Zealand have relatively low annual water stress on average, farmers in many regions in the country have experienced limited water availability during summers with low rainfall due to water restrictions or reduced stream flows or groundwater levels<sup>63</sup>. Hence, episodes of water-scarcity, no matter how frequent or severe, may amplify the negative externalities of Singapore's food consumption.

## D. TRANSLATING RHETORIC INTO ACTION

To reduce water footprint, the most obvious strategy would be to encourage consumers to shift their consumption patterns to those that require less water, such as by reducing their consumption of meat. However, the time scale involved in seeing sustained changes in habits and mindsets may reduce the feasibility of this strategy. Instead, a larger difference can be made by involving every sector of society, from governments to individuals.

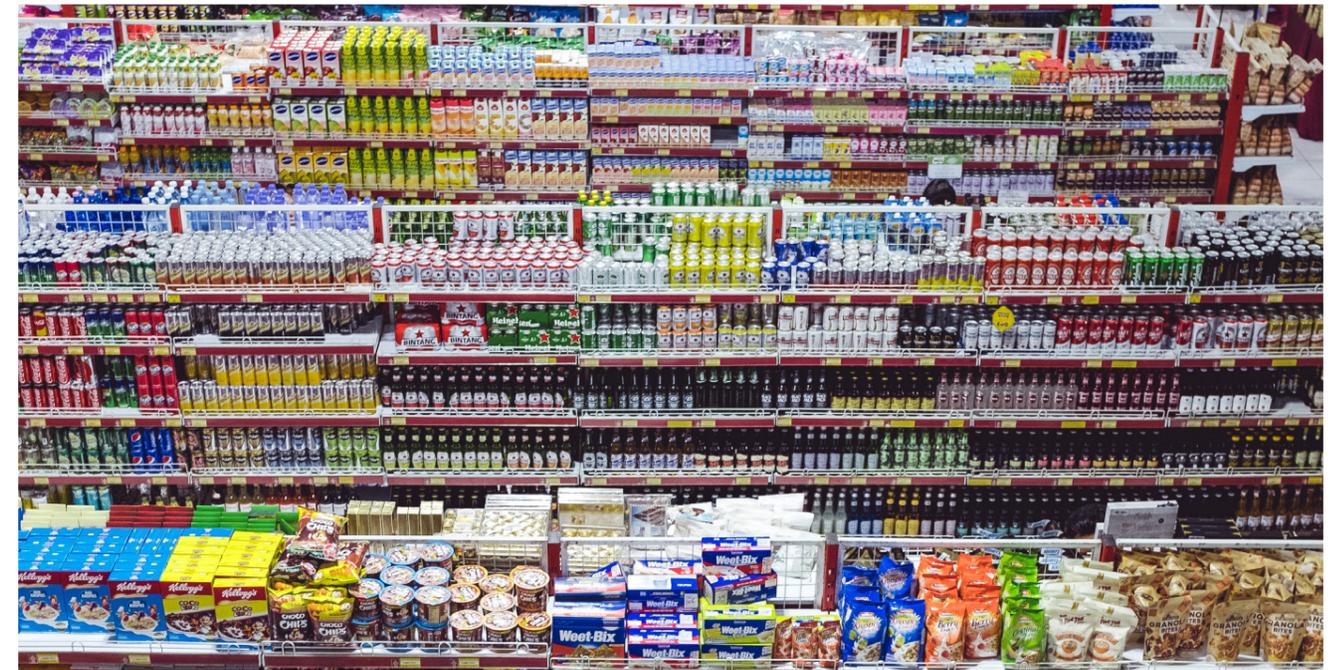


### Government

- In addition to the current content on water resources in the local school curriculum, the concept of water footprint can be included to inculcate a sense of awareness and responsibility in the young generation.
- At the school and community level, there is a need for the continuous expansion of Singaporeans' understanding of their water footprint, their food dependency upon regional food-sheds, and their global responsibilities.
- To encourage the consumption of locally-produced food to reduce dependence and impact on other countries, more land in Singapore can be allocated for the setting up of community gardens.
- To tackle the food waste problem, national agencies such as the NEA can work together with food manufacturers, retailers, hawkers and hotel operators to identify areas of waste in the supply chain and propose strategies to reduce wastage from the source.
- The government leads the way in transforming the agriculture sector to produce more with less resources. This can be done through the provision of funding and supporting the local agriculture sector to increase yield (ensuring resource efficiency) while also ensuring rivers and wetlands have sufficient allocations from the savings gained.

## Businesses

- To encourage a gradual shift in consumption patterns, pricing can be used to reflect the social and environmental costs of products.
- Labelling should include information on the water footprint of the product.
- Brands and retailers should consider the water footprint of raw materials in their decision-making and evaluate the efficiency and effectiveness of water use during the production processes. To better understand the water risks in their own value chains, they can use tools like WWF's Water Risk Filter.
- "Corporate water accountability" should be encouraged in the form of the provision of statements with the records of the volumes of water used in their supply chain and production processes.
- Investors and financial institutions can nudge companies towards sustainability by encouraging them to rank water risk and good water stewardship higher on their corporate agendas. They can also begin to recognise water as an opportunity to create profitable solutions through initiatives like WWF's Bankable Water Solutions to identify viable projects to safeguard and sustain freshwater ecosystems.



## Individuals

- Individuals can drive change for better water resource management by being more aware of the water 'embedded' in the products consumed on every day and by asking questions about sourcing and production.
- Individuals should reduce their consumption of sugar and red meat, especially if it comes from industrial rather than grazing systems.
- Consumers can opt for seasonal products that are grown in accordance to the water availability of the producing area to avoid increasing water stress during dry periods.
- When doing takeaways, individuals should strive to bring their own reusable containers and cutlery to reduce water demand for the manufacture of disposable items, benefitting both rivers and the ocean as well.

## 10. CONCLUDING REMARKS

The water footprint of a nation should be seen as a complementary indicator in the sustainability debate. This study has made visible the unseen volume of water that flows through the consumption of food and beverages by Singapore residents. By comparing the water footprint of individuals with the average domestic consumption of water, it is evident that despite the invisibility and silence of the concept of water footprint, it represents a volume of water that cannot be left out of any water management policy. While the gradual reduction in domestic water consumption may be interpreted as more prudent resource use within the country, it may not accurately reflect changes in lifestyle and consumption and does not necessarily translate to actual 'water conservation'. Rather, it is important to recognise that local 'conservation' may come about at the expense of water resource availability in the countries Singapore imports its food from.

As Earth's climate changes alongside the growth of populations and economies of these countries, water-stress scenarios may be intensified and exacerbated by production demands. The water footprint tool is thus invaluable in helping countries account for their invisible consumption of water resources. Water problems in food-producing areas cannot be solved without governments, businesses and individuals being held accountable for the economic and environmental costs and impacts. Hence, this knowledge is valuable for not only governments and businesses attempting to raise the sustainability of food and beverage products. It also demonstrates the necessity of having consumers change their perspective of water use and product consumption.



*Water problems in food-producing areas cannot be solved without governments, businesses and individuals in consuming countries being held accountable for the economic and environmental costs and impacts.*

In order to attain sustainable food security within local and global freshwater boundaries, the government can also lead the way in educating the populace and supporting the local agriculture sector to increase yield while ensuring resource efficiency. To influence consumption patterns, businesses can adopt price mechanisms and labelling to reflect the social and environmental costs of products. Investors and financial institutions can steer companies towards sustainability by encouraging them to prioritise good water stewardship on their corporate agendas. Finally, dietary modifications and the reduction of food and packaging waste by individuals are crucial. This report has created a base to support further work on Singapore's water footprint. Extensions to the study can take the form of identifying the water footprint of other consumer or energy products or analysing how water footprint may change under different climatic conditions, trade regimes and/or national policies.

However, before one can make a more balanced assessment of the effects on the water resources of the different countries, it is important to acknowledge that the methodology applied produces results that only suffice as overall estimates. As the water footprint for food and beverages in this study were estimated without information about the precise components and ingredients of the products, the results cannot be taken to represent product or locationspecific values. Nevertheless, by estimating and characterising the water footprint of food and beverages consumed in Singapore, this study encourages the identification of roles and prioritising of actions of the various actors in striving towards a more sustainable water future, both locally and abroad.

# 11. APPENDICES

Appendix A - Global average water footprint of selected animal feed components<sup>64</sup>

Feed	Average water footprint
Wheat	2013
Barley	1569
Maize	1347
Millet	4936
Cassava	621
Sugar Beet	147
Soybeans	2363
Rapeseed	2502
Sesame seed	1961
Cottonseed cake	917
Fodder crops	280
Pasture	347

**Global average water footprint of selected animal feed components (litres/kg) (1996-2005).**

Appendix B - Water footprint of selected food products from crop and animal origin<sup>64</sup>

Food products	Average water footprint
Sugar crops	197
Vegetables	322
Starchy roots	387
Fruits	962
Cereals	1644
Oil crops	2364
Pulses	4055
Nuts	9063
Milk	1020
Eggs	3265
Chicken meat	4325
Butter	5553
Pig meat	5988
Sheep/goat meat	8763
Bovine meat	15415

**Average water footprint of selected food products from crop and animal origin (litres/kg).**

Appendix C - Assumptions made in study in calculating Singapore's residents water footprint.

1. Food and beverage variety were limited to items that are commonly available in Singapore.
2. Water footprints figures of each food and beverage category were derived from global averages extracted from the Water Footprint Network database.
3. Portion sizes for meat and vegetables in a typical serving size in Singapore were estimated to be 300g and 150g respectively.
4. The amount of toppings added to selected beverages was assumed to be an average of 5g.
5. Indices for both beverages and toppings are not correlated and not measured-to-scale – it is non-indicative, and not representative of the differences in the actual water footprint of beverages.
6. The water footprint formula for food and beverages, and therefore, the overall water footprint of a typical Singapore resident is specific to the context of this particular study. Direct comparison may not be made against other studies due to differences in methodology.

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## ABOUT RIPPLES

Ripples is an initiative by WWF-Singapore and HSBC Water Programme. We believe that water is vital to building healthy communities and developing national economies. With Ripples, we aim to build a network of Water Warriors, to inspire and equip them to take up the mantle and take meaningful actions in championing water conservation through community based knowledge sharing and action.