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Estimation of environmental awareness among university students

A focus on water scarcity in Taiwan

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前言

台湾缺水是一个重要的资源问题，对环境造成深远影响，对粮食安全和社会经济发展构成威胁。该岛的水问题与其特殊的地理特征，地形和气候密切相关尽管是世界上所有发达国家中降水率最高的国家，但降雨的分布在湿季（夏季）和干季（冬季）之间具有明显的季节性变化。对于台湾南部来说尤其如此，在五月至八月期间，每年的总水量几乎完全沉淀出 (WRA, 2018) 。

水资源分配不均的问题总是使领土分为两部分，即干旱的南部和潮湿的北部，这使该岛的供水状况极为不平衡。此外，陡峭的地形加上其水库的高沉积率以及流域的不适当发展，给该岛带来了难以储存降雨带来的水的困难，这危及了干旱时期供水的可靠性。气候变化进一步加剧了这一挑战，预计气候变化将进一步提高水文变异性和极端天气事件的发生率。

随着全球变暖加剧，干旱条件将持续存在，损害农业产量。由于收成下降，粮食出口国的出口量将减少，而进口国将迫切希望获得供应，从而引发全球对粮食的疯狂争夺。另一方面，随着海洋增温，带来的是极端豪大雨。美国在二〇一三年的气侯变迁报告，即提出亚洲本来就是全球洪涝最严重的区域，未来挑战将更大，因而受灾人数将超过两千九百万人 (National Research Council, 2013) 。台湾从 1901 年到 2018 年的平均降水量统计数据表明，自 1960 年地球开始变暖以来，稳定的降雨时期变得越来越稀少，干旱的发生频率和强度也更高(WRA, 2018)。台湾的人均降水量远低于世界平均水平，可以看出，两次大旱之间的时间间隔从 15 年逐渐缩水到 10 年，如今已不到 10 年，成为“新常态”。

但是，水资源短缺问题背后的因素不仅是自然的。几十年来很少或完全不关心环境的经济和工业发展导致水和空气质量恶化（Grano，2015）。在人口迅速增长和世界上人口密度最高的国家之一的共同推动下，过去 20 年水的需求量大大增加，给环境带来了巨大压力。这些艰难的条件要求提高用水效率，以解决对水的日益增长的需求和对水安全的日益威胁。

集体，个人以及所有部门（工业，农业和家庭）都需要最佳利用有限的水资源。尽管台湾政府及其经济部水利署一直在积极推广可持续性和用水效率指南，但是在水的分配，分配和价格结构方面存在的缺陷仍然阻碍了节水实践和技术的有效采用。一个明显的例子是官方数据，该数据显示每日生活用水量不断增长（2018 年为 280 升），

是美国和欧洲的两倍。事实上，只有当人们认为缺水是一个问题时，才能成功地实施激励措施以促进水资源的可持续利用（WRA，2018）。对当前状况的评估突出了影响个人行为以变得更加环保的重要性。一种强烈争论的观点是，进行此类干预的必要条件是提高环境意识，这是衡量一个人了解环境问题的性质以及与人类活动之间的现有因果关系的能力的一种量度。作为涉及广泛现象的广义概念，传统上将环境意识识别为一个多维概念，具有认知成份(cognitive component)、情感成份(affective component)、以及行为意图(conative component)。它们的复杂性和缺乏统一的定义有助于解释现有措施的巨大差异。为了避免歧义，在本研究中，我们将环境意识定义为环境关注点，态度和行为。

- 对环境的关注是指基于记忆并受先前经验以及信息披露的影响来感知环境状态变化的能力（Du et al.，2018）。它包括有关环境问题的严重性及其主要原因的所有观点和信念。
- 环境态度与一个人对环境问题的信念，感觉和期望有关（Maloney et al.，1975）。它也包括个人对自己对周围环境的影响所产生的情感判断，并且与他或她的责任感紧密相关。
- 环境行为的概念表达反映了人们执行或愿意支持可能影响环境质量的各种行动的意愿（Dunlap and Jones，2002）。

尽管对环境的关注已遍及全球，但台湾提供了一种特殊的环境，可以在此环境下检查公众对与水资源短缺相关的问题的关注，态度和行为。作为工业和经济发展成功的地区，加上最近的民主化，该岛是新兴国家和新民主化国家的参照点。评估环境意识是了解公民对问题重要性的了解程度的第一步。换句话说，一个人意识到自己何时感觉到环境状况变得更糟，并且知道他可能遭受这种后果的痛苦。

因此，为了理解和影响公众对缺水的反应，深入了解公众对缺水的认识和关注是制定充分和有效措施的先决条件。如上所述，经验在形成关注的过程中起着主要作用。后者的产生是因为问题的频率和强度超过主观阈值（Sudarmadi et al.，2001）。因此，水的供应状况是对环境的一种刺激，必须进行充分，频繁的干预，以引起人们对水资源短缺的认识。从以上可以得出结论，对水资源短缺的关注是对水可用性状态的认识。

尽管显然是采取环境行动的先决条件，但仅认识到问题本身并不足以确保采取对环境负责的行为。历史上一直假定对环境的积极态度（和良好的行为意图）是亲环境

行为的重要预测指标。因此，可以说一个人对环境及其保护的态度越好，他/她就越热衷于节约用水。由于这些原因，应分析环境态度，并应采用教育实践来指导公民对其环境有更积极的态度。在这种情况下，用来衡量学生对环境态度的工具在培养积极的环境态度的过程中起着至关重要的作用。

了解公众对水资源短缺的反应并提高环境意识在增强环境管理政策的有效性和响应能力方面起着关键作用。因此，提高环境意识对决策者和社会科学家而言越来越重要。

尽管它对科学研究和政策制定很重要，但在最近的文献中，人们对台湾人的环境意识水平缺缺乏重视。进行这项研究的理由是，没有公众的认识和对环境保护的支持，任何计划或立法的制定和执行都不会成功。特别是要解决台湾的水资源短缺问题，必须立即改变水资源管理和用水方式，只有了解情况并全力以赴解决问题的公民才能采取行动。

此外，了解台湾公民的想法与决策者有关，因为该群体直接参与了政府的法规，计划和激励措施；它们的批准和支持对于未来措施的良好结果极为重要，尤其是在税收和新技术的实施方面（由调查中的某些项目衡量）。

这项研究旨在通过管理在新竹国立清华大学交流学期期间开发的问卷来测量台湾人的环境意识。并非本研究报告了调查中存在的所有问题（第 4 章），但仅出于研究目的选择了最相关的答案。附有完整问题清单的原始问卷副本可在附录 A（中文版）和附录 B（英语翻译）中找到。这项调查是在新竹和台北两个不同的城市（最著名的是亲自下达的城市）进行的。这些城市中的台湾人被视为调查对象，因为正如我们将在下一章中看到的那样，这里用于家庭目的的人均日均用水量是所有台湾中最高的，分别为 307 升和 332 升（WRA 2019）。此外，这两个都是位于该岛北部地区的人口稠密的大城市，其自然特征使它们受水短缺的影响较小。

必须指出的是，受访者都是台湾大学生，被认为是人口和未来统治阶层中受教育程度最高的部分。因此，他们对当今环境的态度和行为将对台湾的可持续发展进程产生重大影响。由于这些原因，重要的是要提高他们对现有问题的认识，并鼓励他们保护环境。但是，正如我们稍后将进一步研究的那样，整个研究中提出的发现均基于人们对环境态度和行为的评价。可能由于社会期望效应，一些受访者夸大了他们对环境的关注。解释数据时应牢记这一点。

本文的结构如下。引言之后，第 2 章介绍了本研究的理论背景和方法。然后在第 3 章中概述了台湾缺水的原因，分为自然因素和管理因素。第四章概述了经验结果，然后在第 5 章中进行讨论。第六章总结。

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1. Introduction

The late 20th and early 21st centuries have witnessed the emergence of the environment as a political and social issue (Dunlap et al., 2000). Already in 1998, the Human Development Report stressed the significant pressure on the environment that was being generated by human consumption (UNDP, 1998). Since then, scientific evidence has been provided that environmental threats can significantly harm human health, either directly or indirectly, making public's concern over environmental problems grow year by year. This renewed interest in environmental degradation, global warming and related environmental concerns has led governments all over the world to increase their efforts in order to achieve a development that is socially, economically and environmentally sustainable. The Sustainable Development Goals[1] (SDGs) were born at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012 with the precise aim of directing these commitments towards common, universal objectives that can help address the urgent challenges of our time (UNDSDG no date). The sustainable use of water is one of the most important of these challenges. As our global population grows and water consumption behavior change, the demand for this essential resource, necessary for the survival of human society and of ecosystems, will greatly increase. At the same time, water availability and quality are also under growing stress from urbanization, industrialization and human-induced climate change. While the magnitude of this change is still subject to uncertainty and will vary from one region to another, it is recognized that semi-arid regions will probably see an increase in the variability of precipitations, leading to more frequent droughts and floods and increasing scarcity of fresh water. According to the estimates provided by international agencies such as the United Nations and the FAO, the global population facing water shortages will increase from 20% in 2000 to 30% in 2025, with 1.8 billion people living in countries or regions with absolute water scarcity[2] (UN-Water and FAO, 2007). These changes will have tremendous implications for human health, global food security, and the peace and well-being of society in general. Ensuring water security has been precisely recognized as one (Goal 6) of the seventeen SDGs by the United Nations (UNDSDG no date a). SDG 6 includes eight global targets that governments should achieve by the year 2030, like "increase water-use efficiency

[1] The SDGs were a sequel to the Millennium Development Goals (MDGs), which marked a historic global mobilization to achieve a set of important social priorities worldwide in the next for 15 years (2000–2015).
[2] Based on the amount of total water resources available, a country is experiencing absolute water scarcity when the freshwater available for each person each year is below 500 m^3.

across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity" (6.4) (UN-Water, 2018). Coherent, concerted strategies on water planning, allocation and pricing must be incorporated into national planning processes, with the aim of increasing water efficiency in industrial, agricultural and domestic water use (UN-Water, 2013). However, despite being necessary, governments' political, institutional and administrative capabilities alone are not enough. Civil society and citizens engagement are key to develop and implement effective measures (Ziadat, 2010; Dunlap ad Jones, 2002). Thus, future environmental policies should consider a public-participated approach in order to achieve sustainable development goals. In doing so, is of the utmost importance for the government to understand current public levels of environmental awareness, a factor deemed to be a prerequisite of environmental protection (Du et al., 2018).

Environmental awareness can be defined as a measure of a person's ability to understand the nature of environmental problems and the existing cause-effect relationship with human activities, as well as his or her willingness to contribute personally to their solution (Liu, Vedlitz and Shi, 2014).

As a broad notion that refers to a wide range of phenomena, environmental awareness has been traditionally identified as a multidimensional concept consisting of a cognitive, affective and conative dimension (Maloney et al., 1975). However, these three components have been defined differently across studies, e.g. knowledge, attitude and behavior (Rannikko, 1996) or even motivation, knowledge and skills (Kokkinen, 2013), just to name a few. Their complexity and the lack of a common definition helps account for the huge diversity in existing measures. In order to avoid ambiguity, in this study we define environmental awareness as divided in environmental concern, attitude and behavior.

Environmental concern refers to the ability to perceive changes in the state of the environment, based on memory and influenced by prior experience, as well as by information disclosure (Du et. al., 2018). It includes all opinions and beliefs about the seriousness of environmental problems and their major causes.

Environmental attitude pertains to a person's beliefs, feelings and expectations relating to environmental issues (Maloney et al. 1975). It also encompasses an individual's emotional judgment about the consequences of his or her own impact on the surroundings and is closely linked to his or her sense of responsibility.

The conative expression of awareness, environmental behavior**,** reflects a willingness to perform, or a commitment to support, a variety of actions that can potentially impact environmental quality (Dunlap ad Jones, 2002). It covers the actual or reported actions taken

by people, as individuals or as a community, because driven by concern for future generations or by social pressure.

Assessing environmental awareness is the first step in understanding the levels of knowledge that citizens possess regarding the importance of a problem. In other words, an individual is aware when he perceives a change for the worse in the state of the environment, and understands that he (she) may suffer from its consequences. As we said above, experience has a major part in the process of forming concerns. The latter are created as the frequency and intensity of a problem exceed a subjective threshold (Sudarmadi et al., 2001). Hence, the status of water availability serves as an environmental stimulus, which must be intensive and frequent enough to trigger perception of water scarcity. From the above it follows that concern for water scarcity is the recognition of the state of water availability as problematic. According to Kokkinen (2013), concern translates into sense of responsibility and willingness to adopt certain measures when people realize casual relations in the environment and their potential influence on its conditions. Unless there is awareness there is no action. Therefore, understand public responses to water scarcity and fostering environmental awareness play a key role in strengthening the effectiveness and responsiveness of environmental management policies. Thus, development of environmental awareness is increasingly important to policy-makers and social scientists and, on the other hand, deeply bound to the birth of environmental movements (Du et. al, 2018).

Although concerns about the environment are world-wide, Taiwan offers a special setting in which to examine public concern, attitude and behavior regarding water scarcity-related issues. As a region that underwent a successful industrial and economic development, along with a recent democratization, the island represents a point of reference for emerging countries and newly democratized countries (Grano, 2015).

Taiwan faced several water threats just in this century alone, with the last one in 2015 being the worst in nearly 70 years of its history (Lu and Liu, 2018). The island's water issue is closely linked to its special geographical characteristics, topography and climate. Despite being the country with the highest rate of precipitation of any developed country in the world, the distribution of rainfall features significant seasonal variability between wet (summer) and dry (winter) seasons (Hung and Shih, 2019). This is especially true for the southern part of Taiwan, where total annual water precipitates

almost completely in the period from May to August (WRA, 2018). The problem of unequal water distribution has always seen the territory split in two, the arid south and the wet north, exposing an extremely unbalanced water supply situation for the island (Hung and Shih, 2019). This spatial mismatch between demand and availability of water greatly affect agriculture, Taiwan's most water-intensive sector, and its semiconductor industry, responsible for Taiwan's rise as one of the "Asian Tigers[3]".

In addition, the steep topography combined with high sedimentation rates of its reservoir along with improper development of watersheds creates difficulties for the island to store water from rainfall, jeopardizing the reliability of water supply during dry periods (Wang et al., 2018).

This challenge is further intensified by climate change, which is projected to ulteriorly enhance hydrologic variability and the incidence of extreme weather events. In fact, researches showed that Taiwan is facing increased risk of longer droughts in the south and more frequent floods in the north regions (Huang et al., 2012; TCCIP, 2019). Climate change is also expected to have a great impact on the occurrence and intensity of natural hazards (Lin, Lin and Lin 2017). In 2005, the World Bank report entitled "Natural Disaster Hot spots – A Global Risk Analysis" indicated that "Taiwan might be the most vulnerable [country] to natural hazards on Earth, with 73% of land and population exposed to three or more hazards (Lin, 2008). House of frequent storms, floods, droughts, and especially typhoons and related landslides, for Taiwan climate change is no longer an abstract concept but a major factor that affects government policy in a huge number of areas.

However, the factors behind water scarcity issues are not only natural. Decades of economic and industrial development with little or no concern for the environment have caused the deterioration of water and air quality (Grano, 2015). Jointly driven by rapid population growth and one of the highest population densities of the world, water demand has increased greatly in the last twenty years, exerting a huge pressure on the environment. These tough conditions call for improved efficiency in water use to address the growing demand for water and the increasing threats to water security.

Despite the fact that the Taiwanese government and its Water Resources Agency (Jīngjì Bù Shuǐlì Shǔ 經濟部水利署) has been actively promoting sustainability and water use efficiency guidelines, existent flaws in water allocation, distribution and pricing structure still

[3] Asian tigers or four dragons is the name given in the late nineties mainly to four Asian countries, namely Hong Kong, Singapore, South Korea and Taiwan because of their high-growth economies.

hinder the effective adoption of water-saving practices and technologies. One clear example is official data regarding ever-growing daily domestic water consumption (280 liters in 2018), twice that of the US and Europe. As a matter of fact, only when water scarcity is perceived as a problem, incentives can be successfully implemented to promote the sustainable use of water resources (WRA, 2018).

Both the natural and managerial factors behind Taiwan's water scarcity have prompted many related studies in which a specific, imperative focus has been placed on finding and implementing better forms of water management (Huang et al., 2019; Wang et al., 2018; Hwang, 2003). But, in spite of its importance for scientific research and for policymaking, a lack of attention has been given to the level of Taiwanese people environmental awareness in recent literature. One of the few exceptions is Chen and Tsai (2016), who studied Taiwanese students' environmental awareness regarding the marine environment. His results suggested that Taiwanese university students generally have a positive attitude and a moderate level of knowledge towards the marine environment, but take little part in environmental activities. Cheng (2011) conducted a survey on Taiwanese's knowledge, attitude, and behavior intention in relation to water resources and reported low knowledge and reluctance to take action, but also the conviction on the part of respondents to have developed the attitude of saving water. These studies do not, however, address the actual Taiwanese's awareness of water scarcity and related issues facing the island. This paper aims at confronting these shortcomings in the literature mentioned above by focusing on the status of concern and perception regarding water problems. The study utilized reviews and discussions of existing literature on the topic, with a second part of research through a questionnaire distributed among 200 students in Hsinchu, a city in northern Taiwan. It's important to point out that the respondents were all Taiwanese university students, deemed to be the most educated section of the population and the future ruling class. Their attitudes and behavior towards the environment today thus will have a significant effect upon the course of Taiwan's sustainable development.

The structure of the paper is as follows. After the introduction, Chapter 2 describes the theoretical background and methodology behind the research. Then an overview of the causes of Taiwan's water scarcity, divided into natural factors and management factors, is provided in Chapter 3. The fourth Chapter outlines the empirical results, which are then discussed in Chapter 5. Chapter 6 concludes.

2. Theory and Research Methodology

A pressing threat to human environments is the relentless overuse of natural resources, such as water, which is becoming increasingly scarce (Hardin, 1968). Water scarcity in Taiwan, similarly to other regions of the world, is a crucial problem with large-scale environmental repercussions to food safety, social development and economic growth (Lu and Liu, 2018). As we shall see more specifically in the next chapter, this ongoing trend sees its origins in a number of different factors, among which also appear our detrimental consumption habits. Optimal use of the limited water resources is required at the collective as well as the individual level and in all sectors: industrial, agricultural and domestic. Since average domestic water consumption in Taiwan is one of the highest in the world (WRA, 2018), further understanding of how Taiwanese people use water is needed as a step toward conservation.

This assessment of the current situation highlight the prominence of influencing individual's behaviour to become more environmentally friendly. However, as argued by Dwyer et al. (1993), permanently changing behaviour through interventions is often fruitless. A strongly argued opinion is that a necessary condition for such interventions is an increase in environmental awareness, inteded as "knowing the impact of human behavior on the environment" (Kollmuss and Agyeman, 2002). Awareness is triggered by concern, which in their turn determine attitudes that affect future behaviors (Folmer, 2009). Hence, to comprehend and influence public's responses to water scarcity, insight into their awareness and concern for the problem is a prerequisite for the development of adequate and effective measures.

As we mentioned in the previous chapter, environmental concern is strictly linked to personal experience and expresses self-interest. For example, Baldassare and Katz (1992) found that perceived personal threats caused by environmental deterioration is an important factor underlying environmentally responsible behaviour. In other words, an individual is concerned about a problem when its frequency and intensity exceed a subjective threshold (Sudarmadi et al., 2001). Hence, the status of water availability serves as an environmental stimulus, which must be intensive and frequent enough to trigger perception of water scarcity. From the above it follows that concern for water scarcity is the recognition of the state of water availability as problematic.

Despite being an obvious prerequisite of environmental action, the realization of the issue and knowledge of it alone do not appear to be sufficient to ensure that environmentally responsible behaviour will take place (Green-Demers, Pelletier and Ménard, 1997; Baldassare and Katz, 1992). Another concept has been the focus of attention of social psychologist in explanations of human behavior: environmental attitudes. Attitudes, described by Allport (1935) as "probably the most distinctive and indispensable concept in contemporary American social psychology", are typically conceived as relatively enduring dispositions that exert pervasive influence in determining a wide range of behaviors (Dooms, 1995; Milfont, 2009). According to the theory of planned behavior, which is an extension of Fishbein and Ajzen's (1975) theory of reasoned action, a central factor is the individual's intention to perform a behavior (Ajzen, 1987). Intentions are assumed to capture the motivational factors that have an impact on a behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior.

Positive attitudes (and good behavioural intentions) toward the environment had been historically assumed to be a significant predictor of pro-environmental behaviors (López-Mosquera, 2016). Thus, it can be argued that the more favourable attitude an individual has towards the environment and its protection, the more he or she will be keen to conservation. There is also evidence to suggest that environmentally and socially motivated households use less water than those homes concerned with cost and convenience (Maas et al., 2017).

For these reasons, environmental attitudes should be analyzed and educational practices should be employed to direct citizens to have more positive attitudes towards their environment. In this context, instruments developed to measure students' attitude towards the environment have a vital role in the process of developing positive environmental attitudes (Ugulu et al. 2008).) According to Maloney et al.'s (1975) research on the concept, it is suggested that a scale aimed at assessing attitude should include three components: cognitive, affective and conative. The cognitive component of attitude refers to the beliefs, knowledge, and thoughts that we have about an attitude object (the environment, in this instance). Affect is a measure of the degree of emotionality related to such issues, and it deals with feelings or emotions that are brought to the surface by them. Lastly, the conative or behavioral component refers to that part of attitude which reflects the intention of an individual in the short-run or long run. When considering economic valuation, environmental studies usually translates the conative component into willingness to pay (WTP) for the use and conservation of different natural resources (i.e.: Cooper et al., 2004; Huang et al., 2014; Chin et al., 2019). These values are taken to analyze

the public's prospective reactions towards needed interventions and therefore may be used in conducting benefit–cost analyses of those measures that can potentially improve the water environment.

According to Ajzen, (1987) specific attitudes to a given behaviour such as water conservation will be a better predictor of intention to engage in that behaviour than will more general attitudes such as a pro-environmental orientation. Similarly to what have been done by Corral-Verdugo, Bechtel and Fraijo-Sing (2003), research into water-conservation behaviors would be possible through a set of specific attitudes toward water as a natural resource. However, in order to maintain the same level of specificity in both the investigation of attitudes and behaviors, direct observations on water use should be conducted and instructions on how to take note of individual consumption should be provided for each respondent. Due to time constraints and an obvious lack of adequate means, this was not possible. For these reasons this study addressed general environmental attitudes and corresponding general engagement in environmental protection, this one intended as "purposeful and effortful engagement in behaviors aimed at preserving or improving the quality of the environment, and increasing public awareness of environmental issues" (Seguin, Pelletier and Hunsley, 1998).

2.1 Questionnaire design

The starting point for this questionnaire was the Taiwan Social Change Survey (TSCS)'s Survey 2010, "Environment" together with materials from a survey conducted by Du et al., (2018)[4]. Following a review of these questionnaires and other relevant studies, and with the collaboration of the department of Sociology of the National Tsinghua University in Hsinchu, Taiwan, this survey was created and administered via an online research software, Qualtrics (Qualtrics LLC, Provo, UT, USA). Participants were expected to complete the survey without any guidance provided by the researcher. The online questionnaire was designed in traditional Chinese in order to ensure that targeted respondents were able to comfortably answer the questions with their mother tongue.

The questionnaire was structured in four parts. Section A, *Demographics,* contained 7 questions to obtain sociodemographic information from respondents and 2 *Preliminary questions* to have an insight regarding the salience of the environment in respondents' consciousness. The core of the survey was divided in the three components of environmental

[4] These materials were kindly provided by my supervisor Daniele Brombal who participated in the research.

awareness: Section B, on *Environmental concern* comprised 22 questions conceived to understand respondents concern for the water environment, their perceptions on the conditions of water availability and quality and the factors causing water scarcity in Taiwan. Some of these questions (i.e. Q. 16, 17, 18, 19, 20) were adapted from questions by Du et al., (2018). Section C focused on *Environmental attitude* and included 22 question, 17 of which were statements on a 5-point Likert scale. These included items adapted from the TSCS (https://www2.ios.sinica.edu.tw/sc/en/home2.php) 2010, Round 6, Year 1, and items self-developed in order to adjust to the water scarcity issue present on the island and related measure to be implemented. Section D, *Environmental behavior*, was composed of just five questions related to participation in environmental behaviors in the previous five years.

It is important to note that not all the questions present in the survey are reported in this study (chapter 4), but only the most relevant answers were selected for the purpose of the research. A copy of the original questionnaire with the full list of questions can be found in Appendix A (Chinese version) and Appendix B (English translation).

Moreover, as we will further investigate later, the findings presented throughout this study are based on what people say about their environmental attitudes and behavior. It may be that some respondents overstated their concern for the environment due to a social desirability effect. This point should be kept in mind when interpreting the data.

2.2 Sample and data collection

The survey was undertaken between 3 December 2019 and 15 January 2020. As part of the development stage of the questionnaire, piloting was carried out to identify questions not clear to participants, or problems with the questionnaire that might lead to biased answers. A total of 5 tests were conducted among a cross-section of respondents before actual collection. The survey was then distributed via Qualtrics either in person, asking prospective respondents to scan a QR code, or with the use of an anonymous link through social media platforms and personal networks. The survey was performed in two different cities (most notably those handed out in person): Hsinchu and Taipei, the capital. Taiwanese people in these cities were targeted as survey subjects because, as we will see in the next chapter, average daily per capita water consumption for domestic purposes here are the highest of all Taiwan, 307 and 332 liters, respectively (WRA 2019). In addition, both are big, densely populated cities located in the Northern region of the island, whose natural characteristics make them less likely to be affected by water scarcity. The sample is also composed of Taiwanese participants coming from other

regions of the island, i.e. Central, Southern and Eastern regions. Non-Taiwanese residents were excluded from the study, based on considerations that newly transferred individuals could have moved to Taiwan too recently to be touched by water scarcity. In terms of implications of the study, knowing specifically what Taiwanese citizens think is more relevant for policy makers as this group is directly involved in the government's regulations, plans and incentives; their approval and support are extremely important for a good outcome of future measures, especially with regards to factors related to taxes and the implementation of new technology (as measured by some of the items in the survey).

In total, 218 responses were collected. Each survey took an average of 13 minutes to complete.

2.3 Analysis and interpretation of the data

Uncompleted surveys, responses with all identical answers and questionnaires filled out by respondents who are not residing in Taiwan were all considered null and discarded. Therefore, in total, a final sample of 140 respondents was obtained. The low response rate was not unexpected given this kind of research design and its excessive length but it nonetheless raises the question of an unrepresentative sample.

In Section C of the survey, scores on various statements related to environmental protection attitudes were determined from the 5-point Likert scale answers. A lower score indicates a more positive attitude. Statements that referred to negative attitudes toward the environment were reverse scored. The purpose of this part of the questionnaire was to determine the level of support to environmental protection through a scale that shall include the three components of attitude mentioned above. To do so, researches commonly resorted to Cronbach's alpha to assess the internal consistency of a survey that is made up of multiple Likert-type scales and items (Kaiser, Wölfing and Fuhrer, 1999; Chin et al., 2019). In this instance, a total of 15 items were developed, 6 measuring the cognitive component of attitude, while affective and conative consisted of 4 and 5 items, respectively. To establish whether the items on this questionnaire all reliably measure the same construct (environmental attitude), reliability analysis was carried out on the three sub-scales. Data analyses were done using the Statistical Package for the Social Sciences (SPSS) Statistics Subscription Trial (IBM Corp, Armonk, NY). In general, a score of more than 0.7 is deemed as acceptable. However, in the current study the pool of items of each sub-scale, as well as a whole, showed low internal consistency ($\alpha = .494$) (see Table 1). As α is sensitive to the number of items in a test, a low value for alpha may mean that there aren't

enough questions on the test (Tavakol and Dennick, 2011). But since the length of the questionnaire was already excessive, as demonstrated by the low response rate, inclusion of more items was not recommended. Despite this, rather insightful results were still produced which will be presented based on descriptive statistics in chapter 4.

Table 1: Internal consistency values for the components of the environmental attitude scale.

Factors	*Cronbach Alpha*
Cognitive component of attitude	0,430
Affective component of attitude	0,540
Conative component of attitude	0,590
The whole instrument	0,412

2.4 Characteristics of respondents

Since the study site was located mainly inside the campus of the National Tsinghua University of Hsinchu and young people were generally more inclined to complete the questionnaire, almost the totality of respondents were between 18–30 years old (98,6%). For these reasons, the subjects analyzed for concern, attitude and behavior were restricted to only university students. Accordingly, variables such as level of education, marital status and income have not been taken into account.

The sample characteristics are summarized in Table 2. Unsurprisingly, most of the respondents live in Northern Taiwan (70,9%) with just 12,7% and 14,1% of them coming from the Central and Southern regions, respectively. In terms of place of residence, more than 30% of the sample described it as "a small town" (30,5%), "a big city" (29,1%) and "the suburbs of a big city" (24,8%).

Since cultural dimensions have proven to strongly influence how societies perceive, respond and adapt to climate-related risks (Chiang and Chang, 2017), respondents were asked to specify their ethnic background. Over two-thirds of participants (78%) stated to be "Fukienese of Taiwan[5]", with just a little minority belonging to aboriginal or local ethnic groups (Hakka[6]).

[5] Fukienese (or Fujianese) people refer to those who came from Fujian, a province in Southern China, to Taiwan during the Ming dynasty (1368 al 1644).

[6] Hakka are another migrant population from Southern Fujian and Northern Guangdong (two southern provinces), which moved to Taiwan following the Dutch colonization of Southern Taiwan in the early 17th century.

Table 2: Demographic statistics from the total of the whole sample.

Demographic variables	Respondents (N=141)
	%
Gender	
Male	42,5
Female	57,4
Residence	
Northern Taiwan	70,9
Central Taiwan	12,7
Southern Taiwan	14,1
Eastern Taiwan	0,7
Place of Residence[7]	
A big city	29,1
The suburbs or outskirts of a big city	24,8
A small city or town	30,5
A country village	11,3
A farm or home in the countryside	4,3
Ethnicity	
Fukienese of Taiwan	78,7
Hakka of Taiwan	10,6
Mainlander	7,1
Aborigine	0,7

[7] Place of residence refers to the place where the students actually live, not the place where their school is located.

3. Review of related literature

Water scarcity has always been one of the top issues being discussed under the climate change. Water scarcity is generally defined as either physical or social water scarcity (Kummu et al. 2016). Physical water scarcity arises because of low availability of water resources, while social water scarcity is caused by unbalanced or uneven distributions of industrial, agricultural, and residential use (Kummu et al. 2016). According to the Special Report of the Intergovernmental Panel on Climate Change[8] (IPCC), "about 80% of the world's population already suffers from serious threats to its water security, as measured by indicators including water availability, water demand and pollution" (Hoegh-Guldberg at al, 2018). Some regions in the world are more likely to suffer from natural hazards than others, and modifications of the climate brought about by climate change in recent years are putting these areas at even greater risk. Actually, not all experts hold a consensus on wether the occurrence of droughts are a natural phenomenon rather than a result of global warming (Zin Kao, 2019), but research by Zhai et al. (2010) clearly show that there is a rising trend in the frequency and duration of these events in many places of Asia. Just in the last 20 years, Taiwan had to deal with ten[9] water threats, so common in fact that they are seen as "the new normal" (Lu and Liu, 2018). The reasons behind such a severe crisis are to be found not only in its geographical and natural characteristics, climate, but also in the allocation, supply, and management of water resources. Furthermore, the water problem lies in the hasty industrialization that the country went through prior to the lift of the martial law in 1987, three decades in which political discourse was developed around the idea of progress and environmental protection was set aside. The same huge economic development responsible for Taiwan's rise to the 21th place in the 2019 world GDP ranking[10] brought forth several problems, which have downgraded both the quality of life and of the environment (Grano, 2015). Increasing industrial and agricultural activities are bound to require more water, and with social development, along with population growth, the problem of water scarcity is growing more and more serious.

[8] Scientific body established to investigate measureable changes in the world's weather and temperature.
[9] Namely in 2002, 2003, 2004, 2005, 2009, 2010, 2011, 2014 and 2015, with the last being in 2017.
[10] Ranking based on projection by International Monetary Fund (IMF) outlook October 2018 for year 2019 and 2023 (Available at :https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/weorept.aspx?pr.)

3.1 Natural Factors

Taiwan is an island located on the western edge of the Pacific Ocean, in the middle of the Huacai Islands and is separated by the Taiwan Strait from mainland China. It is about 600 km long from north to south and 150 km wide from east to west, with an area of 36,000 km^2. The island results from collision of the Luzon arc, on the Philippine sea plate, and the Asian continental margin, reason why its orogen is one of the most geologically active. Situated exactly on the "Ring of Fire[11]" (or Huán Tàipíngyáng Dìzhèndài 環太平洋地震帶 in Chinese), on average, 15.000 earthquakes occur in the Formosa island[12] every year, but only 1,000 of them are perceived.

The Tropic of Cancer passes through the central portion of Taiwan, while the southern and northern portions are under a tropical monsoon climate and a subtropical monsoon climate, respectively (Chen, Li and Shih, 2010). Being surrounded by the sea, due to the action of the monsoons the climate is mild, not rigid in winter and not torrid in summer, with an average temperature of 22°C, apart from the high mountains. Most areas never see snow and frost, which only appear above 3,000 meters. (Li and Liao, 2011). Its climate is strongly influenced by the East Asian monsoon system, which bring northeasterly winds in winter and southwesterly winds in summer. The East Asian summer monsoon is also closely linked with the West Pacific summer monsoon. Both are part of the global climate system and are affected by El Nino—Southern Oscillation (ENSO) which contribute to substantial amounts of rainfall and have major impacts on the region (Kao, Hung and Hong, 2018).

[11] Also known as circum-Pacific seismic belt, is a major area in the basin of the Pacific Ocean including regions like the West Coast of South America, Central America, West Coast of North America, Japan, Taiwan, Philippines, Papua New Guinea, and New Zealand.

[12] The natural forested beauty of Taiwan led Portuguese sailors in 1590 to name it "Ilha Formosa", meaning beautiful Island.

The Northwest Pacific is the world's most active site for the formation of tropical cyclones[13] (TC), but generally just three to four of them hit Taiwan (Chien and Kuo, 2011). While heavy winds and torrential downpours are naturally associated with typhoons, the main cause for the destructiveness of these natural events in Taiwan is strictly tied to the influence of Central Mountain Range (CMR). These mountain reliefs extend along almost all the length of the island, with steep mountains that rise as high as 3.952 m (Taiwan's highest peak Yu-Shan), and occupy about 75% of total area. The CMR can deflect the direction of an approaching TC and significantly modify its wind and pressure patterns, resulting in enhanced precipitation and damaging winds (Chien and Kuo, 2011). According to Liang et al. (2017) and Kuo, Lee and Lu (2016), the high mountain ranges are primarily responsible for the regional variability of Taiwan's climate, especially for the complex rainfall pattern.

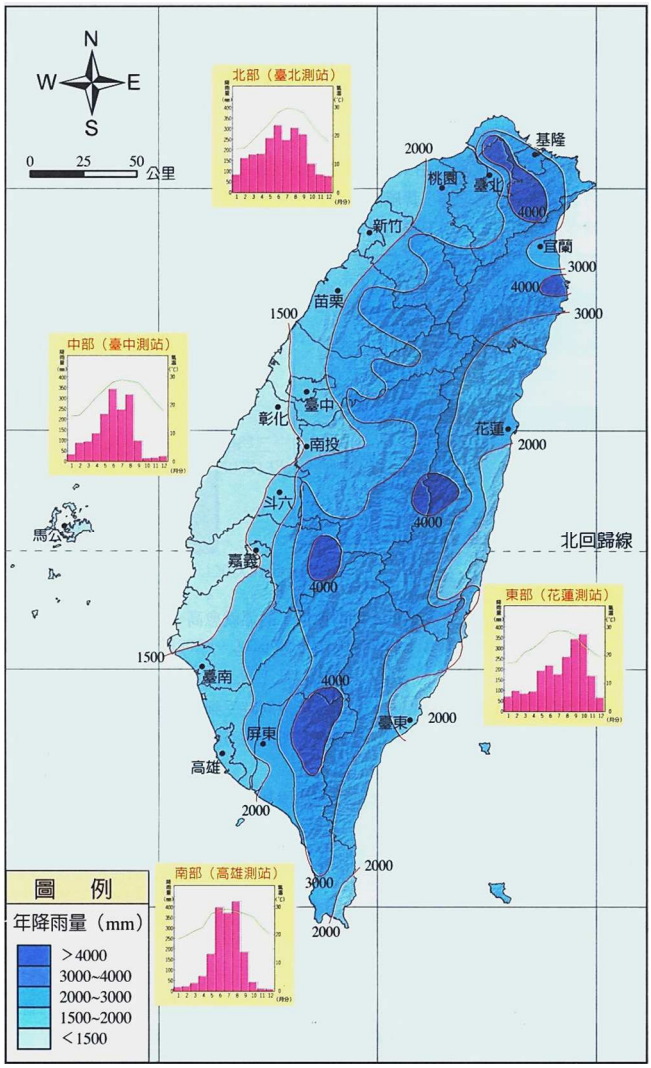


Fig. 1 Distribution of annual rainfalls (mm/year) in Taiwan from the lightest (< 1500mm) to the darkest shades of blue (>4000mm)(legend in the bottom-left) and average monthly precipitation (mm/month) per region(the pink charts). They show in order from top to bottom: northern, central, eastern and southern Taiwan.

3.1.1 Rainfall Pattern

One of the main factors determining water scarcity is the precipitation pattern: the average annual rainfall in Taiwan is 2,511 mm (based on data recorded from 1949 to 2017), which is about 2.5

[13] The only difference between a cyclone and a typhoon, as well as a hurricane, is the location where the storm occurs. In the Atlantic and Northeast Pacific, the term "hurricane" is used. The same type of disturbance in the Northwest Pacific is called a "typhoon", while "cyclones" occur in the South Pacific and Indian Ocean.

times greater than the global average (Water Resources Agency [WRA], 2018). It can even be said to be one of the countries with the richest rainfall in the world. But due to its natural geological and geographical features, the distribution of rainfall is uneven in terms of time which results in a significant difference in wet and dry seasons. In Taiwan water mainly precipitates onto the island over two periods: *Meiyu* (梅雨)[14] and summer (the typhoon season), roughly accounting for the 78% amount of the whole year (WRA, 2018). This period, which goes generally from May to October, is called the wet season. Besides being highly seasonal, precipitation also varies spatially, with a considerable variation based on altitude and latitude. As you can see in Figure 1, the regions characterized by greater annual rainfall (the dark blue areas) coincide with the elevated locations on the CMR, with an average annual rainfall of 3800 mm and peaks that exceed 4000 mm per year. The number is far lower in the plain areas, most notably on the western coastal regions of central and southern Taiwan. Generally northern and eastern Taiwan receive more rain per year than the south, 2.800 mm on average against 2.200 mm, respectively (Xu et al., 2011). As you can see from Figure 1 the water volume in the south (shown in the lowest pink chart) is clearly concentrated between May and August, accounting for the 90 percent of the total rainfall. Over this period the region is under the influence of the southwesterly monsoon, which brings heavy rainfall. During the rest of the year (from September to the next May), a long dry spell takes over the region. On the contrary, in northern Taiwan the distribution of rainwater is clearly much more even throughout the year (chart on the top). For example, this area of the island is affected by cold fronts that originate in Siberia and southern China, which result in significant rainfall in springtime (February–April) (Kao, Hung and Hong, 2018). These two types of cold fronts associated with spring rainfall account for approximately 20% of the total annual rainfall in northern Taiwan and therefore strongly affect the amount of water available for agricultural irrigation in this region in springtime. The precipitation during the winter months occurs mainly over the northeastern and eastern coastal areas, with much less rainfall over the western side of the island (CWB, 2003).

Typhoon rainfall accounts for nearly 50% of the total annual rainfall, which is crucial to the island's water supply during the dry season (Chen et al., 2010). Rivers in

[14] Meiyu, literally “Plum rain”, is the active phase of the East Asian summer monsoon (EASM), a period from May to June characterized by a substantial increase in rainfalls.

Taiwan are short and steep with rapid flow and rich sediment. Owing to the concentrated rainfall in time distribution along with the densely populated and steep terrain, only a relatively small portion of the annual surface runoff can be utilized for agricultural, domestic and industrial uses. According to the statistics of the Water Resource Agency, of the 2,601 mm of annual precipitation registered in 2017, more than 66% of rainwater was directly discharged into the ocean. It is also estimated that only less than 18% of the total annual rainfall in Taiwan was used for water supply. (WRA, 2018). Therefore, the average amount of water that can be distributed per person per year in Taiwan is only about 4,115 cubic meters, one-fifth of the world's average of 22,628 cubic meters (Taiwan Water Corporation, 2013). In terms of United Nations standards, the Taiwan region is the 18th water-scarce country in the world (WWDR, 2003).

3.1.2 Climate change

There has been no obvious change in Taiwan's average total annual rainfall over the past few years. Even in 2002, when the island suffered a serious drought, the average annual rainfall was not lower than that of previous years (WRA, 2002). Experts like Tu and Chou (2013) argue that Taiwan has experienced less lighter rain and more heavier rain, which may in part be related to a general increase in moisture in the atmosphere due to increased evaporation, as sea surface temperature rises because of climate warming.

This trend, contrary to what one might think, reveal that water shortages actually caused by excessive rainwater occurred several times in recent years. The reason has to be found in the acceleration of the earth's water resources cycle brought about by global warming. By analyzing data from "The Science Report of Taiwan Climate Change 2011'' published by the National Science Council (NSC) in 2011, climate models project that the increases of the near-surface temperature of Taiwan at the end of the 21st century will range between 2◦C and 3◦C relative to the end of the 20th century (NSC, 2011). In terms of regional and seasonal changes, northern Taiwan will likely warm faster than southern Taiwan, and spring will be least affected by climate change. Records from a number of weather stations in Taiwan also show that the temperature in Taiwan is increasing twice as fast as the increase in the global mean surface temperature (CWB, 2003). These changes in temperature will result in more and more concentrated rainfalls during periods of high water, less rainfalls during periods of low water and increasing intensity of both floods and droughts. (Huang et al., 2012). The

statistics published this year by the Water Conservancy Department clearly show that, in 2019, rainfalls in Taiwan during the high water (or rainy) season accounted for 71.39% of the annual rainfall, with the highest being 85.58% in the southern part of the island (WRA, 2020). According to the study by the Taiwan Climate Change Estimate Information and Adaptation Knowledge Platform Project[15] (TCCIP) or "Taiwan qihou bianquan tuigu zixun yu tiaoshi zhishi pingtai臺灣氣候變遷推估資訊與調適知識平台", in Chinese, this polarization of the rainfall pattern will continue in the future (TCCIP, 2019). Projections for winter 2050, in fact, will see a decrease in precipitations of 5-10 %, while summer rainfalls will conversely increase by 5-10%, accounting for more than 80% of the total annual rainfall. According to Wang Zhonghe, a researcher in Academia Sinica's Institute of Earth Sciences who has long studied rainfall trends, in the past 60 years, precipitation has declined in three-quarters of Taiwan's land area, and in southern Taiwan the number of rainy days per year has fallen from 195 in the past to only 130 at present (Xiao, 2009). The differences of water volume between wet season and dry season will be greater, thus affect the ability of water allocation seriously. Climate change is projected to affect not only hydrologic variability, but also the occurrence and intensity of typhoons. TCs, as we already noted before, are a fundamental source of rainwater for the island. Several researches have recognized increasing trends in intense typhoon frequencies in the Northwest Pacific, due to sea surface temperature changes in the Northwestern Pacific Ocean (Holland and Bruyère, 2014) (IPCC, 2014). In Taiwan, in fact, high intensity typhoons took place just once every three to four years during the period 1970 to 1999 (Lin, Lin and Lin 2017), while after 2000 these events occurred annually. There is growing concern in the scientific community that the nature of these storms is changing. Tu and Chou (2013) reported an increasing trend from 1970 of heavier rain due to typhoons, increasing the ratio of typhoon precipitation to total precipitation from 15% in the 1970s to the already mentioned 50% of last year. However, most climate models agree that the projections for the late 21st century will likely see a decrease in the number of tropical cyclones annually, along with an opposite doubling in the frequency of the most powerful (Category 4 and 5[16]) typhoons and their associated extreme rainfalls (Holland and Bruyère, 2014; IPCC, 2014; Lin, Lin and Lin, 2017). At this point it is important to understand how

[15] 3-year project planned and implemented by the National Science and Technology Center for Disaster Reduction (NCDR) with the support of the Ministry of Science and Technology (MOST).

[16]These categories refer to the Saffir-Simpson Hurricane Wind Scale which rates typhoons from 1 to 5 based on their sustained wind speed. In the western North Pacific, Category 4 and 5 typhoons are called with the term "super typhoons" and indicate.

this long-term trend of increasing TC-induced rainfall (TCRain) is going to affect the distribution of precipitation.

Despite Taiwan's relatively small size, the distribution of TC rainfall on the island critically depends on the storm's track because of the influence of the central mountain range along nearly the entire length of the island (Liang et al., 2017).

For TCs that directly influence Taiwan, two groups of tracks can generally be identified (**Figure 2**): (1) westward passing southern Taiwan into South China Sea and (2) northward toward Japan or toward South-east China (Liang et al., 2017). Seven of the 10 typhoons with the highest rainfalls in recent decades fall into the northward group (CWB, 2003). The results by Liang et al., (2017) show that, while rainfall has generally increased in the past decades at all stations, the trend is significant only in northern stations; this asymmetry in the rainfall trends is related to the increased preference for TCs to take the northward path in recent decades. Typhoons effects on Taiwan represent a double-edged sword: while they contribute substantially to the total precipitation, their heavy winds and rainfalls can result in fatal disasters, such as floods, landslides, and debris flows. The increase in the frequency of extreme flooding events not only makes Taiwan more unable to effectively retain water resources, but also cause a large increase in the amount of soil and rock washed away from the hillside into reservoirs, which will cause their deterioration and their storage capacity to be weakened.

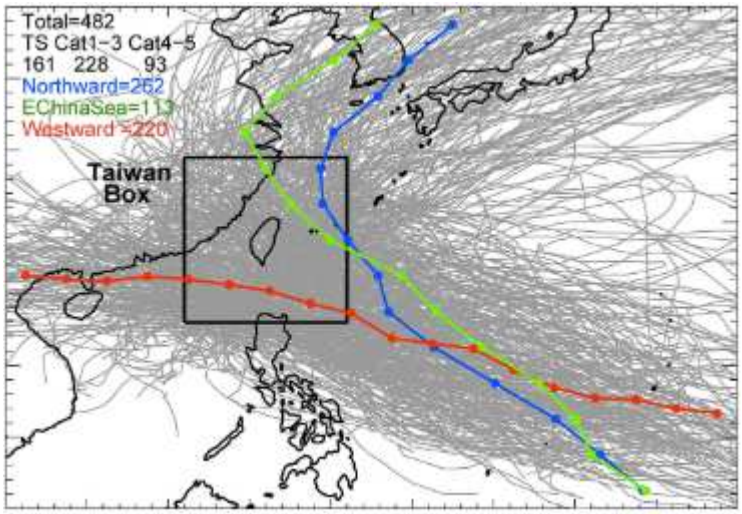


Fig. 2 "[…] TCs passing through the "Taiwan Box" (rectangle). The red and blue colors show mean paths of westward and northward TCs and the green color the mean path of a subset of northward TCs into East China Sea (ECS). The text shows in order the numbers of total TC, tropical storms (TS), categories 1–3, categories 4–5, northward, ECS, and westward TCs". (Liang et al., 2017).

3.1.3 High sedimentation rate of main reservoirs

The differences between high and low water periods makes it impossible to meet the water demand during the long dry season and in dry years, reason why it is necessary for the island to rely on water storage. Besides being critical in order to maintain a stable supply of

freshwater for human uses, reservoirs can also effectively deliver other useful functions: irrigation, flood control, and hydropower services (Wang et al., 2018). They are crucial in those regions of the world characterized by high hydrological variability like Taiwan, where the amount of water flowing in rivers varies significantly both seasonally and from year to year. In these areas, storing enough water for use during severe or multiyear droughts, and thereby ensuring the reliability of water and power supply, requires very large reservoir storage volumes (Annandale at al. 2016).

According to the statistics of the WRA (2018), by the end of 2018 there were 95 declared reservoirs on the island, which supply a total of 4.35 billion tons of water for municipal, industrial, and agricultural consumption to Taiwan's 23 million residents. In total reservoirs make up around 25 percent of Taiwan's fresh water supply, with rivers providing more than 40 percent and groundwater extraction another 41 percent.

In terms of percentage the number of reservoirs located in the southern part of Taiwan account for nearly 40 percent of the total capacity, followed by 30 % of those in the Central Region and about 29 percent of reservoirs located in the North Region (WRA, 2018). However, most southern reservoirs depend on natural rainfall as main source of water, and, above all, their sedimentation rates are among the highest in the world (Dadson et al., 2003). In fact, while the total designed capacity of the existing reservoirs in Taiwan is 2.919 billion cubic meters, the current effective capacity is only 1.980 billion cubic meters (WRA, 2018). Sediment deposition already occupied 32% of the total storage capacity of Taiwan reservoirs and, as stated by Lee Hong-yuan, a former Minister of Interior who is now a National Taiwan University (NTU) professor of civil engineering, the number will climb to 50% by 2030 (TVBS News, 2018). Sedimentation poses a significant threat to the longevity, usefulness, and sustainable operations of storage reservoirs. Over time, sediment builds up in reservoirs and displaces usable storage volume, which in turn reduces the reliability of domestic, agricultural and industrial water supply, as well as flood management services.

To put it simply, the main reason for Taiwan's water scarcity is not a shortage of rainfall, but more a lack of storage capacity (Ferry, 2018). According to statistics, Taiwan can store only about a month and a half's water before its reservoirs dry up[17], and rely on its usually regular rains to replenish the storage capacity (WRA, 2018). As we already mentioned before,

[17] Total water stored / total water used.

the highly seasonal precipitation pattern is characterized by extremely unbalanced water supply outside the typhoon season, especially in the southern regions (Hung and Shih, 2019). Over the dry period, maintaining sufficient water levels in the reservoirs depends on the rare rainfalls which drop onto the island upon the arrival of sporadic cold fronts from the dry regions of continental Asia (Huang et al., 2012). When this did not occur, protracted high temperatures and insufficient rainfalls resulted in a lack of water resources.

If we consider the period from February to June 2002, the climatological data of the Central Weather Bureau (CWB) showed that the monthly rainfall statistics from January to August 2002 was lower than the average rainfall in the previous years (1971 to 2001). As a result, the storage capacity of major reservoirs in the northern regions approached or exceeded the minimum level of water at which the reservoir operates (CWB, 2003). For example, the water level of Shimen Reservoir (Shimen shuiku 石門水庫), Taiwan's third largest reservoir which supply 25% of the water needed by more than three million people in northern Taiwan, fell close to the 195-meter[18] point of being unable to release water (Que, 2015). This led to water shortages in the cities of Taipei, Taoyuan, and Hsinchu, and the implementation of third-phase water rationing in which parts of the city were without water on a rotating basis three days a week.

Shimen Reservoir is one of the reservoirs which has seen its storage capacity depleted the most by silting. Erected in 1963, the reservoir had already lost 6% of its capacity after just one year from the end its construction, and 33% by 2015 (Wang et al., 2018). However, despite earlier studies highlighting the need for sustainable management of sediment in reservoirs, sedimentation was not taken seriously in this reservoir it lost a large fraction of its total capacity during a single typhoon: Typhoon Aere in 2004.

[18] The height of the water level above sea level.

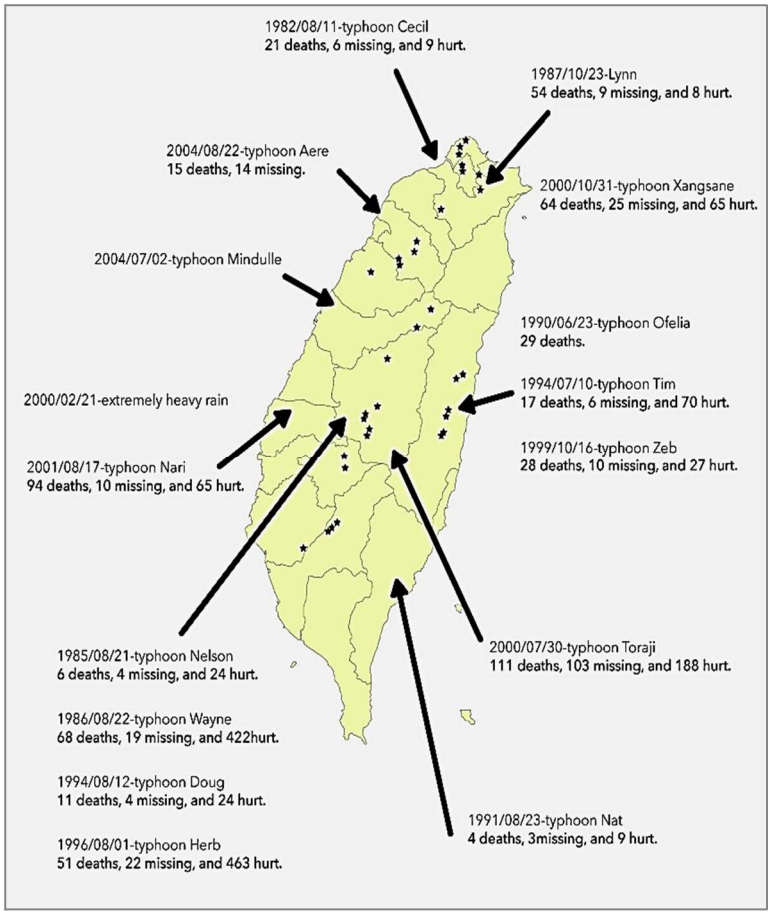


Fig. 3 Distribution of historical extreme landslide events in Taiwan (Lin, Lin and Lin, 2017).

Other five of Taiwan's major reservoirs besides Shimen are high-risks reservoirs, with comparable levels of sedimentation: Deji (Déjī 德基), Wushe (*Wùshè* 霧社), Zengwen (*Zéngwén* 曾文), Nanhua (*Nánhuà* 南化) and Wushantou (Wūshāntóu 烏山頭). The last two, which are located in the south, jointly supply most of the water resources in Tainan, but the siltation of the two reservoirs is quite serious, up to 66% and 48%, respectively.

Which factors determine Taiwan's exceptionally high sediment yields, enough to justify the discharge in the ocean of about 1.9% of the world's total suspended-sedimen[19], from an area that accounts for just 0,024% of the Earth's land surfaces (Dadson et al., 2003)? Reservoir deposition is undoubtedly closely linked to the regular landslides brought about by the steep slopes, frequent natural disasters like earthquakes and typhoons, and intense monsoon and typhoonal rains which can accelerate the weathering process and the consequent debris flow across the island. **Figure 3** show the distribution of historical landslide events from 1982 to 2004 with the corresponding victims. Based on data made available by the National Science and Technology Center for Disaster Reduction (NCDR), the majority of landslide events from 1989 to 2013 occurred next to the mountainous highways close to densely populated areas. The statistics show that about 77%, 15%, and 8%

[19] Data recorded from 1970 to 1999 at over 150 stations across Taiwan.

of landslides were caused by typhoons, heavy rainfalls, and earthquakes, respectively (NCDR, 2014).

Almost all historic landslide disasters with severe casualties in Taiwan were induced by typhoons directly, or indirectly by the torrential rainfalls they bring (Lin, Lin and Lin, 2017). One notorious example of such events is Typhoon Morakot, when a record-breaking 3000 mm of rain fell in 4 days and caused huge mudslides and severe flooding throughout southern Taiwan (Chien and Kuo, 2011). Considered a the time (2009) the deadliest typhoons of the previous 50 years, with 700 casualties and approximately 500 million U.S. dollars of losses, Morakot's torrential rainfalls resulted in the deposition of up to 110 million cubic meters in the two reservoirs of Zengwen and Nanhua, and in a significant stoppage in water service for more than two million residents. The dredging, which took about 1.5 years, eventually cleared only 1.65 million cubic meters, and the completion rate was only 1.5% (NCDR, 2015). As we said before, typhoons in Taiwan are naturally associated with heavy rains which can lead to landslides and bring about severe loss to human life and property.

An article published by *CommonWealth Magazine*, however, argued that besides the inherent limitations due to Taiwan's special geographical conditions, other complex "realities" have a part to play in causing higher erosion (Lu and Liu, 2018). One of these is the overdevelopment in catchment areas, which, although prohibited, still has disruptive consequences on the life of reservoirs. For example the aforementioned Shimen Reservoir has seen an uncontrolled development in its watershed, from roads and camping sites to ginger and fruit farms (Lu and Liu, 2018). Landslip occur naturally, but Annandale at al. (2016) report that human activities like deforestation and road building increased sediment yield by about 155 times on average, compared with natural conditions. In other words, reducing human impact is crucial to save Taiwan's reservoirs, but it's not enough. In its 2017 report on climate change in Taiwan, the National Science and Technology Center for Disaster Reduction estimated that even excluding the impact of extreme weather, sediment will account for 48.6 percent of Shihmen Reservoir's storage by 2030 (WRA, 2018). If we factor in the rising trend of extreme weather, those percentages rise to 62.0 percent. Over time, sediment builds up in reservoirs and displaces usable storage volume, which in turn negatively affects, reduces the reliability of domestic and irrigation water supply and flood management. Without sediment management, reservoir storage space is eventually lost, and it is extremely difficult, if not impossible, to reclaim it.

3.2 Management Factors

Although recent projections speak of water scarcity as a problem that will affect two-thirds of the world's population in the coming years (UN-Water and FAO, 2007), just two decades ago water was not even an issue discussed in the final declaration of the United Nations Conference on Environment and Development in Rio de Janeiro (UN, 1992). Recently, the concept of effective water governance has grown in importance and has led water resource administrations around the world to struggle in order to find pathways to promote sustainable water use. The ambitious Sustainable Development Goal (SDG) 6 of achieving availability and sustainable management of drinking water for all by 2030 was set in 2012 (UNDSDG no date a). The target 6.4, "Ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity" is the focus of the SDG 6, and one of the most difficult targets to reach (UN-Water, 2018). Taiwan's commitment to make even further headway in this regard is evidenced by its adoption of the SDGs and publication in September 2017 of the Voluntary National Review on their implementation (Gao, 2019). The following year, the National Council for Sustainable Development (NCSD) (Xíngzhèng yuàn guójiā yǒng xù fāzhǎn wěiyuánhuì 行政院國家永續發展委员会) approved Taiwan's own version of the SDGs comprising 18 goals and 138 specific targets.

A particular challenge in the achievement of SDG 6 is how to handle urban areas, where over half of the world's population live. According to UN Habitat (2013) by 2050 urban dwellers will account for about 85 % of the population of the more developed world and some 65 % in the less developed regions, seven out of ten people will live in urban settlements. Population growth and increased human activities in these areas will exert greater pression on water systems, boosting the use and pollution of natural resources. Water quality deterioration along with the projections for increased hydrologic variability due to climate change underline the urgent need to find and implement better forms of water management.

As we said in the very first part of this chapter, water scarcity problems are not only related to natural factors, but allocation, supply, and management of water resources must be taken into account.

As distribution management in Taiwan has taken priority over other measures to maintain water supply from existing sources (Yu, 2016), sediment management, curbing

water pollution and water waste, and empowering water organizations all play a major role in tackling the inevitable droughts that are due to happen.

3.2.1 Sediment management

The water resources that supply the needs in Taiwan depend crucially on the reservoirs built at least more than twenty years ago, river abstraction and ground water extraction (Yu, 2016). The detrimental effect of sediment deposition on the sustainability of water supply poses a critical issue for decision makers and governmental agencies. In the light of the foregoing, it proves to be of the of the utmost importance to recur to sediment management in order to prevent or minimize storage loss in the long run. This can be accomplished through a range of different desilting methods including mechanical removal, dredging, and sediment bypass tunnels (Huang et al., 2019). Apart from technical reasons, sediment management implementation in Taiwan didn't have the desired effects, although the great deal of research projects and technological developments made in recent years (Wang et al., 2018). For example, sediment removal by dredging has a heavy environmental impact and is, most notably, prohibitively expensive (Annandale at al., 2016). Under current conditions, clearing a cubic meter of silt cost an average of NT$500[20] per cubic meter (Lu and Liu, 2018). According to the estimates provided by the WRA, of the 309 million cubic meters of initial storage capacity, Shimen reservoir had already lost more than 100 million by the end of 2015 (Wang et al., 2018). "(Clearing) 100 million cubic meters of silt costs about NT$50 billion [...]. It would probably be cheaper to just build a new reservoir" says Northern Region Water Resources Office chief Chiang (Lu and Liu, 2018). To curb this problem in the future, a project for the construction of a desilting tunnel in Shimen Reservoir is expected to be completed by the end of 2020, reducing significantly silt levels (WRA, 2017: online).

The Ministry of Economic Affairs (MOEA) estimates that if new water resources are not developed, Taiwan will face a shortage of 350 million cubic meters of running water a year by 2031. In many regions in Taiwan, however, the geological and topographical conditions make it so that few high-quality sites for new reservoirs remain (Annandale, 2016). Furthermore, water resource development plans in Taiwan faced intense resistance due to competing land uses and increasing social and environmental concerns (Wang et al., 2018). It is often thought that these sources are sufficient to meet the demand for water, but, based on

[20] Approximately €15.

the above, it may be impossible to rely on reservoirs to solve the problem of water shortages. The remaining water resources are rivers and groundwater, but these are often polluted.

3.2.2 Pollution

To aggravate the already difficult situation of lack of water in Taiwan it must be considered that not all the water present in the country can be used. Decades of economic and industrial development, rapid population growth, urban sprawl, along with overexploitation of mountains and forests are responsible for the so-called "Taiwan miracle" (Chi, 1994). According to experts like Rock (1996) and Chi (1994), this rapid growth process, which took place from the 1950s, has been possible thanks to the freedom from restrictions on pollution. The resulting environmental degradation, which became evident by the 1980s, brought forth several problems including hypertrophication[21], an increase of greenhouse gases and watercourses pollution (Chan, 1993; EPA, 2018). Following the rising environmental consciousness among Taiwanese people and the foundation of the Environmental Protection Administration (EPA) in 1987, environmental conditions have improved, although some issues are still to be solved (Grano, 2015).

Relevant research showed that continuous water quality degradation has become one of the major factors restricting the sustainable development of the economy and society (Cosgrove and Loucks, 2015; Oki and Kanae, 2006). Among all freshwater resources, surface water like rivers and lakes are the most susceptible to pollution because they can easily be contaminated by agricultural runoff, industrial and domestic wastewater (Putri et al., 2018). The arrangement of the mountains and the shape of the island have not allowed the birth of long water streams, especially in the eastern part, seen that they quickly reach the ocean; the main rivers, Zhuoshui (187 Km), Gaoping (171 Km) and Tamsui (159 Km) flow directly into the Taiwan Strait. Many lake basins are artificial, the largest of natural origin is the Sun Moon Lake (8 km²), all others have an area of one square kilometer or less. According to the data reported by the WRA, in Taiwan there are 21 major rivers, 29 secondary rivers, and 79 streams, most of which are located alongside cities. (WRA, 2001). In 2001, of the total length of 2.934 kilometers of rivers, the uncontaminated river section was 1.808 kilometers, accounting for 61.65% of the total river length; The EPA reported that water quality of the

[21] Also called eutrophication, is the process of aging of a lake caused by the overgrowth of algae.

remaining kilometers was ranked as slightly polluted (9.08%), moderately polluted (15.38%) and the severely polluted[22] (13.16%) (EPA, 2020).

Since 2002, the Department of Environmental Monitoring and Information Management of the EPA has been carrying out national water quality monitoring work and implemented the first, innovative purification program to relieve rivers from pollution (EPA, 2018). Statistics over the years show that progress has been made in increasing the non-polluted rivers (**Figure 4**). The most promising data is the percentage of heavily polluted

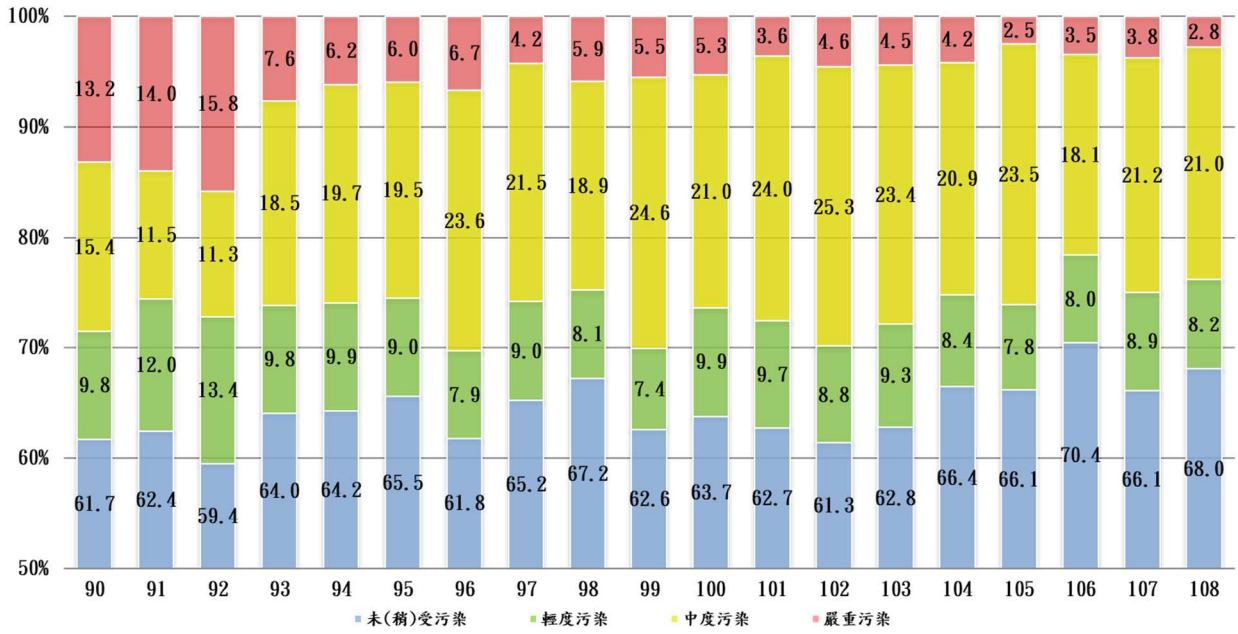


Fig. 4 The progress of river water quality over the years 2002-2019 (EPA, 2020)

segments (i.e. with unusable water), which have shrinked to just 2.8% of total river length (EPA, 2020). Despite the improvement, however, several issues put a strain on the complete recover of Taiwan's water bodies. Some factors are natural, thus related to the above mentioned topographic and typhoon-generated hydrologic characteristics of the island (EPA, 2018). The frequent spells of heavy rain that characterize the sub-tropical environment make Taiwan more vulnerable to nonpoint source (NPS) pollution[23] i.e. that results from land runoff and precipitation, like fertilizer or other chemicals (Putri et al., 2018). As the runoff moves down the steep slopes of the mountain range, it picks up natural and human-

[22] Classification made according to the RPI (River Pollution Index), which is calculated from annual mean values of concentrations of four parameters : suspended solids (SS), biochemical oxygen demand (BOD5), dissolved oxygen (DO) and ammonia nitrogen (NH3-N).

[23] Unlike NPS pollution, point source (PS) pollution has a single identifiable localized source, like, for example, water discharging from an industrial plant or a wastewater treatment plant.

made pollutants accumulated on land surfaces, finally wash them into lakes, rivers, wetlands, coastal waters and ground waters (EPA, 2017). These are of course the source from which public water is obtained ad supplied to Taiwanese households. In 1950s, over 25 percent of public tapwater samples were found to be highly contaminated by bacteria like Escherichia coli (E. coli) and only about 28.4 percent of tapwater quality met the water standard at that time (Harvey, 2015). With the general agricultural growth brought by industrialization in the 1970s, the extensive use of organic wastes, namely night soil, and most notably chemical fertilizers increased threefold between 1952 and 1980, making Taiwan one of the largest fertilizer users. Such overuse affects soil and food, and results in the contamination of surface water as well as ground water, which is commonly used as source of drinking water in the countryside (Chi, 1994). Furthermore, non-point source pollution and inappropriate development in the upstream regions have encouraged algae growth on the water's surface, deteriorating the water quality of reservoirs. Based on official data published on EPA website (EPA, 2018), eutrophication, i.e. “the aging of a lake due to the biological enrichment of the water”, occurred in seven reservoirs in 2019, approximately 35 percent of all reservoirs. Popular awareness of the problem is proved by almost universal social practice of boiling all drinking water before consumption (Selya, 1975). In the southwestern part of the island, near the city of Kaohsiung and the neighboring Pingtung County, the local context of persistent crises of water provisioning and lack of reliability, safety and quality of tapwater, created the circumstances for a dual water economy; the tapwater system, primarily for non-drinking uses, and a separate market for ‘drinking-water garages’, estimated to supply 80 % of the population with drinking water (Harvey, 2015).

In their paper "*The Making of An Environmental Nightmare*", Bello and Rosenfeld (1990) talk about another environmental hazard that was the center of attention in the 90’s: contamination of food products through the soil. In particular, according to estimates of the time, 30 percent of the rice grown on the island was contaminated with heavy metals reportedly caused by the millions of tons of scrap metal recycled in Taiwan.

Water contamination also results from domestic sewage, hazardous wastes produced by factories and animal farms, and is exacerbated by the lack of waste conduits on the island (Chi, 1994). Hence, water pollution must be seen in the context of the rapid population growth, high population density and waste disposal systems, factors that exert a great pressure on the environment.

3.2.3 Urbanization effects and Water conservation

An essential condition for environmental deterioration in Taiwan is its rapid population growth and its high population density (Chi, 1994). In the period between the retrocession and 1974, Taiwanese population doubled from 8 million to 16 million people and population density that year reached 436 persons/km², the highest in the world at the time (Li, 1976). To this day, the population had swiftly increased to 23.58 million people and over 5.7 million households (Department of Household Administration, 2018). The majority of them spreads out on the lowland of the west coast, region that account for only 26.3 percent of the total land area. Official statistics published by the Department of Household Registration Affairs of the Ministry of the Interior (MOI) (Nèizhèngbù Hùzhèngsī 内政部戶政), reveal that the generic data of population density (652 persons/km) doesn't reflect the reality of Taiwan's population distribution. In the capital of the island, Taipei, demographic density is more than ten times higher (9818 persons/km²) (Department of Household Administration, 2018). Over 1/3 of the population, 8,535,000 people, live in the urban agglomeration formed by this big city (2,675,000 ab.) and New Taipei (3,995,000 ab.), the most populous Taiwanese city. Exceed the million inhabitants also Taichung (2,805,000 ab.000 inhab.), Gaohsiung (2,775,000 inhab.) and Tainan (1,885,000 inhab.), all located on the west coast. Relevant studies on the impact of urbanization (Yeh and Liao, 2017) reported that population growth correlates positively with CO_2 emission, an island-wide problem in Taiwan, while high population density entails high costs in terms of water quality (Chou, 2013). According to the official data of the Construction and Planning Agency of Minister of the Interior (CPAMI) (Nèizhèngbù Yíngjiànshǔ 內政部營建署), in Taiwan the general percentage of population served by wastewater treatment plants is just 62,26%, with New Taipei City as the most covered city (90%), and Taidong City the least served (13%) (CPAMI, 2020). Insufficient domestic wastewater treatment is the major source of pollution, as only 50 % municipal sewage is treated in Taiwan, with the rest of wastewater going directly into watercourses (EPA, 2018). Although the treatment rate for industrial and animal husbandry waste is as high as 88 percent, however illegal discharges of unprocessed industrial wastewater, and the waste of domestic animals, are sometimes practiced (Chou, 2013; EPA, 2018). This is especially true for the Taipei-New Taipei conglomeration, which grew along the Tamsui river (淡水河). An EPA investigation conducted in 2016 revealed that, 45 out of the 70

factories along one of the tributaries of the Tamsui river had illegally discharged effluent containing pollutants through hidden pipes, making it very difficult for authorities to identify the perpetrators (Chen, 2016). Despite the heavy fines imposed by EPA, these practices have developed as a consequence of the lack of comprehensive laws and poor integration between departments. Lacking any substantial and enforced public national system for industrial waste disposal, pollutants are dumped into the local environment and water sources with impunity, resulting in the widespread contamination of coastal areas and ground water (EPA, 2018.)

Construction of public underground sewerage systems is the key to minimizing domestic water pollution. However, in Taiwan, rapid population growth has often outpaced its public infrastructure support services. The US, Japan and advanced European nations have considered the extent of public underground sewerage systems as an indicator of national competitiveness (EPA, 2018). In 1991, the extent rate of public underground sewerage systems in Taiwan was merely 3 percent, and after years of construction, the amount reached 10.87 percent in 2003 (Taiwan Water Corporation [TWC], 2013). In the same year, the government incorporated the construction of public underground sewerage systems into the "Challenge 2008: National Development Plans." The hook-up rate to public underground sewerage systems reached 22.58 percent by 2009, and 47.79 percent of wastewater was properly treated (EPA, 2018). Compared to other developed countries like the Netherlands, UK, Switzerland and Germany, where sewage treatment rate was more than 96 percent in 2009 (CPAMI, 2009), in Taiwan it reached 40.25 percent in 2011. According to Chen and Chen (2014), the reason behind the few sewerage systems installed is a lack of attractiveness for the local governments as sewerage systems are invisible and difficult to use to increase political popularity.

Land is used very intensely in Taiwan, whether for agricultural production, industrial production, or human settlement. Moreover, a large amount of agricultural land has been repurposed for development in response to the ever-increasing demand for land for industrial use, urban development and transportation in recent years (Chi, 1994). This “transformation of earth into concrete eliminates the land’s natural ability to replenish (groundwater)”, says Thomas Chan, deputy administrator of the EPA (Lu, 2018). Since water used for irrigation is naturally absorbed into the ground, water diverted to industrial or urban use will eventually be discharged into the ocean, causing the groundwater level to drop in the long run. Another visible effect of the growing expansion of urban areas is the massive reduction of Taiwan’s

virgin broadleaf forests that once covered the east coast (Grano, 2015) and which, for their part, have a very important role in the recharge of the aquifers. The rainwater dropped in a lush natural area is in fact intercepted by plants and infiltrates into the ground, becoming groundwater during the dry season. As mentioned above, groundwater make up 32 percent of Taiwan's water supply, and is usually used for alleviating water shortages during dry periods (WRA, 2018). In recent years, central and southern Taiwan has seen an increasing exploitation of groundwater that may be attributed to the failure to regulate groundwater and to restrict demands. The excessive extraction of underground water is not sustainable in the long run, since it causes land subsidence. This phenomenon destroys infrastructure and also spoils farmland as seawater intrudes on the lowlands during typhoons, leaving fields too salty for plants to grow. As a result, some places in central and southern Taiwan have already sunk to two meters below sea level.

One of these places is Yunlin County, which is a very important county for agriculture. However, 13 out of 20 townships in this county, which are considered the granaries of Taiwan, are located on areas of land subsidence. Additionally, years of the over-pumping of underground water, and saltwater intrusion caused by Typhoon Wayne and Typhoon Abby in 1986 and Typhoon Herb in 1996, led to the formation of an abandoned wetland (WRA, 2018). The impact of this wetland on the region's industry has been substantial, because Yunlin County's extraction of underground water is inseparable from the water usage habits of the residents. Overuse and depletion of groundwater is also intensifying flood conditions, a serious problem for the island, since 1,150 of its 36,197 square kilometers, including the outlying islands, are officially classified as flood prone (WRA, 2017: online).

3.2.4 High water leakage rate

Despite the improvement made till now, another long-tolerated management oversight that contribute to Taiwan's severe water issues is its old, leaky pipelines and aging infrastructure, leading to losses throughout the system. The already mentioned ex minister Lee Hong-Yuan made a statement on the problem saying that "We Taiwanese are simply not qualified to talk about water shortage [...] as we waste it. Every year we leak almost 30% of (our) water, equal to two Feicui Reservoir (TVBS NEWS, 2018). More than 22 percent of the water piped around Taiwan leaks away, higher than the world average of 18 percent (Japan's rate is only 7 percent). The place with the highest water leakage rate is Keelung (about 27%),

in the north of Taipei, followed by Taitung and Taichung City in central Taiwan (China TV News, 2018). Aside from being wasteful, the leakage problem creates unnecessary economic losses. According to data from Taiwan Water Corporation (TWC), the biggest state corporation, a total of 510 million tons of water leaked in 2016 (TWC, 2019).

The reasons behind the water leakage rate are the financial constraints Taiwan Water Company faced in the past. In order to lay more pipelines as to increase the distribution of water supply more quickly, economic pipes such as plastic pipes were used (TWC, 2013). In addition, the water pipe network equipment in all parts of Taiwan is gradually aging and those ruined by the frequent earthquakes were not replaced, leading to serious leaking. Based on data by the TWC, of the 62,000 kilometers of water pipes, 27.000 kilometers exceeded their service life (about 45%) (Fang, 2017). As a result, Non-Revenue water (i.e. lost water), was reported at 23,13% rate in 2018 (TWC, 2019). This worked out to be a NT$2.5 million per day financial loss for the Taiwan Water Corporation (€76,000). To reduce these figures, Lai Qingde, the president of the Executive Yuan[24], started a plan in 2013 to reduce the national water leakage rate in order to relieve water shortages. The "Water Leakage Reduction Plan (2013-2022) sets out to reduce water leakage to under 15% by 2021. Water leakage control can significantly improve the resistance to droughts. Taipei, for example, registered from January to July 2009 the same amount of rainfall as in 2002, year of one of the worst dry years for the island: However, thanks to the reduction of the leakage rate from 28.44% to 22.02%, the recovered water was used to support the city during that period (Taipei Water Department, 2020)

3.2.5 Water supply and water pricing

Another major issue authorities must contend with is the relatively cheap price of water in Taiwan, which have discouraged both conservation and investment in infrastructure. Taiwan's water infrastructures are the result of decades of intervention by external forces such as Japan, China and the US. The foundations of the public drinking water system were laid at the end of the nineteenth century[25], with the military occupation of the island by Japan. By 1945, the publicly supplied water coverage had been raised from zero at the time of the

[24] The Executive Yuan is the executive branch of the government of the Republic of China (ROC) on Taiwan, and is located in Taipei.

[25] More precisely in 1896, after the conclusion of the First Sino-Japanese War (1894–95). Taiwan was ceded by China to Japan with the signing of the Treaty of Shimonoseki.

Japanese rule to over 17 percent of total population in Taiwan (Harvey, 2015). After the Second World War and the restoration of Taiwan to the government of the Republic of China, major works were the repairing of the tapwater systems due to the damage caused by the war. The government didn't have the resources for the development of water systems in the early 1950s, and US investments played a critical role in raising water standards during those years. In particular, the US–Taiwan International Partnership Agency, referred to as the Sino-American Joint Commission on Rural Reconstruction (JCRR) (Zhōngguó nóngcūn fùxīng liánhé wěiyuánhuì 中國農村復興聯合委員會) was responsible for the coverage rate for drinking water to reach 30 percent of the overall population, not only urban citizen but also rural one, by 1960 (Harvey, 2015). Following the growth brought by industrialization, the number increased to over 43 percent and water systems were built under a new national economic plan. In 1972, the Premier of the Executive Yuan Chiang Ching-kuo announced that "In order to effectively develop a public water supply system island-wide, a water corporation must be established immediately at the provincial level [...] (with) long-term plans for the development of water supply, in order to concentrate human and financial resources, increase investment benefits and reduce operational cost." (TWC, 2019). As a result, the Taiwan Water Corporation (Táiwān láizìshuǐ gǔfèn yǒuxiàn gōngsī 台灣來自水股份有限公) was set up in 1974, eventually becoming a national state enterprise under the management of Ministry of the Economy in 1999. The percentage of actual population served by its water infrastructure climbed to 90 percent of total population by 2005 (TWC, 2019). As of now, TWC is responsible for water supply across most part of the island, providing 11,800 million cubic meters of water a day to 93 percent of Taiwanese people (WRA, 2019). The exception are Taipei City, which has its own water system, the Taipei Water Department (Táiběi zìláishuǐ shìyèchù 台北自來水事業處), and to a small extent two archipelagos of outlying islands served by Kinmen County Water Supply Plant (WSP) (Jīnménxiàn zìláishuǐchù 金門縣自來水處) and Lienchiang WSP (Liánjiāngxiàn zìláishuǐchù 連江縣自來水處). According to the Statistics of water resources published by the WRA, of the 23,589,000 people living on the island, 508,922 (6%) are still not reached by the tapwater system, mainly in southern rural and mountainous areas (WRA, 2019).

Despite the completion of almost universal coverage of tapwater, providing good quality water continue to represent a serious challenge to water infrastructures because of extreme natural events. Storms, floods, droughts, and especially typhoons and related landslides all inflicted significant failures of supply over the last two decades (Harvey, 2015). One example is Typhoon Aere, which hit northern Taiwan with abundant rainfall from August 23 to 26 in 2004. Such torrential rain brought a great deal of silt into Shihmen Reservoir, which caused raw water turbidity to be too heavy to be treated. As a result, TWC had to shut down all water treatment facilities that supplied water to Taoyuan and Taipei, leaving 1.45 million families without water for 12 days (Wen et al., 2010). Similar circumstances happened the following year always in Taoyuan and in the area of Gaoxiong. Due to the following interruptions of water provisioning, households were compelled to resort to other sources like pumping groundwater or buying water from water tankers. A peculiar response to continued irregularities of water supply is the construction by almost each Taiwanese household of individual or collective rooftop water tank (Harvey, 2015).

Droughts resulted in serious water shortages every three to four years in the last two decades. From September 2014 to May 2015, as a result of low rainfall in the typhoon season in 2014, the island experienced a nine-month drought event that affected agriculture, industry, and people's livelihood. In response to the poor water conditions, the WRA announced the phase-1 water rationing in September, which entails a reduction in water pressure between 11 p.m. and 5 a.m., in eight areas of the island[26] (NCDR, 2015). Phase-2 restrictions, with reduced or suspended water supply for irrigation purposes, were implemented from December for Taoyuan, Hsinchu, Chiayi, Miaoli, Taichung and Mingde, extending the measure to the whole island in the following two months. About 40,000 hectares of rice crops were stopped for irrigation, the highest in the past decade, causing vehement protests from farmers. The deteriorated conditions of all reservoir water levels forced the Central Emergency Operation Center (Zhōngyāng zāihài yìngbiàn zhōngxīn 中央災害應變中心), created ad hoc to face the emergency, to impose the "gōng wǔ tíng èr 供五停二[27]"phase-3 controls (NCDR, 2015). These measures reduced industrial water supply by 10% and water

[26] Namely Banqiao, Xinzhuang, Taoyuan, Miaoli, Hsinchu, Taichung, Tainan and Kaohsiung.
[27] Literally "supply five and stop two" means to cut the provisioning of water for two days a week to industries and households, only hospitals are exempted.

supply to households in some areas was stopped for five times, cutting water consumption by 188,000 tons per day on average (WRA, 2016).

From the above analysis, we can see that for Taiwan water is a scarce and extremely precious natural resource. Despite this, Taiwan's overly low water prices are one-tenth of the price paid in most of Europe (Li, 2005). Among OECD[28] and neighboring countries, Taiwan's average unit price of water is only higher than that in China and Korea. According to a 2018 report released by the International Water Association (IWA), however, in terms of the price-income ratio Taiwan has the second-lowest drinking water in the world, behind Macau (Cheng, 2019). Based on data by Taiwan Water Corporation, yearly water charges have been frozen on the island for more than two decades, staying around NT$2,900 per household from 1997 until 2018, even though national income has grown 55 percent during that period (TWC, 2019). If we look at statistics from the Department of Household Administration, the average household have 4 people. As the average water price is about NT$10 every 1000 liters, the monthly water fee for each household is calculated to be about NT$230, representing only 0.6 percent of an average family's expenses (TWC, 2019; Department of Household Administration, 2020).

The Water Resources Agency has on several occasions suggested to the government that water prices should be adjusted upwards. However, in the political context, proposing tariff reforms has always been an uncomfortable topic, stirring up polemic consequences and public's reactions (Chen and Chen, 2014). Neither the public, industry, nor even government organizations themselves want to cut down on water use. When talking about the pricing system for water services, it must be taken into consideration that the infrastructure needed to store, transport, distribute, and treat water requires large capital investments (Deyà-Tortella et al., 2016). Overly low water prices hence mean that the Taiwan Water Corporation lacks funds to renew infrastructure (Li, 2005).

Globally, the total amount of easily accessible freshwater on Earth is 45,500 km3/year. Of this total amount, 3800 km3/year are being withdrawn by humanity (Oki and Kanae 2006). Not only, as previously mentioned, the development of new water supply sources decreased over

[28] Acronym for the Organisation for Economic Co-operation and Development, is a united front for countries to share about their common eco-social problems, as well as collaborate on finding solutions. The OECD founders consisted of European countries plus the United States and Canada, and nowadays it comprises a total of 36 countries.

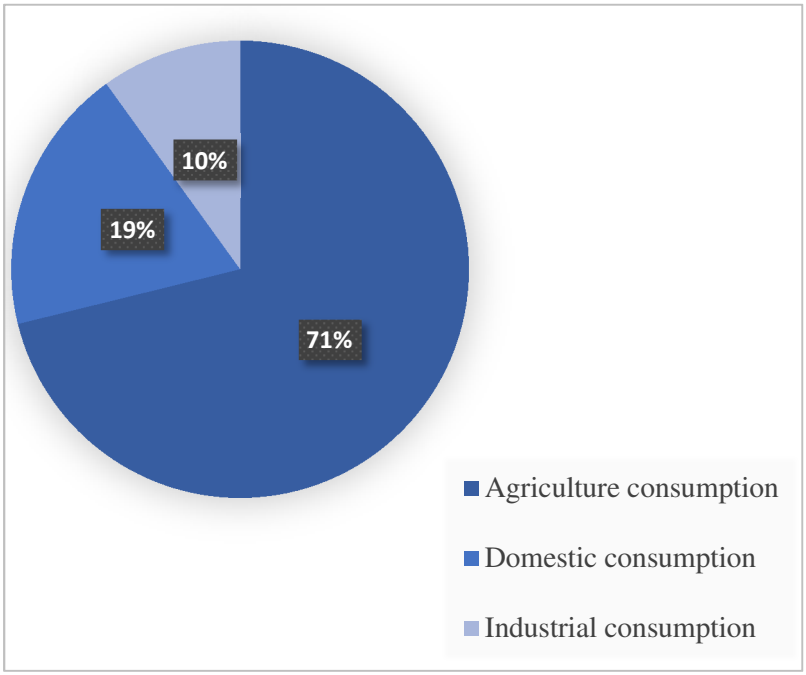
the last decades, water demand global water demand is expected to sharply rise to 5000 km3 by 2025.

In Taiwan, the development and utilization, operation and management of water resources have had different points and strategies throughout its history (Hwang, 2003). From 1984 to 1995, the island's the main strategy was dominated by engineering projects to have sufficient water supply for public use. This supply-driven water resource management style ignores the economic nature of water resources and its value, demonstrated by the low water price, and the potential conflict between locally limited water availability and water demand. This is clearly reflected in the development of the southern part of the island into the center of agriculture and heavy industry, both industries which require a great amount of water, and in the creation of the Southern Taiwan Science Park (STSP), against all scientific recommendations (Hung and Shish, 2019).

Unexpectedly, Taiwan's total annual water consumption has decreased from 17.678 billion cubic meters in 1996 to 16.645 billion tons in 2017 (WRA, 2018). Through the continuous urbanization and industrialization development, the structure of water consumption and water demand in Taiwan have nevertheless changed along with changes in society's structure. Domestic water consumption is 3.14 billion tons of water (18.91 percent), while water destinated to industrial use is just 1.65 billion tons, equal to 9.14 percent of total water consumption. The agriculture sector keep using the largest portion of the total water supply (11.84 billion tons), accounting for 71.15% of total water use (**Figure 5**) (WRA, 2018). However, its role in the economy has declined significantly since the 1950s. In 1952, it provided more than 90% of total exports and contributed 56% of Taiwan's GDP, while employing 56% of the labor force (Chi, 1994). According to official statistics, despite being essential to meet the domestic food demand, agriculture's contribution to GDP is just 3 percent nowadays. Irrigation, the major user of water in Taiwan, comprised 60% of total water

consumption, which is primarily managed by the 17 Irrigation Associations (IAs) (WRA, 2018).

Fig. 5 Total annual water consumption.



Uneven distribution of water usage among sectors have prompted national plans to reallocate water resources from agriculture to non-agricultural users, facing tough reactions from both local governments and agricultural water users alike (Hsu, 2004). According to the prevalent Water Law, water can be regularly transferred from water-rights holders to other users after proper negotiation and agreement on the compensation based on the volume and period of the transfer (Huang et al., 2007). However, in case of serious drought, the government has the power to intervene and carry out emergency water transfers by suspending water rights (WRA, 2014: Art.19). An example of regular water transfer is the one that took places from the Changwa and Yunlin Irrigation Associations to the Formosa Petrolchemical Corporation in 1992. The lengthy and unfruitful discussion between the parties involved did not lead to any agreement on compensation and forced the Central Region Water Resource Office to step in and set the price. Conversely, the 2002 water shortage we mentioned in previous paragraphs, for instance, created the circumstances for an emergency transfer of water from Taoyuan, Shimen and Hsinchu IAs to the domestic and industrial uses during the period 2002–2006 (Huang et al., 2007). Since the 1990s, both the Council for Economic Planning and Development (CEPD) and the MOEA fully endorsed the view that, in order to satisfy increasing demand of industrial needs and promote economic development, industrial water use should take priority over agriculture (Hsu, 2004).

Taiwan has developed an industrial structure that requires a large amount of water and whose consumption is expected to grow in the future, with the pace of growth the fastest in

science parks. The three parks Hsinchu Science Park in northern Taiwan, Central Taiwan Science Park centered in Taichung, and Southern Taiwan Science Park centered in Tainan are the center of the country's famous high-tech industries. Semiconductor foundries, responsible for Taiwan's rise as one of the "Asian Tigers", consume vast amounts of water, and according to the Ministry of Economic Affairs (MOEA) data, their water demand is expected to double by 2031 (MOEA, 2020). Because of the lack of running water, Taiwan Semiconductor Manufacturing Co. (TSMC), the world's most advanced wafer foundry, has taken the lead in recycling wastewater. The water used by the plant is recycled up to 4.5 times, limiting to the maximum water waste.

However, due to low water tariffs, the majority of Taiwan's industries doesn't even consider reclaimed wastewater, which currently costs NT$17 per cubic meter, compared to only NT$10 for tap water. As a result, only 57 percent of water used in industry in Taiwan is recycled, compared to 90 percent in Japan and Germany (TWC, 2019). Other solutions like seawater desalination are considered in water-scarce regions like Kinmen and Penghu Island, but due to its high cost, this technology has not been seen as a viable option till 2018. Following the need for alternative water sources, The Formosa Plastics Group (FPG) recently is teaming up with Israeli-firm IDE Technologies to design a desalination plant in Yunlin, which would produce between 20,000 and 105,000 tons of desalinated water daily for industrial purposes. Nevertheless, according to the data from WRA (2018), only 700 million tons of water a year were reconverted to industrial use in 2018.

As long as Taiwan's water prices continue to be among the world's lowest, industries and citizens alike will find little incentive to adopt effective water-saving practices and technologies. The lack of environmental consciousness resulting from this situation is reflected in the domestic water consumption (WRA, 2018). In Taiwan the average daily per capita water consumption for domestic purposes was 280 liters (332 liters in Taipei) in 2018, twice that of the US and Europe.

Thus, policymakers must consider water price as a key economic tool in water resource conservation policies. Studies have found that, as a water policy, pricing can control the demand sector and is a long-term solution for water scarcity (Deyà-Tortella, 2016; Yuan and Chiueh, 2019). Embed water scarcity into the water price structure is of fundamental importance in improving the usage efficiency of water resources and can be done through different mechanisms. On this matter, some of the latest international water regulations tried to

address this issue. An example is the European Union Water Framework Directive (WFD), which created a pricing structure that taxes water users to reflect the scarce value of water. The European Commission report states that "water pricing should be used as a key tool to support water management decisions, and that underpriced water may lead to its unsustainable use"(European Commission, 2011). The WFD aims to improve the status of European water in terms of both environmental quality and availability and is seen as an example of successful integrated environmental management system (Deng et al, 2015). One of its key elements is extending public participation in water management, which can severely affect the efficiency and effectiveness of other environmental strategies already in place.

3.2.6 Water management organizations

From the past 10 years, Taiwan's environment has suffered serious destruction and pollution causing the disappearance of biodiversity, dwindling of forest, worsening water quality and affects the island's sustainability. The globe's changing climate and frequent occurrences of extreme natural disasters such as earthquake and typhoons due to human continued in their path of over development and over utilization of biological resources. Over the last three decades the Taiwanese government has increasingly emphasized its efforts to take firm action in order to stop environmental degradation, as is illustrated by the prominence of environmental issues in Taiwanese politics, the great deal of national laws and regulations and the number of environmental institutions that have been established. Turning points in the recognition of the importance of environmental protection are the amendment of Article 10, paragraph 2 of the ROC's Constitution, introducing the principle that "Economic, scientific and technological development should simultaneously consider and take care of environmental and ecological protection" (EPA, 2020), the upgrade of the former Bureau of Environmental Protection under the Department of Health to the Environmental Protection Administration (Huánjìng bǎohù shǔ[29]環境保署) in 1987 (Chan, 1993), and the approval, in 1998, of the "National Environmental Protection Plan" (Guójiā huánjìng bǎohù jìhuà 國家環境保護計畫), allocating NT$ 51 billion dollars per year in the prevention and control of water and air pollution, as well as in the improvement of the national waste disposal system (EPA, 2020).

[29] By definition of its Chinese title, Huanbao 'Shu' (Agency), the staff size of such an agency is roughly about that of a branch of a larger ministry under the regular title of 'Bu'.

Another important step is the implementation in 2002 of the Basic Environment Act (Huánjìng jīběnfǎ 環境基本法), a sort of constitution of the environment which states the fundamental ideals behind Taiwan's pursue of sustainable development by promoting environmental protection. The most important feature of this law is contained in Article 3, which officially places environmental protection on the same level of economic growth, and declares that "in the event that economic [...] development has a seriously negative impact on the environment or endangers the environment, the protection of the environment shall prevail" (EPA Laws & Regulation Database of the ROC, no data). According to the Basic Environment Act "The Central Government shall formulate relevant environmental protection laws and regulations, formulate national environmental protection plans, establish sustainable development indicators, and promote their implementation.". Such indicators are for example national environmental standards like the River pollution index (RPI), Drinking water quality standards and Surface Water Classification and Water Quality Standards, issued by the EPA.

From 1998 onwards, Taiwan enacted and implemented 417 environmental laws and regulations, including the Water Pollution Control Act (Shuǐ wūrǎn fángzhì fǎ 水污染防治法), which marked Taiwan's commitment in the prevention and control of water pollution. According to the provisions contained in its Article 10, the EPA's competent departments at all levels should set up water quality monitoring stations to assess the effectiveness of policy administration and curb water quality deterioration (EPA, 2020: online). The overall monitoring work started in 1976 and is carried out through 318 monitoring sites at 87 rivers, 114 monitoring sites at 58 reservoirs, 104 monitoring sites based in 19 different coastal areas, 10 seaside recreation areas, 431 underground water wells (EPA, 2020: online).

Besides the government's endeavors in the continuous promotion of water pollution discharge control (Water Pollution Prevention and Control Law), groundwater pollution control, especially for drinking source areas (Soil and Groundwater Pollution Remediation Act in 1990; Drinking Water Management Act in 1972), the EPA has actively coordinated with the Construction Department to promote the construction of sewage sewers. In addition to the centrally administered EPA, twenty-two city and county departments of environmental protection (DEPs) exist. The EPA supervises these local DEPs; however, the agenda of each local group is set by individual DEP directors who are appointed by the county commissioner or city mayor (EPA, 2020). Despite the undeniable improvements as a result of the efforts made at the central and local levels, the tough present conditions of hydrological variability and the future challenges we discussed above in this chapter call for further intensive efforts to

eradicate water pollution. In this regard, a new version of the "National Environmental Protection Plan" has been released and approved by the Executive Yuan on the 14th 2020, echoing the United Nations Agenda 2030[30]. The targets to be achieved by 2030 are: 1) reduce carbon and natural hazards (Jiǎn tàn shǎo zāihài 減碳少災害): reduce greenhouse gas emissions are by 20% compared to 2005; 2) breath at ease (Zìzài hǎo hūxī 自在好呼): increase the ratio of days with healthy air quality from 84% to 93%; 3) leisurely enjoy clear water (Yōuyóu xiǎng qīnshuǐ 優遊享親水): reduce the length ratio of the 50 severely polluted river sections from 3.8% to zero; 4) make garage a resource (Lèsè biàn zīyuán 垃圾變資源): increase general waste recycling rate ì from 55.69% to 60%; 5) zero forest loss (Sēnlín líng sǔnshī 森林零損失): maintain the forest coverage rate above 60.7%; 6) coexist with the land (Yǔ yě gòng shēngcún 與野共生存): maintain the legal land protection area to national land area ratio at 19.2% (EPA, 2020). In the second chapter of the plan, the EPA recognize that "(Taiwan's) inherent natural restrictions reduce available water resources" and underline "the need [...] conserve water".

The same United Nations stressed the importance of the global water crisis by announcing on the 22nd March 2020 the "World Water Day". UN Secretary General Guterres pointed out in his speech that 2020 is a critical year for the success or failure of climate action and that poor management of water resources often exacerbates the effects of climate change. The report require calls for concrete efforts to address the increasing pressure on water resources and improve the efficiency of water use (NSDN, 2020).

Taiwan's constitution confers primary water governance authority on the national government (Laws & Regulation Database of the ROC, no data: Art 10). National responsibility for water governance, however, has been fragmented and involves: the Ministry of Economic Affairs (MOEA) in the center; the municipal government in the municipality; and the county (city) government in the county (city) (WRA, 2014: Art.4). According to the 2018 revised Water Law (Shuǐlì fǎ 水利法), "water is a natural resource and belongs to the state. It is not affected by the people 's acquisition of land ownership" (WRA, 2014: Art.2). The central government is responsible for managing water resources areas that involve two provinces (municipalities) or more, more than two counties (cities) or a county (city) that is difficult to

[30] Refers to the universal policy agenda adopted by all United Nations Member States in 2015 which has at its heart the 17 Sustainable Development Goals.

establish. The municipality or county (city) government is responsible for the water conservancy undertakings, and those whose interests involve more than two municipalities or counties (cities) have to be approved by the central competent authority.

Since the mid-1980s, government institutions in Taiwan have been reorganized by democratization processes and intergovernmental reforms. In addition to opening up national political institutions to public participation and representation, the process of democratic transition in Taiwan has restructured intergovernmental relations to increase local autonomy and improve governmental efficiency and effectiveness (Hsu, 2003). However, rather than decentralizing, democratization fostered a centralizing trend when the 1997 constitutional reform deprived the Taiwan Provincial Government (TPG) of its functions ad merged all of its agencies into the national government. Both the Water Resource Department (WRD) and the Taipei Water Resources Specific Committee under the TPG became part of the national MOEA in July 1999 (WRA, 2020). The current the Water Resources Agency is the result of the integration of the former TPG's agencies with the MOEA's own Water Resources Bureau into a more centralized water institution. This expansion of national authority has altered Taiwan's fragmented system of water governance and water policies.

Including the WRA, there are around 10 government agencies who play a role in the water resource management system in Taiwan (**Figure 6**). Under the Executive Yuan, the highest administrative organ of the country, we find the Department of Land Administration of the Ministry of the interior (MOI) (*Nèizhèngbù* 內政部), with tasks related to wetland construction (Shīdì yíngzào 濕地營造), flood detention ponds (Zhìhóng chí 滯洪池), plants beautification (Zhí zāi měihuà 植栽美化) and sewage treatment facilities control (Wūshuǐ chǔlǐ shèshī 污水處理設施) (MOI, 2020). The Ministry of Economic Affairs (MOEA) (Jīngjìbù 經濟部), with its WRA, is in charge of rivers and lakes (Héchuān 河川), coastal areas (Hǎi'àn 海岸), and responsible for a number of essential functions ranging from reservoir storage area management to water engineering works like drainage (Páishuǐ 排水), flood detention pond (Zhìhóng chí 滯洪池) and coastal dykes, etc (WRA, 2020). Taiwan Water Corporation, always under the MOEA, in charge of water supply and developing the public water infrastructure. Another important government agency is the Council of Agriculture (COA) (Nóngyè Wěiyuánhuì 農業委員會): two major agencies working under this organization are the Forestry

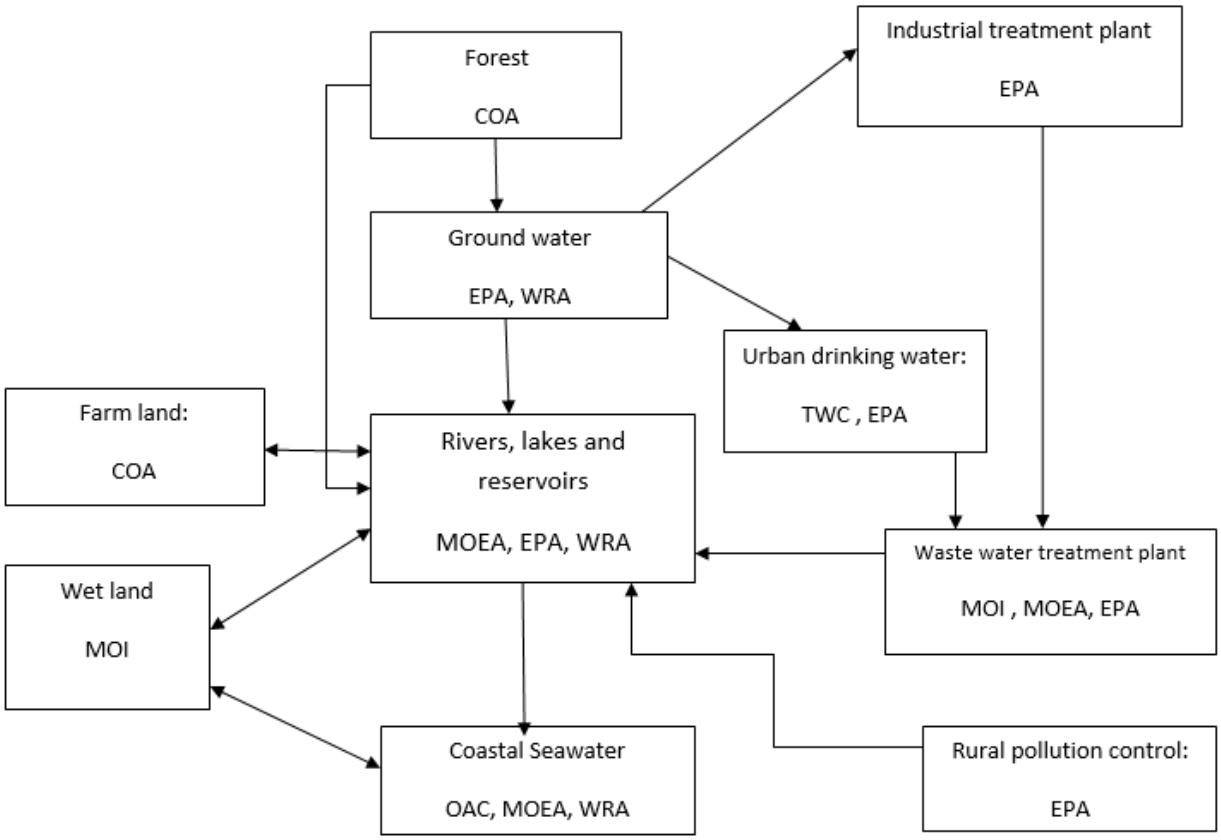


Fig. 6 Government agencies involved in water environmental management.

Bureau (Lín wù jú 林務局) and the Soil and water conservation Bureau (Nóngyè Wěiyuánhuì Shuǐtǔ Bǎochíjú 農業委員會水土保持局) (Liao, 2017).

The EPA, as we said before, is responsible for the prevention and control of water pollution as well as the issuance of water quality standards. Finally, the Ocean Affair Council (OAC) of the Coast Guard Administration (Hǎiyáng wěiyuánhuì hǎi xún shǔ 海洋委員會海巡署) is in charge of marine conservation and control of coastal areas. For the past century, many countries in water-scarce regions have placed heavy reliance on their ability to augment water supply in order to deal with water threats (Richter, 2017). One example is Taiwan, whose water resource management in the last decades has been dominated by engineering projects to satisfy water demands rather than improving water use efficiency (**Table 3**) (Yu, 2016). The most recent example is the "Forward-Looking Infrastructure Development Program" (FIDP)

(Qiánzhān jīchǔ jiànshè jì hu 前瞻基礎建設計畫), a huge public infrastructure construction project announced by the latest ROC president Tsai Ing-wen (WRA, 2020).

Name of project	Work items	Period	Budget (billion TWD)
Development of Water Resources Technologies	Improvement of flood and drought disaster risk assessment	2002-2012	2.302
Groundwater Conservation and Management Project	Enhanced groundwater recharge project for Changhua and Yunlin Regions	2009-2014	2.598
Hushan Reservoir Engineering Project	Reservoir construction project Water diversion project	2002-2014	20.475
Major River Environment Building Project	Mainly for implementation of survey, monitoring, planning, and study of rivers under central government jurisdiction and cross-city rivers	2012-2014	29.7
Coastal Environment Building Project	Implementation of coastal protection and management of sea dike facilities	2009-2014	8.0
Regional Drainage Management and Environment Building Project	Implementation of regional drainage improvement operations in areas under central government jurisdiction	2009-2014	17.0
Offshore Island Water Supply Improvement Project	New desalination plant construction projects Lake & reservoir dredging and improvement project	2007-2015	4.267
Deep Seawater Resources Utilization and Industry Development Project	Promotion of deep sea water operations Establishment of deep sea water technical inspection and certification system	2006-2011	1.147

Table 3 Significant projects launched by the WRA (2002-2015). Source: WRA, 2020.

Unveiled in 2017 by the government, the FIDP is a comprehensive initiative aimed at addressing Taiwan's key infrastructure needs over the next 30 years. Aquatic environments,

budgeted at around NT$25 billion (US$833 million) for the first stage of the FIDP ending 2018, accounts for the second largest share of funding among the program's eight focus areas.

This tendency to cope with water scarcity problems by increasing water supply, e.g., by expanding surface and groundwater storage through the creation of new infrastructure (dams, reservoirs), desalination plants, reuse of wastewater, has prevailed over focusing on reducing water demand, e.g., by tackling the losses in transport and distribution systems, implementing adequate tariff systems, which seek to encourage lower water demand levels, and, generally, increasing the efficiency of water use in domestic, industrial, and irrigation systems; in other words, to better conserve water resources.

3.2.7 Current status of public participation

Regardless of implementing supply-oriented or demand-oriented water management, water resources should not be wasted. As a valuable, limited resource, water policies should account for their economic nature in relation to their natural characteristics and embedded scarcity. However, despite being necessary, governments' political, institutional and administrative efforts alone are not enough. Civil society and citizens engagement are key to develop and implement effective measures to gain relief from recurring water shortages (Ziadat, 2010; Chen and Chen, 2014).

Depending on the openness and responsiveness of their underlying political institutions, different environmental management systems have incorporated different degrees of public participation in their decision-making structures. Traditionally, Taiwan's authoritarian legacy initially gave rise to an environmental protection system with limited channels for public participation and high susceptibility to political influence (Tang, Tang and Lo, 2005). The democratisation process starting in the 1980s, however, has triggered public pressure to develop more channels for various social actors who can act as advocates for the environment. Relevant studies claim that public participation in public policy making seems to increase in a democratic society through a process of public engagement involving public affairs in which stakeholders (residents) may influence the decision of development projects (Chen and Chen, 2014; Hsu, 2004). Although on the other hand public engagement may be regarded as cumbersome and unnecessary because citizens lack necessary expertise, the presence of these

non-governmental forces in the decision-making process has proved strongly necessary for ongoing environmental transitions. (Tang, Tang and Lo, 2005).

Public activism in Taiwan has been key in the development of an environmental protection movement on the island. With the formation of the ROC's EPA, modeled after the U.S. Environmental Protection Agency, along with the suspension of the martial law, Taiwan saw the birth of a great number of nongovernmental organizations (NGOs) and social movements (Chan, 1993). Given the growing environmental pressure, governmental officials were forced to react to environmental movements initiated by local civil society. One example is the Anti-Dam Movement, that managed to block the construction of the Meinung Dam in southern Kaohsiung County. The five-year project, already approved by The Executive Yuan in 1992, had been carried on without the consultation with local residents, triggering angry protests (Hsu, 2004). There has also been a widespread coverage of environmental issues by the newly liberalised media (Grano, 2014). Elected officials have begun to feel increasing pressure to show their support for environmental protection, marking a deep change between the Taiwan of the pre-democratization, where people valued economic interests above everything, and the following two decades. As a result, the EPA gained more political support to address certain ecological imbalances, which were previously left aside. A fundamental step in this direction is the adoption by the Legislative Yuan in 1994 of the formal Environmental Impact Assessment (EIA) Act (Huánjìng yǐngxiǎng pínggū fǎ 環境影響評估法), a critical instrument for environmental management which enables the active involvement of environmental groups in legislative activities (Tang, Tang and Lo, 2005). The final Act provides for the setting up of an independent board which has to include public interest representatives as scholars and nongovernment experts (Laws & Regulation Database of the ROC, no data). Noticeably, the 1994 Act also requires developers to formally announce the project for a certain period before starting the review process, and the environmental impact report has to be made available for public examination (Tang, Tang and Lo, 2005). Even though the institute of the EIA has progressed from a closed-door discussion to an open review process, yet many problems remain as to how participatory processes can be improved. In reality, researches by Grano (2015), show that the political component still remains the priority when it comes to a project termination, no matter how well-founded the evidence gathered by activists and experts are. It's the case of the project of the Kuokuang Petrochemical Technology Co. (Guóguāng shíhuà kējì,國光石化科技) (KPT), a naphtha facility in central Taiwan, and the fourth nuclear power

facility (following the collapse of Fukushima), whose constructions were blocked near the elections in the period 2011-2014 (Grano, 2014).

While Taiwan's environmental governance system has seen a gradual shift from an essentially top-down organizational structure to an increasingly bottom-up structure with growing procedural participation (like in the case of the EIA), structural constraints to an effective environmental management are still numerous, especially looking at the institutional system of water resource management (Ho, 2005). Although many years have passed since the establishment of the EPA, it continues to have very limited powers, as its very name suggests[31]. The real responsible for environmental decisions is still the Executive Yuan. The same goes for the WRA and the TWC, which are under the Ministry of Economic Affairs, a strong signal of their subordination to the economy.

The United Nations World Water Development Report 2 (WWDR, 2003) has observed that water shortages can be improved with water management systems in which governments, private firms and the civil society work collaboratively. Despite Taiwan having witnessed an upsurge in activism and public involvement in the past few years, liberal associability resulting from democracy does not guarantee success. According to Ho (2005) "without persistent mobilization from below, the movements are not likely to make significant progress". Aware of this, both the EPA ad WRA have recently taken steps in involving local people in individual actions to improve the water environment. In order to eliminate the water pollution problem at its roots, the EPA has strengthened the Water Pollution Prevention and Control Law, creating a system of public report where a certain percentage of the total amount of fines to be paid by those who violate the law goes to the reporter (EPA, 2020). On the other hand, to address the main water issue of diminishing and uncertain water security in the face of increasing consumption, water authorities also recognized the need to manage water demand. In this regard, the Water Resources Agency has proposed a special plan for water saving and the recycling of water resources. This "Plan for Active Implementation of Water Saving Measures" includes enforcing the use of products with the water-saving label, holding water-saving activities, in the attempt to move towards the "water-saving society" of advanced countries (WRA, 2020). The target set is lower the average annual per capita water consumption from 280 liters (332 liters in Taipei) to 250 l/day, the quantity suggested by the United Nations. To get to that point, given the current tough conditions described above, Taiwan needs to urge the

[31] The character "署"(Shǔ) at the end of the EPA (and WRA as well) denominates cabinet-level institutions, with fewer members and fundings and, of course, power.

awareness of water resource protection, educate correct water knowledge and encourage water-saving behaviors.

4. Empirical results

In times of increasing environmental concern, today's societies are characterized by more and more pronounced social norms regarding environmental protection. In many areas of life, social norms associated with the protection and conservation of environmental resources influence individual behavior (Fahlquist, 2009). Over two decades ago, academic commentators began referring to environmental protection as a "valence issue" that few individuals, if none, would dare to openly oppose or reject (Rudig, 1995). In this vein, a survey by The Henry J. Kaiser Family Foundation conducted in 2000 showed that 64% of Americans considered the protection of the environment to be a moral issue involving beliefs about what is right or wrong (Brandy, 2004). For these reasons, any attempt to obtain a rounded picture of public concern and engagement with the issue must consider, not simply how concerned people say they are about the environment, but how much importance they attach to it compared with other prominent issues and concerns. Accordingly, to provide some context for the survey findings this chapter considers the relative salience of the environment in the public consciousness, in other words, how much the environment is at the front of people's minds.

In the very first part of the questionnaire, respondents were asked what they considered to be the most important issues facing Taiwan today. Overall, 3,5%[32] of respondents considered the environment or environmental issues (such as climate change) as the most important issue facing Taiwan today. As **Figure 7** shows, the predominant response was diplomacy and foreign affairs, with more than half of respondents (52,4%) mentioning it. Other common answers were the economy (15,6%), followed by education (12,7%), domestic politics (7,8%) and health care (6,4%).

This ranking of importance is not surprising for several reasons. First, Taiwan is in a difficult geopolitical position, especially since Tsai Ing-wen, leader of the ruling Democratic Progressive Party (DPP), assumed power in 2016. In the last four years, the Tsai government has lost seven diplomatic partners, the last two countries, Solomon Islands and Kiribati, in September 2019, leaving it with just 15 diplomatic allies (MOFA, 2020). Since China refuses to have diplomatic relations with any country that recognizes Taiwan as a sovereign nation, the island has become increasingly isolated and has been barred by international organizations like the United Nations (from which it was expelled in 1971) and the World Health Organization (Wang, 2019). Moreover, it must be noted that the survey was distributed in a period from

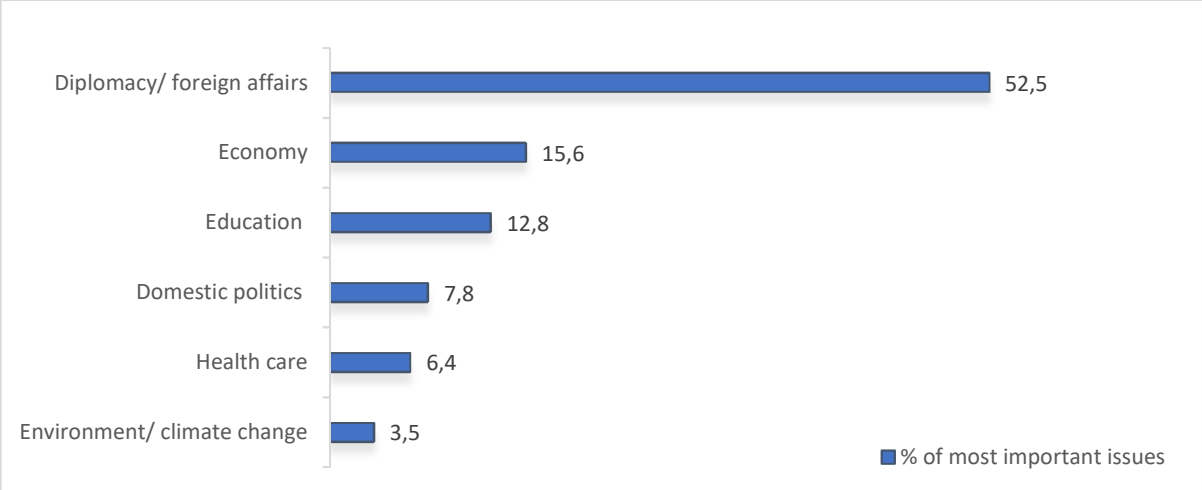
[32] All figures are rounded to the nearest percentage point.

mid-November 2019 to early January 2020, just before the incoming presidential elections held on the 11th of January. The two most promising candidates running for the elections were Tsai Ing-wen, the President-in-Office and Han Kuo-yu, from the mainland-friendly Chinese Nationalist Party (KMT). The central issue in this campaign was the emergence of the island's relationship with China, whose president, Xi Jinping, earlier in January 2019 gave a speech emphasizing the urgency for Taiwan's unification under the "one country, two systems" model[33] (Ogasawara, 2019). As already mentioned in the previous chapter, in Taiwan the environment is by no means absent from political and media debate in the run-up to elections, when is frequently used as a mere instrument to capture more votes (Grano, 2014). It seems reasonable to conclude that while a minority of students see the issue as important for their country, the majority feel there are other, more pressing concerns.

Fig. 7: Most important issues facing Taiwan

Q. Which of these issues is the most important for Taiwan today?

(Q. 請問您認為以下哪個項目是目前台灣社會最重要的議題?)



However, its importance becomes strikingly higher when respondents were asked what were the most important issues facing the world today. In this case, the environment has far exceeded other answers, with over two thirds (77,3%) of respondents identifying it as the single most important issue facing the world. Other issues like the economy (5%), poverty (3,5%), diplomacy ad immigration (2,8%) scored significantly lower, with just three or even only one

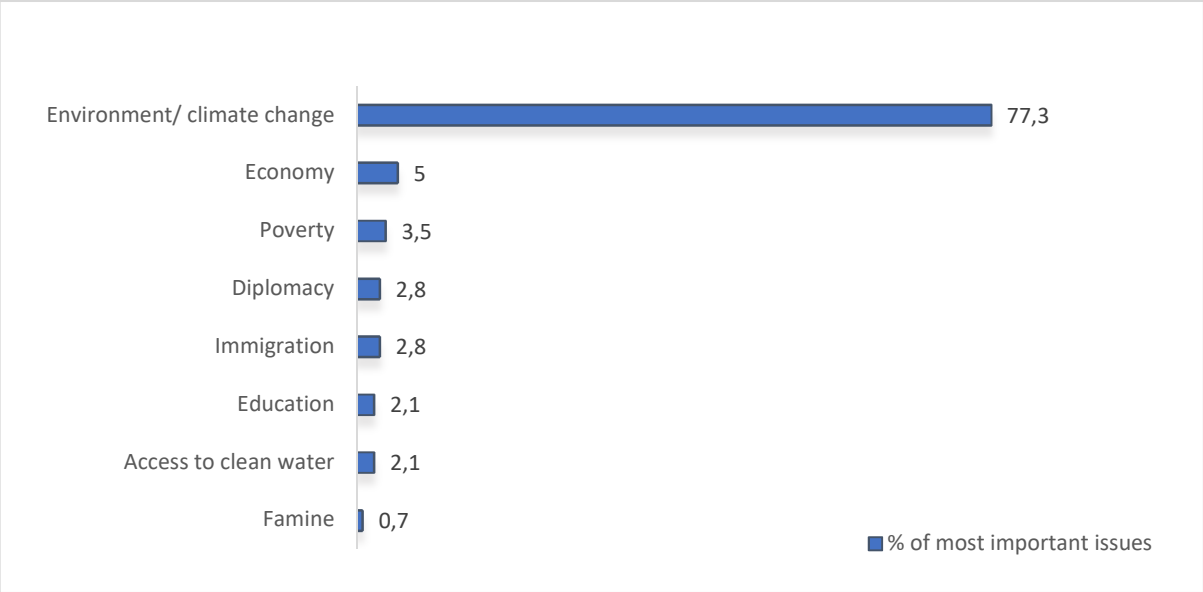
[33] "Yīguó liǎngzhì 一國兩制" is a constitutional principle describing the governance of Hong Kong and Macau since they became regions of China in 1997 and 1999, respectively.

respondent mentioning problems such as education (2,1%), access to clean water (2,1%) and famine (0,7%)(see **Figure 8**).

These results suggest that in Taiwanese students' minds the environment may not be regarded as the most important issue of the island, but it has clearly gained currency as an issue among the public. In other words, the majority of respondents see the environment more as a global concern rather than something that personally involves them. This is somehow confirmed by the rather low number of participants in the Global Climate Strike[34] movement taking place from September 20 to September 27 2019. While millions of young people gathered in squares and streets across 185 countries in what has been defined as "the biggest climate protest in history" (Qiu, 2019), just a few hundreds demonstrated in Taipei City.

Fig. 8: Most important issues facing the world

Q. Which of these issues is the most important for the world today?
(Q. 哪個項目是目前全世界最重要的議題？)



[34]The Global Climate Strike were a series of international strikes and protests started by the Swedish school striker Greta Thunberg in August 2018. The demonstrations urged governments to take urgent action to cut emissions andaddress climate change.

4.1 Environmental concern

As we said in the second chapter, environmentally-friendly behavior and environmental protection require a widespread recognition that the problem in question do exist. For this reason, it's crucial to understand the level of public's concern of current water scarcity and how much this and related issues are prominent in the mind of Taiwanese people.

To do so, respondents were first asked to indicate, from a list of ten options:

- which specific environmental issue was the most important challenge for Taiwan; and,
- to rank other existing environmental problems, indicating what were in their opinions the second and third most important issues.

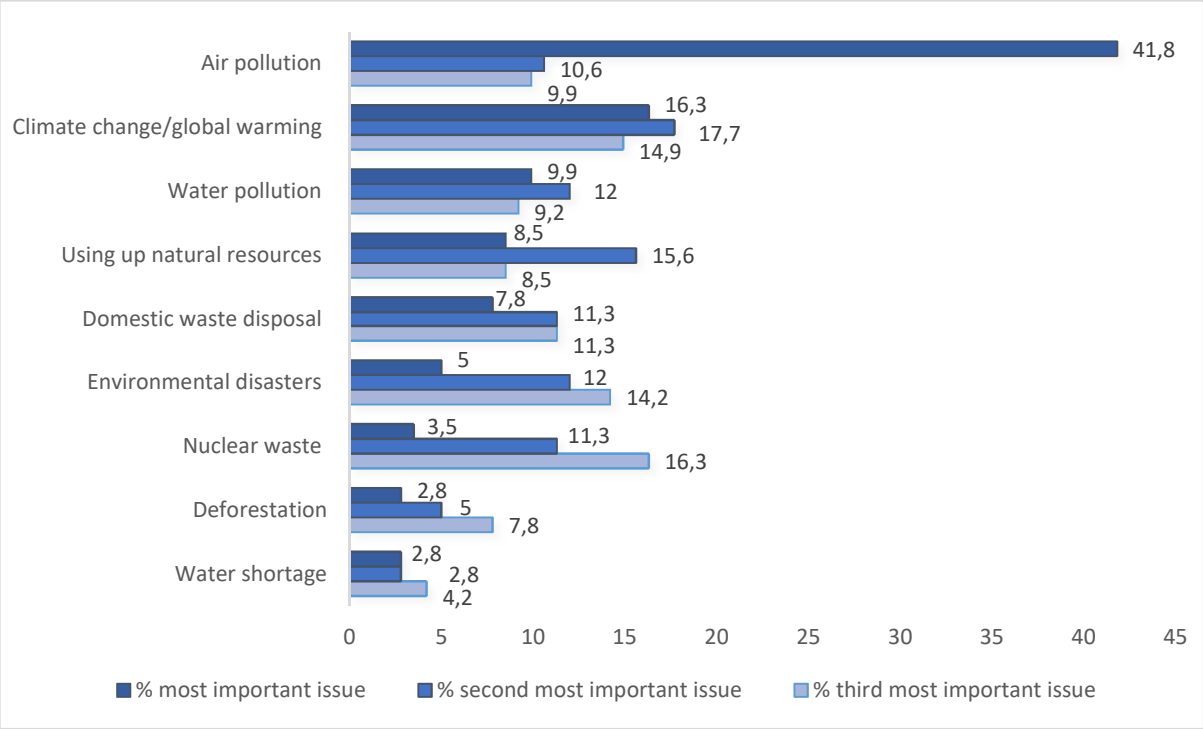
As illustrated by **Figure 9**, air pollution was by far the most mentioned problem, with 41,8% of respondents indicating it as the most important environmental issue for their country. Climate change/global warming was the second most common choice (16,3%), followed by water pollution (9,9%) and using up natural resources (8,5%). According to results, other environmental issues comprised: domestic waste disposal (7,8%), environmental disasters (e.g. typhoon, earthquake) (5%) and nuclear waste (3,5%). Water shortage, as you can see, as well as deforestation are at the very bottom (2,8%), with just 4 respondents who deem them to be the single most important environmental challenge facing Taiwan.

This ranking is somewhat unsurprising because unhealthy air is a widespread, pervasive problem of global concern (WHO, 2016). In Taiwan, particularly in the central and southern regions, air pollution has long been a critical issue. Although EPA's monitoring results claim that Taiwan's air conditions have steadily improved from year to year, Kaohsiung, Pingtung, and Chiayi City average PM2.5 [35] levels registered throughout 2017 severely exceeded standards, with "good" air quality rating for just 39 percent of the time during the entire year (Xiao, 2018).

[35] PM2.5 stands for particulate matter measuring 2.5 micrometers in diameter. These fine particles, which are more than 100 times thinner than a human hair, can get deep into lungs and pose a great threat to human health.

Fig. 9: Most important environmental problems for Taiwan

Q. Which problem, if any, do you think is the most important environmental challenge facing Taiwan?
Q. And what are in your opinion other existing problems? (Please sort them in order of importance)
(Q. 請問您認為對台灣整體來說，最重要的環境問題是哪一項？
Q. 那您認為現在還有哪些其他問題？)



Looking also at the second question, despite having given a relatively high importance to water pollution (31,2% in total), less than one in ten respondents in total make any mention of water shortage across the two questions. With 90% of respondents failing to mention the issue at all, it is clear that the threat of water scarcity is far from being a priority and does not worry Taiwanese students. It is of major importance to determine whether or not this situation is the result of a lack of ability to perceive the seriousness of the mentioned problem and its major causes, as well as changes in the state of the environment.

Based on its definition given in chapter 2, the survey analyzed the level of *concern* through four factors: (a) knowledge of current water availability status, (b) knowledge of the current water quality status, and knowledge of the change in the availability (*c*) and quality (d) of water.

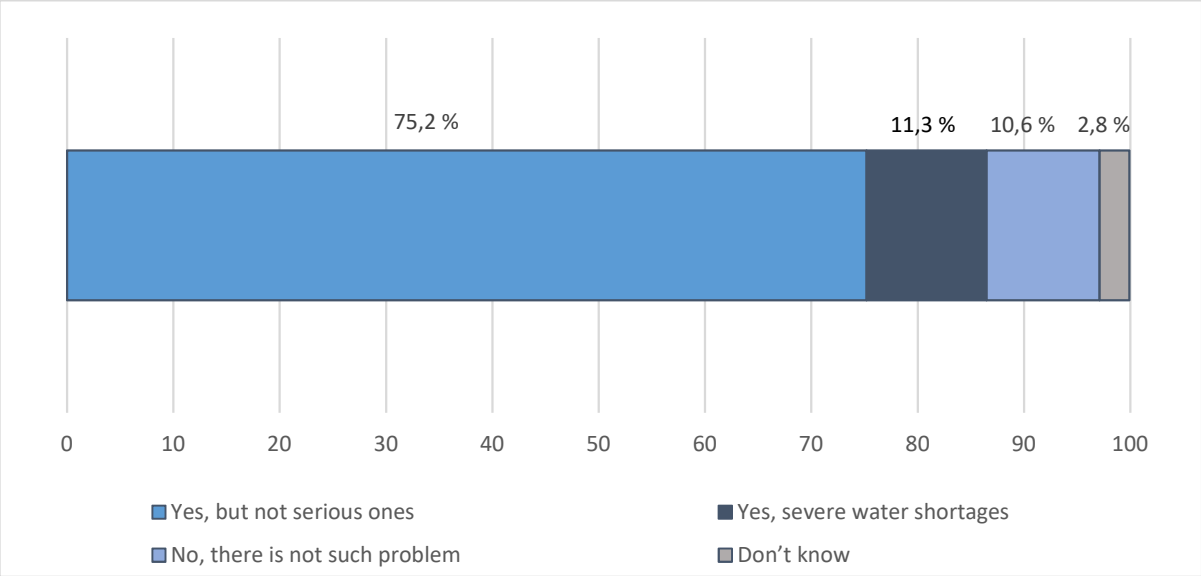
Most respondents (75,2%) report that "there is water scarcity in Taiwan, but it's not serious", and 11,3% think there is severe water shortage. On the contrary, 10,6% affirm that

"there is not such a problem", while a small group (2,8%) answered they didn't know at all (**Figure 10**).

Fig. 10: Taiwan current water availability status

Q. Do you think that Taiwan is facing water shortages?

(Q. 您覺得在台灣有缺水問題情況嗎?)



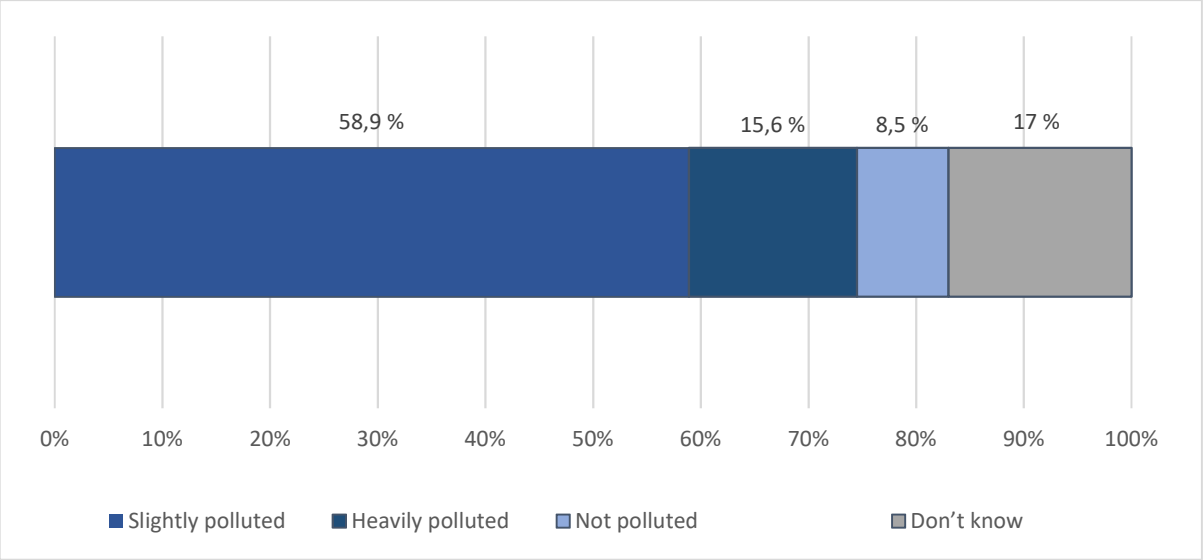
As already mentioned, experience plays an important role in the process of raising environmental concerns (Sudarmadi et al., 2001; Brombal, Moriggi et. al, 2018). Hence, the status of water availability may become more important to the individuals that directly experience problems related to water shortages. For this reason, students were asked another question: "Have water shortages or droughts ever affected you (or your family members) in your everyday life (e.g., water rationing, increase in the prices of food)?" The results partly match findings from Figure 10, with the majority of respondents (70,2%) reporting having experienced personally water scarcity in their everyday lives.

As regards current water quality, more than two thirds of respondents rated water conditions in their surrounding areas as "slightly polluted" (58, 9%) and "heavily polluted" (15,6%), while 8,5% denies that there is water pollution (**Figure 11**). However, there was a significant increase of respondents that said they have no idea (17%).

Fig. 11: Taiwan current water quality status

Q. What do you think about the current water quality in your surroundings?

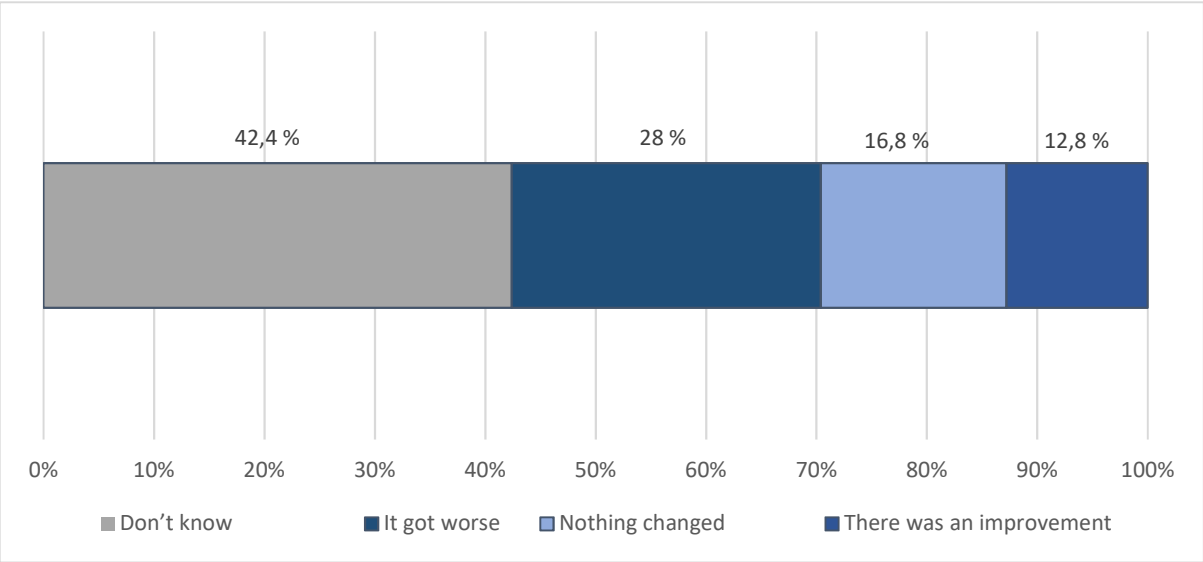
(Q. 您認為週遭環境的水汙染情況為何?)



When asked if they noticed a change for better or worse in the water scarcity issue over the past ten years 42,4% of respondents report that they "don't know" (**Figure 12**). While 28% express the belief that water shortages worsened in Taiwan, a consistent group think that water availability didn't change over the last ten years (16,8%), or that its conditions actually improved (12,8%).

Fig. 12: Changes in water availability status

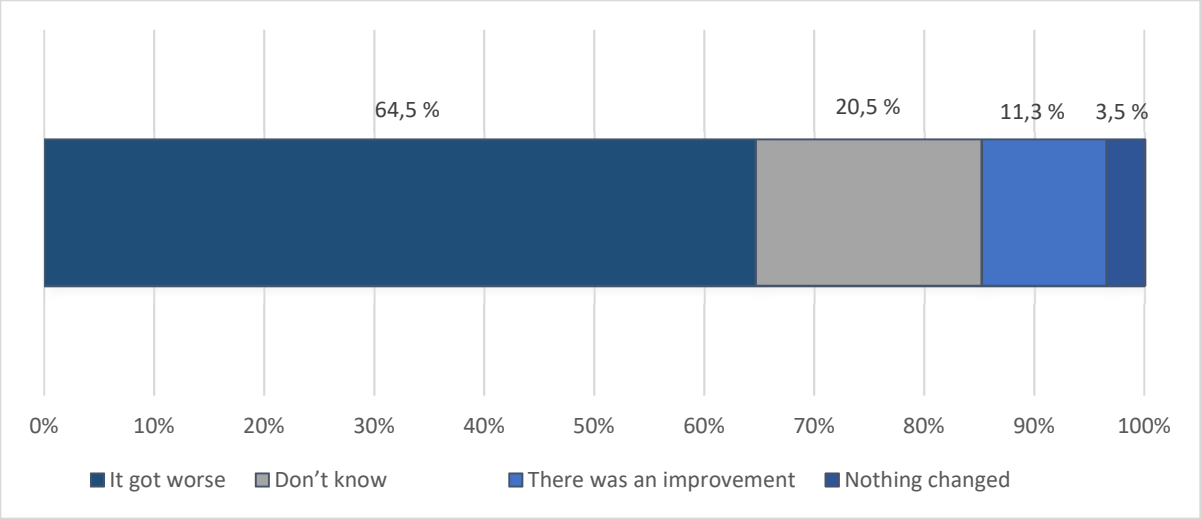
Q. Do you think that the water scarcity's issue in your country changed in the last ten years?
(Q. 您覺得最近十年缺水情況有了變化嗎?)



Lastly, respondents were asked if they perceived a change in water quality conditions over the past ten years (**Figure 13**). In this instance, nearly two thirds (64,5%) of respondents reported that water quality "got worse" in recent years while another 20,5% admit having no idea. A minority (3,5%) thinks that water quality is no different from before and a higher percentage (11,3%) of students answered that they thought "there was an improvement" in water conditions.

Fig. 13: Changes in water quality status

Q. Did you notice a change in terms of water pollution in the last ten years?
(Q. 您認為最近十年汙染情況有了變化嗎?)



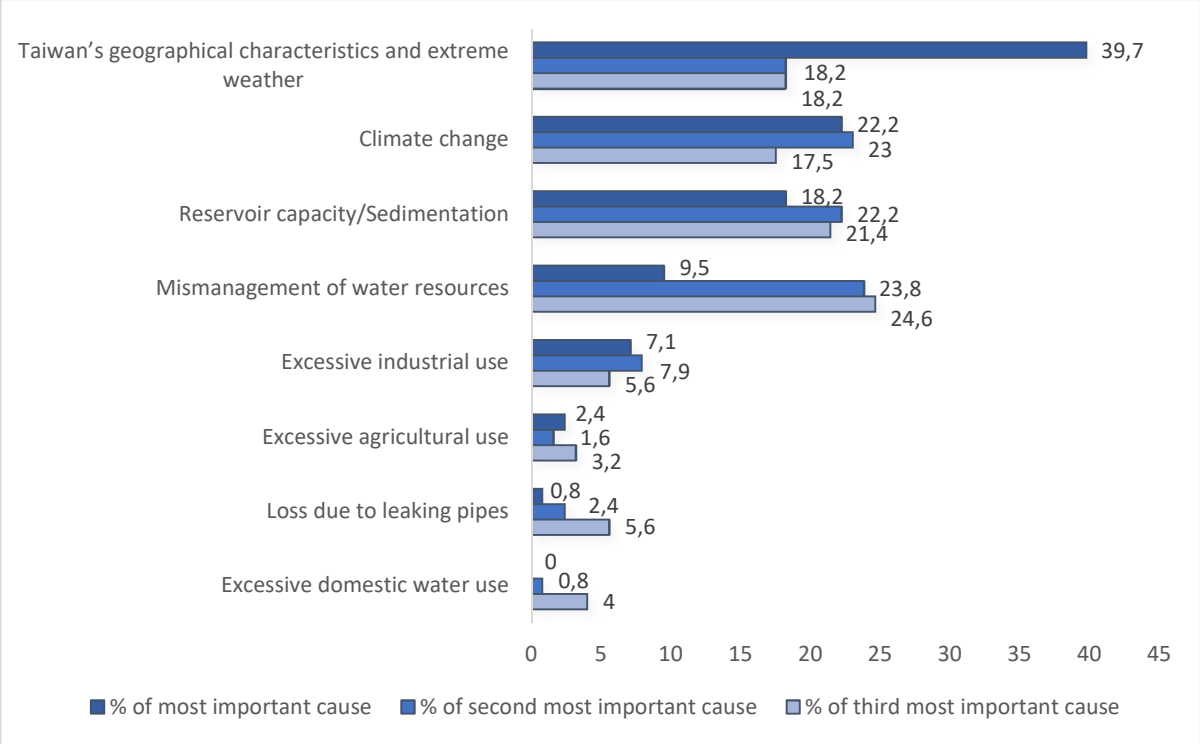
To obtain a more comprehensive picture of how students perceive water scarcity, respondents were asked to rank which factors they believed contribute the most to water shortages. Respondents were required to choose from eight factors, all correct and described in chapter three, and to rank their significance from the first to the third most significant one.

Figure 14 shows that, unsurprisingly, "Taiwan's geographical characteristics and extreme weather" was by far the most common answer, with 39,7% of students who deemed it to be the main cause of water scarcity on the island. Climate change takes "second place" (22,2%), followed immediately by insufficient reservoir capacity/sedimentation (18,2%). These three environmental factors related to Taiwan's hydrological variability were indicated with just as much frequency as the second and third most important factors bringing about water shortages, with just one exception: mismanagement of water resources. As you can see, almost one respondent in four (23,8% and 24,6%) think that this problem contributes greatly to the lack of water availability in the region.

Fig. 14: Main causes of water scarcity in Taiwan

Q. Between the following options, what are in your opinion the main causes of water scarcity in your country? (Please sort them in order of importance)

(Q. 您認為以下選項造成缺水原因的優先順序為何? (請排序最重要三個)



As was to be expected, Taiwan's inherent limitations discussed in the previous chapter are perceived as the main problem causing water scarcity, while water consumption itself, whether industrial, agricultural or domestic, is generally not seen as a contributing factor. With little exception for water for industrial use, which is deemed by more than 20% of respondents as an important factor. But what's interesting is the importance attached to bad management, which seems to suggest that a sizeable proportion of students (a total of 57,9% mentioning it), are somewhat unsatisfied with water institutions. Finally, another finding that requires to be mentioned is the acknowledgement of climate change significance in respondents' minds, with 62,6% of them recognizing its influence on water availability.

In the analysis of water scarcity factors presented in the previous chapter we have already emphasized the impact of climate change on Taiwan's hydrologic variability and extreme weather. There is a growing consensus among researchers that the island is projected to face increased risk of longer droughts in the south and more frequent floods in the north regions

(Huang et al., 2012; TCCIP, 2019). The need to limit greenhouse gas emissions, a primary cause of climate change, is recognized in the "Greenhouse Gas Reduction and Management Act" (Zhìdìng wēnshì qìtǐ jiǎnliàng jí guǎnlǐ fǎ 制訂溫室氣體減量及管理法), which legislates a 50% emissions reduction target for 2050 compared to 2005 levels. This ambitious target enacted in July 2015 by the Legislative Yuan will require both the private and public sectors to be actively involved, and also changes to the public's behavior (ICAP, 2020).

4.2 Environmental attitude

Values and attitudes are generally viewed as a person's overall evaluation of an object (i.e. the environment in this instance), and as having a clear influence in determining the motivation for actively participating in environmental improvement and protection (Dooms, 1995; Milfont, 2009). According to the theory of planned behaviour, the most dominant psycho-social model of attitude-behaviour relations, positive attitudes lead to good behavioural intentions (López-Mosquera, 2016). For example, taking public transport as often as possible, recycling waste in a responsible manner, and watching electricity consumption might be classified as indicating a favorable attitude toward the environment, whereas refusal to perform these behaviors, or performing actions like littering, might be taken as indications of an unfavorable attitude.

As individuals' attitudes are latent variables, which means that cannot be observed directly, we have to infer them from a representative sample of responses (Daly, Hess, Patruni, et al., 2012). To collect such data, researchers usually resort to Likert's attitude scale, where each item presents a favorable or unfavorable statement about the object in question (the environment) (Ajzen, 1987). In Maloney et al.'s (1975) study of the concept, it is suggested that a scale aimed at assessing attitude should include three components: cognitive, affective and conative. As already mentioned in chapter 2, the conative or behavioral component of attitude is here represented as willingness to pay (WTP) for environmental protection. In the survey, the cognitive component consists of 6 statements while affective and conative consist of 4 and 5 constructs, respectively, for a total of 15 items divided then into three categories:

a) statements that were pro environmental protection (e.g., "Environmental problems have a direct effect on my everyday life.");

b) against protection (e.g., "Many of the claims about environmental threats are exaggerated."); and,

c) statements on willingness to pay (WTP) for environmental protection ("I would pay a higher price for water in order to protect the environment.")

The above-mentioned constructs were measured by a five-point Likert scale wherein respondents were asked to mark their responses from 1 (''Strongly Agree") to 5 (''Strongly Disagree")[36]. A lower score indicates a more positive attitude. The objective of this part of the questionnaire was to examine students' attitudes toward environmental protection, and whether they would be prepared to consider changes to their lifestyles pertinent to water scarcity (**Figure 15**).

Attitude items comprise a mix of statements related to general feelings toward ecology and the environment, concern for specific environmental issues, and feelings toward acting to improve environmental conditions (**Figure 15a, 15b**). Statements in **Figure 15b** contain unfavorable assertions toward environmental protection, in which the environment is deemed as unimportant or secondary to something else. And lastly, we measure environmental support as a series of trade off questions based on willingness to modify their purchasing behavior, willingness to increase prices, and willingness to accept cuts in one's standard of living in order to protect the environment (**Figure 15c**). As mentioned previously, these items don't have properties that allowed it to be treated as a scale, so results will be presented in a descriptive manner.

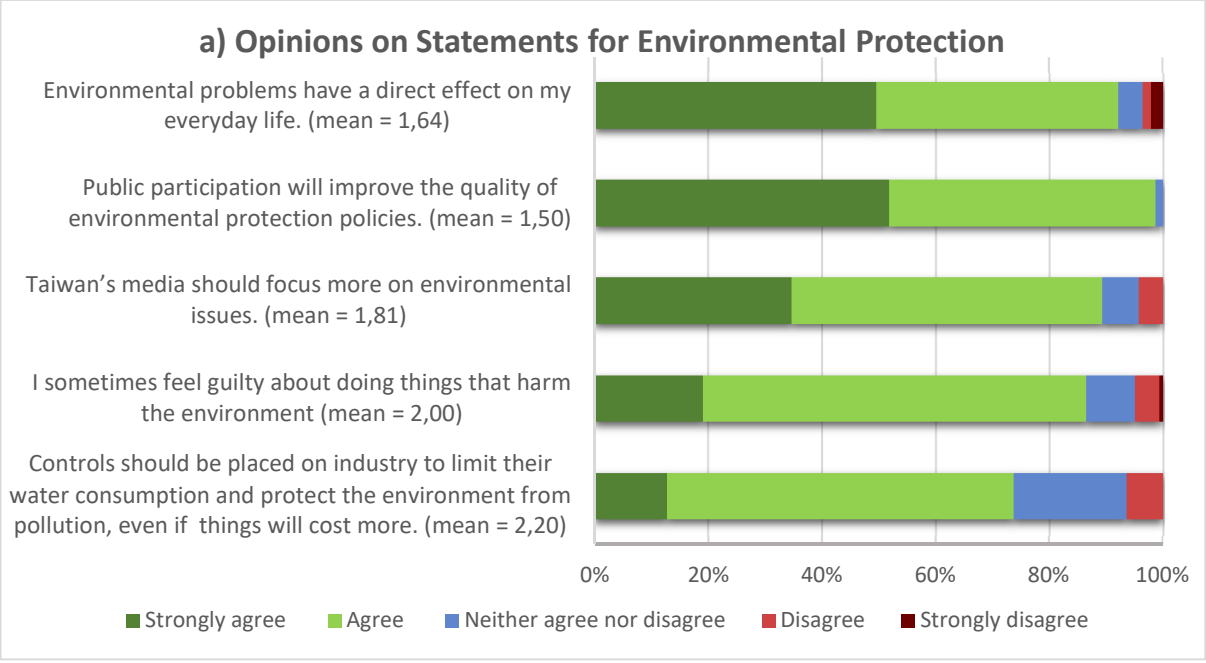
The mean scores for both the statements that support environmental protection and that are against it were all smaller than 3,0 (neutral), with a greater uniformity in responses to the former. As you can see from **Figure 15a**, the strongest agreement was observed for general statements, such as "Public participation will improve the quality of environmental protection policies" (mean = 1,50), or "Environmental problems have a direct effect on my everyday life" (mean = 1,64). The analysis presented in the previous paragraph showed that only a small portion of students see the environment as one of the most important issues facing Taiwan (**Figure 7**). While the factors that underpin environmental behavior change are complex, without accepting that environmental threats are real and that action is needed, it is unlikely that the public will change their behavior for environmental reasons. The fact that more than 90 percent of respondents agreed or strongly agreed with both of these statements shows a widespread recognition of the environment as problematic, despite not being seen as a priority. It has been noted that one barrier for attitude change is insufficient information about a certain aspect of life, and that exposure to new information is crucial in this sense (Oweini and Houri 2006).

[36] Except for statements about WTP, where answers were determined from 1 ("Very willing") to 5 ("Very Unwilling") but are represented in Figure 15 with the Agreement/Disagreement pattern to ensure consistency. Statements against environmental protection are reverse scored.

When confronted with the statement "Taiwan's media should focus more on environmental issues" (mean = 1,81), almost 90 percent of students agreed or strongly agreed that the environment have not received adequate media coverage or attention in Taiwan (**Figure 15a**). Higher mean scores were about feelings towards the environment, such as "I sometimes feel guilty about doing things that harm the environment" (mean = 2,00), and opinions about specific issues e.g. "Controls should be placed on industry to limit their water consumption and protect the environment from pollution, even if things will cost more" (mean = 2,20). Guilt is a "self-conscious emotion" especially relevant in the context of pro-environmental behavior, because it arises when one "feels responsible for an individual act and evaluates this act with respect to personal or social standards" (Onwezen, Bartels and Antonides, 2014b). According to n, Onwezen, Bartels and Antonides (2014a) it mediates the effects of personal norms, attitudes, and social norms on environmentally friendly intentions.

Fig. 15: Agreement/disagreement with statements about the environment

Q. How much do you agree or disagree with each of these statements?
(Q.請問您是否同意以下說法?)



There was a slightly broader variation in responses to statements that were against environmental protection, which were reverse scored when calculating mean pro-environmental scores. Being a phenomena widely disseminated by media, scientists and politicians, climate change is often misunderstood and its seriousness diminished in the public

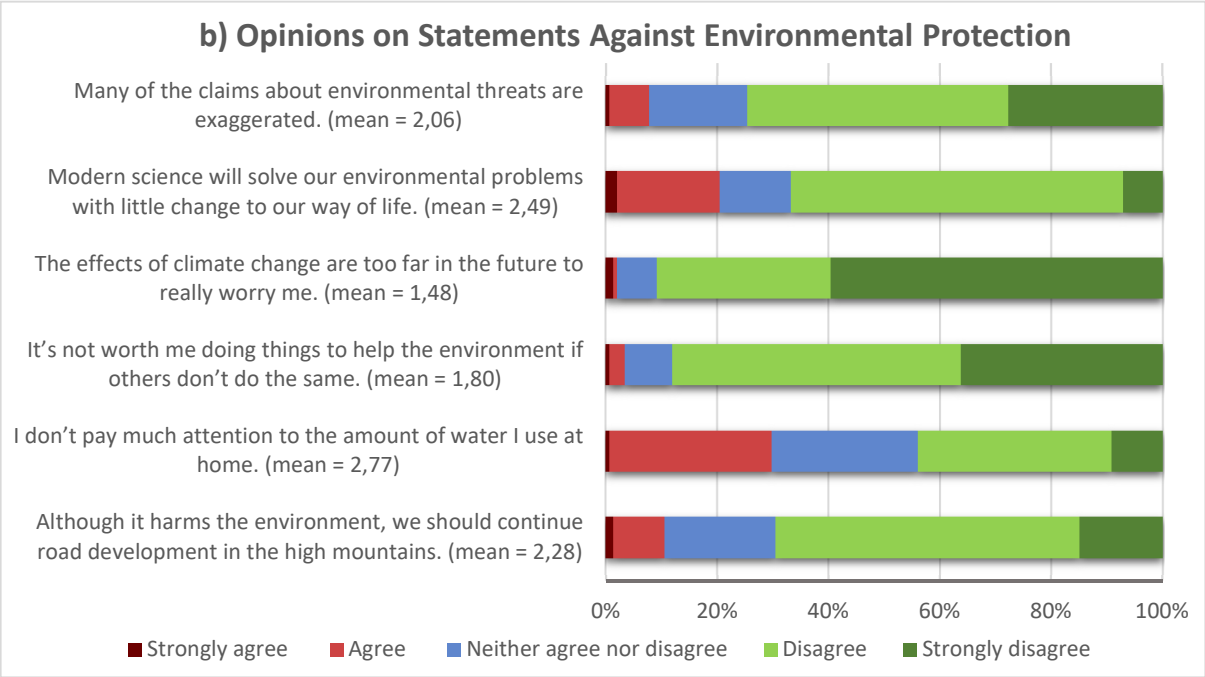
debate. As already illustrated before, the sensitivity of Taiwan's climate and hydrology to climate change and its projected effects in this area require a clear awareness of such a pressing problem, given the fact that "slowness of environmental changes makes their direct sensory perception impossible" (Bonnes and Bonaiuto, 2002). The lowest score and therefore highest pro-environmental score is observed regarding this issue: "The effects of climate change are too far in the future to really worry me" (mean = 1,48), with almost 60 percent of students strongly disagreeing to it (**Figure 15b**).

According to the definition of environmental attitude given in chapter 2, we know that it's strictly linked to personal responsibility, i.e. the individual's sense of obligation toward the environment, either in general or to a specific aspect (for example, reducing water pollution or consumption) (Ugulu, Sahin and Baslar, 2013). The statement that assessed individual responsability had substantially lower agreement from respondents, "It's not worth me doing things to help the environment if others don't do the same" (mean = 1,80), with 88 percent of students disagreeing.

People's perceptions regarding others' pro- or anti-environmental behavior are one of the motivational factors mentioned by Corral-Verdugo et al. (2002) to explain environmental destructive behaviors. For many individuals, the conservation effort they observe in other persons is a fundamental reason to act themselves. More specifically Jorgensen, Graymore and O'Toole (2009) argued that trust plays a role in household water consumption, since people will not save water if they feel others are not minimizing their water use. If people don't trust others to conserve water, they will use this to justify their lack of motivation to conserve water resulting in their higher water consumption (Corral-Verdugo et al., 2002).

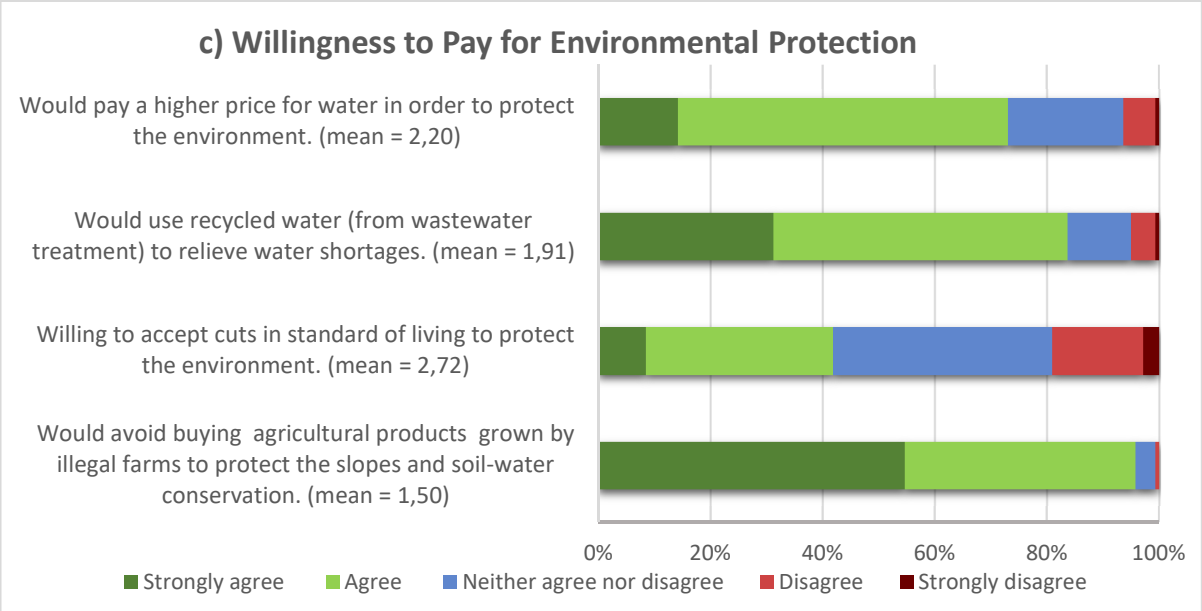
As a matter of fact, the high consumption of water registered in Taiwan is reflected in the following question that asked the respondent to report his/her actual behavior, "I don't pay much attention to the amount of water I use at home" (mean = 2,77). The mean score was the closest to neutral, with 30 percent of student openly agreeing to it and over a quarter of them "neither agreeing or disagreeing".

Higher agreement and therefore lowest pro-environmental scores were seen in responses to statements that placed environmental protection as overrated or secondary to something else (convenience for example), like "Many of the claims about environmental threats are exaggerated" (mean = 2,06) and "For the sake of more convenient transportation, we should continue road development in the high mountains (e.g., one of the major highway routes, TAI 8th road), even though it will harm the environment" (mean = 2,28). Furthermore, in statements that framed these issues as beyond the scope of an individual's action, such as "Modern science will solve our environmental problems with little change to our way of life" (mean = 2.49). A study by Gigliotti (1994) of college students' willingness to engage in pro-environmental behavior found that those who believe technology and growth will solve environmental problems were less likely to make personal sacrifices. These findings suggests that one Taiwanese student in five might not see the need and will be less willing to engage in pro-environmental behavior with the implicit lifestyle changes.



As previously explained, we defined the items clustered among the initially intended conative component of a potential attitude scale as 'willingness-to-pay' for water scarcity prevention and control. The list of items in this subscale makes a reference to the necessary changes to water management, mentioned in chapter 3, that Taiwan has to implement in order to enhance water use effeciency. These require the approval and support of the population to be enacted, in particular those measures long opposed (like the rise in water prices) or, in any case, viewed with distrust by the public (the use of recycled water, for example). Here too mean

measures are all lower than 3 (neutral), with a majority of respondents largely in agreement with these statements, although there is some reluctance to answer (**Figure 15c**). The lowest agreement was observed with a statement that ask for a significant sacrifice, "I am willing to accept cuts in my standard of living in order to protect the environment" (mean = 2,72), where more than one respondent in four neither agreed or disagreed with these statements and just 40 percent openly agreeing to it (**Figure 15c**). When it comes to water pricing, "I would pay a higher price for water in order to protect the environment" (mean = 2,20), 25 percent of students are not ok with it, despite the majority agrees to the idea of a rising in prices in order to improve water security. Other statements that suggests the environmental importance of consumer power had substantially higher agreement from respondents, "I would avoid buying agricultural products grown by illegal farms in the high mountains in order to protect the slopes and soil-water conservation" (mean = 1,50) or "I would use recycled water (from wastewater treatment) in order to relieve water shortages" (mean = 1,91), with nearly 90 percent of respondents either agreeing or strongly agreeing with it (**Figure 15c**). Since individual activities have major environmental consequences in the aggregate, there can be major environmental effects from change in the behavior of individuals and households. These three items were self-developed in order to adjust to the water scarcity issue present on the island and related measure that should be executed to curb it.



As we said before, while water authorities attempt to cope with water scarcity problems by increasing water supply (through reuse of wastewater, for example), they do understand that reducing water demand is just as important. In this matter public's approval, support, as well

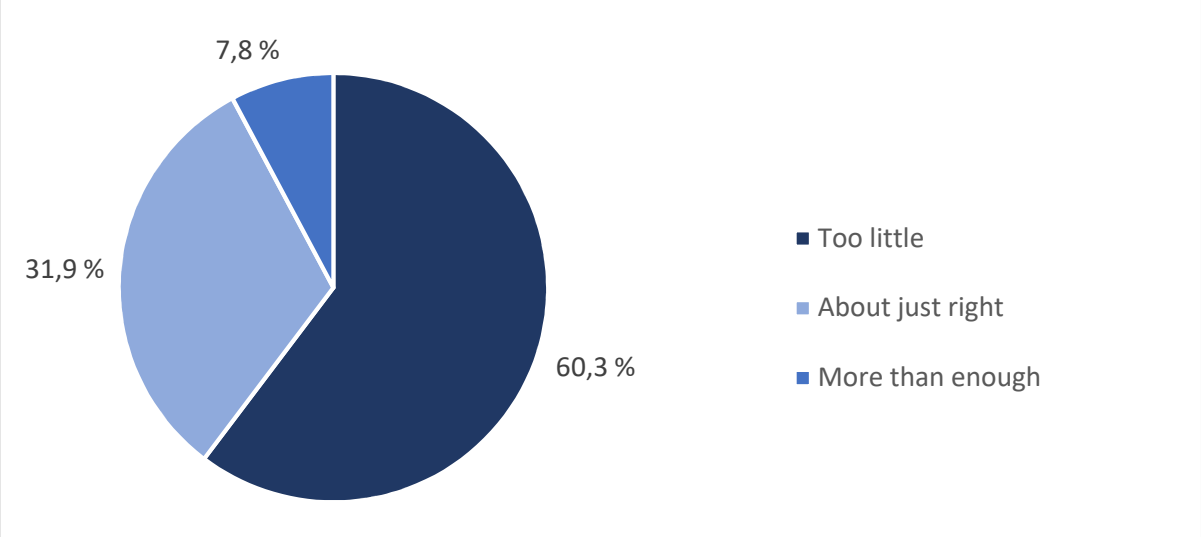
as engagement are key to develop and implement effective demand management strategies (Ziadat, 2010). According to Jorgensen, Graymore and O'Toole (2009) cutting down demand by enhancing the efficiency of water use requires an insight of how water is used and how people think about it. Their study shows that water restrictions reduce consumption over the short term when motivations to comply exist among consumers. Aside from the acceptance of responsibility for the problem and inter-personal trust (i.e., others are saving water too), another element involved is institutional trust, i.e. trust that the government or water authority is doing all it can to conserve and provide enough water(Corral-Verdugo et al., 2002). For these reason, people might be less likely to develop water-saving behaviors if they do not trust the water authority.

That a sizeable proportion of respondents are somewhat dissatisfied with the management of water institutions had already emerged in this questionnaire (**Figure 14**). Answers to another question (included in the survey but not mentioned for consistency reasons), have confirmed these findings (**Figure 16**). When asked to appraise Taiwan's performance in the protection of the environment, a great majority of respondents (60,3 %) reported that the island has done "too little", while 31,9% of them answered that it has done "about the right amount". The remainder of students (7,8 %) think that Taiwan has done "more than enough" in this matter.

Fig. 16: Taiwan contribution in environmental protection

Q. Some countries are doing more to protect the world environment than other countries are. In general, do you think that Taiwan is doing?

(Q. 在全球環境保護上，有些國家比其他國家做得更多。一般來說，請問您覺得台灣做了多少？)



4.3 Environmental behavior

People greatly differ in the level of their environmental involvement and in the amount of time and energy they are willing to invest in behaviors aimed at preserving or improving the quality of the environment. Studies on motivation toward the environment found that these behaviors are not always on the same level of difficulty (Green-Demers, Pelletier and Ménard, 1997). Some behaviors, like recycling, are perceived as being easier to perform than others, such as those pertaining to educating people toward ecological issues or demonstrating for the protection of the environment, for example. The more these behaviors are perceived as difficult, the more motivation and stronger environmental attitude are required to carry them out. Thus, according to Green-Demers, Pelletier and Ménard (1997), there is a class of actions that require more involvement and the greatest amount of effort and determination on the part of individuals: activists' behaviors. Examples of these behaviors include the following: protesting, rallying, petitioning, educating the public, lobbying government and corporations, participating in direct actions such as blockades or participating in voluntary conservation work (Fielding, McDonald and Louis, 2008).

Survey findings suggest that the majority of students in Taiwan display concern for the problems that are occurring and show highly positive attitudes toward the environment. According to Dunlap et al.'s (2000), positive general attitudes will predict positive activism intentions. In other words, more positive general attitudes to the environment are likely to motivate behaviors that require greater effort and determination.

In this last part of the questionnaire, we examined students self-reported behavior to understand whether this link between attitude and behavior really exists, as well as to analyze students level of environmental activism. It consisted of just 4 items, each describing a particular behavior that give a picture example of environmental activism: (a) circulation of a petition about an environmental issue, (b) financial support of an environmental group, (c) taken part in a protest or demonstration against current environmental conditions (d) participation in community environmental protection activities[37]. Participants were asked to indicate if in the previous five years they performed or not these behaviors. These questions got

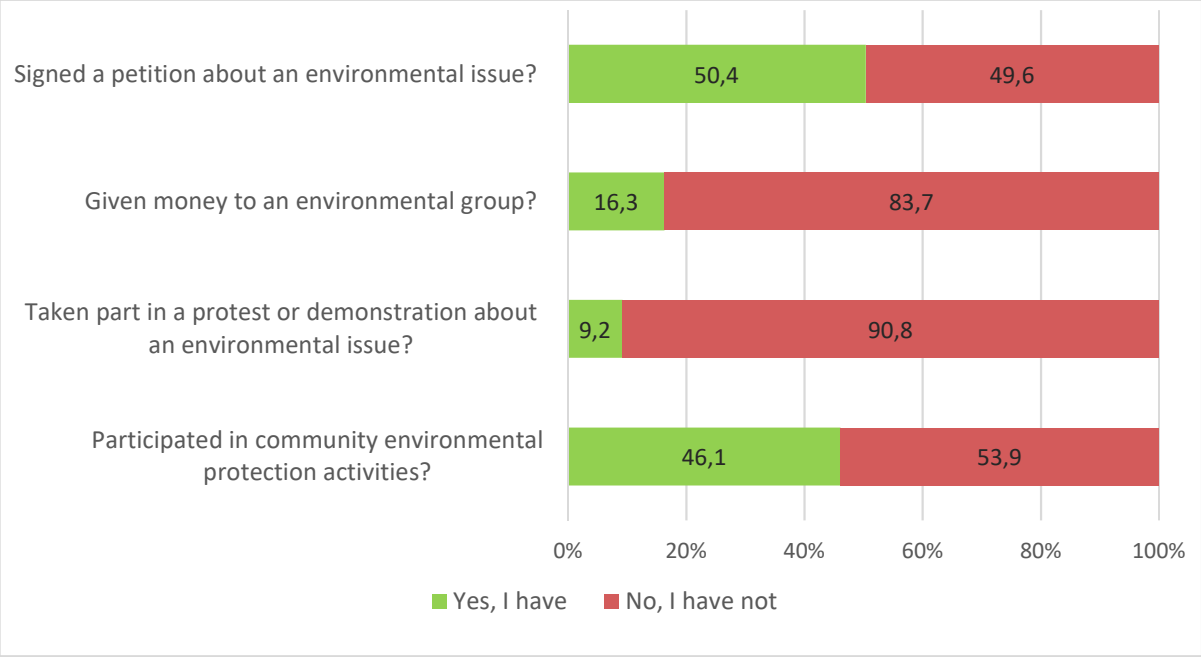
[37] In the questionnaire respondents were given two examples to better understand this question, i.e. the "Green Point Scheme" and "Protect Our Species—Sustainable Environment". These are two different initiatives, launched by the EPA in 2016 and 2019, respectively, aimed at encouraging the use of public transport and to promote the importance of biodiversity. Citizens that perform environmentally friendly behaviors can earn "green points" as rewards, then use them to pay for green products they purchase.

conflicting answers, ranging from a full or almost half of students reporting they participated in such activities, to just a small minority of them (**Figure 16**).

Fig. 17: Taiwanese environmental activism

Q. In the last five years, have you...

(Q. 在過去五年間，請問您有沒有…)



It can be observed that actions that require less effort and initiative, like signing a petition (online maybe) and earning green points by taking the subway scored remarkably higher (50,4% and 46,1%), than activities that imply greater involvement or a significant (monetary) loss, with 90,8% and 83,7% of respondents admittedly saying they have never performed such actions in the last five years.

5. Discussion

This study examined the prominence of the environment in Taiwanese students' minds, their concern for water scarcity and pollution and their awareness of the causes of water shortages on the island. In the second part, their opinions regarding the environment and its protection were outlined, together with their willingness to pay for environmental protection and their self-reported environmental behaviors. As we have already said, results show that the environment and environmental issues (such as climate change) are far from being perceived as current priorities for Taiwan. At the same time, however, the environment becomes strikingly more important if students are asked what is the most important issue facing the world today. It is reasonable to think that the perception of proximity affects the significance that a person attaches to a problem, a phenomenon called "environmental hyperopia" by García-Mira, Real and Romay (2005). In their study, they have demonstrated that environmental problems are perceived as more worrying when they take place at greater distances. Local environmental problems, on the contrary, are felt as being less important unless they constitute immediate risk.

To determine the level of concern of current water scarcity and how much this and related issues are prominent in the mind of Taiwanese people, students were first asked to rank existing environmental problems in order of importance. Across these two questions, water shortage was the least chosen answer, with less than one in ten respondents in total making any mention of the issue at all.

In an attempt to ascertain whether or not this situation is the result of a lack of ability to perceive the seriousness of the mentioned problem and changes in the state of the environment, we analyzed the level of respondents' environmental concern. We found that, although the majority of Taiwanese students do perceive water as scarce, they generally don't regard water scarcity as a pressing matter and are not aware of how water availability changed over time. According to Chiang and Chang (2017), risk perception is influenced by complex social, political and cultural processes, and so further work to understand associated impacts on behaviours related to water scarcity would be valuable. Of the minority of respondents who did perceive water shortages as an issue, we found that students who live in big and small cities were more likely to perceive water scarcity as serious (81,2%) compared to those coming from a country village or the countryside. These rural-urban differences in environmental concern were explained by Tremblay and Dunlap (1978), who argued that city dwellers experienced environmental risks at a higher rate and were more likely to express concerns over the environment. With regards to water quality, most respondents (74,5%) are concerned about water pollution and state that water conditions deteriorated in recent years.

Notwithstanding these results, an equally important finding is the high proportion of respondents who answered they "do not know". Except for the question related to current water availability status (**Figure 10**), questions illustrated in Figures 11, 12 and 13 all feature high percentages of respondents unable to answer, more specifically one student in five does not have a clear idea about the issue at hand. Therefore, this suggests that there is still some confusion about the actual conditions of water resources on the island.

We also attempted to determine students' perceptions of the factors contributing to the water scarcity in Taiwan. The majority of respondents recognized "Taiwan's geographical characteristics and extreme weather" as the major contributing factor, followed by climate change, and other natural factors such as insufficient reservoir capacity/sedimentation. Water use on the contrary, whether industrial, agricultural or domestic, is generally not seen as a contributing factor. This perception is consistent with recent literature analyzed in chapter 3 (Wang et al., 2018; Hung and Shih, 2019) and official data regarding water consumption (WRA, 2018). Similarly, only a minority of students (30%) reported to pay attention to the amount of water used at home. Corral-Verdugo et al., (2002) argued that institutional trust (i.e. trust that the government or water authority is doing all it can to conserve and provide enough water), has a great influence on individuals' water consumption. If the public doesn't believe that the water authorities are doing their part, they might be less likely to develop water-saving behaviors. What emerges from this question is the importance given to mismanagement of water resources, with a total of 57,9% mentioning it as a triggering factor of the island's water problems. Dissatisfaction These findings suggests that a sizeable proportion of students are somewhat unsatisfied with water institutions and highlight the need for new communication campaigns on the part of the WRA.

Then we tried to analyze students' attitudes toward the environment and to get a measure of their level of support for environmental protection. As mentioned in the results, while respondents were largely in agreement with statements that recognized the state of the environment as problematic ("Environmental problems have a direct effect on my everyday life"), and that environmental protection should come at some cost ("Controls should be placed on industry to limit their water consumption and protect the environment from pollution, even if things will cost more"), some (20,5%) actually believe that science will find the solution to any environmental problem ("Modern science will solve our environmental problems with little change to our way of life"). A study by Gigliotti (1994) of college students' willingness to engage in pro-environmental behavior found that those who believe technology and growth will solve environmental problems were less likely to make

personal sacrifices. These findings suggests that one Taiwanese student in five might not see the need and will be less willing to engage in pro-environmental behavior with the implicit lifestyle changes. Nevertheless, individual responsibility for environmental problems seems already in place ("It's not worth me doing things to help the environment if others don't do the same"). People's perceptions regarding others' pro- or anti-environmental behavior are one of the motivational factors mentioned by Corral-Verdugo et al. (2002) to explain environmental destructive behaviors. For many individuals, the conservation effort they observe in other persons is a fundamental reason to act themselves. More specifically Jorgensen, Graymore and O'Toole (2009) argued that trust plays a role in household water consumption, since people will not save water if they feel others are not minimizing their water use. We also found significant support (89,3% agreeing or strongly agreeing) for the statement "Taiwan's media should focus more on environmental issues". It has been noted that one barrier for attitude change is insufficient information about a certain aspect of life, and that exposure to new information is crucial in this sense (Oweini and Houri 2006). Further studies should be conducted to understand whether this lack of information is responsible for the low level of concern for environmental problems on the island.

Finally, we attempted to determine the WTP of Taiwanese students. The objective was to understand whether they would be prepared to consider changes to their lifestyles and to approve necessary measures pertinent to water scarcity. Despite some respondents' reluctance to tolerate a cut in their living standards to protect the environment (with just 41,8% agreeing), almost the totality of respondents are willing to change their consuming behavior (95,7%), willing to use recycled water (83,7%) and willing to accept an increase in water tariffs (73,1%).

In conclusion, the recognition of the importance of environmental protection and willingness to act seems already in place, at first glance. The high levels of support among Taiwanese students suggest that younger generations on the island are very keen to change and ready to actively take part in pro-environmental behaviors. At the same time, however, the highly positive attitudes observed are not linked in a consequent high environmental activism, as previously postulated considering findings by Dunlap et al.'s (2000). As we have seen, just a little minority of respondents (9,2% and 16,3%) took part in the last five years in activities that required a greater effort and involvement (e.g. donations and demonstrations.)

It can be argued that, since the majority of measures of environmental behavior and attitudes are self-reports, there is probably a significant "social desirability effect" governing how people portray their level of concern and engagement (Milfont, 2009). Researches by Dunlap and Jones (2002) and Milfont (2009), have shown that people appraise environmental issues in a different way because there are variables that influence people's perception and evaluation of these problems. One of these

variables is "social desirability" a term that refers to the two-factor theory[38] of socially desirable responding by Paulhus (1984). According to this theory, people consciously deceive others "with regard to self-presentation by socially desirable overt behaviors and attitudes", in the attempt to impress others or to give a better image of oneself.
As previously mentioned in the very first part of this chapter, environmental protection has become in recent years a moral issue, so that no one would actually dare to admit disinterest or even anti-environmental attitudes. Therefore, social desirability seems to be one factor that may explain why in this research, similarly to other studies on the subject (e.g. Kollmuss and Agyeman, 2002; Blake, 1999), it is possible to observe very high self-reported environmental attitudes, but at the same time an attitude-behavior gap.

Coming back to the main topic of water issues, this lack of a direct link between attitude and behavior result in individuals believing water saving is important, but for various reasons this attitude is not reflected in their water use behavior (Aitken et al., 1994). Besides environmental attitudes, convenience, cost and social pressure have been identified as motivating factors in conservation (Maas et al., 2017).

Different theories attempted to explain this inconsistency between attitude and action, such as the "Minimum Cost Theory". Diekmann and Preisendörfer (1998) suggest that environmental consciousness will convert into behavior only when the monetary and/or non-monetary cost is adequately low. Kollmuss and Agyeman (2002), instead, argue that despite potential good intentions and attitudes, "altruistic and social values are often covered up by the more immediate, selective motives, which evolve around one's own needs (e.g. being comfortable, saving money and time)". Thus, even if households are environmentally and socially motivated, these attitudes may not translate into actions if significant barriers to conservation exist. Accordingly, the influence of an increase in water tariffs on Taiwanese water use behaviors should be of great interest to policy makers attempting to design effective conservation programs (Maas et al., 2017).

It must be noted that this survey still has several limitations. For instance, the nature of the sample may restrict the generalizability of results. Firstly the low number of participants, which raise questions about the reliability of findings. Secondly, since the majority of participants come from the northern part of Taiwan (70,9%), it could be argued that these findings can only be relatable to this geographic region and that the sample is unrepresentative of the overall population. Further country-wide research with a broader, differentiated sample is thus required to better understand this wider context. It could also be argued that, besides social acceptability or political correctness, the reason

[38] The two factors of the socially desirable responding theory are "self-deceptive positivity" and "impression management".

behind such high levels of environmental support registered might be the nature of the study. Because of the topic (environmental concern and attitude), and length of the questionnaire, there is the possibility that only the most involved individuals would respond.

And finally, since the lack of internal consistency of the clustered attitude items in the present study did not allow it, attitudes towards environmental protection have been analyzed descriptively. Further studies should developed new items, specifically created for the Taiwanese context and water scarcity, and should also include direct observation of water use to guarantee reliability of the survey.

Conclusions

The rationale for conducting this study is that the development and execution of any program or legislation could not be successful without public awareness and support for environmental protection. In particular, tackling the water scarcity issue in Taiwan requires immediate changes to water management and in consumption practices that only citizens who are well aware of the situation and fully dedicated to its resolution could carry out. Taiwan's university students, as the most educated section of the population and potential future decision-makers in society, have the right and the responsibility to drive change towards sustainable development. For these reasons, it is important to foster their awareness of existing problems and encourage them to conserve the environment.

Findings presented in this paper suggest that the great majority of Taiwanese students don't see environmental issues as a priority. Students in the sample are mostly aware of water scarcity on the island, although they generally do not consider it as a pressing matter and are not concerned by it. Their answers clearly show that there is still some confusion about the actual conditions of water resources in Taiwan and how they changed in recent years.

The evidence also suggests that the recognition of the importance of environmental protection and willingness to act are already in place. The high levels of environmental support found among Taiwanese students suggest that younger generations on the island are very keen to change, but this is not coupled with environmental activism endeavors, particularly ones involving spending personal incomes and political action. While always being mindful of the potential effects of social desirability bias, this lack of a direct link between attitude and behavior results in individuals believing water saving is important, but for a number of different reasons this attitude is not reflected in their water use behavior (Aitken et al., 1994). Consistent with previous studies on environmental behavior (Bayard and Jolly, 2007), before individuals can take a given measure to limit the effects of environmental degradation, they have to be conscious of the problems and their seriousness. In this instance, higher water prices would generate a higher level of concern for water scarcity and a greater awareness of this issue. Moreover, findings suggest that the environmental issues have not received adequate media coverage or attention in Taiwan. It has been noted that one barrier for attitude change is insufficient information about a certain aspect of life, and that exposure to new information is crucial in shaping awareness of environmental issues (Oweini and Houri 2006). Further studies should be conducted to understand if this lack of information is responsible for the low water use efficiency on the island and whether greater disclosure of environmental information and relevant policies can stimulate behavior change.

Another relevant data is that bad management of water resources is largely deemed as a contributing factor to water scarcity. This finding is consistent with Corral-Verdugo et al. (2002) assertion that institutional trust, i.e. trust that the government or water authority is doing all it can to conserve and provide enough water, has a major impact in the development of citizens' water-saving behaviors. The finding has the crucial implication that, as long as the public regard water agencies as untrustworthy, they may be unreceptive to initiatives that the government propose as a means of conserving water and securing supply. Therefore, it is crucial that water organizations such as the WRA and local authorities develop a climate of trust to ensure voluntary acceptance of their decisions and active engagement by the public (Jorgensen, Graymore and O'Toole, 2009). In this sense, effective public communication between water providers and consumers, this one intended within an educational framework of information dissemination, should be the base under which all water saving initiatives are implemented.

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ABBREVIATIONS

Central Mountain Range	CMR
Central Weather Bureau	CWB
Construction and Planning Agency of Minister of the Interior	CPAMI
Council for Economic Planning and Development	CEPD
Council of Agriculture	COA
El Nino—Southern Oscillation	ENSO
Environmental Impact Assessment	EIA
Environmental Protection Administration	EPA
Food and Agriculture Organization	FAO
Formosa Plastics Group	FPG
Forward-Looking Infrastructure Development Program	FIDP
Intergovernmental Panel on Climate Change	IPCC
International Water Association	IWA
Joint Commission on Rural Reconstruction	JCRR
Kuokuang Petrochemical Technology Co.	KPT
Ministry of Economic Affairs	MOEA
Ministry of the Interior	MOI
National Council for Sustainable Development	NCSD
National Science Council	NSC
National Science and Technology Center for Disaster Reduction	NCDR
National Taiwan University	NTU
Ocean Affair Council	OAC
Organisation for Economic Co-operation and Development	OECD
Southern Taiwan Science Park	STSP

Statistical Package for the Social Sciences	SPSS
Taipei Water Department	TWD
Taiwan Climate Change Information and Adaptation Knowledge Platform Project	TCCIP
Taiwan Provincial Government	TPG
Taiwan Semiconductor Manufacturing Corporation	TSMC
Taiwan Social Change Survey	TSCS
Taiwan Water Corporation	TWC
United Nations Development Programme	UNDP
United Nations Division for Sustainable Development Goals	UNDSDG
Water Resources Agency	WRA
Water Resource Department	WRD
Water Supply Plant	WSP
Willingness to pay	WTP
World Water Development Report	WWDR

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APPENDIX A – Survey (Chinese language)

調查

A、基本狀況

1.性別:

□(1) 男性 □(2) 女性

2.年齡：

□(1) 18-25 歲 □(2) 26-35 歲 □(3) 36-45 歲 □(4) 46-55 歲 □(5) 55 歲以上

3.現居地：

_____ 省（市）_____ 縣（市）

_____ 鄉（鎮、市、區）

4.請問您認為現在所居住的地方為何:

□(1)大城市 □(2) 大城市旁的郊區

□(3) 小城市 □(4) 小鎮

□(5) 農村地區

5.婚姻狀況：

□(1) 已婚 □(2) 同居關係

□(3) 配偶去世 □(4) 離婚

□(5) 分居 □(6) 單身且未婚

6.教育程度:

☐(1) 小學

☐(2) 國（初）中

☐(3) 高中(普通科)

☐(4) 高中(職業科)

☐(5) 大專

☐(6) 軍警專修班

□(7) **大學**

□(8) **碩士**

□(9) **博士**

□(10) **其他** _____

7. 請問您的父母是哪裡人?

□(1) 台灣閩南人

□(2) 台灣客家人

□(3) 大陸各省市

□(4) 台灣原住民

□(5) 其他

核心題組

8.a **請問您認為以下哪個項目是目前台灣社會最重要的議題**?

□(1) **健康照顧** □(2)**教育** □(3) 對外政策/外交

□(4) **環境/** 氣候變化 □(5) 飢餓 □(6) **經濟**

□(7)國內政治 □(8) **貧窮** □(9) **移民**

□(10) 獲得清潔水 □(11) 以上皆非_____

8.b **哪個項目是目前全世界最重要的議題？**

□(1)**健康照顧** □(2)**教育** □(3) 對外政策/外交

□(4) **環境/** 氣候變化 □(5) 飢餓/ 獲得清潔水 □(6) **經濟**

□(7)國內政 □(8) **貧窮** □(9) **移民**

□(10) 獲得清潔水 □(11) 以上皆非_____

B、環境知覺

9.一般來說，您對環境問題的關心程度為何?

(請從 1 到 5 當中選一項，1 指的是 「一點 也不關心」、 5 指的是 「非常關心」。)

一點也不關心 非常關心

□1 □2 □3 □4 □5

以下列出了一些不同的環境問題。

10.a **請問您認為對台灣整體來說，最重要的環境問題是哪一項？**

□(1) **空氣污染** □(2) **基因改造食品** □(11)自然災害 (如颱風、 地震等)

□(3) **水資源短缺** □(4) **水質污染** □(12) 其他_____

□(5) **核廢料** □(6) **家庭廢棄物**

□(7) **氣候變遷** □(8)濫伐森林

□(9) **自然資源耗盡** □(10) **以上皆非**

10.b 那您認為現在還有哪些其他問題?
(請從以下選項當中排序最重要三個，1 指的是對你來說最重要，再按重要性順序選擇 2 和 3。)

□(1) **空氣污染** □(2) **基因改造食品** □(11)自然災害 (如颱風, 地震等)

□(3) **水資源短缺** □(4) **水質污染** □(12) 其他_____

□(5) **核廢料** □(6) **家庭廢棄物**

□(7) **氣候變遷** □(8)濫伐森林

□(9) **自然資源耗盡** □(10) **以上皆非**

10c. **請問您認為哪一些環境問題對您和您的家庭影響最大？**

(請從以下選項當中排序最重要三個，1 指的是對你來說最重要，再按重要性順序選擇 2 和 3。)

□(1) **空氣污染** □(2) **基因改造食品** □(11)自然災害 (如颱風, 地震等)

□(3) **水資源短缺** □(4) **水質污染** □(12) 其他_____

□(5) **核廢料** □(6) **家庭廢棄物**

□(7) **氣候變遷** □(8)濫伐森林

□(9) **自然資源耗盡** □(10)**以上皆非**

11.**整體來說，請問您認為自己對於上述環境問題發生的原因是否瞭解？**

(請從 1 到 5 當中選一項，1 指的是 「 **一點也不瞭解**」、 5 指的是 「非常**瞭解**」。)

一點也不瞭解 非常**瞭解**

□1 □2 □3 □4 □5

12.**請問您是否同意以下說法？**

a. **現代科學可以解決環境問題，而且對我們的生活方式不會改變太多。**

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

b. **許多環境危機的報導或主張，都是過度誇大。**

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

c.我不太擔心**氣候變遷的影響**, 因為那是在遙遠的將來，跟現在沒有多大關係。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

d. **環境問題對您的日常生活有或會有直接影響**。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

13. 根據您所知道或聽到的，您認為氣候變遷產生的主要影響是哪些? (您可以複選。)

□(1) 天氣冷熱劇烈變動　　□(2) 冰川融化/ 海平面上升 □(3) 地球暖化

□(4) 水旱災害接踵而來　　□(5) 某些生物滅種　□(6) 水資源短缺

□(7) 以上皆非　　□(8) 其他_____

14.請問您認為「氣候變遷」 是人為的原因，還是自然的原因造成的?
(請從 1 到 5 當中選一項，1 指的是 「人為的原因」、 5 指的是 「自然的原因」。)

人為的原因　　自然的原因

□1　　□2　　□3　　□4　　□5

15.您認為最近十年汙染情況有了變化嗎?

□(1) 不清楚　　□(2)沒變化　　□(3)改善了

□(4) 惡化了

16.您認為週遭環境的水汙染情況為何?

□(1) 不清楚　　□(2)沒有汙染　　□(3)有輕微汙染

□(4)汙染嚴重

17.您認為水汙染對您健康會有多大的影響?

☐(1) 不清楚　　☐(2)沒有影響　　☐(3)有點影響

☐(4)有很大的影響

18.您認為以下選項造成水污染的優先順序是什么?
(請從以下選項當中排序最重要三個，1 指的是對你來說最重要的，再按重要性順序選擇 2 和 3。)

☐(1) 工業廢水　　☐(2) 農業廢物(如農藥、化肥等)

☐(3)生活汙水　　☐(4) 牲畜廢物

☐(5) 河岸垃圾填埋　　☐(6) 廢水處理不善

☐(7) 未完成的排污系統

19. 您覺得在台灣有缺水問題情況嗎?

☐(1) 不清楚　　☐(2) 沒有清水　☐(3)有輕微缺水

☐(4)嚴重缺水

20.您覺得最近十年缺水情況有了變化嗎?

☐(1) 不清楚　　☐(2) 沒變化　　☐(3)改善了

☐(4)惡化了

21.您認為以下選項造成缺水原因的優先順序為何?
(請從以下選項當中排序最重要三個，1 指的是對你來說最重要，再按重要性順序選擇 2 和 3。)

☐(1)氣候變化　　☐(2)水庫容量不足/沉積

☐(3)家住用地太多　　☐(4) 工業用地太多

☐(5)水資源的管理　　☐(6)農業用地太多

☐(7)管道漏洞造成的損失　　☐(8) 台灣的地理特徵和極端天氣

22.請問您或您的家人有沒有因為天然災害（如風災、水災、地震等），而遭受過心理、身體或財產上的損失?

□(01)**有**　□(02)**沒有**

23.請問缺水或旱災問題有沒有曾經影響您或您家人的日常生活?
（如限制用水、食品價錢上漲等）

□(01)**有**　□(02)**沒有**

C、環境態度

24.整體**來說**，對於上述(10a、10b)的環境問題，以下哪一種情緒最接近您的感受?

□(1) 放心□(2) 擔心 □(3) 害怕

□(4) 憤怒 □(5) 冷漠□(6) 無奈

□(7) 沒有特別感覺□(8)其他

25.**請問您是否同意以下說法**?

a. 我有時因為做了對環境有傷害的事情而感到罪惡。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

b. 為了保護環境不受汙染而限制工業用水量，即使這意味著物價會上漲。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

c. 為了交通方便，台灣應該開發高山道路（如中橫），雖然會傷害環境。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

d. 台灣媒體很少重點環境問題。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

26.請問您認為環境問題的發生，誰的責任最大?

□(1) 人民 □(2)市政府 □(3)政府

□(3)企業 (產業和農場)

27.**在全球環境保護上，有些國家比其他國家做得更多。一般來說，請問您覺得台灣做了多少？**

□(1) 做了很多 □(2) 剛好 □(3) 做了太少

28.請問您認為以下哪一個方法是促使台灣民眾保護環境的最好方法?

□(1) 對於破壞環境的民眾處以高額罰金

□(2) 鼓勵公眾參與環境保護活動

□(3) 加強執行環境保護政策

□(4) 擴大環境保護教育

29.您從哪些資訊來源收到有關環境問題的信息?(您可以複選。)

□(1)政府製作的傳單/其他出版物　　□ (2) 學校教育

□(3)聽過親戚朋友說　　□(4) 親身經歷/閱讀

□(5) 媒體　　□(6) 網路、部落格

□(7)其他

D、環境行為

30.請問您是否同意以下的說法?

a. 投票時，您會因為某候選人提出環保政策而投他一票。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

b. 民眾參與有助於提升環保政策的品質。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

c. 如果其他人不這麼做，那麼就不值得為保護環境而自己努力。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

d. 台灣努力應對氣候變化是不值得的，因為其他國家只會取消我們的行動。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

e. 我對家庭用水量不太關注。

□(1) **非常同意**□(2) **同意** □(3) **無意見**

□(4) **不同意**□(5) **非常不同意**

31. 請問您願不願意…

a. 為了保護環境，付出更高的水費?

□(1) 非常願意□(2) 願意　　□(3) 無意見

□(4) 不願意　□(5)非常不願意

b. 為了緩解缺水問題，利用再生水/回收水(來自廢水處理)?

□(1) 非常願意□(2) 願意　□(3) 無意見

□(4) 不願意　□(5)非常不願意

c. 為了保護環境，接受降低生活水平的降低?

□(1) 非常願意□(2) 願意　□(3) 無意見

□(4) 不願意　□(5)非常不願意

d. 為了水土保持，不買非法的高山農產品?

□(1) 非常願意□(2) 願意　□(3) 無意見

□(4) 不願意　□(5)非常不願意

32.在過去五年間，請問您有沒有...

a. 連署一份有關環保議題的請願書?

□(1)有 □(2) 沒有

b. 捐款給環保團體?

□(1)有 □(2) 沒有

c. 參加有關環保議題的抗議活動或遊行?

□(1)有 □(2) 沒有

d. 參加有關環保議題的社區活動(如綠色消費享特惠,「與野共生—永續環境」等)?

□(1)有 □(2) 沒有

APPENDIX B – Survey (English translation)

SURVEY

A. Demographics

1.Gender:

□(1) Male □(2) Female

2.How old are you?

□(1) 18-25years old □(2) 26-35 years old □(3) 36-45 years old □(4) 46-55 years old □(5) above 55

3.Where do you live at present?

_____ Province (Municipality)_____ County (City)

_____ Township (Town, City, District)

4.Would you describe the place where you live as…

□(1) A big city □(2) The suburbs or outskirts of a big city

□(3) A small city or town □(4) A country village

□(5) A farm or home in the country

5.What is your current marital status?

□(1) Married □(2) Cohabiting

□(3) Widowed □(4) Divorced

□(5) Separated □(6) Single and never married

6.What is the highest level of education that you have attained?

☐(1) None/illiteracy

☐(2) Elementary school

☐(3) Junior high school

☐(4) Senior high school (general subjects)

☐(5) Senior high school (vocational subjects)

☐(6) Junior college

☐(7) Military/police one-year junior college

☐(8) University

☐(10) Graduate school (Master's degree)

☐(11) Graduate school (doctoral degree)

☐(12) Other (Please specify)

7.What are your parents' ethnic background?

☐(1) Fukienese of Taiwan

☐(2) Hakka of Taiwan

☐(3) Mainlander

☐(4) Aborigine

☐(5) Other (Please specify) _____

Preliminary questions

8.a Which of these issues is the most important for Taiwan today?

☐(1)Health care ☐(2)Education ☐(3)Foreign affairs/diplomacy

☐(4)Environment/Climate change ☐(5) Famine/ access to clean water ☐(6)The economy

☐(7)Domestic politics ☐(8)Poverty/Inequality ☐(9) Immigration

☐(10) Other (Please specify) _____

8.b Which of these issues is **the most important** for the world?

☐(1)Health care ☐(2)Education ☐(3)Foreign affairs

☐(4)Environment/Climate change ☐(5) Famine/ access to clean water ☐(6)The economy

☐(7)Domestic politics ☐(8)Poverty/Inequality ☐(9) Immigration

☐(10) Other (Please specify) _____

B. Environmental concern

9.Generally speaking, how concerned are you about environmental issues?

(Please tick one box below to indicate what you think, where 1 means you are not at all concerned and 5 means you are very concerned.)

Not at all concerned Very concerned

☐1 ☐2 ☐3 ☐4 ☐5

Here is a list of some different environmental problems.

10.a Which problem, if any, do you think is the most important environmental challenge facing Taiwan?

☐(1)Air pollution ☐(2)Genetically modified foods ☐(11)Environmental disasters (typhoon, earthquake)

☐(3)Water shortage ☐(4)Water pollution ☐(12) Other (Please specify) _____

☐(5)Nuclear waste ☐(6)Domestic waste disposal

☐(7)Climate change ☐(8)Deforestation

☐(9)Using up our natural resources ☐(10)None of these

12.b And what are in your opinion other existing problems?

(Please sort the most important three, where 1 means the most important in your opinion, then select 2 and 3 in order of importance.)

☐(1)Air pollution ☐(2)Genetically modified foods ☐(11)Environmental disasters (typhoon, earthquake)

☐(3)Water shortage ☐(4)Water pollution ☐(12) Other (Please specify) _____

☐(5)Nuclear waste ☐(6)Domestic waste disposal

☐(7)Climate change ☐(8)Deforestation

☐(9)Using up our natural resources ☐(10)None of these

12c. Which problem, if any, affects you and your family the most?
(Please sort the most important three, where 1 means the most important in your opinion, then select 2 and 3 in order of importance.)

☐(1)Air pollution ☐(2) Genetically modified foods ☐(11)Environmental disasters (typhoons, earthquake)

☐(3)Water shortage ☐(4)Water pollution ☐(12) Other (Please specify) _____

☐(5)Nuclear waste ☐(6)Domestic waste disposal

☐(7)Climate change☐(8)Deforestation

☐(9)Using up our natural resources ☐(10)None of these

11.How much do you feel you know about the causes of these sorts of environmental problems?
(Please tick one box below to indicate what you think, where 1 indicates you feel you know nothing at all and 5 indicates you feel you know a great deal.)

Know nothing at all Know a lot

☐1 ☐2 ☐3 ☐4 ☐5

12.From what you know or have heard, what would you say are the main effects of climate change?

☐(1) Dramatic temperature increases or decreases ☐(2) Melting ice caps/ rising sea levels

☐(3) Global warming ☐(4) More flooding/ drought ☐(5) Loss of plant/ animal species

☐(6) Water shortages ☐(7)None of these

13.Do you think climate change is the result of human or natural causes?

(Please tick one box below to indicate what you think, where 1 indicates you think they are exclusively related to human causes and 5 indicates you think they are the result of natural causes.)

Human causes Natural causes

☐1 ☐2 ☐3 ☐4 ☐5

14. Did you notice a change in terms of pollution in the last ten years?

☐(1)Don't know ☐(2)Nothing changed ☐(3)There was an improvement

☐(4)It got worse

15.What do you think about the current water quality in your surroundings?

☐(1)Don't know ☐(2)Not polluted ☐(3)Slightly polluted

☐(4)Very polluted

16.How much do you think that water pollution may affect your health?

☐(1)Don't know ☐(2)Doesn't affect at all ☐(3)Slightly affect

☐(4)Affects a lot

17. Between the following options, what are in your opinion the main causes of water pollution? (Please sort the most important three.)

☐(1)Industrial wastewater ☐(2)Agricultural waste (pesticides, chemical fertilizers)

☐(3)Domestic sewage ☐(4)Domestic animal waste

☐(5)Riverbank landfills ☐(6)Poor wastewater treatment

☐(7)Uncompleted sewage systems

18. Do you think that Taiwan is facing water shortages?

☐(1)Don't know ☐(2) No, there is not such problem ☐(3)Yes, but not serious ones

☐(4)Yes, severe water shortages

19.Do you think that the water scarcity's issue in your country changed in the last ten years?

☐(1)Don't know ☐(2)Nothing changed ☐(3)There was an improvement

☐(4)It got worse

20.Between the following options, what are in your opinion the main causes of water scarcity in your country? (Please sort the most important three, where 1 means the most important in your opinion, then select 2 and 3 in order of importance.)

☐(1)Climate change ☐(2)Insufficient reservoir capacity/Sedimentation

☐(3)Excessive domestic water use ☐(4)Excessive industrial use

☐(5)Mismanagement of water resources ☐(6)Excessive agricultural use

☐(7)Loss due to leaking pipes ☐(8)Taiwan's geographical characteristics and extreme weather

21.Have you (or your family members) ever experienced a property loss or a physical or

emotional loss because of a natural disaster or a weather-related disruption (e.g., typhoon, flood,

earthquake)?

□(01)Yes □(02)No

22.Have water shortages or droughts ever affected you (or your family members) in your everyday life (e.g., water rationing, increase in the prices of food)?

□(01)Yes □(02)No

C. Environmental Attitudes

23.Generally speaking, which one of the following best describes your feeling toward the environmental issues mentioned in Q12a and Q12b?

☐(1) Fine with them ☐(2) Worried ☐(3) Scared

☐(4) Angry ☐(5) Indifferent ☐(6) Helpless (have no choice)

☐(7)No special feeling ☐(8)Other (Please specify) _____

24.How much do you agree or disagree with each of these statements?

a. Modern science will solve our environmental problems with little change to our way of life.

☐(1)Agree strongly☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree☐(5)Disagree strongly

b. Many of the claims about environmental threats are exaggerated.

☐(1)Agree strongly ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Disagree strongly

c. The effects of climate change are too far in the future to really worry me

☐(1)Agree strongly ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Disagree strongly

d. Environmental problems have a direct effect on my everyday life.

☐(1)Agree strongly ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Disagree strongly

25.How much do you agree or disagree with each of the following statements?

a. I sometimes feel guilty about doing things that harm the environment

☐(1)Agree strongly ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Disagree strongly

d. Taiwan's media should focus more on environmental issues

☐(1)Agree strongly ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Disagree strongly

b. Controls should be placed on industry to limit their water consumption and protect the environment from pollution, even if it means that things will cost more.

☐(1)Strongly Agree ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Strongly disagree

c. For the sake of more convenient transportation, we should continue road development in the high

mountains (e.g., one of the major highway routes, TAI 8th road), even though it will harm the environment.

☐(1)Strongly Agree ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Strongly disagree

26.Who do you think bears responsibility for environmental problems?

☐(1) People ☐(2)Local government ☐(3)Central government

☐(3)Enterprises (industries and farms)

27.Some countries are doing more to protect the world environment than other countries are. In general, do you think that Taiwan is doing:

☐(1)More than enough ☐(2)About the right amount ☐(3)Too little

28.Which of these approaches do you think would be the best way to make people and their families in Taiwan to protect the environment?

☐(1)Heavy fines for people who damage the environment

☐(2) Encouraging public participation

☐(3)Strengthening policy implementation

☐(4) Broadening environmental education

29.From which sources, if any, have you received information about environmental issues?

☐(1)Leaflets/other publications produced by government ▫(2)General education at school

☐(3)I heard from a relative or friend ☐(4) Personal readings/experiences

☐(5)Mass media ☐(6)Internet or blog

☐(7)Other (Please specify)

30.How much do you agree or disagree with each of these statements?

a. You will cast your ballot for a candidate who supports policies regarding environmental protection.

☐(1)Strongly agree ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Strongly disagree

b. The public participation will improve the quality of environmental protection policies.

☐(1)Strongly agree ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Strongly disagree

c. It’s not worth me doing things to help the environment if others don’t do the same.

☐(1)Strongly agree ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Strongly disagree

d. It's not worth Taiwan trying to combat climate change, because other countries will just cancel out what we do.

☐(1)Strongly agree ☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree ☐(5)Strongly disagree

e. I don't pay much attention to the amount of water I use at home

☐(1)Agree strongly☐(2)Agree ☐(3)Neither agree nor disagree

☐(4)Disagree☐(5)Disagree strongly

31. How willing would you be to..

a. pay a higher price for water in order to protect the environment?

☐(1)Very willing ☐(2)Willing ☐(3)Neither willing nor unwilling

☐(4)Unwilling ☐(5)Very unwilling

b. use recycled water (from wastewater treatment) in order to relieve water shortages?

☐(1)Very willing ☐(2)Willing ☐(3)Neither willing nor unwilling

☐(4)Unwilling ☐(5)Very unwilling

c. accept cuts in your standard of living in order to protect the environment?

☐(1)Very willing ☐(2)Willing ☐(3)Neither willing nor unwilling

☐(4)Unwilling ☐(5)Very unwilling

d. avoid buying agricultural products grown by illegal farms in the high

mountains in order to protect the slopes and soil-water conservation?

☐(1)Very willing ☐(2)Willing ☐(3)Neither willing nor unwilling

☐(4)Unwilling ☐(5)Very unwilling

D. Environmental Behavior

32.In the last five years, have you ...

a. signed a petition about an environmental issue?

☐(1)Yes I have ☐(2) No I have not

b. given money to an environmental group?

☐(1)Yes I have ☐(2) No I have not

c. taken part in a protest or demonstration about an environmental issue?

☐(1)Yes I have ☐(2) No I have not

d. participated in community environmental protection activities (e.g., Green Point Scheme, “Protect Our Species—Sustainable Environment”)?

☐(1)Yes I have ☐(2) No I have not