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Review

Beyond the Pipeline. Advancing sustainable water management in the Turkish Republic of Northern Cyprus

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Abstract: The Turkish Republic of Northern Cyprus has experienced persistent water stress resulting from historical, geographic, climatic, demographic, and geopolitical factors since the 1960s and increasingly after the island's division between the TRNC and the Republic of Cyprus in 1974. As a result, mismanagement, overexploitation, and contamination of crucial water resources over the decades have exacerbated water stress in the TRNC, like in the rest of the island. Since its full implementation in 2015, the Peace Water Pipeline connecting Turkey and the TRNC has provided 75 million cubic metres (MCM) of water yearly, a stable water source that has decisively helped relieve the rising pressure over Northern Cyprus' limited freshwater resources. However, the Pipeline alone cannot fix water shortages in the TRNC, especially considering the challenges on the horizon, with climate change, population growth, and increasing water demand being the most predominant and urgent to address. Sustainable and long-term solutions to address water security issues are more necessary than ever. After reflecting on the historical dynamics and current situation of water resources in the TRNC, the article presents some solutions being implemented on the island to reduce water stress further. Among these is the increased reliance on wastewater treatment, a field in which the Peace Water Pipeline could play a paramount role thanks to the high-quality water it already provides to the TRNC. Increased cooperation between the Greek and Turkish Cypriots, as demonstrated by some ongoing examples of joint action in water management, further help sustainably address the island's water security.

Keywords: Turkish Republic of Northern Cyprus, Peace Water Pipeline, Turkey, wastewater management, sustainable water management.

1. Introduction

The Turkish Republic of Northern Cyprus (Kuzey Kıbrıs Türk Cumhuriyeti, in Turkish) is a de facto state established after the Turkish military invasion of the northern portion of the island of Cyprus in 1974, fourteen years after the Republic of Cyprus' independence from the United Kingdom in 1960. Its territory stretches around 3.200 km2 from the narrow Karpass Peninsula in the Northeast to the Kokkina enclave in the West. A green line corresponding to a demilitarised zone established and patrolled by the United Nations since 1963 divides the TRNC from the Republic of Cyprus (RoC), where the Greek Cypriot community resides. The word Cyprus will be employed throughout the text to refer to the whole island, thus including the Turkish Republic of Northern Cyprus, the Republic of Cyprus, and the southern territories of Akrotiri e Dhekelia, still under the United Kingdom's authority. At the same time, the terms TRNC and Northern Cyprus will refer to the Turkish Republic of Northern Cyprus.

Water stress, a challenge with roots dating back to the 1960s, has been a persistent and increasingly severe issue for the island's authorities and residents. Over the past three decades, the situation has steadily worsened, primarily due to the combined effects of socio-political tensions between Greek and Turkish Cypriots, as well as changes to the island's ecosystem resulting from climate change and population growth. This combination of historical, socio-political, and anthropogenic factors further complicated water-related issues in Cyprus, whose territory inherently displays severe water resources and supply shortcomings. The whole island can rely on limited water sources throughout its territory. This challenge is particularly severe in the Turkish Republic of Northern Cyprus, which comprises about 37% of the island's land area (Thompson et al., 2004). Here, surface water sources are restricted to a few non-perennial streams that can only provide a minor percentage of water supply.

The Turkish Cypriots have depended heavily on groundwater resources to meet their increasing water demands for decades. The island's aquifers primarily rely on rainfall and, to a lesser extent, snowmelt for recharge. However, the TRNC faces disadvantages in this regard, too. Rainfall is unevenly distributed across the island, with most precipitation occurring in the southeastern regions, notably the Troodos Mountains and coastal areas (Park, 2020), which belong to the RoC. Consequently, these vital water sources have been severely damaged and are now largely unreliable due to mismanagement, over-pumping, and contamination provoked by seawater intrusion over time.

In light of this intense water stress, Turkey, the only country in the international community that officially recognises the TRNC, has implemented several initiatives to address the water issue among the Turkish Cypriot community. The most significant of these is the Peace Water Pipeline Project. This impressive infrastructure features a 107 km water pipeline, of which 80 km runs under the sea, connecting two dams: the Alaköprü Dam in the Turkish town of Anamur, located in the Mersin province, and the Geçitköy Dam near the Northern Cyprus town of Laphitos. This pioneering project in long-distance offshore engineering is expected to supply 75 MCM of water to the TRNC annually for the next fifty years (Bryant, 2015; Verre, 2021). However, while this project has improved the water security situation on the island's northern side, it has not entirely solved the problem. Additional solutions are necessary to tackle water issues in Northern Cyprus decisively and sustainably. Many of these solutions require close cooperation between the TRNC and the Republic of Cyprus, emphasising how unity is essential in addressing water issues.

Long-term objectives can only be achieved through sustained investment, coordination, and collaboration among the agencies and communities managing water resources to ensure adequate water security for everyone living on the island, regardless of the borders dividing the two communities (Elkiran et al., 2020). This is particularly important, considering that many of the island's water resources, especially groundwater resources, are divided between the two sides of the island, and, therefore, the two communities need to work together to make good use of them, making sustainability the central element of this long-term strategy.

2. Historical Background. Water mismanagement in a divided island.

Thanks to its unique and highly strategic geographical position at the intersection between three continents, namely Europe, Asia, and Africa, the island of Cyprus has witnessed the occupation and rule of countless civilisations and powers throughout the millennia. In 1571, the Ottoman Empire wrested control of the island, which had been under Venetian rule for almost a century. It maintained complete authority until 1878 when the United Kingdom stepped in to obtain de facto control of the island, which nevertheless remained under the formal Ottoman rule for many more decades (Biswas, 2010).

The Republic of Cyprus was founded in 1960, one year after obtaining independence from the United Kingdom. After establishing the newborn state, enhancing the country's water security instantly became crucial in the Cypriot government's nation-building plan. However, for a long time, other issues, such as territorial disputes, political power struggles, and economic development, occupied the top of the two communities inhabiting the island's agendas and those of their main partners, namely Greece and Turkey. The divisions along religious and ethnic lines between the Greek and the Turkish Cypriots, fostered by desires of self-affirmation and predominance, resulted in prolonged intercommunal clashes. Consequently, the water management issue was on the back burner for a long time.

The focus on water security was abruptly shifted in 1974 when a series of significant events unfolded. In

just a few days between July 15th and 20th, Greece's coup d'état allegedly to create a puppet state and exert full influence on the island was followed by Turkey's military occupation of the North and the establishment of the Turkish Republic of Northern Cyprus (Thompson et al., 2004; Mallinson, 2005). These events had a profound and lasting impact on the water security in Cyprus, pushing the Mediterranean island into a socio-political landscape marked by division, distrust, and violence. Over time, several talks and negotiations have attempted to solve the Cyprus issue, all of which have failed. In April 2004, the Annan Plan was probably the last significant of these attempts. This United Nations-backed referendum aimed to re-establish the United Republic of Cyprus, but it was rejected by the Greek Cypriots, who saw it as unjust, despite its general approval by the Turkish Cypriots. A few weeks later, the Republic of Cyprus joined the European Union, widening the gap between the North and the South (Thompson et al., 2004; Biswas, 2010).

The island's frozen conflict directly contributed to the lack of coordination and cooperation between the two sides in water security. The ongoing tensions directly involving Greece and Turkey have obstructed the development of a long-term water strategy for too long. As a result, urgent short-term issues related to the Cyprus Issue have often taken priority over necessary long-term planning in water security and other fields (Mason & Bryant, 2017). These facts resulted in the following decades' mismanagement and overexploitation of water resources. Over-pumping has reached alarming levels multiple times in the last few decades to meet increasing water demand. This behaviour often resulted in the decline of the water table and the subsequent intrusion of seawater into the freshwater reserves, thus making several water sources unsuitable for agriculture or domestic use (Elkiran et al., 2020). These lasting mistakes, combined with the changes triggered by climate change, especially the higher evaporation, transpiration, and more frequent droughts, have further exacerbated Cyprus' water security by gradually instilling persistent water insecurity. Population growth, rising tourism, and other anthropogenic factors have also significantly determined the precarious situation in which the island finds itself today.

3. The leading causes behind water stress in Northern Cyprus

This section underscores the profound and alarming impact of human-triggered changes on the Earth's ecosystem and hydrological cycle on the whole island of Cyprus, which directly affect both the TRNC and the RoC's water stress conditions. The planet is characterised by increased variability and unpredictability, two elements that negatively impact the correct organisation and management of the resources that sustain human life, of which water is a primary example. Factors such as temperature and rainfall patterns directly and decisively impact a community's or a country's quality of life and organisation in several ways, from the choice of the materials employed to build roads and roofs to the long-term strategy to guarantee the presence and quality of the local water resources (Gökçekuş et al., 2022; Lazoglou et al., 2024). More than other regions, the Mediterranean is strongly affected by the changes triggered by climate change. Higher average temperatures and variations in rainfall patterns, which become increasingly unpredictable and reduced, trigger several consequences detrimental to the island.

Groundwater, an essential water source, cannot recharge optimally due to the lack of the necessary precipitations. Moreover, higher evaporation rates and more frequent and intense droughts affect the everyday life of the inhabitants and workers of the island, especially those employed in the agricultural and tourist sectors, which makes the TRNC's economy more unstable. The amount of rainfall that has reached Cyprus has steadily decreased over time, and today, predicting how much water will fall on Cypriot soil is increasingly problematic, often making rainwater an unreliable resource for the inhabitants. A study conducted by Elkiran et al. (2021) based on downscaling models to frame future rainfall patterns concluded that between 2018 and 2040, the rain falling over the areas of Famagusta and Nicosia, where critical aquifers for the whole of the TRNC are located will further decrease by another 22%. These phenomena affect islands more deeply than the mainland, given their limited resources and consequent dependence on the continent to supply essential goods such as water, energy, and food

(Park, 2020; Lazoglou et al., 2024). Population growth and increasing tourism flows are other phenomena that significantly and profoundly affect water security on the island. Although it is difficult to find accurate sources related to population growth in the TRNC, the population on the island is expanding and is expected to grow further in the next few decades. More people lead to higher water usage for food and irrigation, energy, leisure activities, healthcare, etc. On the other hand, the increasing population also results in more water pollution, industrialisation, and urbanisation. Tourism, too, significantly adds to water insecurity since short-term visitors use freshwater for most of their leisure activities, for instance, in hotels, swimming pools, and golf clubs (Arslan & Akün, 2019; Gökçekuş et al., 2023). As a result of these phenomena, the island of Cyprus has been classified by the World Resources Institute as one of the top five countries affected by the highest water stress index in the world (the other countries being Bahrain, Kuwait, Lebanon, Oman, and Qatar) (Kuzma et al., 2023).

4. Water Resources in the TRNC

Water quantity and quality are fundamental parameters when assessing a country's water condition. Water quantity determines how much water is available for activities that require it, such as agriculture, domestic use, industry, tourism, healthcare, leisure activities, etc. On the other hand, water quality involves studying a specific water resource's chemical and physical characteristics to determine which activities that specific water can be destined for, and which require higher quality (Arslan & Akün, 2019). The TRNC's water comes primarily from groundwater resources, precipitation, non-perennial water streams, dams, ponds, and desalination plants. For a very short period, between 1998 and 2002, the Turkish Cypriots even imported water bags from Turkey to face increasing water demand. However, this method proved unsuccessful and was rapidly abandoned (Elkiran et al., 2020). Groundwater resources have long been vital to the island's water sustenance. The TNRC is home to thirteen aquifers beneath its land surface, the four most prominent being the Güzelyurt (or Morphou), Magosa (or Famagusta), Kyrenia (or Girne), and Karpass (or Karpasia) aquifers. Water extracted from these sources is primarily utilised for domestic purposes and agriculture, two vital activities that require high-quality water. Among them, the Güzelyurt aquifer, located in the northwest, is the most significant on the island regarding recharge and storage capacity. However, of the total area of 180 km², approximately 80 km² extends beyond the UN-established green line and falls under the jurisdiction of the Republic of Cyprus (Arslan & Akün, 2019).

These water sources are highly dependent on the rivers originating from the island's mountain ranges in the North (the Kyrenia Mountains) and the South (the Troodos Mountains), on rainfall, and, to a lesser extent, on snowmelts to recharge. Usually, when no external variable impacts the recharge processes, groundwater constitutes an invaluable renewable water source for the island's inhabitants. However, several factors, such as population growth, urbanization, and agricultural expansion over the decades, have contributed to the overexploitation, mismanagement, and partial depletion or contamination of these crucial water sources. While many coastal aquifers have been severely damaged by seawater intrusion, inland aquifers have suffered from over-pumping and seepage of pollutants. The consequences of these phenomena have been and will be detrimental to the whole island, considering that groundwater resources are key to sustaining the most critical activities, especially agriculture, which is tightly tied to food security, but also tourism, another growing industry that decisively contributes to economic development in the TRNC. On the other hand, the TRNC's surface water sources are limited. The island's small territory is home to 38 non-perennial rivers, which largely depend on the rainy seasons and can only contribute a small portion of the national domestic water demand. The island's geography, characterized by steep

inclines and short rivers, often results in surface water streams rapidly reaching the sea through runoff, making them unsuitable for exploitation. While around 30 dams have been built to conserve this water, it is not enough (Gökçekuş et al., 2020). The potential impact of water scarcity on the TRNC's economy is significant and should be a priority for the organizations and authorities in charge.

5. The Peace Water Pipeline Project

Water in Northern Cyprus is mainly managed by the state, which owns the majority of dams and wells. However, some private entities, too, are entitled to manage some wells employed to extract water from beneath the land surface. This condition is not optimal considering that the privately owned water wells are not as subject to control and inspection as the state-owned ones, potentially leading to not-always-transparent management of these resources (Arslan & Akün, 2019). Turkey built many of these infrastructures, such as dams, wells, and ponds, in the TRNC over the decades. However, these efforts have proved insufficient to solve the island's water stress, which has also gradually worsened in light of the phenomena affecting the island and discussed above.

Since the late 1990s, Turkey has designed and built the Peace Water Pipeline Project (officially the Turkey-Northern Cyprus Water Supply Project) in an attempt to tackle the issue decisively. Construction of the Pipeline occurred between 2011 and 2015, and Ankara took care of paying more than $500 million for its implementation. This infrastructure constitutes a unique project of its kind, setting the bar for other long-distance offshore engineering and subsea projects that might arise in the future. A 107 km long water Pipeline, of which 80 km is laid at around 250 metres underwater, directly connects the Alaköprü Dam, built in the Turkish town of Anamur, in the Mersin province, and the Geçitköy Dam, situated on the other side of the sea in the TNRC. What is more important, the Pipeline provides and is expected to provide for the next 50 years about 75 MCM of water from Turkey to Northern Cyprus yearly (Bryant, 2015; Mason, 2020). Among the key goals of the Pipeline, besides ensuring a stable water supply to the Turkish Cypriot community for the main activities, namely agriculture and domestic use, is decisively decreasing groundwater overexploitation. Thus, according to its creators, the Pipeline should revive the region's aquifers. Moreover, the project is expected to significantly improve the quality of life by supporting irrigation in key regions for crop production, such as the Güzelyurt and Mesaria areas (Elkiran et al., 2020). The Peace Water Pipeline has undoubtedly helped address water shortages in the TRNC, providing a stable water supply that the Turkish Cypriots rely on for their main activities. Regarding agriculture, a significant business in the TRNC that involves a large portion of the population, the support provided by Turkey's Pipeline is unmistakable.

A staggering 56% of the TRNC's land is dedicated to agriculture, and it is plausible to believe that in the future, the country's crop production will further increase, especially in the East, where several land portions are still unused (Gökçekuş et al., 2020). It is fundamental to stress that agriculture encompasses and is tied to several economic activities, such as crop production, livestock farming, fishery, and forestry, which are all water intensive. All of these combined account for about 70% of the total water supply to Northern Cyprus, making it the most critical water demand to meet (Elkiran et al., 2020).

However, the Pipeline has not solved all the problems related to water stress. It should be noted that the population in the TRNC is unevenly distributed, with a concentration of people in the six major municipalities out of a total of 25. Just like its population, water incoming from Turkey is unevenly distributed across the island. This is because the web of water distribution infrastructures is still being developed to reach as many areas of the

country as possible. As of 2020, 12 municipalities were relying entirely on the Pipeline's water, while the other 13 were still mixing the Pipeline's water with other local resources, especially groundwater extraction and small-scale desalination plants. Some parts of the country continue to experience several problems related to water scarcity, which makes it necessary for all stakeholders to collaborate and find further solutions to address the issue (Gökçekuş et al., 2020; Elkiran et al., 2020).

The project has not without its critics. Various groups concerned about the increasing Turkish influence on the island have manifested their opposition. Some members of the Turkish Cypriot community, who advocate for the reunification of the two sides and oppose Turkish interference in local affairs, have strongly condemned the project. Similarly, the Greek Cypriot community in the Republic of Cyprus has also criticised the Pipeline, reflecting their apprehension towards Ankara's expanding presence on the island. Despite Turkish President Recep Tayyip Erdoğan's assertion during the Pipeline's inauguration on 17th October 2015 that it could serve as a potential channel for peace between the two sides, many view the project unfavorably from a geostrategic perspective (Mason, 2020; Verre, 2021).

Environmental groups and associations on the island have raised valid concerns about the Pipeline. While it has undoubtedly improved short-term water security, it is not a sustainable solution for the long term. The challenges posed by dry summers in Cyprus, such as increased temperatures, reduced rainfall, and tourism waves, cannot be addressed by the Pipeline alone. The environmental risks associated with the project, including significant changes in the landscape, the relocation of entire communities, and the construction of dams, are issues that cannot be ignored (Verre, 2021). These concerns highlight the urgent need for sustainable and environmentally friendly solutions to the island's water stress, particularly in the TRNC.

6. Toward Sustainable Management of Water Resources in Northern Cyprus

Water demand is gradually increasing in Northern Cyprus due to population growth and is expected to grow further in the years and decades to come. Modernising and developing the infrastructures and techniques related to water use are crucial to minimise water losses, align water demand, and offer for all activities and sectors that largely depend on water to function correctly. The Peace Water Pipeline Project has undoubtedly helped address water scarcity in Northern Cyprus, providing a vital resource for the country's main activities. However, Turkey's 75 MCM of water yearly cannot satisfy the TRNC's overall water demand. For this reason, Northern Cyprus has implemented and continues implementing numerous projects and techniques to cope with its population's increasing demand for water and the decreasing reliance it can place on its traditional water resources due to climate change and the other phenomena discussed above.

In the twenty-first century, and even more so in delicate contexts involving water resources such as the island of Cyprus, sustainable water management has become indispensable to achieving meaningful water security results. The inhabitants' increasing reliance on wastewater reuse could be a decisive way to improve the water supply in Northern Cyprus. Besides those already mentioned, one of the advantages of the Peace Water Pipeline is that it provides the TRNC with high-quality water. Therefore, rather than being directly discharged into the sea, wastewater generated from using the Pipeline's supply could be re-employed in several activities. For instance, wastewater generated from the Pipeline could help address the urgent need to recharge the island's aquifers. Furthermore, as mentioned earlier, the potential increase in agricultural production by the TRNC in the future would inevitably lead to a rise in water demand in parallel with the increase in agricultural production. Again, the

wastewater generated from the Pipeline's water supply could be very useful to the island's workers in this sector and considerably decrease the reliance on groundwater (Gökçekuş et al., 2020).

Desalination of seawater and brackish water, a widespread activity in the Republic of Cyprus, which heavily relies on this activity to meet its increasing water demand, could also benefit Northern Cyprus. This technique is already present in the North, mainly at the local level, to supply water to structures involved in the tourist sector, such as hotels and resorts, for example, to carry out their gardening activities. Developing sustainable desalination systems, especially those that employ solar and wind energy, could further improve sustainability and water security. The TRNC already has six operating wastewater treatment plants with an overall capacity of 17.400 m3/d, which amounts to about 13% of the municipal water consumption in the whole territory. The most significant of these is located in Nicosia and treats water for both sides of the city (Elkiran et al., 2020; Gökçekuş et al., 2020).

7. Examples of joint projects between the TRNC and the RoC in wastewater management.

In this context, the joint projects between the two sides of the island have demonstrated significant growth over the past ten to fifteen years, serving as a prime example of sustainable water management. This progress is attributed mainly to the active involvement of international organizations such as the United Nations Development Program (UNDP), the European Union (EU), the World Bank, and various global and local stakeholders. Their support, which has been paramount in occasionally overcoming the longstanding divisions that characterize the island, at least in water security, underscores the global significance of these initiatives and could function as a driving force involving other scenarios marked by division and tension over natural resources.

These projects are significant in Cyprus, where cooperation is particularly complicated since the two communities do not acknowledge each other's legitimacy. However, the shared challenges related to climate change, population growth, and water scarcity have already and hopefully will further result in cooperation between the two sides of the island. Since only Turkey officially recognizes the Turkish Republic of Northern Cyprus, international cooperation in water security directly involving Northern Cyprus is sometimes tricky. However, the first steps toward joint efforts date back to 1978, when representatives and technicians from both communities agreed to implement a shared sewerage system in Nicosia (UNDP, 2024). This marked a small but significant beginning for collaboration between the two sides, and the continued support of international organizations is a source of encouragement for further progress.

Between 2010 and 2013, with financial support from the European Union and the Sewerage Board of Nicosia, the UNDP addressed Nicosia's unsustainable water supply conditions by establishing the New Nicosia Wastewater Treatment Plant. This facility produces high-quality treated sewerage effluent (TSE) for irrigation to enhance agricultural sustainability in both communities and constitutes an upgrade from the system introduced in 1978. The project’s relevance also lies in its focus on the sustainable reuse of water for irrigation and fertilizer production rather than just on preventing environmental damage caused by the dispersal of these waste liquids into the environment. Recent advancements further enable the reuse of treated water and its nutrients for irrigation and fertilizer production, effectively reducing the ecological footprint, and their implementation in a context like the TRNC is of the uttermost importance (UNDP, 2024).

More recently, in 2023, the UNDP, in collaboration with the European Commission, inaugurated the Morphou/Güzelyurt Wastewater Treatment Plant. Located in northwest Cyprus, Morphou (Güzelyurt) is governed by the Turkish Republic of Northern Cyprus but recognized as part of the Nicosia district of the Republic of Cyprus.

Like the other examples mentioned above, this project aims to foster confidence and cooperation between the Greek and Turkish Cypriots. It constitutes a valuable alternative to groundwater resources by treating wastewater to provide around 500 million litres of high-quality water yearly to irrigate the local crops. Besides reducing groundwater exploitation, the project aims to reduce competition over water resources among those employed in the agricultural sector. These projects demonstrate a deep commitment to tackling water stress. Despite the mutual non-recognition, the direct involvement of authorities and professionals from both sides of the island is proof of the potential for long-term benefits from these initiatives, not just as strictly related to water management but also to overcome longstanding divisions and to bring a new life on the island through the most essential source of life on Earth: water.

8. Conclusion

Water stress in Cyprus, particularly in the Turkish Republic of Northern Cyprus, is a crucial topic that must be adequately addressed by the communities, authorities, and organisations involved in its territory. The negative consequences of climate change, population growth, and increasing water demand already create problems for towns, economic activities, and many people's everyday lives. The next few years and decades risk putting the island of Cyprus under further pressure, just like many other contexts characterised by growing water stress. Therefore, implementing the proper long-term, sustainable, and cooperative solutions cannot wait any longer. As stressed throughout the text, Turkey's Peace Water Pipeline Project, which helps sustain the water supply to the TRNC, has achieved substantial results and has relieved some of the local resources after decades of mismanagement and overexploitation. However, besides the geopolitical concerns of a part of the island's population among the Greek and Turkish Cypriots alike, several doubts persist about the Pipeline's ability to satisfy the TRNC's water demand fully. Studies based on water demand data projection for the TRNC show that the local population needs more water to sustain its vital activities and keep up with the growth of the agriculture and tourism sectors, which are central to the island’s economy. The increasing reliance of the TRNC on wastewater reuse, to which the high-quality water provided by the Peace Water Pipeline could decisively contribute, is a step to minimise waste and further decrease the reliance on water sources strained by decades of mismanagement. Further expanding the development and capacity of sustainable desalination plants by exploiting solar and wind power is another essential point to stress. Moreover, the ongoing projects implemented with the collaboration between the TRNC and the Republic of Cyprus, with the involvement of international organisations, open another glimmer of optimism about the possibility of increasingly joint management of the island's water resources and achieving increasing water security, also avoiding the escalation of tension over water resources, as it is already unfolding in other scenarios characterised by division and resource scarcity.

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