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Examining the Nexus Water Demand-Economic Growth in Morocco: A Tapio Decoupling Index Analysis

Examen du Nexus Demande en eau-Croissance économique au Maroc : une analyse de l'indice de découplage Tapio

Fatima Zahra MOUSSAID, (*Doctorante*)
Faculty of Economics and Management of Kenitra
Ibn Tofail University of kenitra, Morocco

Mounir JERRY, (*Enseignant -Chercheur*)
Faculty of Economics and Management of Kenitra
Ibn Tofail University of kenitra, Morocco

Ahlam QAFAS, (*Enseignante-Chercheuse)*
National School of Commerce and Management of Kenitra
Ibn Tofail University of kenitra, Morocco

Correspondence address :	Faculty of Economics and Management of Kenitra Ibn Tofail University Morocco B.P 242 -Kenitra.
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Abstract:

Water, the lifeblood of our planet, plays a crucial role not only in sustaining ecosystems but also in driving economic activities. Its pivotal importance in agriculture, industry, and human consumption makes it a non-negotiable element for societal progress and well-being. Yet, as vital as it is for economic development, its waning availability is sounding alarms worldwide, emphasizing the need for decoupling economic growth from water use. This holds especially true for nations like Morocco, grappling with water management challenges due to its arid and semi-arid climate. This research paper delves into the relationship between Morocco's economic growth and water demand from 1980 to 2017, utilizing the Tapio decoupling index. The findings indicate that water demand is decoupled from economic growth only in the absence of drought, suggesting that Morocco lacks resilience to climate change. These insights underscore the pressing need for robust and resilient water management approaches to ensure long-term economic and environmental sustainability in Morocco. Relying solely on adaptation might not suffice given the recurrent droughts intensified by climate change risks. Hence, a priority for decision-makers should be formulating strategies that enhance resilience.

Keywords: Water scarcity, Tapio decoupling index, Economic growth, Resilience, Morocco.
Classification JEL : Q21- Q25- Q56
Paper type: Empirical Research

Résumé :

L'eau, élément vital de notre planète, joue un rôle crucial non seulement dans le maintien des écosystèmes, mais aussi dans la conduite des activités économiques. Son importance capitale dans l'agriculture, l'industrie et la consommation humaine en fait un élément non négociable pour le progrès et le bien-être de la société. Pourtant, aussi vitale soit-elle pour le développement économique, sa disponibilité décroissante sonne l'alarme dans le monde entier, soulignant la nécessité de découpler la croissance économique de l'utilisation de l'eau. Cela est particulièrement vrai pour des pays comme le Maroc, aux prises avec des problèmes de gestion de l'eau en raison de son climat aride et semi-aride. Ce document de recherche se penche sur la relation entre la croissance économique du Maroc et la demande en eau de 1980 à 2017, en utilisant l'indice de découplage Tapio. Les résultats indiquent que la demande en eau n'est découplée de la croissance économique qu'en l'absence de sécheresse, ce qui suggère que le Maroc manque de résilience face au changement climatique. Ces informations soulignent le besoin pressant d'approches de gestion de l'eau robustes et résilientes pour assurer la durabilité économique et environnementale à long terme au Maroc. Compter uniquement sur l'adaptation pourrait ne pas suffire étant donné les sécheresses récurrentes intensifiées a cause du changement climatique. Par conséquent, une priorité pour les décideurs devrait être de formuler des stratégies qui renforcent la résilience.

Mots clés : Pénurie d'eau, Indice de découplage Tapio, Croissance économique, Résilience, Maroc.
JEL Classification : Q21- Q25- Q56
Type du papier : Recherche Empirique

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1. Introduction

Water, often referred to as the lifeblood of our planet, is indispensable in nourishing ecosystems, supporting diverse species, and fostering economic expansion. From irrigating vast agricultural landscapes to powering industries and satisfying the hydration needs of billions, water's importance to societal advancement and well-being cannot be overstated. The United Nations' Sustainable Development Goal (SDG) 6 underscores the commitment to "Ensure availability and sustainable management of water and sanitation for all." This global goal not only highlights the significance of clean water access but also draws attention to its prudent management for future generations. However, despite its critical importance, the steady decline in water availability is ringing alarm bells across continents. As the world continues to grapple with the complex challenges of climate change, resource scarcity, and sustainable development, the interconnected relationship between economic growth and environmental pressure has come under intense scrutiny (Hurlbert et al., 2019). Among the most pressing issues is the escalating demand for water resources, a vital element for human existence and economic progress (UN-Water, 2019). The burgeoning demand, coupled with erratic climatic patterns, accentuates the pressing need to decouple economic growth from unsustainable water consumption, emphasizing the urgency to address this critical challenge.

In countries where water scarcity is prevalent, such as Morocco (SIWI & UNICEF, 2023; World Bank Group, 2021), the quest for achieving economic growth without exacerbating the strain on water resources has become an imperative task (World Bank, 2016). Morocco's geographic location, predominantly arid and semi-arid landscape, and population growth have significantly amplified the pressure on its already strained water resources(Hssaisoune et al., 2020). Moreover, its ambitious economic agenda necessitates a thorough understanding of the potential consequences of such growth patterns on water consumption.

This research paper conducts an in-depth examination of the connection between water demand and economic growth specifically within the Moroccan landscape. To achieve an understanding of this relationship, we employ the Tapio Decoupling Index (TDI) as a robust analytical framework to assess the patterns of water demand and their association with economic growth over a defined period.

The TDI is a widely recognized tool that enables the evaluation of the extent to which economic growth has been coupled or decoupled from water consumption, illuminating the efficiency of water use in driving economic advancement (Tapio, 2005). Additionally, to provide a richer perspective on our findings derived from the Tapio Decoupling model, we immerse ourselves in the historical backdrop of Morocco. This historical dive aims to offer a profound interpretation of the results.

By employing this innovative methodology, this research objective is to shed light on key questions, including:

To what extent has Morocco achieved decoupling between water demand and economic growth, if any?

What practical interventions could be recommended to support sustainable water management and economic development in Morocco?

The findings of this study will have significant implications for policymakers, water resource managers, and stakeholders involved in shaping sustainable development strategies. Understanding the dynamics between water demand and economic growth is vital for fostering resilient economies that can thrive while safeguarding the essential ecosystems upon which they depend.

In the subsequent sections, this paper will present an in-depth literature review on the existing research and theories regarding the water-economy nexus, then, explain the methodology employed, present and analyze the empirical results derived from the TDI assessment, and finally, conclude with recommendations designed to promote sustainable water use in Morocco and propose directions for future research.

2. Literature review

The landmark study " Options for decoupling economic growth from water use and water pollution" by the IRP (UNEP, 2015), argues that decoupling water use from economic growth guarantees water resources sustainability. This concept of decoupling was initially utilized in physics then its application has been extended to the environmental field to evaluate the relationship between environmental stress and economic growth (Z. Wang & Yang, 2015; Yin et al., 2014; Z. Zhang et al., 2015). The first definition of decoupling in this field is the interpretation of the (OECD, 2002) which states that decoupling refers to attempting to remove the impact of economic growth on resources and the environment or altering the intensity of resource consumption and pollution to counteract the intensity of economic expansion.

Using the OECD decoupling method, the absolute decoupling or relative decoupling of the two elements can be identified; however, the degree of decoupling between them and the type they belong to cannot be determined. To correct this shortcoming, (Vehmas et al., 2003) introduced the elasticity method to the decoupling research and proposed six decoupling states which develops and improves the decoupling theory. Two years later, (Tapio, 2005) refined the degree of decoupling into eight states for better accuracy and precision and therefore a good interpretation.

In the field of resource and environment, the decoupling model is mainly used for pollutant emissions such as CO2 and PM 2.5(J. Hu et al., 2017; Lai et al., 2021) and for energy consumption (Chen et al., 2020; Fiorito, 2013; Yasmeen & Tan, 2021). Decoupling is rarely used in the field of water resources. The existing research on the decoupling of water and economic development is divided into two categories, focusing on water footprint and water consumption as the research subject (Jin et al., 2016; Kong et al., 2019; Pan et al., 2021; Tian et al., 2017; Z. Yu & Qingshan, 2014), or water pollution and wastewater discharge as the subject of research (Q. Wang et al., 2018; Z. Wang et al., 2015; Y. Zhang et al., 2021)

In recent years, numerous studies have delved into the relationship between water consumption, economic factors, and various other parameters. Pan et al. (2021) focused on the "water-energy-food" perspective and revealed instability in the decoupling status, with decoupling being a recurrent issue. Wang and Wang's (2020) study looked into the national intensity of water consumption, pinpointing only two decoupling states: strong and weak.

Shifting the focus to groundwater consumption with GDP growth, Qiu et al. (2018) used the Tapio decoupling elastic method for coastal provinces like the Yellow Sea and Bohai Sea, and they observed a predominantly positive decoupling status. Zhu et al. (2013), on the other hand, highlighted non-ideal decoupling levels between water use and economic progress in two Chinese provinces by using the Vehmas decoupling method.

In 2014, Yu and Qingshan tapped into the water footprint method, spotlighting a prominent decoupling relationship spanning water consumption, water environmental strain, and crop production. A few years later, Kong et al. (2019) used the Tapio model and found that while decoupling between the water footprint and economic expansion was weak over several years, it remained strong when evaluating water footprint intensity against economic growth.

Hu et al. (2019) presented a layered analysis, suggesting that primary industry decoupling was unstable and volatile, whereas the secondary and tertiary sectors displayed encouraging decoupling patterns. Zhang et al. (2021) applied the tapio model and provided insights on the progression from weak to strong decoupling concerning wastewater discharge and economic advancement.

Highlighting the challenges in the textile industry, Li and Wang (2019) emphasized the complexity of double decoupling compared to single decoupling in water consumption and wastewater discharge. Lastly, Yu et al. (2017) noted a strong decoupling between wastewater release and economic growth, particularly in Chongqing, amidst six environmental pressures they studied.

Most of the aforementioned studies focused either on wastewater discharge (Liang et al., 2020; C. Zhang et al., 2017; Y. Zhang et al., 2021) which is the end link in the system or on water footprint assessment which is not an appropriate guide for allocating water efficiently in water-scarce countries such as Morocco. (Wichelns, 2018) states that Water footprints contain insufficient information to identify policies for achieving public goals in agriculture, natural resources, and livelihoods. Furthermore, (Sušnik, 2018) states that water withdrawal is usually greater and more reliable than water consumption. Therefore, to ascertain the extent to which existing water resources are being strained, this study selected water withdrawal (Dalstein & Naqvi, 2022) as an indicator of water demand to discuss the nexus between water demand and economic growth in Morocco. Furthermore, the viability and feasibility of environmental pressure decoupling from economic growth are currently being discussed and require additional investigation (Kallis, 2011; O'Neill et al., 2018). Therefore, this paper uses the Tapio decoupling approach which is without a doubt, one of the most effective short-run elasticity techniques for analyzing sustainable development recently, and it offers policymakers meaningful insights.

The existing literature offers various insights into the relationship between water demand and economic growth, but there is no study that explore this connection in the Moroccan context using robust analytical frameworks such as the Tapio Decoupling Index. Given these gaps, this study aims to make a significant contribution by applying the Tapio Decoupling Index to assess whether water demand and economic growth are decoupled in Morocco from 1980 to 2017.

Building on the literature review and identified gaps, this study posits the following hypotheses:

Null Hypothesis (H0): There is no decoupling of water demand from economic growth in Morocco as measured by the Tapio Decoupling Index.

Alternative Hypothesis (H1a): There is decoupling of water demand from economic growth in Morocco as measured by the Tapio Decoupling Index.

Alternative Hypothesis (H1b): The degree of decoupling between water demand and economic growth in Morocco, as measured by the Tapio Decoupling Index, varies over a range of years.

These hypotheses will guide the analytical framework and research methods employed in this study to explore the nuanced relationship between water demand and economic growth in Morocco.

3. Data and Methodology

This study aimed to assess the degree of decoupling between water demand and economic growth from 1980 to 2017. To measure water demand, annual data of water withdrawals in billion cubic meters (m3) is used as a proxy, while GDP constant 2015 in million USD was employed to gauge economic growth. The water withdrawal data were obtained from the Aquastat database and HCP reports, whereas GDP data were retrieved from the World Bank database.

Table 1:Data description and sources

Variables	Description	Unit	Source
WW	Water withdrawal	Billion cubic meters	Aquastat-FAO and HCP
GDP	GDP constant 2015	Million USD	World Bank

Source: Authors

It's important to note that the water withdrawal data contained some missing values. To address this issue, an imputation algorithm based on a model-based imputer using Orange data mining software (Demšar et al., 2013) version 3.24 was employed. This widely utilized imputation approach has been well-established in the field of handling missing data (Quinlan, 1986; Salzberg, 1994) and offers several key benefits. Notably, this technique can accommodate uncertain information in the data (Tsang et al., 2009) while preserving the original data's pattern with minimal alterations in terms of centring, distribution, dispersion, and extreme values.

The decoupling model determines the degree of correlation between environmental pressure and economic development in addition to measuring the extent of decoupling between these two elements. The main decoupling methods are the OCED decoupling index analysis method, the Vehmas decoupling index method, and the Tapio elastic coefficient analysis method. The Tapio model can further subdivide the decoupling into eight states to make the decoupling result more accurate than the first two methods. Therefore, the present study selected the Tapio model to study the decoupling relationship between water withdrawal and economic growth in Morocco.

The calculation formula is as follows:

$$DI = \frac{(WW_t - WW_{t-1})/WW_{t-1}}{(GDP_t - GDP_{t-1})/GDP_{t-1}} = \frac{\Delta WW/WW_{t-1}}{\Delta GDP/GDP_{t-1}} = \frac{\%\Delta WW}{\%\Delta GDP} \tag{1}$$

where DI is the decoupling index, WW represents water withdrawals as a proxy for the environmental pressure, GDP refers to GDP (constant LCU) as a proxy for the economic driving indicator, and t and t-1 indicate the previous period and current period, respectively.

Tapio identifies three categories of decoupling “coupled, decoupled and negatively decoupled” along with eight distinct scenarios “strong decoupling, weak decoupling, expansive coupling, expansive negative decoupling, strong negative decoupling, weak negative decoupling, and recessive decoupling”. **Figure 1** provides the classification criteria for the eight decoupling states.

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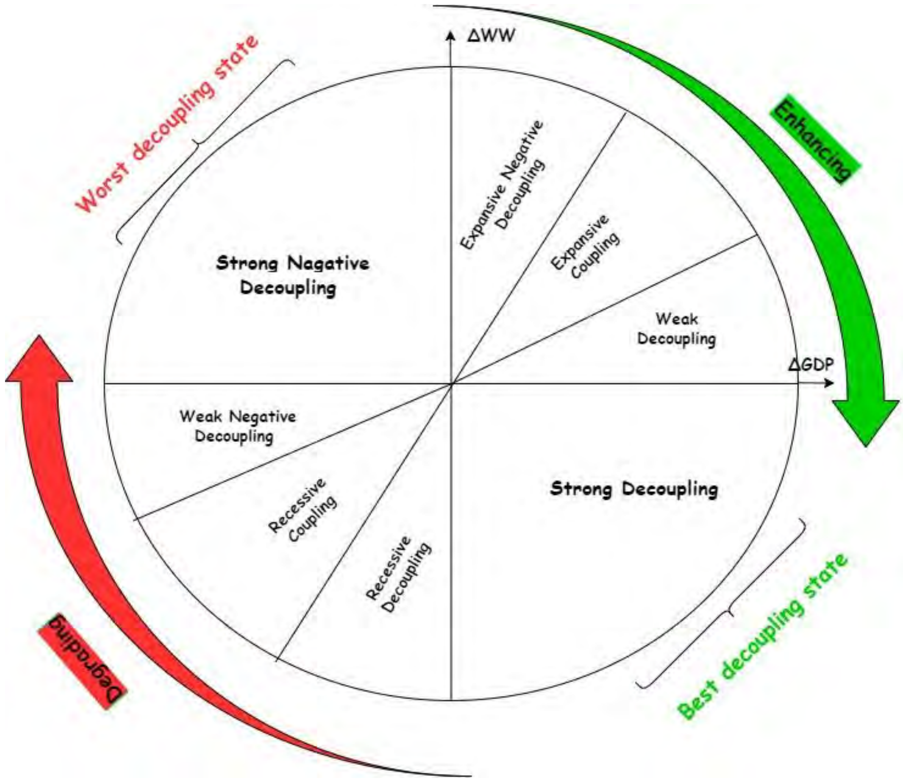
Figure 1. Tapio decoupling diagram



Source: Authors

The Judging criteria for the degree of decoupling between economic growth and water withdrawal are outlined in Table 2.

Table 2.The division and meaning of the Tapio decoupling index

Decoupling		**ΔWW**	**ΔGDP**	**Range of DI**	**Meaning**
Category	**Status**				
Coupling	Expansive	> 0	> 0	0.8 ≤ DI ≤1.2	The increasing rate of environmental pressure (water withdrawals) is equal to the rate of economic growth
	Recessive	< 0	< 0	0.8 ≤ DI ≤1.2	The decreasing rate of environmental pressure (water withdrawals) is equal to the rate of economic growth
Decoupling	Weak	> 0	> 0	0 ≤ DI <0.8	The increasing rate of environmental pressure (water withdrawals) is slower than the rate of economic growth.
	Strong	> 0	< 0	DI < 0	The economy expands as environmental pressure (water withdrawals) declines =**Ideal status**
	Recessive	< 0	< 0	DI >1.2	The environmental pressure (water withdrawals) rate decreases faster than the economy growth rate

Negative Decoupling	Weak	< 0	< 0	0 ≤ DI <0.8	The economic growth rate decreases faster than the environmental pressure (water withdrawals) rate
	Strong	< 0	> 0	DI < 0	The economy decreases as environmental pressure (water withdrawals) increases **= Worst status**
	Expansive	> 0	> 0	DI >1.2	The environmental pressure (water withdrawals) rate increases faster than the economy growth rate

Source: Authors

4. Results and Discussion

The complex relationship between economic growth and water demand is a paramount consideration for policy development, especially in regions facing water scarcity. In understanding the dynamics of water demand vis-à-vis economic performance, the concept of decoupling becomes pivotal. Decoupling, in this context, refers to the deviation or detachment between water demand and economic growth. Different forms of decoupling provide insights into the sustainability of growth with natural resource consumption.
Our study, as illustrated in **Source:** ***Authors***
A particularly encouraging trend is the strong decoupling evident across numerous years mainly the period of the 2000s. This indicates that Morocco managed to achieve sustainable economic growth while simultaneously reducing water demand—a testament to potential efficient water resource management and progressive economic strategies. During the 2000s, Morocco demonstrated a strategic commitment towards achieving a strong decoupling of economic growth from water demand. The country's forward-thinking Water Strategy 2020 (SEEE, 2009), initiated in 2009, aimed for universal drinking water access and emphasized the development of advanced infrastructure such as dams and water treatment plants. This vision was reinforced by awareness campaigns and public-private collaborations encouraged by the Moroccan government for water-related projects. The launch of the "Green Morocco Plan" in 2008 further advanced this objective, focusing on water-efficient agricultural practices and embracing renewable energy sources (MAMF, 2008). Concurrently, as tourism grows, Morocco efficiently managed the rising water demands by investing in robust infrastructure and prioritizing wastewater treatment, turning potential challenges into sustainable solutions. Together, these efforts demonstrate Morocco's intentional and successful journey towards decoupling economic aspirations from escalating water demands.
Table 3 and visualized in **Figure 2**, presents an examination of the decoupling phenomenon in Morocco over selected years. The outcomes of our analysis reveal nuanced patterns and confirms the **Alternative Hypothesis (H1b)** since the degree of decoupling between water demand and economic growth in Morocco, as measured by the Tapio Decoupling Index, varies over a range of years.

Figure 2. Tapio decoupling results

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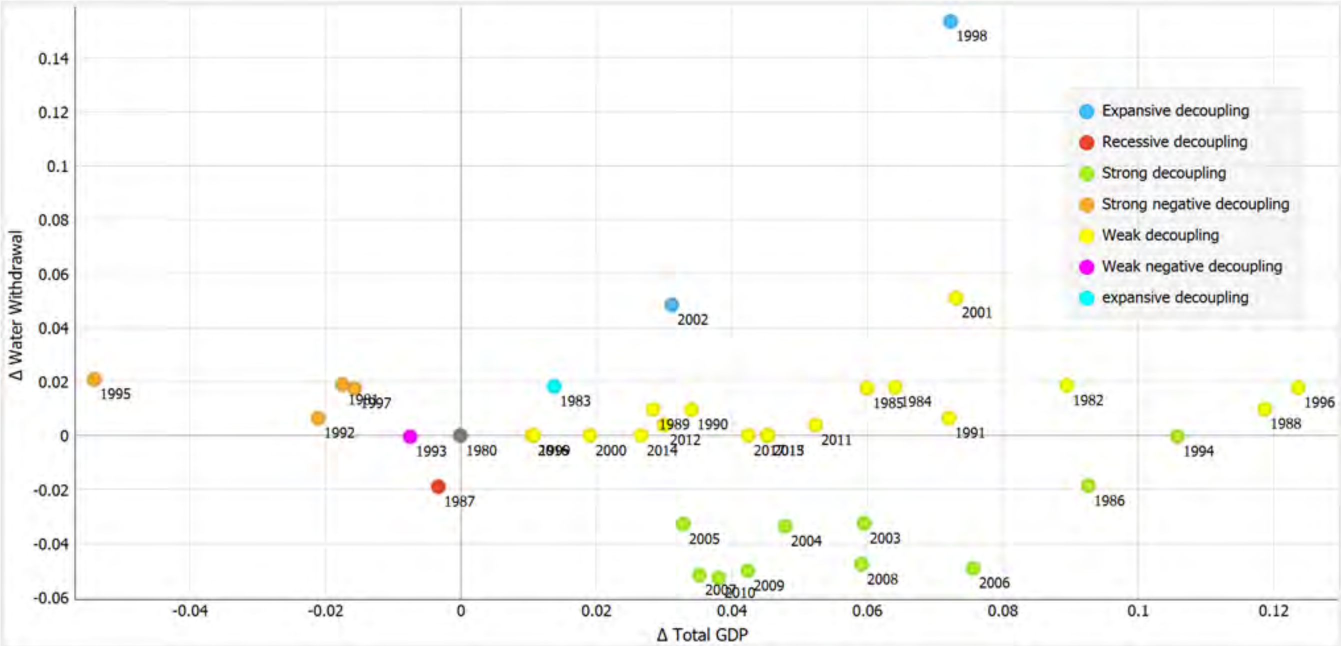

Source: Authors

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Table 3: Tapio Decoupling Index from 1980 to 2017

year	Δ WW	Δ GDP	DI	Decoupling relationship
1980	-	-	-	-
1981	0.01890547	-0.0174343	-1.0843807	Strong negative decoupling
1982	0.01855469	0.08957372	0.20714432	Weak decoupling
1983	0.01821668	0.0138657	1.31379506	Expansive decoupling
1984	0.01789077	0.06418386	0.27874253	Weak decoupling
1985	0.01757632	0.06007652	0.29256552	Weak decoupling
1986	-0.0186364	0.09271106	-0.2010155	Strong decoupling
1987	-0.0189903	-0.00325	5.84308773	Recessive decoupling
1988	0.00975763	0.11875236	0.08216791	Weak decoupling
1989	0.00966334	0.02846203	0.339517	Weak decoupling

1990	0.00957086	0.03411812	0.28052116	Weak decoupling
1991	0.00642202	0.07216088	0.08899584	Weak decoupling
1992	0.00638104	-0.0209774	-0.3041866	Strong negative decoupling
1993	-0.0004529	-0.0074059	0.06115361	Weak negative decoupling
1994	-0.0004531	0.10588	-0.0042794	Strong decoupling
1995	0.02085222	-0.0540545	-0.3857631	Strong negative decoupling
1996	0.01776199	0.12372876	0.14355586	Weak decoupling
1997	0.01745201	-0.015607	-1.1182149	Strong negative decoupling
1998	0.1535163	0.07238553	2.12081478	Expansive decoupling
1999	0	0.01081333	0	Weak decoupling
2000	0	0.01912873	0	Weak decoupling
2001	0.05092937	0.07319967	0.69575949	Weak decoupling
2002	0.04846127	0.0312145	1.55252436	Expansive decoupling
2003	-0.0325574	0.05961162	-0.5461578	Strong decoupling
2004	-0.033653	0.04797018	-0.7015401	Strong decoupling
2005	-0.0328401	0.0329164	-0.997683	Strong decoupling
2006	-0.0492537	0.07574632	-0.6502459	Strong decoupling
2007	-0.0518053	0.03531594	-1.4669108	Strong decoupling
2008	-0.0477373	0.05923278	-0.8059272	Strong decoupling
2009	-0.0501304	0.04243757	-1.1812739	Strong decoupling
2010	-0.0527761	0.03815718	-1.3831233	Strong decoupling
2011	0.00386473	0.05245697	0.07367437	Weak decoupling
2012	0.00384986	0.03009961	0.12790383	Weak decoupling
2013	0	0.04535424	0	Weak decoupling
2014	0	0.02669494	0	Weak decoupling
2015	0	0.04536378	0	Weak decoupling
2016	0	0.01059856	0	Weak decoupling
2017	0	0.04248949	0	Weak decoupling

Source: Authors

During an extended phase marked by weak decoupling, the Moroccan economy experienced growth, with water demand rising, though not as rapidly as economic progression. This pattern hints at a trajectory towards sustainability. Nonetheless, the persistent increase in water demand cannot be ignored. This status of weak decoupling was observed in two different periods: the 1980s and the 2010s.

Notably, during the 1980s, Morocco predominantly experienced weak decoupling, a situation where economic growth and water demand were both on the rise but at differential rates. A key contributor to this phenomenon was the severe droughts that the country grappled with during the decade (Swearingen, 1992). These droughts not only reduced water availability but also significantly impacted predominantly rain-fed agriculture, causing a substantial decline in crop yields, especially in cereals. As agricultural production decreased, it forced the country to reconsider its economic strategies, especially given the significant role agriculture played in Morocco's GDP (El Khatri & El Hairech, 2014).

Furthermore, the economic pressures of the era, such as mounting external debt and the need for industrial modernization, compelled Morocco to embark on structural adjustment programs with the International Monetary Fund (IMF) and the World Bank. These programs advocated for economic diversification and reduced dependency on agriculture (Esslimi, 1990). As Morocco leaned into liberalization, reducing tariffs and encouraging foreign investments, there

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was an observable shift from agriculture-centric industries to others like phosphate mining, tourism, and textiles. Such diversification aimed to reduce the economy's vulnerability to climatic changes and water scarcity.
The focus on non-agricultural sectors and reduced dependency on water-intensive agricultural practices can be linked to the weak decoupling scenario. While the economy was slowly diversifying and growing, its absolute water demand, though increasing, was doing so at a slower pace than the economic growth. This could also be attributed to the increased urban migration patterns, as rural inhabitants seek employment in urban areas, and the subsequent changes in water usage habits. The state's efforts to balance the budget through subsidy reductions on public services could have indirectly influenced more conservative water usage, given the rising costs of essentials.
In essence, while Morocco faced multifaceted challenges during the 1980s, its strategic responses, emphasizing economic diversification and structural adjustments, played a pivotal role in the observed weak decoupling of economic growth from water demand.
Throughout the 2010s, Morocco's journey towards the weak decoupling of economic growth from water demand was significantly influenced by a combination of policy initiatives, environmental conditions, and socio-economic shifts. Central to this was the Green Morocco Plan, initiated in 2008 and hitting its stride in the 2010s (MAMF, 2008). It aimed to modernize Moroccan agriculture with a keen eye on water sustainability. By introducing water-efficient agricultural methods, like drip irrigation, and steering the agricultural sector towards less water-intensive crops, it sought to detach agricultural productivity from excessive water use (Molle & Tanouti, 2017). Furthermore, the emphasis on value addition in agribusiness ensured that while the sector's economic contributions grew, its water footprint became progressively efficient.
The mid-2010s, particularly around 2015-2016 saw severe droughts (IWMI, 2018; Silva-Novoa Sánchez et al., 2022), amplifying the importance of the water-saving measures highlighted in the Green Morocco Plan. Droughts reduced agricultural outputs, underscoring the necessity of drought-resistant crops and water conservation. This, coupled with the potential increase in food prices, signalled the intertwined nature of water availability, agriculture, and economic stability.
Urbanization further complexified the water demand scenario. As urban areas expanded rapidly, due to migration from rural areas, water needs shifted. Urban regions faced amplified domestic and industrial water demands, and simultaneously, certain rural zones observed diminished water requirements due to reduced populations(Ben-Daoud et al., 2021). Responding to these urban challenges, Morocco began emphasizing integrated urban water management systems, aiming to harmoniously cater to diverse water needs while championing conservation (Ait Kadi & Ziyad, 2018).
Collectively, these dynamics of the 2010s—agricultural modernization, environmental challenges, and urban growth—guided Morocco towards the path of weak decoupling, accentuating the necessity of policies and practices that sustainably balance economic progress and water conservation.
In the transformative 1990s, Morocco's concerted shifts in water management and economic diversification epitomized the country's attempt at navigating the delicate balance between economic growth and water demand, resulting in a non-stable status of decoupling. The establishment of River Basin Agencies and the pivotal Water Law of 1995 underscored the nation's dedication to regionalized and sustainable water use, emphasizing efficient techniques like drip irrigation, especially amidst recurring droughts. Concurrently, Morocco's economic pivot was manifested through its engagement in Structural Adjustment Programs, Free Trade Agreements, notably with the EU, and the allure of Foreign Direct Investments, propelling sectors beyond traditional agriculture like tourism, mining, and manufacturing (Davis, 2006).

Yet, the simultaneous drive of intensifying water conservation initiatives while broadening economic horizons showcased the complex and often unstable relationship between water demand and economic expansion.

5. Conclusion, recommendations and future research

In conclusion, Morocco's historical trajectory, spanning 1980 to 2017, presents a compelling objective of the country's objective to strike a balance between economic development and sustainable water demand. These decades have witnessed the adoption of ambitious policies and strategies, most notably the visionary Water Strategy 2020 and the Green Morocco Plan. Such initiatives are clear indicators of Morocco's unwavering commitment to sustainable growth and water conservation. Economic diversification, an essential part of the country's approach, further wishes to decrease dependency on water-intensive sectors. As a shining testament to these strategies, the 2000s present a period of strong decoupling, where economic growth and water demand began to diverge, hinting at sustainable progression. However, the nonlinear relationship between economic progress and water demand became evident as we delve into other decades. The 1980s and 2010s, characterized by weak decoupling, showcased the persistent challenges the nation faced, exacerbated by recurrent droughts, ever-shifting socio-economic landscapes, and a heightened need for dynamic policy frameworks. The 1990s stood out as a transformative era, where the volatile balance between economic growth and water demand was underscored by rapidly evolving economic models and infrastructural innovations. But amidst these strides, an undeniable reality looms large. Morocco's geographical and climatic positioning makes it vulnerable to climate change, which is evident in the chronic droughts that have intermittently plagued the nation. These environmental challenges have, to an extent, diminished Morocco's ambitions to decouple economic growth from water demands. Given these vulnerabilities, the solution now lies in transitioning from mere adaptability to resilience. The lessons from the past, though invaluable, need to be augmented with strategies focused on resilience, ensuring that Morocco remains resilient in the face of looming and complex environmental challenges in the decades to come.

To bolster resilience against the impacts of climate change on its water systems, Morocco should consider a multi-faceted approach. First and foremost, the country must revise its Integrated Water Resources Management (IWRM) approach. Drawing from its past initiatives, this would emphasize the holistic management of water resources, safeguarding their sustainable use and protection. Additionally, given the increasing vulnerability to droughts, diversifying water sources becomes essential. This could involve significant investments in desalination plants, systems for harvesting rainwater and implementing methods for reusing treated wastewater in both agriculture and industry.

Furthermore, a focus on infrastructure is vital. This means rehabilitating and expanding current water infrastructure to ensure resilience against impending climatic events, including the reinforcement of dams, broadening storage capabilities, and enhancements to distribution networks. The development and roll-out of advanced early warning systems for droughts and other climatic adversities are crucial, offering a proactive approach that mitigates potential water resource impacts. With agriculture consuming a significant portion of water, the introduction of water-efficient practices such as water-saving technologies, effective irrigation methods like drip irrigation, and the cultivation of drought-resistant crops can aid in diminishing water resource depletion.

The involvement of local communities in water management is equally significant. This could be achieved by initiatives and forming local water committees, both of which can provide invaluable insights, advocate for water-saving habits, and inculcate a conservationist water culture. On the policy front, Morocco should periodically reassess its water policies, ensuring

alignment with evolving climate patterns. Such evaluations might entail modifications to water tariffs, revisiting allocation norms, and redefining conservation incentives. Investing in research and development can pave the way for innovative water management solutions. Partnerships with international entities, academic institutions, and research organizations might provide cutting-edge techniques tailored to Morocco's distinct challenges.
Moreover, capacity building, encompassing training sessions for various stakeholders like policymakers, water managers, and farmers, can deepen the understanding of climate change repercussions and the optimum methods to counteract them. Financially speaking, it would be wise for Morocco to establish a dedicated fund or mechanism to support water resilience initiatives, especially given its vulnerability to climate change despite not significantly contributing to it. While programs like the "NOOR project" address the energy sector, Morocco shouldn't limit its pursuit of climate finance to this area alone. Seeking funds for the water sector is equally crucial to ensure climate justice. Potential sources of funding can be through public-private partnerships, international grant schemes, or the introduction of green bonds earmarked for water resilience. Lastly, the protection and restoration of watershed and catchment zones are crucial. Initiatives like afforestation and reforestation within these regions can augment groundwater recharge and reduce surface runoff. Incorporating these varied suggestions into its strategic plan will surely strengthen Morocco's resilience against water issues caused by climate change.
In light of our findings using the Tapio decoupling model to study the relationship between economic growth and water demand, it becomes evident that a more comprehensive exploration is imperative. While the Tapio model provides invaluable insights into the short-run dynamics, a crucial avenue for future research lies in the application of the Environmental Kuznets Curve (EKC) model. The EKC model, which explores the inverted-U relationship between environmental pressure and economic growth, could shed light on the long-run decoupling status. This would complement our current understanding by bridging the knowledge gap between short-term and long-term dynamics. Furthermore, by disaggregating the economic growth variable into specific sectoral incomes, researchers can achieve a finer result, offering precision and nuance that can significantly influence policy directions. Beyond economic indicators, incorporating additional anthropogenic factors into the analysis will offer a more holistic perspective on the multifaceted drivers of water demand. Lastly, should data availability permit, an expansion of the timeframe of analysis will be excellent in capturing the evolutionary trends over extended periods. Pursuing these suggested directions can further the academic discourse, presenting a multi-dimensional understanding of the nexus between economic progression and water resource dynamics.

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