



Analysis of impacts of climate change on the grant and protection of patents related to the water industry

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ABSTRACT

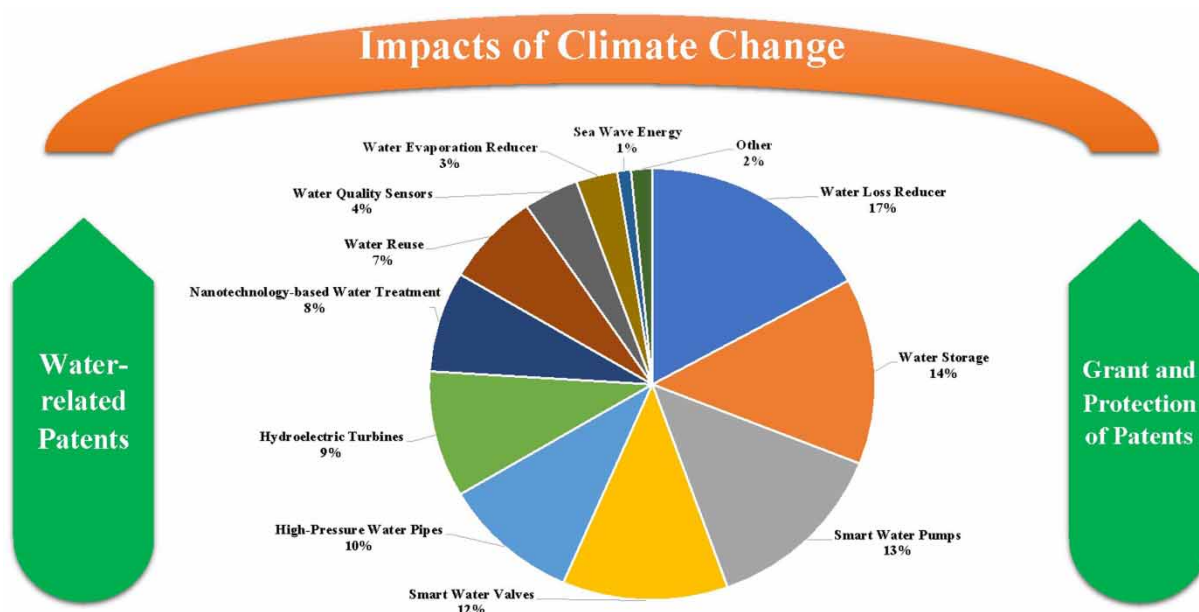
Various inventions are presented in the water industry, essential for the water supply, distribution, treatment, storage, and consumption optimization. It is necessary to confirm their novelty, innovative steps, and industrial applicability to protect water-related patents. However, the impacts of climate change are not considered in the granting of patents, and water-related inventions are registered or rejected regardless of these impacts. For example, an invention that causes greenhouse gas emissions may be patented because it is new. This research addresses this significant challenge using a descriptive-analytical approach and a library-field method. Based on the results, it is necessary to impose strictness on inventions that aggravate climate change (29% of the inventions investigated) and protect inventions that adapt to climate change impacts (71%). Furthermore, it is possible to use the tool of compulsory licensing to adapt to climate change and reduce its negative impacts. Moreover, the patent offices should evaluate climate change impacts by examining innovative steps and industrial applications. An invention that has negative impacts will be deprived of patent protection and considered one of the limitations and exceptions. Also, it is necessary to provide new interpretations of protection elements of the patent system.

Key words: climate variables, compulsory exploitation license, intellectual property rights, three-stage test, water management

HIGHLIGHTS

- Providing a new interpretation of the triple conditions of patenting can prevent the granting of patents that exacerbate climate change.
- Compulsory license capacities and exceptions can be used for the use of inventions that have a positive effect on adapting to climate change.
- Considering climate change impacts on the water industry, it may be necessary to use the invention without the inventor's permission.

GRAPHICAL ABSTRACT



ABBREVIATIONS

CH ₄	Methane
CO ₂	Carbon dioxide
IPCC	Intergovernmental Panel on Climate Change
IRI	Islamic Republic of Iran
JPO	Japan Patent Office
N ₂ O	Nitrous oxide
PCT	Patent Cooperation Treaty
TRIPS	Trade-Related Aspects of Intellectual Property Rights
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

1. INTRODUCTION

Climate change is a significant challenge regarding water management in various parts of the world. The impacts of climate change may result in the formation or intensification of torrential rains in some dry regions. There is, however, a significant amount of evidence around the world that shows that global warming has increased, rainfall has decreased, and climate change has had negative impacts on the supply, distribution, treatment, storage, and consumption of water (Intergovernmental Panel on Climate Change (IPCC) 2022). In addition, the discharge of wastewater (e.g., brine) degrades water quality, and thus water cannot be directly used for potable water (via desalination) and industrial applications (Panagopoulos & Giannika 2022a, 2022b, 2023). These impacts can harm human life, health, the environment, security, the economy, and infrastructure and disrupt the balance and function of existing structures (Rashidi Mehrabadi *et al.* 2019). Many countries consider climate change the greatest threat to sustainable development (Hughes *et al.* 2021).

Paying serious attention to water-related inventions and technologies is one of the most important steps to address this threat (Shakeri *et al.* 2020). Various inventions are presented in this context to reduce water loss and evaporation, increase water storage, enhance energy efficiency in water pumps, generate electricity from water power, produce energy from sea waves, etc. Among the inventions with minimal detrimental impacts on greenhouse gas emissions and intensification of climate changes are advanced hydro turbines used in dams to generate electricity (Karamouz 2021). Furthermore, intelligent pumps and valves are available today to optimize water use and help adapt to the limited availability of water due to the

impacts of climate change (Kydyrbekova *et al.* 2022). In addition, some chemicals have been developed to reduce the evaporation of dam water under solid sunlight (Onwude *et al.* 2021). Furthermore, nanotechnology-based products have been developed that improve water treatment and reuse efficiency (Gupta & Yadav 2019). There have also been developments in the manufacture of pipes that are more resistant to physical pressure, thereby reducing water leakage from water networks (Leflaive *et al.* 2020). As a result, developing and using these inventions can significantly reduce climate change impacts on water-related issues and adapt to climate change (Shakeri *et al.* 2021c).

Due to this, inventions and technologies aimed at adapting water supplies, distributions, treatment, and consumption to the impacts of climate change or reducing the factors that cause climate change (such as greenhouse gas emissions) and the adverse impacts caused by these impacts or even turning these threats into opportunities, should be a priority for social and economic policymakers. Achieving these significant goals requires macro-planning and developing strategies at the national and even international levels. Since climate change is a large-scale global issue, various factors may influence related strategies (Shakeri *et al.* 2022).

Among the most critical factors affecting the development and application of water-related inventions under the impacts of climate change is the issue of intellectual property rights. Over the past decade, some researchers have focused on the policies and legal challenges that affect the development and use of water-related inventions under the impacts of climate change in different countries. For example, Urban (2018) examined the possibilities for facilitating technology transfer in China under the impacts of climate change. In his research, he found that despite the necessity of prioritizing inventions with a reduced carbon footprint to facilitate technology transfer, the economic benefits of inventions remain the most essential factor in facilitating technology transfer under the impacts of climate change. However, in this context, he failed to present a solution for facilitating the grant of water-related patents in light of the impacts of climate change. Ferreira *et al.* (2020) explored the importance of technology transfer across the European continent to deal with the adverse impacts of climate change on the environment and water. As a result of examining data from several countries, they concluded that facilitating the transfer of technologies compatible with the impacts of climate change and their environmental importance results in economic growth throughout Europe. However, they did not suggest protecting water-related patents under climate change's impacts. Leflaive *et al.* (2020) investigated water-related technological inventions in the United States, South Korea, Germany, Russia, England, Canada, Italy, Australia, and Chile. Their studies found that water-related inventions typically aim to reduce pollution, manage demand, and manage water consumption. However, they did not consider the impact of climate change on the commercialization and protection of related patents in most of the cases they examined. According to them, this negligence may have severe consequences for water security. To improve the industrialization of water-related patents, Zheng & Zhang (2020) investigated the performance of patent systems in the United States, Europe, Japan, and South Korea. In their study, the researchers demonstrated that the regulations of the patent system can guarantee the industrial application, novelty, and innovative steps of water-related patents. Nevertheless, when analyzing water-related inventions and patent protection, the authors did not consider the impact of climate change. Nyiwul (2021) examined the challenges of developing water-related inventions in Africa under the impact of climate change between 1990 and 2016. Despite the severe water tensions in Africa, this study revealed that African governments have not given adequate attention to research and development of inventions that are compatible with climate change impacts on water, nor have they provided sufficient protection for the patenting of inventions compatible with the impacts of climate change.

Coromaldi & Auci (2022) identified and examined the motivations necessary for developing inventions under the impacts of climate change in Italy. It was found that despite the significance of the climate change issue, economic incentives remain the most significant factor in the development of new inventions. They failed to consider the impacts of climate change on the grant and protection of water-related patents. Kydyrbekova *et al.* (2022) examined different strategies for protecting water-related inventions in Kazakhstan and its neighboring countries. According to their findings, increasing financial support and investment is the most important factor for protecting water-related inventions. Nevertheless, they failed to consider climate change impacts and their significance in evaluating and protecting water-related inventions' intellectual property rights. Based on data from 2000 to 2018, Khurshid *et al.* (2022) investigated the role of environmental innovations in reducing the carbon footprint in Western and Southern European countries. According to their findings, new environmental patents have resulted in a reduction in carbon dioxide emissions. However, environmental policies and taxes have limited the use of these inventions. Nevertheless, they did not examine the issues affecting water-related patents in light of climate change.

Badrzadeh *et al.* (2022) proposed a simple framework for identifying pollutant-sensitive areas along the river and management strategies to improve water quality. Based on their results, nitrate and phosphate leaching into the river decreased to

18.1 and 8.35%, respectively, by reducing the consumption of urea and phosphate fertilizers by 50%. However, they did not consider the protection of water quality-related patents under the impacts of climate change.

Nivesh *et al.* (2023) developed an integrated water resource management system for the Dhasan River Basin by employing a scenario analysis approach in conjunction with the Water Evaluation and Planning Model to analyze trends in water use and anticipated demand between 2015 and 2050. Based on their results, implementing improved irrigation technologies, advancing farm agricultural practices, and constructing water conservation and retaining structures could significantly reduce the unmet demands and shortfalls. However, they ignored the importance of protecting water-related patents in adapting water resource management to climate change.

Aggarwal *et al.* (2023) quantified uncertainty in assessing the impact of climate change on crop production by using all available climate models under both harsh and mild emission scenarios from 2020 to 2095. Their results showed that uncertainty is prevalent even in relatively small regions while selecting different climate change scenarios. However, they failed to consider the importance of water-related patents in adapting crop production to climate change.

Shakeri & Motiee (2023) examined the risks associated with water reuse projects in Iran under the impact of climate change. In this study, the authors identified and quantified the relationship between changes in climate variables and hazards in the water reuse industry. Their findings demonstrate that new plans and inventions related to water reuse should be based on future climate changes, including greenhouse gas concentrations and emissions scenarios. They did not, however, examine the challenges of intellectual property rights and the impact of climate change on the grant and protection of water-related patents.

Although there have been numerous examples in past studies in which the challenges of water-related inventions have been examined under the impacts of climate change, no analysis has been conducted regarding the issue of granting and protecting water-related patents considering the impacts of climate change and appropriate measures have not been provided to solve any possible challenges. Meanwhile, as one of the most important elements of intellectual property rights, the patent system contributes to the emergence of patents that can have either a negative or positive effect on the emergence of climate change impacts and factors that adapt to it. The patent system can, therefore, be viewed from the perspective of the rulers. Countries have incorporated specific rules and principles into the system in their laws. For instance, national regulations codify protective conditions, limitations, exceptions to patent rights, and penalties and civil liability for infringements of rights.

As a result, there are substantial research gaps in granting and protecting water-related patents under the impacts of climate change, including the following: (1) How can the patent system prevent patents that exacerbate the negative impacts of climate change and contribute to its causes? (2) How are patent components interpreted in light of climate change? (3) In what ways can inventions that reduce the factors causing climate change or adapt to its impacts on water supply, distribution, treatment, and consumption be exploited and protected?

As a result of these questions/needs, this research aims to analyze the impacts of climate change on the grant and protection of patents related to the water industry, thereby answering as many of the questions/needs as possible. In this research, on the one hand, about the existing legal possibilities, an attempt is made to provide the context for the use of inventions that have a positive effect on reducing the negative impacts of climate change and, on the other hand, to examine what changes are necessary for the future of the patent system so that the relevant regulations are compatible and help solve the challenges caused by climate change. Based on the library-field approach, this research applies the descriptive-analytical method. In this context, the status of patents related to the water industry in Iran under the impact of climate change is investigated as a case study. Throughout this research, it is assumed that the registration of inventions related to the water industry results in their further commercialization, and it is beyond the scope of this research to analyze this issue. This research represents the first research on how the patent system interacts with the issue of climate change in the water industry. The practical importance of this research is that it can change the conditions of patent protection. This sentence means fewer patents may be issued and fewer exclusive rights. The current research seeks to manage intellectual property rights concerning the public interest. The advantage of this research is that it provides guidance for the future governance of countries and encourages inventors to patent patents in this field.

The role of this research in the world literature is to present ideas to the World Intellectual Property Organization (WIPO) to prepare a global document and oblige countries to pay attention to the change in the intellectual property rights system. Undoubtedly, it is crucial to add guidance for the international search authorities of the Patent Cooperation Treaty (PCT), emphasizing the assessment of climate change impacts of inventions and not accepting inventions that do not help humanity

and the environment adapt to climate change. This research will say that governments should reconsider the water patent system in future governance.

2. MATERIAL AND METHODS

2.1. Case study: Patent registration related to the water industry under the impacts of climate change in Iran

Based on the data from the Intellectual Property Office of Iran, 2071 patents have been registered in water supply, distribution, treatment, storage, and consumption between 2001 and 2023. This technology can be applied to various applications, including reducing water loss and evaporation, increasing water storage, energy efficiency in water pumps, producing electricity from water power, and generating energy from sea waves. Based on applicability, [Figure 1](#) shows the frequency of these patents.

It is possible to classify these patents into two main categories. As a first group, some inventions exacerbate climate change and increase the factors that contribute to it. An excellent example is the production of asbestos-cement pipes for water transportation, which are highly resistant to physical damage and water leakage. Despite this, since they require extensive use of fossil fuels for cement production, they exacerbate climate change by increasing greenhouse gas emissions. About 29% of the inventions investigated fall into this category. In the second group, however, are inventions that can reduce the factors contributing to climate change or adapt to its effects on water issues. For example, water usage-reducing valves significantly impact water consumption management under water resource shortages (caused by climate change impacts). About 71% of the inventions investigated belong to this group. Given the importance of climate change and its impacts, is it necessary to register both groups of the inventions mentioned above?

As per Articles 1 and 2 of the Iran Patent Law ([Islamic Republic of Iran \(IRI\) 2008](#)), new patents have inventive steps and are also industrially applicable and can be registered regardless of the specific field (such as the water industry). The legislator has also considered patent restrictions, such as excluding scientific discoveries and mathematical formulas from legal protection. Additionally, the patent system is considered limited by paragraph 'f' of Article 4, which prohibits the exploitation of inventions contrary to religious principles, public order, and good morals.

Management of consequences of climate change and dealing with environmental threats are emphasized in paragraph 7 of Iran's High Environmental Policy document ([Kolahi 2020](#)). Accordingly, based on this high document, it is recommended

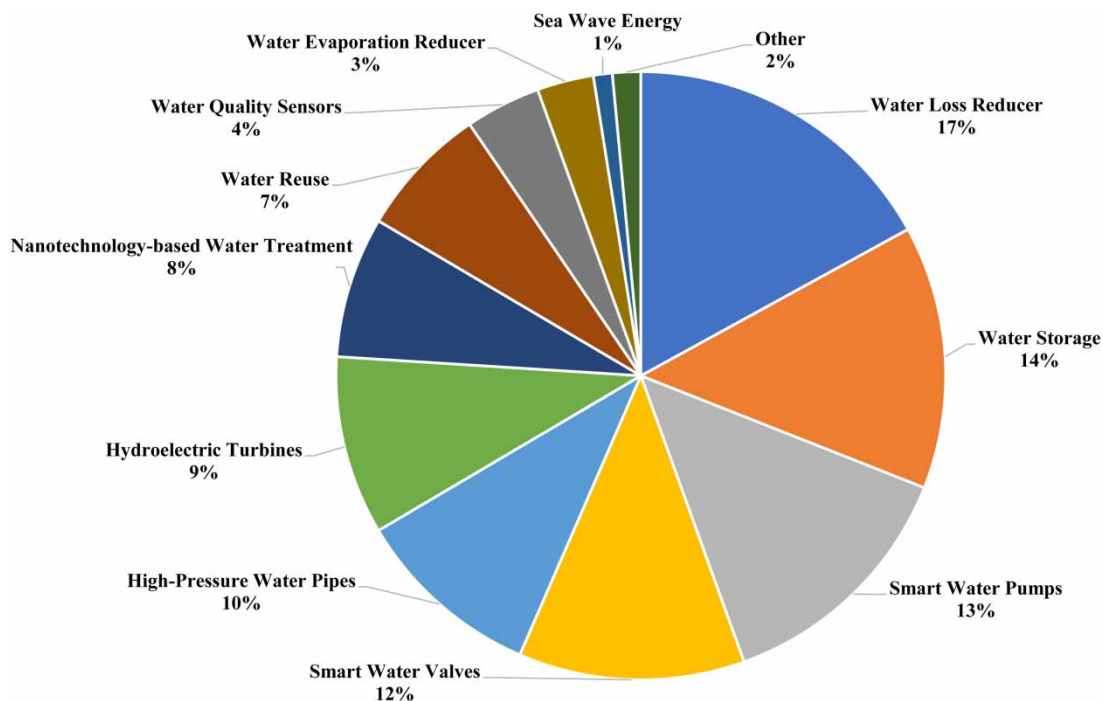


Figure 1 | Frequency of patents related to the water industry in Iran between 2001 and 2023.

that the relevant institutions in Iran prioritize addressing the adverse effects caused by climate change and that laws should be enacted in this area. Therefore, it is possible that in the future, based on these policies, inventions that harm the supply, distribution, treatment, storage, and consumption of water (under the impacts of climate change) will face registration limitations in Iran or even be classified as non-registerable.

2.2. Methodology

This research is based on an analysis of national and international sources, such as laws, agreements, reference books, papers, reports, judgments, and judicially registered data. According to Article 27 of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) (World Trade Organization (WTO) 1994), any invention can be patented in all fields of technology provided that it meets the triple conditions (including novelty, inventive step, and industrial applicability). Some Members may, however, prohibit the commercial use of particular inventions within their territory, whether to maintain public order, morals, human, animal, or plant life or health or to prevent severe environmental damage; however, this exception must not be based solely on the fact that their domestic law prohibits such use. Thus, in general, it is possible to register patents that aggravate climate change and increase the factors that cause it, as well as those that are contrary to the adaptation of the water industry to climate change, by following the triple conditions unless the exploitation of the patent violates public order. However, this statement needs a more comprehensive analysis and investigation considering the various impacts of climate change.

On the other hand, it would be desirable to examine the patentability of inventions that exacerbate climate change from the standpoint of the triple conditions and answer the question, how are the triple conditions analyzed in the case of these inventions? In light of climate change, how are patent components interpreted? How can the patent system prevent patents that exacerbate climate change and increase the factors that contribute to it? Generally speaking, if an invention in this field is patentable and positively impacts water supply, distribution, treatment, storage, and consumption, can the public use it? How can inventions that reduce climate change factors or adapt to climate change impacts on water supply, distribution, treatment, and consumption be exploited? Can they be included in the patent exceptions? Based on the 'library-field' approach, this research utilized the 'descriptive-analytical' method to answer these questions. It has been determined that national and international references related to intellectual and industrial property rights have been considered, and the results and findings associated with them have been discussed.

The limitations of this research are that due to uncertainty in climate change factors, it may be proved later that an invention was not compatible with the impacts of climate change. This sentence means that the relevant compulsory license has been wrongly issued or the inventor has been denied a patent. In addition, the patent certificate is always revocable because it may be proved that the invention does not meet at least one of the conditions for patenting. Therefore, this is the legal risk involved in technology transfer contracts.

3. RESULTS AND DISCUSSION

Based on a review of national and international references, it appears that the main policy of the patent system has been to protect new inventions to encourage inventors and create incentives for commercialization. According to some researchers, however, the patent system has failed to achieve this goal (Lemley 2011). As a result, the first issue is whether changing the general policies of the patent system can be a positive development. The importance of this issue lies in the fact that today's human concerns go beyond just technological advancement and that preserving water resources and dealing with the adverse impacts of climate change on water-related issues are also crucial. Would it be possible to reform the existing legal structures and, by reforming the traditional goals of the patent system, create a sense of motivation for creativity and innovation in the desired areas, including reducing the factors causing climate change or adapting to the impacts of climate change on water-related issues? By modifying the goal, existing concepts may be altered.

Developing patent policies involves political, economic, and legal standards and several institutions such as patent offices, specialized courts, and other government departments (Thambisetty 2008). Even if this action is justified legally, synchronizing multiple institutions would require extensive expert work. It would be unaffordable regarding possible time and costs until other paths could be explored.

However, to achieve this goal, it may be necessary to modify the more detailed concepts of the patent system, such as the triple condition (i.e., 1. novelty, 2. inventive step, and 3. industrial applicability). By this means, the triple conditions can be

considered as a factor to measure the possibility of negative or positive effects of the invention in the issue of the impacts of climate change on the water industry:

1) Novelty of the invention

This term refers to the fact that the invention has not been disclosed anywhere in the world in writing, orally, or practically before the date of filing the application (or the date of its right of priority). Databases are checked for this purpose. If the database is up-to-date and complete, the invention's novelty is appropriately checked, and the possibility of patent invalidity will decrease.

1-1) New use:

When examining the novelty of inventions related to the impacts of climate change on water issues, it should be noted that the product or process may have already been applied or presented. What matters most to the examiner of the invention is whether the applicant has come up with a new idea that can reduce the factors that contribute to climate change or adapt to climate change's impact on water issues. Based on this method, new use compatible with the impacts of climate change on water issues can also be considered to be the cause of the condition of being new by modifying the approaches. New uses adapted to the effects of climate change on water issues were accepted as a novelty of the invention. New functions can be a scientific discovery, but in this view, new use is considered a novelty, an issue of particular importance in biotechnology inventions. In the jurisprudence of certain countries, it has also been noted that a new use for an old composition based on the unknown characteristics of the composition may be registered as a process of use (Kelly 2005). Therefore, a researcher who states that this invention has positive effects on adapting to the impacts of climate change can have a good chance of receiving a patent.

1-2) Transformation of novelty's absolute concept into its relative notion:

Although Iranian law accepts the concept of absolute novelty as stated in Article 4 of the law, this approach can be reduced when inventions are designed to adapt to the impacts of climate change on water issues, where the mere fact that the invention is new at the national or regional level is sufficient to grant a patent. Thus, granting patents that address water issues in response to climate change (even with less protection) may incentivize their commercialization.

1-3) Change of the prior-art level concept:

Prior art refers to any information made available to the public in various formats, including written, oral, applied, or otherwise, prior to submitting the respective application (WIPO 2004b). When anyone can access the content of a document, there are no restrictions on the confidentiality of the information or its use or publication (Habiba & Bahadori 2015). A change in the concept of prior art can be suggested here. For example, only written documents about climate change are considered prior art, verbal and scientific references are not an obstacle to registration, and the inventor's previous applications are not an obstacle to patenting.

1-4) Change in the examination methods:

Changing the method by which the examiner verifies the novelty condition is also possible. It is crucial to mention that there are three separate standards for novelty across countries:

1-4-1) Strict novelty:

This invention will not be patentable if the claimed invention has been disclosed expressly or by implication in an earlier application.

1-4-2) Broader novelty:

It does not matter if the claimed invention was not fully disclosed (explicitly or implicitly) in the previous application or if there was only a slight difference between the two applications; the first application still ruins the patentability of the claimed invention (Habiba & Bahadori 2015).

1-4-3) Novelty and inventive step (non-obviousness) (WIPO 2004a):

Meeting one of the novelty or inventive step terms in this review is sufficient. If it is only a new invention, it will be registered. The inventive step will not be examined further.

The Iranian Patent Office is applying the first concept (strict novelty). In other words, all the technical features stated in the claim are not found in a prior art document. Therefore, novelty is determined only by comparing the claim with the closest document of the prior art. If the document covers all the features of the claimed technology, then the claim is not new (IRI 2008). Thus, to expand patentability for inventions compatible with the impacts of climate change on water issues and increase inventor motivation for research and activity in this area, it may be recommended that the third concept be used as a criterion for inventions compatible with the impacts of climate change on water issues.

2) Inventive step:

According to [WIPO \(2020\)](#), the inventive step is defined as follows: ‘Given the relevant prior art, the invention is not obvious to a person having ordinary skill in the field’. Several countries, including Japan and South Korea, have used the term ‘not easily produced’ by having ordinary skills in the field ([Japan Patent Office \(JPO\) 2004](#)). It is possible to propose several solutions to facilitate the patentability of inventions with a positive effect on adapting to the impacts of climate change concerning the inventive step:

2-1) Proposing an innovative concept of inventive steps to identify useful inventions under climate change impacts:

As part of the concept of the new inventive step, adaptation to the impacts of climate change on water issues can also be included; this means that it is an acceptable initiative that contributes to a positive outcome in addressing the impacts of climate change. What is necessary for the examiner in this section is that less fossil fuel is consumed in the production or use of the invention. Fewer greenhouse gases are emitted during the production or use of the invention, as this will help adapt water supply, distribution, treatment, storage, and consumption to climate change. In this case, there has been an essential and noteworthy development. Consequently, the negative mode of operation of this method is more evident; this means that during the process of examining inventions, if they harm climate change phenomena or increase the consumption of water, decrease the quality of the water, cause water loss, etc., they will be considered as lacking an inventive step.

2-2) Modification of standards for innovative steps with a positive effect under climate change impacts:

In the second approach, without changing the concept of the inventive step, it can be made easier for inventions compatible with the impacts of climate change on water issues and stricter for inventions with a negative impact on the impacts of climate change. This change can be applied to various practical components of the innovation step:

2-2-1) Expert person in the sector:

Instead of a person with ordinary skills, an expert can be employed. This sentence means that an environmental engineer who studies and works in the field of climate change can judge the invention instead of a person with ordinary skills (subjective criterion). It should be noted that reducing the skill level of the examiner in the case of inventions that address the impacts of climate change on water issues will directly affect the verification of the initiative, resulting in more registrations in this category.

2-2-2) The level of prior art that has previously been considered concerning the condition novelty.

2-2-3) Obviousness:

The standard can be used floating when the inventive step has been achieved in this approach. It is possible, for example, to train examiners to consider inventions compatible with climate change impacts on the water industry, following the verification of their novelty, and to consider even a small amount of innovation as effective in achieving the inventive step rather than focusing on dramatic and significant changes.

3) Industrial applicability:

When examining industrial applicability, the examiner considers whether the invention can be manufactured and produced. Nevertheless, the new concept of industrial applicability implies that it can be implemented in industry and does not negatively impact the environment. If, during the examination, the manufacture of the invention causes a significant amount of greenhouse gas emissions or results in water loss, then its industrial applicability may be questioned. Consequently, it is necessary to consider the optimal design and possible damage factors.

As a result, the results of experiments such as the amount of greenhouse gas production, such as carbon dioxide (CO₂) ([Khurshid et al. 2022](#)), methane (CH₄) ([Zheng et al. 2021](#)), and nitrous oxide (N₂O) ([IPCC 2022](#)), the amount of fossil fuel use ([Khurshid et al. 2022](#)), the amount of heat and thermal energy production ([Zheng et al. 2021](#)), the energy efficiency of the invention ([Wu et al. 2021](#)), the amount of physical resistance ([Kydyrbekova et al. 2022](#)), the efficiency in reducing water loss ([Ramírez-Agudelo et al. 2021](#)), the enhancement in water storage function ([Karamouz 2021](#)), the enhancement in water quality parameters ([Shakeri et al. 2021b](#)), the positive impact on water reuse ([Shakeri et al. 2021a](#)) should be examined at the stage of industrial applicability. Therefore, tangible and positive environmental results can effectively achieve industrial applicability. This sentence means that the invention is valuable and efficient for society and deserves to receive a patent.

In [Habiba & Bahadori \(2015\)](#), the subject of interpreting the novelty condition and the innovative step in nanotechnology inventions is discussed. However, the current research tries to express that climate change as an issue that can create a critical future for the world can be brought up by evaluating innovative steps and industrial applications. It is stated here that the usefulness of inventions compatible with climate change can replace industrial use.

3.1. Compulsory licenses

It is possible to grant a government license to use an invention in certain circumstances, such as health needs, competition, and security issues, as indicated in Article 17 of Iran's Patent Law (IRI 2008). In other words, one person's invention can be temporarily used to meet people's urgent needs, such as fighting the COVID-19 pandemic, which is not commercial and can only be realized under exceptional circumstances. As a matter of pathology, a compulsory license can only be granted in emergencies. Once the problem has been resolved, the invention cannot be used. It may, therefore, be helpful to use inventions that have the property of neutralizing or adapting to the negative impacts of climate change on water issues as long as there are negative impacts of climate change on water issues. Since consideration has been paid to the patent owner, it is possible to justify the damage caused to the owner's legal interests. Compulsory licenses are granted only for a specific country and do not mean they may be used worldwide. Inventions compatible with climate change's impacts must be applied over a wide geographical area. Undoubtedly, reducing greenhouse gases or other positive measures for water supply, distribution, treatment, storage, and consumption should also be used in other places to have the corresponding effect. Therefore, compulsory licenses are not a comprehensive legal measure in the present discussion.

3.2. Exceptions and limitations to patents

Exceptions to intellectual property rights include those cases where the intellectual property can be used without obtaining the permission of the owner of the right (including the author, inventor, etc.). For example, according to paragraph (c) of Article 15 of the Patent Law of Iran (IRI 2008), exploitations only for experimental purposes are free. According to Article 31 of the TRIPS Agreement (WTO 1994), 'Members may provide limited exceptions to the exclusive rights conferred by a patent, provided that such exceptions do not unreasonably conflict with a normal exploitation of the patent and do not unreasonably prejudice the legitimate interests of the patent owner, taking account of the legitimate interests of third parties'. This Article needs to be analyzed; the patent exception must have three components: first, it must be limited; second, the exception should not be inconsistent with the regular use of the invention; and third (taking into account the interests of third parties), it should not cause unreasonable damage to the interests of the patentee. Each component is an independent condition that must be present in every exception, containing all three components.

First, the exception must be limited and have a specific scope, such as limited to the experimental use of another invention. In the critical dispute between Canada and Europe, Canada believed that the limited exception means the exception is limited in scope and extent. At the same time, Europe believed that the exception should have a limited, insignificant, or little effect on legal patent rights (WTO 2000). In this section, there is no index for determining the limitation. However, the level of patent disturbance must be evaluated. In each case, it can be checked what effect the exception will have on social interests (Rodrigues 2012).

Some researchers believe that when interpreting exceptions, one should pay attention to the policies of the patent system of the countries. Suppose the goal of a country is to promote innovation by granting patents. In that case, the patent will be interpreted to benefit the inventor, and the exception will have a very narrow scope. However, if the patent itself is an exception to freedom of access, the exception to it can be interpreted in the interest of social goals (Azizi Morad Pour 2012; Rodrigues 2012).

Moreover, some researchers have adopted the doctrine of fair use in the literary and artistic property rights system in interpreting the permissible use of the invention. According to the nature of the invention, the purpose of the breach, the nature and extent of the market that hinders the formation of the exploitation contract, and the effect of the use on the inventor's motivation and social welfare, they interpret the permissibility or impermissibility of the exception (Azizi Morad Pour 2012). Therefore, to understand the first step, it is essential to illustrate each country's patent system policy.

In the second step, this exception should not conflict with the normal exploitation of the invention; here, the critical question is what is normal exploitation. In this context, researchers think that the normal exploitation of the patent should be interpreted in the framework of commercial activities and the form of one of the rights specified in Article 28 of the TRIPS Agreement (WTO 1994) (or the exclusive rights specified in national laws such as production and manufacturing of inventions); through which the owner uses his exclusive rights to obtain economic income (Azizi Morad Pour 2012). It appears that it is necessary to supervise the potential and actual markets of the right holder according to his capabilities. In cases where the right holder tries to earn income in a specific geographical area, for instance, in the electronic environment, these areas should be considered normal exploitation.

As a third step, exceptions should not harm the right holder's legal interests. This issue is in consideration of the public interest; that is, in the application of exceptions, two matters should be considered in the third step: not to harm the legal interests that the patent system has provided for the inventor and, at the same time, to consider the public interests of third parties in access to the invention. The countries' laws determine the patentee's legal interests, perhaps by custom. However, the public interests of third parties must be considered. Who is the third party? Moreover, what are their interests? In general, a third party is a person who is outside the bilateral relationship of the parties to the contract; this person can be a private person or the general public and even competitors of the producers (Azizi Morad Pour 2012). In this context, some researchers refer to consumers of the invention, including scientists, industrial owners, and all potential and actual users of the invention, as third parties (Rodrigues 2012). Thus, the interests of third parties broadly include the benefits of the invention for health, competition, and society. The point is, what is reasonable and unreasonable harm? Suppose the harmful effects of the exception on the patent exceed its benefits to the right holder. In that case, the exception is not reasonable. On the other hand, if the adverse effects on the interests of the right holder are less than the benefits created, then the damage is reasonable. Nevertheless, the mentioned interpretation is influenced by the interests of third parties, and it is necessary to see in which direction the policy of the national system of innovation and invention of a country is directed.

National patent systems reflect the three-step criteria differently; in some countries, the standard is applied to all exceptions; in others, it is one of the exceptions; and in some, portions of the standard are applied to a specific exception.

Several important examples of national legislation regarding patent exceptions can be cited: In paragraph 2 of Article 16 of the Costa Rican Patent Law (Costa Rica 2012), the three-step criterion is applied to the legally enumerated list. The second and third criteria are, of course, included selectively in this law. However, it is noteworthy that the licensee's interests are mentioned instead of the legal interests of third parties. Additionally, there are five topics included in the list, which include personal and non-commercial uses, as well as research uses. Similarly, Article 10 of the Egyptian Intellectual Property Law (Egypt 2002) sets forth a list of exceptions. However, instead of three-step criteria for each exception, it is stated as an independent criterion at the end of the list (paragraph 6). According to paragraph one of Article 39 of the Uruguayan Inventions Law (Uruguay 1999), except for personal use, this usage must not result in economic damage to the inventor; the lawmaker has considered a part of the three-step criteria as an example.

In Azizi Morad Pour (2012), there is no comparative study of countries, and an attempt is made to discuss the three-step test in general. In the current research, the issue of climate change is raised as one of the examples of public interest. This research recognizes that climate change is an issue that should be considered in evaluating the three-step test. The current research provides a guide in interpreting Article 31 of the TRIPS Agreement (WTO 1994) regarding the issue of climate change.

In general, the three-step test in inventions can be seen as an exception that allows inventions compatible with climate change impacts on water issues to be freely used. For comparing the exceptions and compulsory licenses, it is essential to note that the licenses are granted under exceptional health and security conditions with payment to the right holder and for domestic use only. However, the exceptions can be free or with a return. On the other hand, the unclear territory of the exceptions in the three-step test can help secure public interest. The question has been raised about whether inventions that positively impact climate change or enable adaptation to climate change's impacts on the water industry can be included among the exceptions. No doubt providing such an exception can benefit the public interest. However, it should be noted that the expansion of exceptions implies modifying the scope of the inventor's exclusive right, which is based on the goal of motivating and providing social welfare. In other words, this can impact the incentive to make inventions with the outcome of influencing or adapting to climate change. By disclosing his invention, the inventor acquires a certificate and expects the government to provide adequate protection. Hence, in applying the three-step test, there is no conflict with normal exploitation or unreasonable damage to the right holder's legal interests. Nevertheless, the provision of consideration to the right holder or the requirement of non-commercial use of inventions with the feature of impact on climate change may be functional in free use. In this research, an attempt is made to find legal mechanisms to understand the issue of climate change in the patent system. Downgrading the absolute concept of newness to a relative one, considering adapting to climate change as an innovative step, and understanding the valuable function as an industrial application of water domain inventions are some of the solutions that help to patent/non-patent inventions with the intended purpose of this research. In addition, it is essential to issue compulsory licenses for inventions compatible with climate change and reduce adverse environmental effects. Although this solution has only a national aspect and faces climate change's dangers, global ways should be sought. The third mechanism is exceptions. Referring to Article 31 of the TRIPS agreement (WTO 1994), using water inventions that are useful for relief or adaptation to climate change without permission can be considered legal.

Another legal mechanism that can be used to adapt to climate change is the doctrine of exhaustion (also called the doctrine of first sale in the United Kingdom and the United States). [Habiba & Shakeri \(2008\)](#) have stated that this doctrine limits intellectual property rights. When an example of intellectual property, such as an invention, is marketed with the consent of the right holder or his representatives, the right holder's right to sell or re-rent the same product is exhausted. This doctrine is applied at three national, regional, and international levels. When the national level is involved, it means that with the first sale of the invention in a country, the patent rights in that country will be exhausted. However, importing the same product to the country is still prohibited. [Garrison \(2006\)](#) pointed out that if the international level of the doctrine is applied to reduce prices, it favors developing countries. In other words, by selling a product with a patent in any country, the patent exhausts the whole world, and imports from all over the world are free. Now, imagine that the mentioned invention is in the field of adapting to climate change. This is a unique opportunity, and the possibility of global access to that invention, especially in less developed and developing countries, is provided. Therefore, it is suggested that countries should consider the international level of doctrine regarding the inventions of the water domain, considering the climate change debate. Some authors, such as [Abbas \(2023\)](#), have proposed a legal mechanism for particular and critical fields, such as inventions in the field of health.

4. CONCLUSION

This research analyzed the impacts of climate change on the grant and protection of patents related to the water industry. Based on the results, it was determined that inventions that minimize the factors contributing to climate change and its consequences, as well as inventions that assist in adapting the supply, distribution, treatment, storage, and consumption of water to climate change impacts, must be accepted and protected by law and the government. Production and use of inventions that do not produce greenhouse gases, emit low amounts of greenhouse gases, or act toward declining greenhouse gas emissions are prioritized; on the other hand, inventions that exacerbate the negative impacts of climate change will be subject to strictness and minimal protection. Based on the findings of the current research, it has been concluded that providing an interpretation of patent components under the requirements that arise from managing climate change impacts is extremely important; therefore, it is necessary to anticipate such mechanisms in the patent system regulations of countries. Furthermore, compulsory licenses and exceptions are also helpful to enable society to benefit from inventions that contribute to the reduction of climate change or are compatible with climate change's impact on water; however, their interpretation is determined by the policy governing the field of innovation production. Nevertheless, the choice between strengthening patents and managing the impacts of climate change must be considered from a fundamental point of view. It is undeniable that the application of the three-step test can prove to be beneficial in this regard, depending on the respective country's policies. Governments need to understand climate change as a matter of public interest. It is recommended that national legislators anticipate climate change as one of the influential factors in patent laws. Also, by training their examiners, patent offices should draw their attention to the climate change dimensions of each invention. Therefore, the way should be opened for obtaining a patent that positively reduces the negative results of climate change. According to the topics of this research, some challenges should be studied in future research: if a patent is issued that harms the environment, who should compensate for the damages? Who is responsible? Governments, the Ministry of Environment, or patent offices? Is it possible to imagine absolute responsibility against the issuance of patents that accelerate climate change? These are parts of future governance against climate change.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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