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Analysis Of The Effectiveness Of Infiltration Wells In Disaster Risk Reduction: Literature Study

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Abstract

Infiltration wells are wells or holes located on the surface of the ground. The rapid urban development has led to a decreasing area of rainwater infiltration, as the increasing coverage of buildings reduces the open space and results in longer accumulation times for water, potentially causing flood disasters. Aside from flooding issues, the availability of groundwater is crucial for the areas where rainwater infiltration occurs. If groundwater decreases, the supply of groundwater will be affected, impacting communities whose clean water needs depend on groundwater in their region. The research method used in this study is an internet-based literature review. Downloaded articles are then imported into Nvivo 12 Plus software. The data is examined and analyzed to draw conclusions. Based on the analysis of the five articles, the author concludes that infiltration wells are effective in reducing disaster risks. Additionally, infiltration wells can be used as a substitute for groundwater and enable communities to adapt to climate change. Efforts from all layers of society are essential to create infiltration wells in their respective areas because infiltration wells are not meaningful if only a few communities implement them.

Keywords: Disaster Risk Reduction, Infiltration wells, Groundwater Conservation

INTRODUCTION

Infiltration wells are wells or holes located on the ground surface. This well functions to collect rainwater from the roof of a building or surface runoff, then the water is absorbed into the ground, so that it can fill groundwater pores (Putri et al., 2022). Infiltration wells are an alternative measure because apart from collecting rainwater and absorbing water into the ground, infiltration wells can also prevent flooding (Firmansyah & Permana, 2022).

The working principle of infiltration wells is to channel and collect rainwater into the well hole so that the water can have a longer stay on the ground surface, so that little by little the water can seep into the ground (Bahunta & Waspodo, 2019). Infiltration wells channel rainwater that falls on the roof of the house into the well through pipes or water channels to reduce the amount of runoff that occurs. Therefore, infiltration wells are an effective solution for reducing discharge which can cause flood disasters (Firmansyah & Permana, 2022; Muntaha et al., 2022).

Rainwater that falls to the ground surface will find it difficult to seep into the ground because the land which was originally a natural environment has now been converted into a residential area (Indramaya & Purnama, 2013). In several places there has also been a decrease in the soil's ability to absorb water as a result of areas covered by pavement which is the impact of housing development (Yassir, 2018).

Changes in land use due to housing development can indirectly damage water catchment areas. The population is increasing, resulting in housing and settlements also increasing (Muntaha et al., 2022). The rapid development of urban settlements has resulted in a reduction in rainwater catchment areas, due to the increase in the area covered by buildings and resulting in a much shorter time for water to gather, so that the accumulation of collected rainwater exceeds the existing drainage capacity (Yassir, 2018).

Drainage is a series of water source structures that function to reduce and dispose of most of the water from an area, but if the collected water exceeds the existing capacity, it will result in waterlogging (Firmansyah & Permana, 2022). In some cases, drainage channels experience a decline in function because they are covered in rubbish so that the channels become narrower and cannot function properly. In Putri's research (2023), it was found that the drainage system was not integrated between one building and another, resulting in rain runoff from all buildings spilling over into the lowest areas in the area and causing puddles of water.

The IPCC (Intergovernmental Panel on Climate Change) report outlines evidence that climate change is already occurring. Climate change is characterized by changes in climate elements which include rainfall patterns, air temperature, and an increase in extreme climate events that cause floods and droughts (Legionosuko et al., 2019). With climate change, it is predicted that the dry season will become longer, causing the sustainability of water resources in Indonesia to be threatened (Bahunta & Waspodo, 2019).

As a result of global climate change, Indonesia is experiencing changes in rainfall characteristics. In general, the rainy season is shorter, but the dry season is longer. The number of rainy days tends to decrease, but maximum daily rainfall and its intensity tend to increase (Suripin & Kurniani, 2016). Rainwater that falls on the roof of the building and then does not drain into the gutter or yard causes water to puddle after the rain occurs. This is due to surface flow that is greater than the soil capacity. The inability of the soil to hold rainwater creates standing water which continuously causes flooding. Increased surface runoff will cause flooding and flooding problems (Muntaha et al., 2022).

Apart from flooding problems, the availability of groundwater is also very important for water catchment areas. If groundwater decreases, groundwater supply will decrease, thereby impacting communities whose clean water needs depend on groundwater in their area. The lack of water seeping into the ground causes groundwater to become shallower, causing a reduction in the quantity of well water sourced from groundwater (Yassir, 2018). As the availability of groundwater decreases, the supply of groundwater also decreases, in fact the need for drinking water continues to increase in line with the increase in population (Indramaya & Purnama, 2013; Widiyanto et al., 2015).

So it is necessary for the author to conduct a study regarding the effectiveness of infiltration wells in reducing disaster risk. The contribution of this study is to map previous studies regarding infiltration wells in a broader context, so that they can be followed up in the form of field research, based on recommendations from the results of this study.

RESEARCH METHODS

The research method used in this study is an internet-based literature study. The literature study method consists of a series of activities related to methods of collecting data from libraries, reading and taking notes, as well as managing research materials. This type of literature research is narrative literature study. Narrative literature study is a comprehensive, critical and objective analysis of knowledge about a topic (Efron & David, 2019). All literature was collected through searches in academic databases, namely Google Scholar. Google Scholar was chosen as a research database because researchers can select interesting articles related to absorption wells. The types of literature collected in this study are limited to articles contained in scientific journals, which were published in the 2018-2023 period. The articles that have been downloaded are then entered into the Nvivo 12 Plus software. In the Nvivo software, researchers carry out validity and then carry out analysis by forming a mind map. The data is then studied and analyzed to produce a conclusion.

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RESULT AND DISCUSSION

All the articles that the author has selected are 5 (five) articles that have the same topic, namely regarding infiltration wells, then the author uses the Nvivo application to prove that the five articles have the same words, here are the results:

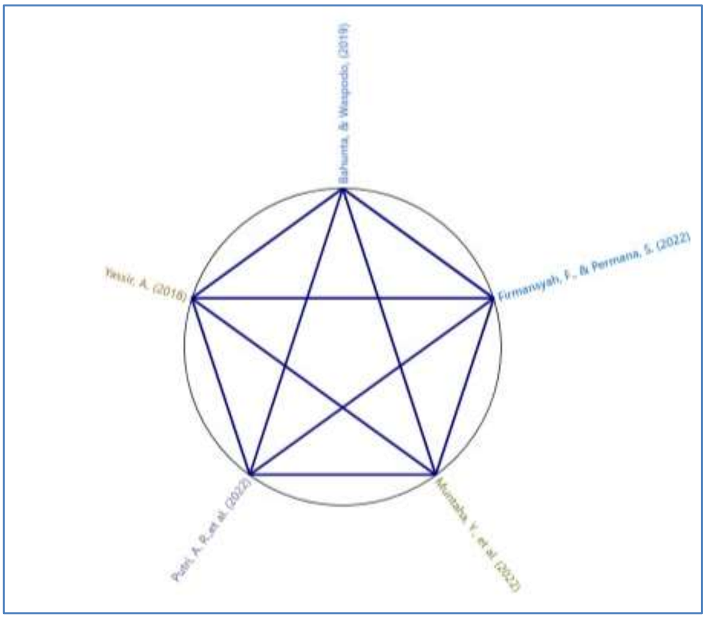

Figure 1. Data Validity Using Nvivo 12 Plus

The results of the data analysis in the picture prove that there is an ideal loading factor value, namely above .7. The general standard put forward by experts (Hair Jr. et al., 2019) is "a good rule of thumb is that standardized loading estimates should be. 5 or higher, and ideally .7 or higher". Thus it can be concluded that the higher the loading factor value, the higher the validity of a research instrument.

Once the article data is valid, the data can be visualized in the form of a mind map as shown in Figure 2.

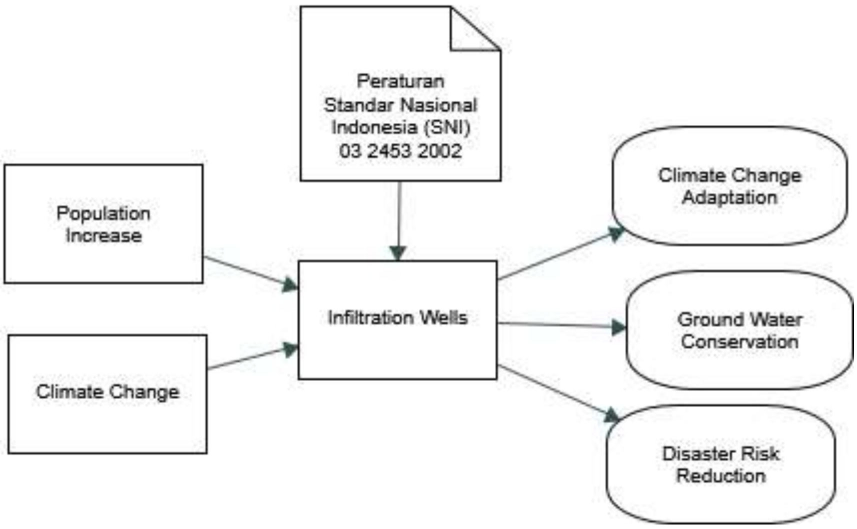

Figure 2. Mind Map Using Nvivo 12 Plus

Based on the problems explained in the introduction, including population density which has resulted in increasing house construction, coupled with climate change which has actually occurred, it is necessary to build infiltration wells to overcome these problems. The construction of infiltration wells is made in accordance with the Indonesian National Standard Regulation (SNI) 03 2453 2002 concerning Procedures for Technical Planning of Rainwater Absorption Wells for Yard Land.

Some of the requirements for infiltration wells according to Indonesian National Standard No.03-2453-2002 are:

1. Rainwater absorption wells are located on fairly flat land.
2. When determining the position of a rainwater dug well, the safe condition of the buildings adjacent to it must be evaluated.
3. The water that infiltrates the infiltration well is spilled water that has not been contaminated with dirt.
4. Local regional regulations must be taken into consideration.
5. If there is an inaccuracy in fulfilling these provisions, approval must be obtained from the competent office or agency in the area.

This regulation also stipulates the shape and size of infiltration wells, including:

a) has a rectangular or circular mold model.
b) The pipe that goes into the ground measures Ø 110 mm
c) The minimum cross-sectional diameter of the well is 0.8 meters
d) The size of the well overflow pipe is 110 mm in diameter.
e) Maximum cross-sectional area measuring 1.4 meters.

The infiltration well that is built must meet the requirements so that its working capacity can be accounted for and does not cause new impacts on the environment. Several factors need to be taken into account, including the following: (Kusnaedi, 2011).

1. **Climatic factors**: Climate is a factor that needs to be considered in designing infiltration wells. The factor that needs to be considered is the amount of rainfall. The greater the rainfall in an area, the larger the absorption well needed.
2. **Groundwater conditions**: infiltration wells need to be built on a large scale because the land really needs water supply from infiltration wells. On the other hand, in areas with shallow water levels, infiltration wells are less effective and will not function well. Especially in swamp and tidal areas, infiltration wells are less effective.
3. **Soil conditions**: Soil conditions greatly influence the size of the soil's absorption capacity for rainwater. Thus, the construction of infiltration wells must pay attention to the physical properties of the soil. The physical properties that directly influence the amount of infiltration are soil texture and pores. Sandy and porous soil is better able to absorb rainwater quickly. As a result, the time required for rainwater to stay in the infiltration well is relatively shorter compared to soil with high clay content and stickiness.

The effectiveness of infiltration wells in reducing disaster risk includes water conservation, disaster risk reduction and climate change adaptation.

1. Groundwater Conservation

Infiltration wells can be used as groundwater replacement or groundwater conservation, because clean water sources are decreasing, infiltration wells can absorb rain runoff which causes the hydrological cycle.0 research results The use of infiltration wells, although it does not reduce runoff discharge significantly, is around 0.1 to 0.2 m3/sec, however, one infiltration well with a diameter of one meter and a depth of two meters can store water reserves of 5.65 m3 in 1 hour (Putri et al., 2022).

Groundwater conservation using infiltration wells is an alternative for increasing groundwater reserves in areas with low soil permeability (Muntaha et al., 2022). In accordance with the results of research conducted by Putri (2023), it is stated that the permeability value greatly influences the construction of infiltration wells, the higher the permeability, the shallower the depth of the infiltration well being built and vice versa if the resulting permeability is low.

Infiltration wells are an environmentally friendly form of drainage that is used to manage rainwater effectively and sustainably. Environmentally friendly in the sense that making infiltration wells is natural and does not damage other ecosystems around it. Infiltration wells function to reduce waterlogging, improve groundwater quality, and support environmental sustainability (Novrianti, 2017).

Apart from maintaining water stability, groundwater conservation is also useful for maintaining soil stability to avoid land degradation. Groundwater conservation is able to maintain and improve the ecosystem of a land so that it remains natural. With natural land conditions, land functions will be maximally beneficial (Tri Sulistyowati et al., 2023). Suppressing the rate of erosion, with a decrease in surface flow, the rate of erosion will also decrease. If surface flow decreases, less soil will be eroded and washed away. The impact is that the surface flow of rainwater will be small and erosion will be small (Yassir, 2018).

Based on research conducted by Muntaha (2022), there are 2 types of infiltration wells, where innovative infiltration wells have biopore holes added to the bottom of the infiltration well, the surface walls of the infiltration well are made with paving that is spaced apart and every two layers of the paving pair are given geotextiles. This research states that innovative wells are more effective than conventional infiltration wells. Innovative infiltration wells can be applied as an alternative to support water conservation in areas with soil that has low permeability.

2. Climate Change Adaptation

According to the UNFCCC, adaptation is defined as efforts to adapt to a changing climate system. Therefore, efforts to reduce the impact or risk of climate change, including disaster management, are included in the category of climate change adaptation. This is because these activities include the meaning of adapting to changing natural conditions such as climate change (Aldrian, el al., 2011).

Adaptation to climate change is a key aspect that must be on the national development agenda in order to develop development patterns that are resilient to the impacts of climate change and the disruption of weather anomalies that are currently occurring as well as anticipating their impacts in the future.

So far, we have tended to drain rainwater as quickly as possible into the sea. Many canals have been built by the government to reduce flood disasters. People also always direct water into drainage channels which empty into rivers and ultimately into the sea. The aim is to reduce flood disasters. In fact, just building canals and drainage channels is still not enough to prevent flooding, but only moving the location of the flood.

In fact, rain is not a disaster, if we consider rain as a friend and use infiltration wells so that the return of water that has undergone hydrolysis can run smoothly without any obstacles, so we need human help to make this process easier, by making infiltration wells or other technology that allows water can seep into the soil naturally without any hardening barriers due to the closure of water catchment areas due to the development process.

3. Disaster Risk Reduction

One simple concept that is effective in reducing runoff that can cause flooding is absorption wells. Infiltration wells function to accommodate, retain and absorb surface water into the ground to increase the amount and position of the ground water table. Rainwater is given a way to seep into the ground to become groundwater through infiltration wells. Rainwater, which is basically clean water, is channeled into the ground through infiltration wells. The remaining rainwater that is not absorbed is then drained and thrown into the sea (Tumpu, et al., 2021).

The rainwater collection and absorption system is a drainage system to reduce surface flow due to rain. The basic concept of this system is to give rainwater the opportunity to seep into the ground by storing the water in an infiltration system. Infiltration wells function to reduce the volume and speed of surface flow thereby reducing flood peaks (Bahunta & Waspodo, 2019).

Water catchment areas can be damaged indirectly due to changes in land use, even though the availability of ground water is very important for water catchment areas and if ground water decreases, the land supply will also decrease. Besides that, floods and droughts can occur if there is surface flow and a lack of water seeping into the ground (Muntaha et al., 2022). If each house is able to make an absorption well which can then absorb one cubic meter of water into the ground. This area can reduce surface runoff which will burden downstream drainage channels and can reduce the problem of drought in the dry season because it helps replenish groundwater (Yassir, 2018).

Based on research results from Firmansyah (2022), it was found that the infiltration well or vertical drainage method is for future prevention in dealing with flood disasters or excessive water runoff. Supported by the results of other research such as Bahunta and Waspodo (2019) which found that the total volume of flood contribution could be reduced by the presence of absorption wells. Apart from that, Yassir's (2018) research conducted in residential areas found that infiltration wells that absorb rainwater into the soil can reduce the load on downstream drainage channels.

In several cases, a mismatch was found between the capacity of the well and the incoming rainwater. This condition makes the construction of infiltration wells less than optimal in water conservation efforts. However, the aim of reducing the risk of flood and drought disasters can still work well (M. Yamassan Jayasin et al., 2022).

No.	**Author (Year)**	**Research Title**	**Location**	**Research Result**
1.	Firmansyah, Sulwan Permana, Mirza Fathir (2022)	Analysis of Infiltration Wells to Prevent Floods and Runoff in the Tarogong Kidul Area	Garut, West Java	The use of absorption wells can prevent flooding or excessive water runoff and can be applied for the next 6 to 9 years. With a flood discharge of 251472 m3/hour and a well wall area of 9.42m2, the well base area is 0.785m2.
2.	Lussiany Bahunta dan Roh Santoso Budi Waspodo (2019)	Design of Rainwater Absorption Wells as an Effort to Reduce Runoff in Babakan Village, Cibinong, Bogor Regency	Bogor, West Java	Based on the results of calculations that have been carried out, the total volume of flood contribution that can be reduced by the presence of infiltration wells and ditches is 620.62 m3. The volume of the total flood contribution of Babakan Village is 805.79 m3, so the absorption wells and ditches can reduce 77.02% of the total runoff that occurs.
3.	Yassir Arafat (2018)	Reducing Surface Drainage Flow Loads Using Infiltration Wells	Palu, Central Sulawesi	The use of infiltration wells with soil conditions in Permata Garuda Palu Housing Type 70 houses using 1 infiltration well per unit of 66 housing units can reduce surface flow by 103.63 m3 during 70 seconds of rain falling and being absorbed into the ground. In this way the load on downstream drainage channels can be reduced.
4.	Andini R. Putri, Feril Hariati, Nurul Chayati,	Study of the Use of Infiltration Wells on the UIKA Bogor	Ibn Khaldun University (UIKA) Bogor, West Java	The analysis results show that 4 circular infiltration wells with a diameter of 1 m and a depth of 2 m are needed in each building. The use of this infiltration well can accommodate 5.65

	Fadhila M.L. Taqwa, Alimuddin (2022)			m3 of water, and reduce runoff discharge by 0.02 m3/sec.
5.	Yasnuar Muntaha, Tri Budi Prayogo, Emma Yuliani (2022)	Innovative Infiltration Well Modeling for Low Permeability Groundwater Conservation in the Malang City Area	Malang State Polytechnic, East Java	From the results of analysis of infiltration well model tests that have been applied on a field scale, innovative infiltration wells are more effective than conventional infiltration wells.

Based on the five articles that have been analyzed, the author finds that infiltration wells are effective in reducing disaster risk. Apart from that, infiltration wells can be used to replace groundwater and enable communities to adapt to climate change. However, the use and calculation of the volume of water that can be stored differs in each region. Based on the five research locations above, each has different calculations but shows the same results, namely the influence of infiltration wells on existing problems. Efforts from all levels of society are needed to build infiltration wells in their respective areas, because infiltration wells are meaningless if only a few communities implement infiltration wells.

CONCLUSION

This study concludes that infiltration wells are thematically effective in reducing disaster risk, including for water conservation, disaster risk reduction and climate change adaptation. Based on the articles studied, all of them provide the same results, namely that infiltration wells are effective in reducing the risk of flood and drought disasters by paying attention to factors in the area, including climate conditions, groundwater conditions and soil conditions. The recommendations or suggestions from the results of this study are: 1) future researchers can focus on conducting research on the effectiveness of infiltration wells in the field of disaster risk reduction; 2) future researchers can focus on researching infiltration wells and other drainage technologies using comparative methods; 3) Future researchers are expected to make new discoveries related to infiltration wells in order to find the best solution for disaster management in Indonesia.

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