International Journal of Sustainable Engineering

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tsue20

New methodology for identifying sustainable freshwater resources for the production of green hydrogen

Miklas Scholz

To cite this article: Miklas Scholz (2024) New methodology for identifying sustainable freshwater resources for the production of green hydrogen, International Journal of Sustainable Engineering, 17:1, 1-7, DOI: 10.1080/19397038.2024.2321612

To link to this article: https://doi.org/10.1080/19397038.2024.2321612

Published online: 21 Feb 2024.

INTERNATIONAL JOURNAL OF SUSTAINABLE ENGINEERING
2024, VOL. 17, NO. 1, 1–7
https://doi.org/10.1080/19397038.2024.2321612

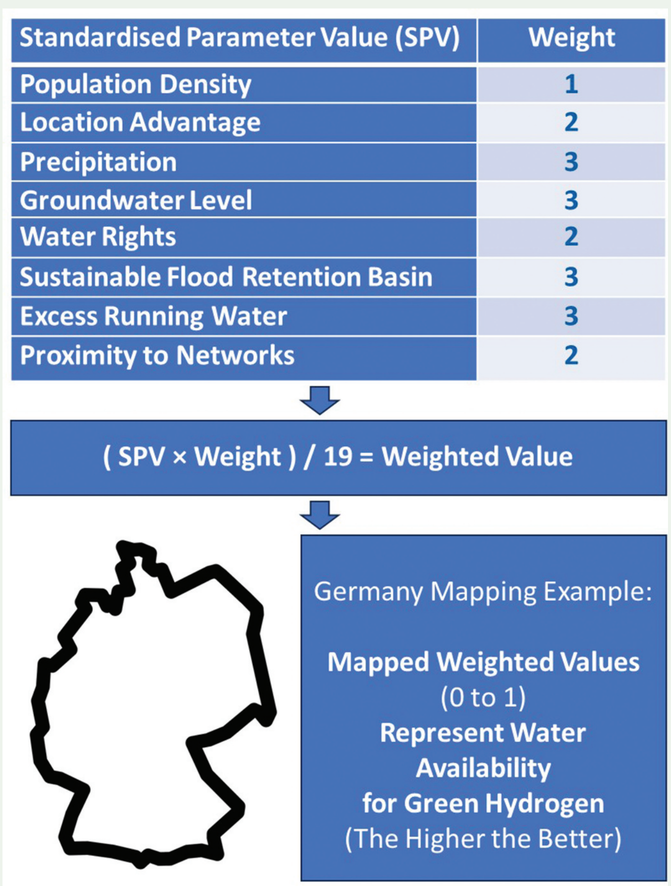
New methodology for identifying sustainable freshwater resources for the production of green hydrogen

Miklas Scholz [a,b,c,d,e,f]

[a]Innovation Management, Aconium GmbH, Berlin, Germany; [b]School of Science, Engineering and Environment, The University of Salford, Salford, UK; [c]Department of Civil Engineering Science, School of Civil Engineering and the Built Environment, University of Johannesburg, Johannesburg, South Africa; [d]Department of Town Planning, Engineering Networks and Systems, South Ural State University, Chelyabinsk, The Russian Federation; [e]Nexus by Sweden, Västerås, Sweden; [f]Kunststoff-Technik Adams, Elsfleth, Germany

ABSTRACT

Managing sustainable and digital transformations in the water industry is a challenge. The identification of freshwater resources for green hydrogen production is necessary for the energy transition away from fossil fuels such as oil and gas. This can be achieved through the sustainable flood retention basin (SFRB) concept for identifying optimal locations for the retention of surface water. This unbiased concept helps in conflict resolution between stakeholders with water rights. Moreover, it serves as a simple tool to produce a digital water supply atlas based on dimensionless parameters with the short names' population density, location advantage, precipitation, groundwater level, water rights, SFRB, excess running water and proximity to networks. While the first five parameters can be determined during a desk study, the last three parameters require site visits for verification purposes. Germany was used as a representative case study country to demonstrate the proposed methodology to obtain a water atlas based on mapped weighted values. The Kaiserstuhl in Germany served as a worked calculation example indicating well above average potential for water storage using existing retention basins. The water atlas can be used to supplement a (green) hydrogen atlas, supporting decision-makers in building hydrogen infrastructure.



ARTICLE HISTORY
Received 27 October 2023
Accepted 16 February 2024

KEYWORDS
Groundwater level; location selection; population density; precipitation; sustainable flood retention basin; water atlas

CONTACT Miklas Scholz mscholz@uj.ac.za Department of Civil Engineering Science, School of Civil Engineering, and the Built Environment, Faculty of Engineering and the Built Environment, University of Johannesburg, Kingsway Campus, PO Box 524, Aukland Park, Johannesburg 2006, South Africa

1. Introduction

> Water is the coal of the future. Tomorrow's energy will be water that has been broken down by electric current. The elements of water broken down in this way, hydrogen and oxygen, will secure the earth's energy supply for an indefinite future. Prophecy by Jules Verne (1825–1905), founder of science fiction literature, in 1875

Already Verne (1875) predicted the use of water as an energy source in the future. Nowadays, hydrogen applications are commonplace (Bian et al. 2023; Luo et al. 2023; Zhang et al. 2023). For Europe and especially Germany, there is a strong political preference for green hydrogen. This is due to the high and low-risk benefits for both environmental and climate protection. In addition, German industrial policy is aimed at developing domestic water electrolysis systems.

Green hydrogen is produced through the electrolysis of pure water. Water electrolysis takes place using electricity from renewable energies. Theoretically, 9 kg of water are required for 1 kg of hydrogen (stoichiometric ratio). Technically, however, a significantly higher amount of raw water is necessary due to the required water treatment. In extreme cases, such as when using seawater, between 20 and 30 kg of salt water is often required to produce 1 kg of hydrogen. Concerning the use of wastewater, the ratio is similar or even higher depending on the contaminants present.

For the German building sector, replacing natural gas with green hydrogen in the existing natural gas network would make sense (Ishaq, Dincer, and Crawford 2022). In recent years, natural gas sales in Germany amounted to 940 billion kWh. About 30% of this energy is used in the construction sector. To replace this amount of energy with green hydrogen, someone would need around 215 million m^3 of water. This corresponds to the water needs of around 5 million inhabitants (6% of German citizens). Complete natural gas replacement is currently only an alternative for around 10% of buildings.

The substitution of natural gas technology and infrastructure with green hydrogen is economically necessary (Ishaq, Dincer, and Crawford 2022). Decentralised production of green hydrogen would therefore be the logical consequence. Locations with sufficient green electricity, high-quality water, customers in industry and opportunities for feeding hydrogen into the grid must be identified to support the energy transition in countries such as Germany.

The production of green hydrogen in regions with favourable conditions for the production of electricity with renewable energies (sun and wind) as well as an infinite amount of water (sea water in coastal regions) often has other locational disadvantages (protected Wadden Sea; Wattenmeer in German) and requires long transport routes (from the coast to metropolitan areas in the Ruhr area (in German Ruhrgebiet or Ruhrpott), Stuttgart and Munich). The concentrated brines resulting from the desalination of seawater using reverse osmosis and other desalination technologies also represent a costly environmental problem. This makes the decision-making process as to where and from which raw water hydrogen should be produced very complicated.

There is a lack of clean water for hydrogen production. Drinking water could theoretically be utilised. The consumption per inhabitant in Germany is quite stable at 130 L/day. Only 4% of this rate is needed for food and drink purposes. However, around 36% is applied for personal care (showering and bathing), 27% for flushing toilets, 12% for laundry, 9% for small businesses and 6% each for dishwashing and cleaning interior spaces. At least the toilet flushing water could be replaced with industrial used water and harvested rainwater. This has been known for a long time, but large-scale implementation has not yet taken place (Arnold 2016; Scholz 2023).

Figure 1. Example of a sustainable flood retention basin near Unterentersbach, Baden.

Due to the lack of clean water, there is a need to utilise retained surface water in addition to potable water for hydrogen production. This could be achieved with sustainable flood retention basins (SFRB). The SFRB concept is rather new and based on the definition of a SFRB according to Scholz and Yang (2012). Such a basin is an artificial or natural water body (e.g. dam or wetland) that has flood and environmental protection functions (Figure 1). Subgroups of SFRB can also aim to cater for other functions such as sustainable drainage, pollution reduction, increasing biodiversity and increasing recreational value. This is a holistic definition, which should not necessarily be equated with common technical definitions such as dam or retention basin (Scholz and Yang 2012).

The SFRB concept (Yang et al. 2011) can be applied to identify and weigh up different applications that benefit different interest groups using both expert opinion as well as sophisticated big data tools. The concept can also be used for the identification and further use of water supply areas for hydrogen production and resolve possible conflicts of interest without bias (Steinhäußer et al. 2015; Yang et al. 2011).

The aim of this document is to develop a method to identify sustainable freshwater resources to produce green hydrogen in Germany. This can be achieved by the first objective to expand the SFRB concept defining new variables. This updated concept will serve to identify optimal locations for the retention of unused surface water, which would otherwise simply flow unused into the sea. The application of the method should be used for the second objective to create a water supply atlas for the hydrogen industry. The new method will support the sustainable and digital transformation of the water industry.

2. Materials and methods

2.1. Assumptions of the method proposed

The proposed strategy is based on the following assumptions and boundary conditions, which serve to simplify the complex challenge:

- Only green hydrogen is currently considered to be suitable for the long-term future compared to other hydrogen colours (Ishaq, Dincer, and Crawford 2022).
- The import of hydrogen, especially from poor and dry countries in South America, Africa, and Asia, is neither considered sustainable nor ethically justifiable.
- Seawater desalination is currently viewed as too expensive and unsustainable.
- Big target countries such as Germany are self-sufficient in terms of water supply (no active foreign water import).
- A decentralised hydrogen supply is strategically preferable to a centralised hydrogen supply.
- Future industrial plant locations with waste heat and oxygen requirements were not given special consideration at this stage of the methodology development.

2.2. Strategy for identifying sustainable freshwater resources

2.2.1. Overview and case study calculation example

To help decision-makers such as cities and municipalities to identify the most optimal sustainable freshwater resource locations that could be used for the production of green hydrogen, the author proposes the development of a water supply atlas. The author has highlighted the most important variables in the remaining sub-sections of Section 2.2.

The following steps presented in sub-Sections 2.2.2 to 2.2.6. can be carried out rather easily using existing databases and geographical information systems for most developed and some developing countries. In contrast, the work steps thereafter (subSections 2.2.7 to 2.2.9) require a more complex approach by assessors on site, which is rather time-consuming and expensive for an entire region or state. It follows that this method paper only uses one representative case study as an example. The public sector and its water associations should, however, support this work logistically and financially in the future.

This section describes the further advancement and development of the SFRB concept methodology and associated research procedures. The original method was previously validated for Baden (Germany; Scholz (2008) and Scholz and Yang (2012)), the Central Belt in Scotland (United Kingdom; Scholz and Yang (2012) and Yang et al. (2011)) and Greater Manchester (United Kingdom; Danso-Amoako et al. (2012)).

An overview of universal variables to be considered for the identification of suitable locations for water bodies such as SFRB serving the hydrogen industry is provided in Table 1. The proposed weighting factors can be changed by decision-makers within reason, considering different case study boundary conditions.

Table 2 shows a worked calculation example for The Kaiserstuhl (Scholz 2008), which is a small low mountain range in the Upper Rhine Plain (North-west of Freiburg (im Breisgau); Figure 2). This area is located in the districts of Emmendingen (only a small part of The Kaiserstuhl in the North) and Breisgau-Hochschwarzwald. The weighted value of 0.69 indicates that The Kaiserstuhl area is suitable for the

Table 1. Factors to be considered for the identification of locations suitable for potential water provision.

No.	Parameter	Section	Estimation	Grid	Error	WF
1	Population density	2.2.2.	Calculated	1 × 1	Very low	1
2	Location advantage	2.2.3.	Estimated	15 × 15	Very high	2
3	Precipitation	2.2.4.	Predicted	5 × 5	Low	3
4	Groundwater level	2.2.5.	Predicted	5 × 5	Medium	3
5	Water rights	2.2.6.	Calculated	10 × 10	Low	2
6	SFRB	2.2.7.	Calculated	10 × 10	Low	3
7	Excess running water	2.2.8.	Predicted	10 × 10	High	3
8	Proximity to networks	2.2.9.	Estimated	10 × 10	High	2

Table showing seven columns explaining eight parameters.
SFRB, Sustainable flood retention basin; Grid, preferred minimum grid size resolution (km2); WF, proposed average weighing factor.

Table 2. Calculation example (The Kaiserstuhl, Baden) for identifying the suitability of an area for water provision using the revised SFRB concept.

Parameter	Value	WF	Value×WF	
Population density	0.7	1	0.7	
Location advantage	0.6	2	1.2	
Precipitation	0.8	3	2.4	
Groundwater level	0.6	3	1.8	
Water rights	0.5	2	1.0	
SFRB	0.9	3	2.7	
Excess running water	0.7	3	2.1	Weighted value
Proximity to networks	0.6	2	1.2	
	Sum	19	13.1	0.69

Calculation of a weighted value based on eight parameters SFRB, Sustainable flood retention basin; WF, proposed average weighing factor.

storage of excess water to be used for green hydrogen production. A weighted value of 0.5 would represent an average suitability as all parameters are standardised. Similar investigations would need to be performed for all districts of a country to determine a map showing the potential for water supply.

2.2.2. Population density

Toilet flushing water could be replaced with industrial water and rainwater to produce drinking water for hydrogen production. A region or neighbourhood with a high population density would therefore be favourable for storing tap water for hydrogen production. A high density of buildings with high natural gas heating also has potential for replacing natural gas pipes with hydrogen pipes. High building densities should therefore also be identified.

The population density on a fine grid with cell volumes of 1 km^2 should be defined across a target country. The parameter should be standardised and displayed on a national map between 0 and 1.

2.2.3. Location advantage

Locations with clear advantages such as currently sufficient green electricity, high-quality water, potential hydrogen customers in industry and opportunities for feeding hydrogen into the grid must be identified. Free or released energy capacities should also be recognised.

This complex sum parameter needs to be estimated by experts for a course grid cell area of $15\,km^2$. Values between 0 and 1 should be mapped.

2.2.4. Precipitation

The future precipitation potential for all of Germany needs to be determined with software prediction packages on a grid as fine as possible, but at least 5×5 km. The parameter should be standardised and displayed on a national map between 0 and 1. This parameter is particularly important for regions where droughts are predicted in the future. These should be protected from water over-exploitation.

2.2.5. Groundwater level

Stable and rising groundwater levels should be determined nationwide on a grid of preferably 5×5 km and displayed after standardisation. Areas with falling levels should be avoided as target locations.

2.2.6. Water rights

Regions where water extraction is still possible due to unused water rights (Queitsch 2020) should be recorded. Districts with acute competitive conflicts over water access should also be identified but decision-makers can be helped by mediation and the application of the SFRB concept weighing stakeholder interests against one another using unbiased big data techniques (Scholz 2023; Steinhäußer et al. 2015). The parameter water rights could be estimated in terms of available volume for a course grid cell area such as $10\,km^2$, and subsequently standardised.

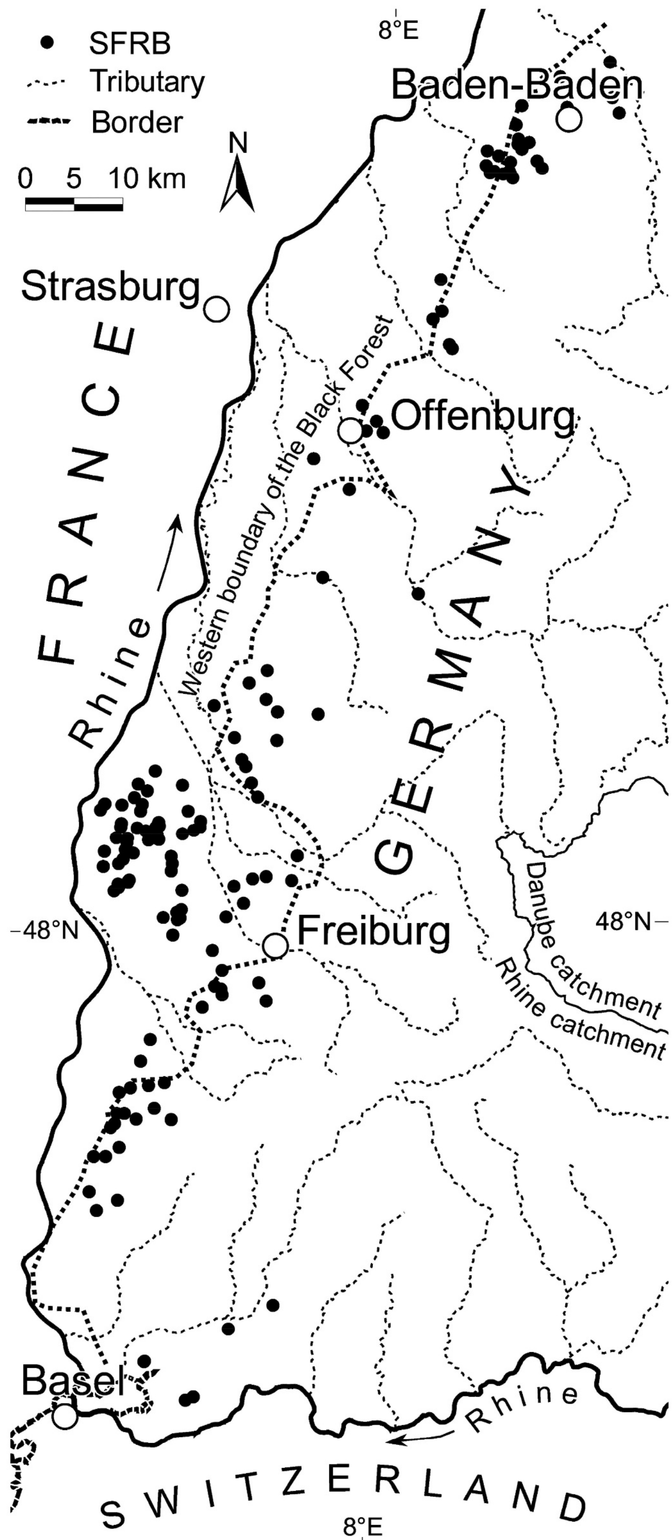


Figure 2. Identified sustainable flood retention basins in Baden: most Basins have enough potential for storing raw water for hydrogen production.

2.2.7. Sustainable flood retention basin

The identification of existing and potential SFRB locations with large volumes and flood protection functions must be carried out for all regions that are not too dry. Figure 2 shows an overview example of SFRB that have already been identified as suitable for the storage of water in Baden.

This identification work is a complicated task because not all basins are formally managed and their legal status regarding their benefits is unclear; for example, neglected basins can become nature reserves). The SFRB concept can be used here to advise interest groups without bias (Scholz 2023).

The SFRB density calculated in terms of total maximum storage volume on a grid cell area such as 10 km^2 have to be defined across a target region. The volumes per cell should subsequently be standardised and displayed on a map between 0 and 1.

2.2.8. Excess running water

The sections of streams and rivers with excess water that could be diverted into a retention waterbody must be identified. These could be possible locations for retrofitting SFRB. The predicted excess water rate (volume/time) for a network of river and stream stretches within a grid cell area of preferably 10 km^2 should be determined and subsequently be standardised.

2.2.9. Proximity to networks

The proximity of existing and specially planned SFRB to drinking and industrial water as well as hydrogen and natural gas networks should be estimated in terms of length (km) and subsequently be standardised and displayed on a 10×10 km grid. A short distance to networks is a location advantage.

3. Method validation results and discussion

3.1. Conventional water supplies

It should be carefully considered where in target countries such as Germany green hydrogen can be produced cost-effectively and sustainably, as production requires a lot of pure water. The large demand for both water and green hydrogen can rarely be met directly on site for an industry.

Neither sea water, purified wastewater treatment plant wastewater, river water nor tap water can be used untreated for hydrogen production. Rather, only deionised water, which is close to distilled water, is suitable. There is currently neither enough energy from wind and solar for water treatment nor sufficient deionised water available in most countries (Ishaq, Dincer, and Crawford 2022).

If neither surface water nor groundwater is largely available, other water sources can also be used. At locations on or near the North Sea or Baltic Sea, offshore electrolysis with desalinated seawater may be an option. Wind farms in the North Sea would perhaps have between 30 and 40% capacity to provide energy for suitable offshore areas. However, the production and transmission of hydrogen is expensive. The freshwater requirement would be reduced accordingly.

Another alternative source of raw water for regions remote from the coast is the use of wastewater from municipal sewage treatment plants and industry. However, producing ultrapure water from wastewater through electrolysis is also complex and expensive.

3.2. New water sources

Precipitation feeds ground and surface water and varies greatly per district and region. The statistical mean precipitation is currently 800 l/m^2 in Germany. The theoretically usable ground and surface water in Germany is 190 billion m^3/year. Approximately 70% of drinking water is produced from relatively clean, deep groundwater and spring water (Arnold 2016; Scholz 2023).

A lot of surface water, such as street water runoff, is discharged unused into rivers and flows ultimately into the sea. Stream and river water is also often available in excess and flows into the sea but could otherwise be collected and treated in SFRB and thereafter be recycled for hydrogen production.

3.3. Water rights

Water abstraction in Germany is regulated by water law (in German: Wassserrecht). This not only provides for (theoretically) fair water distribution for all sectors such as water associations, processing industry and agriculture, but also for the sustainable protection of groundwater resources and environmental sustainability (Arnold 2016; Queitsch 2020). Recent droughts in German federal states such as those in Saxony, Saxony-Anhalt, Brandenburg and Lower Saxony do not allow the groundwater level to fall further due to additional water extraction for hydrogen production at many possible locations. The proposed method focuses on the use of these alternative water sources (Section 3.2) as water rights for traditional sources of water (Section 3.1) are almost exhausted for most regions.

3.4. Competitive conflicts

The need for water to produce hydrogen in Germany is currently often estimated at around 10 million m^3 per year. German water associations are currently reluctant (sometimes justified) to make such quantities of drinking water available for hydrogen production (Arnold 2016). They also do not want to give up their water law rights (Section 3.3) and often see green hydrogen production as strong competition (Queitsch 2020; Steinhäußer et al. 2015). Here, the author proposes the SFRB concept as a neutral solution to resolve conflicts of interest using big data methods (Yang et al. 2011).

3.5. Location selection and networks

The site selection criteria in Section 2.2 consider the availability and quality of water resources as well as the regional impacts and long-term economic and natural consequences. This is particularly true for agriculturally rich regions, which are often affected by drought (Arnold 2016; Scholz 2023). Therefore, Table 2 illustrates a case study dominated by viniculture in The Kaiserstuhl suffering from dry summers.

Many industrial processes often use more water than necessary to produce hydrogen. The right choice of locations for water treatment and optimisation options are therefore crucial.

Section 2.2.9 highlights the importance of the variable proximity to networks. There are currently only three small and short regional hydrogen networks in Germany: Ruhr area (240 km), Central German Chemical Triangle (Bitterfeld, Schkopau and Leuna; 150 km) and Schleswig-Holstein (30 km). In comparison, the natural gas network (550,000 km) is very long, branched and, after minor modifications, could also be used cost-effectively for hydrogen transport. However, natural gas is in competition with hydrogen. This conflict should be resolved politically. However, public authorities should seek independent advice and support in the collection of scientific information and present interpretative solutions to decision-makers. The proposed methodology is a practical and impartial tool for such service providers.

Drinking water will sooner or later be partially replaced by used water (Brauchwasser in German). Therefore, soon to be surplus drinking water pipes could also be used for wastewater and/or surface water in the future. However, water boards are currently preventing this on a large scale, because drinking water networks are their main assets.

3.6. Possible addition to the hydrogen atlas

The German Federal Ministry of Research and Education (2022) recently had the Hydrogen Atlas designed as a contribution to the (water and) energy transition for Germany. This atlas shows where the use of hydrogen technologies could be worthwhile based on current demand calculations. However, the lack of clean water to produce hydrogen is not solved by this atlas. To give decision-makers a helpful tool to identify sustainable freshwater resources for the production of green hydrogen in German administrative units such as districts (in German Kreis) and one district cities (in German kreisfreie Städte), the author would like to supplement this Hydrogen Atlas with a water (supply or availability) atlas. The method presented, which is based on the updated SFRB concept, can be a decisive solution even in the event of conflicts of interest between stakeholders such as water associations and federal agencies (Steinhäußer et al. 2015).

For the worked example case study area, The Kaiserstuhl (Table 2), the potential in hydrogen is about 15,000 GWh. This is a rather average value for Germany. However, the potential for access water storage is well above average with a corresponding weighted value of 0.69 for the closest district. It follows that The Kaiserstuhl might be a suitable region to supply access freshwater to the nearby large city of Freiburg (Figure 2), which takes a lead role sustainable water and energy technology development in Germany. The high density of already existing SFRB in The Kaiserstuhl indicates a reduced need for extra capital expenditure (Scholz 2008).

4. Conclusions and recommendations

A practical and simple methodology for identifying sustainable freshwater resources to produce green hydrogen in Germany and similar regions with the modified SFRB concept was presented. The identification of optimal locations for the retention of surface water that is not used for maintaining regional water balances is necessary not only for example regions such as Baden, but for entire (federal) states and countries.

The application of the proposed method will require considerable step-changes in current water resources management strategies to enable the hydrogen energy industry to get established across countries. Future research will have to support competing stakeholders with the need for clean water to share resources more effectively and an upgrade of the current system of water access rights.

To give decision-makers a practical tool for identifying sustainable freshwater resources to produce green hydrogen in districts such as the Kreis Breisgau-Hochschwarzwald, the first step is to supplement the German hydrogen atlas with water supply sheets and maps (water atlas) of currently underutilised SFRB and locations for future SFRB. This requires funding from the public sector such as districts that need independent support from consulting engineering firms in map production and conflict resolution between stakeholders.

National and federal government authorities will have to support municipalities and water associations also financially with the identification of sustainable freshwater resources to produce green hydrogen applying the proposed digital method as an impartial tool. This would considerably support the sustainable and digital transformation efforts in the water and energy industries making countries such as Germany more independent from foreign energy imports.

Acknowledgments

The author thanks his colleagues at the aconium GmbH (previously atene KOM) for provision of information. Dr Qinli Yang supported previous work on sustainable flood retention basins as part of her former PhD studies.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributor

Miklas Scholz, BEng (equiv), PgC, MSc, PhD, DSc, CWEM, CEnv, CSci, CEng, FHEA, FIEMA, FCIWEM, FICE, Fellow of IWA, Fellow of IETI is a Senior Expert in Water Management at atene KOM and a Distinguished Professor at Johannesburg University. Miklas holds the Chair in Civil Engineering as a Professor at The University of Salford and is a Senior Researcher at the South Ural State University. He is also a Technical Specialist for Nexus by Sweden and a Hydraulic Engineer at Kunststoff-Technik Adams.

He has published 9 books and 317 journal articles. Prof. Scholz has total citations of about 14,350, resulting in an h-index of 58. Miklas also belongs to the World's Top 2% Scientists by Stanford University. A bibliometric analysis of all constructed wetland-related publications and corresponding authors with a minimum number of 20 publications and 100 citations indicates that Miklas is on place 5 in the world of about 70 authors.

In 2019, Prof. Scholz was awarded EURO 7 M for the EU H2020 REA project Water Retention and Nutrient Recycling in Soils and Streams for Improved Agricultural Production (WATERAGRI). He received EURO 1.52 M for the JPI Water 2018 project Research-based Assessment of Integrated approaches to Nature-based SOLUTIONS (RAINSOLUTIONS).

ORCID

Miklas Scholz http://orcid.org/0000-0001-8919-3838

Data availability statement

The associated datasets are available on request, but the exact locations and names of constructed waterbodies are considered as critical infrastructure both in Germany and the United Kingdom and may not be disclosed for national security reasons.

Author contribution statement

Miklas Scholz is responsible for the conception, design, analysis, interpretation of data and writing of this method paper. He is accountable for all aspects of the work.

References

Arnold, N. G. 2016. "Corporate Social Responsibility Representation of the German Water-Supply and Distribution Companies: From Colourful to Barren Landscapes." *International Journal of Innovation and Sustainable Development* 11 (1): 11–22. https://doi.org/10.1504/IJISD.2017.10000535.

Bian, L., Z.-Y. Zhang, H. Tian, N.-N. Tian, Z. Ma, and Z.-L. Wang. 2023. "Grain Boundary-Abundant Copper Nanoribbons on Balanced Gas-Liquid Diffusion Electrodes for Efficient CO_2 Electroreduction to C_2H_4." *Chinese Journal of Catalysis* 54:199–211. https://doi.org/10.1016/S1872-2067(23)64540-1.

Danso-Amoako, E., M. Kalimeris, N. Scholz, Q. Yang, and J. Shao. 2012. "Predicting Dam Failure Risk for Sustainable Flood Retention Basins: A Generic Case Study for the Wider Greater Manchester Area." *Computers, Environment and Urban Systems* 36 (5): 423–433. https://doi.org/10.1016/j.compenvurbsys.2012.02.003.

Federal Ministry of Research and Education, 2022. "Hydrogen Atlas Germany." Accessed October 5, 2023. www.bmbf.de/bmbf/shareddocs/faq/wasserstoffatlas-deutschland.html.

Ishaq, H., I. Dincer, and C. Crawford. 2022. "A Review on Hydrogen Production and Utilization: Challenges and Opportunities." *International Journal of Hydrogen Energy* 47 (62): 26238–26264. https://doi.org/10.1016/j.ijhydene.2021.11.149.

Luo, M., J. Yang, X. Li, M. Eguchi, Y. Yamauchi, and Z.-L. Wang. 2023. "Insights into Alloy/Oxide or Hydroxide Interfaces in Ni–Mo-based Electrocatalysts for Hydrogen Evolution Under Alkaline Conditions." *Chemical Science* 14 (13): 3400–3414. https://doi.org/10.1039/D2SC06298D.

Queitsch, P. 2020. *Wasserrecht (Water Law)*. Wiesbaden, Germany: KSV Verwaltungspraxis (in German).

Scholz, M. 2008. "Classification of Flood Retention Basins: The Kaiserstuhl Case Study." *Environmental and Engineering Geoscience* 24 (2): 61–80. https://doi.org/10.2113/gseegeosci.14.2.61.

Scholz, M. 2023. *Wetlands for Water Pollution Control*. 3rd ed. Amsterdam, The Netherlands: Elsevier.

Scholz, M., and Q. Yang. 2012. "Novel Method to Assess the Risk of Dam Failure." *Sustainability* 3 (11): 2200–2216. https://doi.org/10.3390/su3112200.

Steinhäußer, R., R. Siebert, A. Steinführer, and M. Hellmich. 2015. "National and Regional Land-Use Conflicts in Germany from the Perspective of Stakeholders." *Land Use Policy* 49:183–194. https://doi.org/10.1016/j.landusepol.2015.08.009.

Verne, J., 1875. Quote About Water as a Possible Source of Energy.

Yang, Q., J. Shao, M. Scholz, and C. Plant. 2011. "Feature Selection Methods for Characterizing and Classifying Adaptive Sustainable Flood Retention Basins." *Water Research* 45 (3): 993–1004. https://doi.org/10.1016/j.watres.2010.10.006.

Zhang, Z.-Y., H. Tian, L. Bian, S.-Z. Liu, Y. Liu, and Z.-L. Wang. 2023. "Cu-Zn-Based Alloy/Oxide Interfaces for Enhanced Electroreduction of CO_2 to C^{2+} Products." *Journal of Energy Chemistry* 83:90–97. https://doi.org/10.1016/j.jechem.2023.04.034.