Measuring Water Risk: The Challenges for Passive Index Investment

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1 Why Is Water so Important to Investment Decision-Making?

1.1 Water Informs Climate

Water is essential to life, but is not typically a commodity that is considered by investors when selecting and weighting companies in their portfolios. According to the World Economic Forum (WEF), nine out of the ten worst global risks are linked to water (Berggren, 2019; WEF, 2019) and as a result, investors increasingly use water risk as a proxy for climate risk. Water stewardship will directly impact future corporate earnings and risks (AWS, 2019), and consequently, stock prices and investment portfolio performance.

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1.2 Water Impacts Company Earnings Much More Than Carbon Emissions

There is no doubt that CO_2 emissions have been the primary input to climate investment strategies since the first climate indices were launched in the early 2000s. It appears that every climate investment product appears to be entirely focused on CO_2 emission levels as the basis for stock selection and constituent weighting. This is counterintuitive because companies can continue to spew carbon into the atmosphere while not impacting their ability to manufacture or process products. So, while we completely agree that carbon emissions are highly detrimental to the environment, they have little impact on corporate earnings and therefore shouldn't be considered a source of return to investors. A low carbon index should not be expected to outperform the market merely because it has a lesser carbon footprint. And yet the authors of various low carbon indices claim that this factor generates market outperformance when it may be due to sector exposures relative to the benchmark or single stock selection (Kolostyak, 2021).

Consider a low carbon investment strategy that has large underweights in the big carbon emitting Energy sector, which was offset by much higher exposure to the low carbon emitting Technology sector. Between 2016 and 2021, the MSCI World Information Technology Sector Index outperformed the MSCI World Energy Index by 39.36% on an annualized basis (MSCI, 2022), and there is no doubt that this outperformance was not due to low carbon emissions. It was a huge sector bet that paid off while energy prices were flatlining, and Technology stocks soared. However, during the first half of 2022, this pattern changed dramatically, where a spike in energy prices boosted the sector at the same time as the Technology sector corrected. During the first half of 2022 through June 30, the MSCI World Energy Sector Index outperformed the MSCI World Information Technology Sector Index by 54.36%! During this period, some low carbon indices underperformed the market. So much for low CO_2 emissions being alpha-generators.

Furthermore, it has recently come to light that many of the so-called "Climate" investment products include companies from highly carbon-intensive industries such as Oil & Gas and Utilities. This is most likely a result of the Climate Index providers' desire to reduce the amount of sector exposure risk in their indices from excluding entire high carbon emissions sectors. For obvious reasons, including Energy companies in a

Low Carbon Index is counterintuitive. In 2022, financial regulators in the United States and Europe began to issue warnings to asset managers who advertised low carbon investment strategies that, upon closer inspection, are not.

Water is the other side of the climate coin. Global water scarcity is well-documented, and investors who fail to account for water risk in their portfolios face significant financial risk (CDP, 2020). Water risk has a meaningful and direct impact on future corporate earnings, and investors who fail to account for water risk in their portfolios may experience significant market underperformance in the future.

However, it is not widely recognized that nearly all companies rely on water to varying degrees and therefore possess some portion of water risk. In addition to the obvious agricultural requirements, industries such as beverages, industrials, textiles, mining, utilities, and semiconductors (to name a few) all require vast amounts of water as a critical input to their production and operating processes. For example, most fashion-conscious investors may not realize that it takes over 7,000 liters of water to manufacture a single pair of denim jeans (Mukherji, 2020).

Consider the stark contrast between carbon and water usage today. A company that emits carbon into the atmosphere can still manufacture products, produce revenues, and grow earnings—which support our premise that high carbon emissions do not directly or materially impact corporate profitability. While planned European Union (EU) Emissions Trading Scheme (ETS) reforms may have an impact on costs incurred by companies in the future, their materiality is unknown at this point and there is still the United States (US) and the rest of the world to contend with.

If a manufacturing facility can't obtain one economic source of power, there are alternatives, whereas if a Coca-Cola plant cannot obtain water, the firm must close the plant or at the very least, pay a much higher price to transport the water to the plant from another location. Either way, Coke's costs would increase, and their earnings could be negatively impacted.

Why aren't investor portfolios focused more on water risk when considering climate investments? Two of the seventeen Sustainable Development Goals (SDGs) are directly related to water, with water linked to many of the other SDGs. A. Poberezhna, Founder of ClearHub/Smart4tech states that the "total cost of water is US$1.9

trillion per year, when including the full economic, social, and environmental costs of water pollution, flooding, and drought. With an estimated US$670 billion of required annual spending by 2030 to meet the Sustainable Goals related to water, it is unlikely that those targets will be met" (Poberezhna, 2021).

According to a recent study by the Carbon Disclosure Project (CDP) Global Water Forum, "the financial penalty for failing to mitigate water risk is over five times larger than the mitigation costs" (Lamb, 2021; see also CDP, 2020). Access to water is therefore a concern not only for humanity that needs clean, potable water to sustain life, but also to businesses for whom it is the lifeblood of their operations. Managing water in a sustainable manner is good for the environment, but also good for investors too as water risk is poised to impact the performance and ratings of companies that rely on water to produce goods and run their operations.

2 Water Scarcity Portends Water Risk

2.1 What Is Water Risk?

The term water risk denotes all uncertainties and challenges relating to water availability (Dumont-Bergeron & Gramlich, 2021). Water risk is closely connected to climate. Changing climate, which is substantially manifested through water scarcity, portends unprecedented disruption in supply chains, which pose threats to production and distribution channels. Essentially, water informs climate. Water risk is not only environmental, but also ubiquitous across all sectors; it impacts future earnings, AND it is wholly unaccounted for in market benchmarks. The drivers of water risk include climate change/climatic events, failing infrastructure, pollution, weak regulations, and poor company water stewardship. These risk drivers result in operational, reputational, and regulatory financial risk effects, which can lead to earning shortfalls, litigation, and penalties. The scarcity of water will directly impact the earnings of companies which will translate into lower share prices for those companies that fail to manage water properly.

2.2 How Is Water Risk Measured?

There are many complexities with water data. Primarily, there are no accounting standards for reporting of water data (CDP, 2020), therefore, quantitative techniques must be applied to ensure comparability across companies and geographies. The greatest challenge in sourcing raw water data is the wide disparity in the availability and reported levels of water usage, disposal, and recycling. Some companies report tens of billions of cubic meters, while others barely report thousands. A mathematical approach helps to design a workable distribution from lowest to highest water risk at the company level. This enables index construction in the aggregate to lead to a lower water risk exposure.

There is minimal incentive for companies to report and disclose water data because there are no regulatory restrictions. Over the past few years, we have observed a marked increase in the number of companies who are reporting water utilization and water stewardship metrics (CDP, 2020). However, we are still a long way from a world where water data is as consistently reported as traditional financial statement data. The change needs to come from within the company managements and for this to occur, regulators and the company management boards must apply pressure to modify the mandate of a CEO from "maximizing shareholder value" to "maximizing shareholder value while minimizing environmental impact." When this becomes the new CEO mantra, disclosure will improve, and investors will be able to better understand and assess water risk and water security. It is also not surprising that company managements do not wish to report water data that could highlight risk or negative environmental impact as this could lead to lower stock prices as the market prices this risk into the stock's valuation.

Considerable research and analysis are required to develop a means to systematically stratify water risk at the company level. After several years' analysis, we have developed an approach that applies certain statistical techniques to enable water risk to be quantified, which results in a company-level ranking system across the broader capital markets.

2.3 What Are the Main Determinants of Water Risk?

There are two aspects of water risk:

Water Utilization—How well has a company used water? These metrics can be measured by total water withdrawal, freshwater withdrawal,

water discharged, water pollution, and water recycled as reported by each company as part of their annual report. These also assess a company's Water Footprint and reflect where they stand in terms of water usage. For example, a beverage company requires water as a key input to production, and they source water from either utilities or from the ground or by purchasing it—which is their freshwater utilization. Companies that utilize water in their production processes have to expel that water in some way (draining into a sewer or trucking it to another disposal area) which represents their water discharged.

Water Stewardship—Is the company doing anything to mitigate future water risk? Stewardship is a more forward-looking measure of water risk, and it focuses on the existence (or lack) of corporate water procedures such as (AWS, 2019):

i. Is there a water policy?
ii. Does the company target water conservation?
iii. Does the company use technology to mitigate water risk?

2.4 How Does Water Risk Differ from Water-Themed Investments?

There is a big difference between Water Indices and Water Security. The market is flooded with so-called "water indices" with assets exceeding $30 billion (Citywire, 2022), but their approach completely ignores water risk and water security. They are nothing more than highly concentrated (30–40 stocks) portfolios of companies in the water purification/water recycling equipment manufacturing industry as well as some water utilities. These indices are purely speculative, based on the assumption that as water becomes scarcer, these companies will benefit from the increased demand for their products.

While this is a viable thematic, none of these water investment strategies incorporate water risk or water security. "Water security is the reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks" (Grey & Sadoff, 2007). Water Security (Taka et al., 2021) relates to all companies and not just companies from a few industries. Every company has a measure of water risk and water stewardship which permits them to be analyzed at the portfolio construction level to assess and regulate portfolio exposure to water risk with a bias toward water security and

good water stewardship. In addition, a typical water-themed strategy has a substantially higher level of market risk compared to benchmarks because of the high concentration and exclusion of most sectors.

2.5 Introducing the Water Footprint

Most climate investors are familiar with the concept of a carbon footprint (Harkiolakis, 2013). It is essentially a measure of the amount of a company's carbon emissions that are reported each year. There are different levels of CO_2 emissions that inform the carbon footprint including direct emissions—which are the amount of CO_2 emissions from the company's operations; indirect emissions—which measure emissions from the supply chain to the company as well as the impact from utilities that provide energy to the company and its suppliers.

It should be simple to apply a similar methodology to calculate a water footprint (Hogeboom, 2020). Instead of measuring carbon emissions, a water footprint can be measured by the water utilization metrics described in Sect. 2.3. This footprint can be calculated for each company that reports at least one of the water utilization metrics. The water footprint of a portfolio or an index of companies can also have a combined water footprint by simply aggregating each constituent's water footprint and then weighting that footprint by the percentage of each company's weight in the portfolio or index. The water footprint is an accurate measure of a portfolio's environmental impact from water risk, and it enables investors to compare the level of water risk across different investment alternatives, portfolios, and indices.

3 Mitigating Water Risk in a Passive Investment Strategy

Developing a methodology for pricing water risk into securities has proven to be quite a challenge. All the major index providers have tried with no success. The issues with data, quantifying water risk and how to construct an index all present significant hurdles. However, a collaboration between Thomas Schumann Capital (TSC) and Anatase Ltd Consulting, has cracked the code. A systematic methodology for measuring and quantifying water risk at the company level was developed and applied to the construction of a suite of Water Security Indices which

were finalized in November 2020 and launched in January 2021 on the Moorgate Benchmark Index platform (Moorgate Benchmarks, 2022).

Stratifying water risk results in a ranking system that enables portfolio constituent weights to be adjusted to reflect the degree of water risk. This effectively reduces portfolio water risk as companies with low water risk are overweighted while companies with higher water risk are underweighted. By including many large capitalization companies from all sectors, the risk exposure to market benchmarks has been minimized. This has facilitated the creation of an index that allows investors to mitigate water risk while not having to deviate from country, regional, and sectoral weights in the benchmarks.

Performance of the indices regularly outperformed comparable market benchmarks with similar risk levels, and the indices have shown a much lower water footprint and carbon footprint than their corresponding equity market benchmarks.

Similar to how CO_2 emissions can be used to determine a company's carbon footprint and, consequently, the weighted carbon footprint of a portfolio, a portfolio's water footprint can also be calculated using a similar approach. Water utilization informs the water footprint which enables such a footprint to be calculated at the corporate and portfolio level.

By using the water risk metrics described in Sect. 2.3, it is relatively simple and transparent to reweight a broad universe of companies across all industries, resulting in an average 53% lower water footprint than traditional market benchmarks such as the S&P 500, MSCI World, and the EuroSTOXX 50. This approach can significantly mitigate water risk without sacrificing diversification across sectors, countries, and regions. Investors may hedge potential future negative earnings impact from high water risk without making large bets and accepting unintended and undesirable risks.

3.1 Calculating the First Component of Water Risk—Water Utilization

As mentioned earlier in Sect. 2.3, there are two aspects of water risk—the first one is water utilization, which is a measure of a company's water footprint. The inputs to calculating water utilization are defined by Refinitiv (our source for the analysis) and are:

Total Water Withdrawal: The total volume of water (in cubic meters) from any water source that was either withdrawn directly by the reporting organization or through intermediaries such as water utilities—different sources of water like well, town/utility/municipal water, river water, surface water, etc. are considered.
Freshwater Withdrawal: Total freshwater withdrawal in cubic meters—freshwater refers to water with low salt content. Sources of freshwater include surface, underground, well, boreholes, rain, and distributed/purchased water—municipal water, industrial water, and tap/drinking water. Saline, gray, and brackish water are not considered.
Total Water Discharged: The total volume of water discharged in cubic meters. This includes water discharged for which there is no further use by the company which is considered wastewater—treated wastewater and discharged information are also in scope.
Total Water Recycled: Amount of water recycled or reused in cubic meters. Recycled or reused water refers to water being sourced internally by recycling or reusing water in place of additional withdrawals. Treated water does not qualify.

Most water data is reported by companies in their annual reports, but some of it is also available via government and municipal water suppliers. Refinitiv is one of the few collectors of this type of data which is why we have chosen them after considerable comparison across the various ESG data vendors.

As previously stated, converting raw water data into a measure of water risk requires some statistical techniques. The fundamental issue with water data relates to the scale of water metrics reported by companies. As the table below highlights, the range of values reported by companies can be extreme, which makes creating a viable ranking system difficult at best. Due to the wide variance in how companies use water, depending on the industry, these measures can be either very, very large or very small (some even zero). The table indicates the maximum and minimum reported water utilization measures values of 1,500 of the largest by market capitalization global market public companies as of December 31, 2021 (Table 1).

To facilitate a more productive distribution of water metrics, we proportionately scale each company's water data by dividing the water metric by the company's annual revenues in millions of US dollars.

Table 1 Maximum and minimum reported raw water metric data (December 31, 2021)

Water utilization metric	*Maximum*	*Minimum*
Total water withdrawal (cubic meters)	94,394,100,000	2,689
Freshwater withdrawal (cubic meters)	9,337,000,000	1,016
Total water discharged (cubic meters)	12,159,000,000	1,358
Total water recycled (cubic meters)	5,800,000,000	0

Source Anatase Ltd, Refinitiv, used by permission from paid subscription for non-commercial use

Refinitiv does this for part of their water data but not for all, therefore we must make the required adjustments as needed. In environmental reporting, it is a common practice to divide by revenues; the resulting measure is often referred to as "intensity." For example, *Total Water Withdrawal* is converted into *Total Water Withdrawal Intensity* and so on. This helps to adjust the magnitude of water utilization to the scale of the company's revenues. Smaller companies *should* have smaller water utilization than larger ones. However, when extracting water data from company annual reports or using other sources, it is crucial to note whether they are reporting these measures in cubic meters or metric tons or cubic meters per a million US dollars of revenue.

Once we have converted all of the required water data, the maximum and minimum water metric intensities reflect what is shown in Table 2.

Clearly, the revenue adjustment has narrowed the wide range of reported values, however, we aren't quite ready to move to the derivation

Table 2 Maximum and minimum reported water utilization intensity (December 31, 2021)

Water utilization intensity metric	*Maximum*	*Minimum*
Total water withdrawal (cubic meters/m$)	14,948,308	2,689
Freshwater withdrawal (cubic meters/m$)	740,572	1,016
Total water discharged (cubic meters/m$)	511,290	1,358
Total water recycled (cubic meters/m$)	445,785	0

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of water risk just yet. While the conversion into intensity has reduced the magnitude of the water risk metrics, there are still individual data observations for individual companies that are extremely high compared to most of the other companies. A process called "winsorization" is applied to render the data set more manageable (Wilcox, 2005).

Winsorizing mitigates the effects of outliers by replacing them with less extreme values, thereby curbing in the extreme levels and reducing their impact on the overall data set. Without going into too much detail, the process of winsorization simply reduces the extreme levels to a level that is statistically very high but not as high as the raw data. For example, let's assume we have 1,000 different data points for the Total Water Withdrawal intensity. As we see from Table 2, the maximum is 14,948,308 which is considerably larger than the minimum of 2,689. While it is critical to realize that the very high levels are still of the highest risk, the specific numerical value of that risk is not important as we are only looking to rank the universe of companies and assign them into quartiles—the top quartile (top 25% of companies) by utilization would have the lowest level of risk, while the next quartile (next 25%) would have the next lowest level of risk, and so forth. It should be clear that, as long as these extreme companies are in the proper quartile, it is not important that their water intensity is ten times larger than those in the 2nd quartile…only that they are in the highest water risk category. By applying winsorization to each of the company water metrics, we can reduce the extremes to a more manageable level which still results in their being in the exact same quartile. We are performing this to prepare for the following statistical adjustment, which is much more critical to the measurement of water risk and will determine how each company is weighted in a Water Security Index.

To keep this chapter on point and avoid lengthy quantitative formulas, we will not go into detail about the next statistical adjustment as there are plenty of statistics textbooks that handle that quite well (e.g., Forbes et al., 2011; Krishnamoorthy, 2016). For our discussion, we will simply describe what happens rather than the complex mathematical process that gets us there.

The subsequent adjustment to the water data is called "applying a gamma distribution." In simple terms, what the gamma distribution accomplishes is to spread the distribution of each of the water metrics across a scale of 1 to 100, so that we eliminate the "clusters" at either

end and smooth the data. This is required because even after winsorization, we are still left with what is called a barbell distribution. As the name suggests, the number and magnitude of the data points are heavily clustered at each end of the distribution (therefore looking a lot like a barbell). We need to be able to separate all the companies into four quartiles based on their water risk and utilization, therefore, the data distribution is "spread-out" so that the individual quartiles are accurately reflecting the degree of water risk for each company.

Once each company is assigned to a water risk quartile, we can use this information to determine the water risk adjustment to their calculated weighting in the index.

3.2 Creating the Second Component of Water Risk—Water Stewardship

The second aspect to consider when calculating water risk is the presence of water policies as reported by the company in their annual report. These results will also contribute to the adjustment of each constituent in the index. While water utilization is a numerical measurement of a company's inputs to their water footprint, water stewardship indicates whether a company is aware of its water risk, has a water policy in place, targets water conservation, and/or uses technology to mitigate water risk. These inputs are digital and not numerical—either the company does or doesn't have any of the above water stewardship policies. The three key policies as defined by Refinitiv are:

> **Water Efficiency Policy**: Does the company have a policy to improve its water efficiency? Is there a system or set of formal documented processes for efficient use of water and driving continuous improvement? In scope are the various forms of processes/mechanisms/procedures to improve water use in operations efficiently.
> **Targets Water Efficiency**: Has the company set targets or objectives to be achieved on water efficiency? In scope are the short-term or long-term reduction targets to be achieved on efficiently using the water at business operations.
> **Water Technologies**: Does the company develop products or technologies that are used for their own water treatment, purification or that improve water use efficiency? In scope are the products or

services addressing water purification or greater water conservation or efficiency as well as those using technology and/or software to detect water leaks.

Given that these three data points are either yes or no, there is no need for any statistical techniques such as those used in the water utilization components, to measure water risk. However, they are equally important to ascertaining water risk because they point to whether companies are incorporating water risk in their day-to-day operations (i.e., the future). This forward-looking measure of water risk management is, in our view, sometimes more important than where the company has been (its water footprint). It also suggests that companies with superior water stewardship policies will be more likely to minimize their water footprint going forward—thereby highlighting lower water risk.

3.3 One Last Sanity Check—Environmental Controversies

When designing a water security investment strategy, it made sense to reduce the index weighting of companies which have had an environmental controversy over the past twelve months (i.e., is the company under a public spotlight because of an environmental accident?).

Focusing on the past 12 months makes more sense than a prolonged historical period because a longer period might penalize a company for an accident that occurred in the distance past and therefore already long since remediated. It might even suggest that companies which have already experienced environmental controversies in the further past are less likely to endure them again in the future by having learned how to better prevent them from occurring in the first place. However, we haven't taken this concept so far as to further increase index weighting based on environmental mishaps that occurred in the more distant past.

This last perspective in determining the index weighting is more about avoiding overweighing companies that may have low water risk but still are well-known to have had recent environmental accidents.

4 Constructing a Water Security Index

Establishing a methodology for pricing water risk into securities has proved to be quite a challenge. The major index providers have attempted but with no success. The issues with data, how to quantify water risk

and how to construct an index all present significant hurdles. However, a collaboration between TSC and Anatase resulted in an innovative and first of its kind investment solution that generates an average 53% reduction in water footprint and an average 34% reduction in carbon footprint compared to traditional equity benchmark indices. In addition to the more environmentally friendly climate profile, the Water Security Indices are over 99% correlated to traditional benchmarks with essentially the same market risk (volatility). This new and innovative approach to mitigating climate change by investing in good water stewardship enables investors to hedge their water risk exposure without taking unnecessary and unintended bets on sectors, countries, and regions.

The process of identifying a selection universe of companies, recalculating their water risk, determining their new index weights, and reconstituting the positions (called "index rebalancing") is performed four times per year to ensure that the data is as up-to-date as possible.

4.1 Determining the Selection Universe of Companies for Each Index

The methodology for the three permutations of the TSC Water Security Indices (USA, Eurozone, and Global) is all rebalanced in the same manner with only the number of constituents and geographic allocation differing between them. For illustrative purposes, we will refer to a single index—the TSC Water Security Index.

Each selection pool (the universe of companies from which an index is constructed) consists of a fixed number of the largest stocks in a geographical region according to free-float market capitalization (the number of shares available to the public for trading in the secondary market). Table 3 highlights for each Water Security Index, what those selection pool parameters are.

In addition to selecting the number of companies eligible for each index, there are also exclusions based on certain ESG and Business Lines. These exclusions represent common types of companies that are frequently regarded as undesirable in certain investment communities and countries. They are excluded to ensure the resulting indices are more palatable to a broader geographical and cultural set of investors. The aggregate number of companies excluded from the Global selection universe (out of the 1,500) is relatively insignificant. Table 4 indicates

Table 3 TSC Water Security Index selection pool criteria

Region	*Number of companies*	*Countries included*
USA	600	The United States
Eurozone	250	Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain
Global	1,500	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, Singapore, Spain, Sweden, Switzerland, the UK, the United States

Table 4 TSC Water Security Index industry activity exclusion list

Aerospace and defense	Drone manufacturing
Aerospace and defense electronics	Internet gaming
Arms and ammunitions	Military aircraft manufacturing
Manufacturing	Military clothing and accessories
Casinos and gaming industry	Military vehicles manufacturing
Coal industry	Tobacco industry

which companies are excluded when their activities are classified in any of the listed categories.

4.2 Measuring Water Risk and Determining Weighting Adjustments

Each of the remaining companies is eligible to be in the TSC Water Security Index and the water utilization, stewardship, and number of recent environmental controversies are collected for each company, if available. When only a limited amount of data is available, we use what we can obtain to measure the water risk. As more companies are reporting and increasing amounts of water data become available, we are confident that the quality and quantity of water data reporting will continue to improve over time.

The process of determining an index constituent's weight is relatively straightforward. The simplicity is based on the theory that companies with

lower water risk will be future beneficiaries in terms of earnings' growth and stock price appreciation, whereas the companies with higher water risk will suffer the opposite. Therefore, to "tilt" the portfolio toward lower water risk and a consequently lower water footprint, we merely adjust each constituent weight in the index either up or down (bonus or penalty) based upon their water risk ranking. Companies that do not report any water data whatsoever are left unadjusted.

The underlying principle is that the company's free float market capitalization is how most traditional indices are weighted. The larger the company, the larger the weighting and vice versa. By adjusting the market capitalization up or down, we effectively end up with a portfolio that is overweight low water risk and underweight high water risk. This approach is also sometimes referred to as "fundamental weighting," "alternative weighting," or "smart beta." Each of these terms basically means the same thing—an index weighted with some adjustment to skew the index toward a factor other than market capitalization.

Without delving into too much mathematical detail, there are a series of weight adjustments that get us from raw data to final index constituent weights:

i. **Water Utilization Quintile Adjustment**—All companies are ranked by water utilization and then assigned to one of four quartiles with the first quartile having the companies with the lowest water utilization and the second containing the next highest water usage, and so forth. Companies in the first quartile get the largest increase in their weight followed by the next largest increase for the second quartile. The third and fourth quartile companies have their weight decreased by the negative of the first and second quartile adjustment percentage amounts with the fourth quartile having the largest decrease applied.
ii. **Water Stewardship Adjustment**—Each of the three water stewardship policy adjustments is based on whether the answer to each is "yes" or "no." Companies who answer a stewardship policy question "yes" have their weight increased while those who answer "no" have their weight decreased. The three stewardship adjustments are applied cumulatively to each company.
iii. **Environmental Controversies Adjustment—**The number of reported environmental controversies occurring in the latest fiscal year is multiplied by a fixed reduction percentage to a maximum

of four occurrences. It is not specifically a water risk measure and is only present to avoid potentially overweighting a company that has been in the news for polluting the environment. While there is also no way to separate water-related environmental controversies from other types, typically, when the environment is damaged, water supplies are negatively impacted.

iv. **Determining the Aggregate Weight Adjustment**—Once the above three adjustments are calculated, they are summed to form the Aggregate Weight Adjustment. This number is multiplied by the company's free float market capitalization as of the rebalancing date to generate a water risk-adjusted free float. That water risk-adjusted free float is how the index constituents are weighted.

4.3 Minor Modifications to the Weighting Scheme

The original TSC Water Security Indices were designed as market water risk benchmarks and therefore as unrestricted as possible. The number of constituents in the resulting indices may be too large for some investors to manage, especially in smaller notional amounts. Fortunately, there are several simple solutions to significantly reduce the number of final constituents without impacting the performance of the index or the financial characteristics, water and carbon footprint.

i. Remove smallest weighted constituents—For example, if we remove all constituents that have below 0.01% index weight and then simply reallocate that weight proportionally to the remaining constituents, the number of index constituents reduces by as much as half with basically only 10–25% of the index actually changing and ostensibly no impact to the index characteristics. If fewer constituents are desired, the minimum weight cutoff could be increased to 0.02%, or 0.05% all with very little impact to the index characteristics.

ii. Optimization—A very common portfolio management technique that uses complex quantitative modeling to create a portfolio or index of significantly fewer constituents but with nearly the exact same "factor" exposure, which basically means that a mathematical set of formulas is able to replicate the "look and behavior" of an index with a fraction of the number of constituents. This is often applied to Exchange Traded Funds (ETFs) that track indices with

unwieldy numbers of constituents. A more detailed discussion of these techniques is outside the scope of this chapter and there is plentiful information available in the literature for those interested.

5 Measuring the Performance of the Water Security Indices

To analyze the performance of our water risk investment methodology, we performed a backtest, which is common in the industry and merely reflects what would have happened had we started performing this process beginning in October of 2015. We have the benefit of a robust historical database containing as reported water data, free float market capitalization, and the presence of all historically listed companies. It is simple to build the backtest. We perform the rebalancing process at each quarterly period and identify the selection universe, measure the water metrics, and determine the constituents and weights. This is repeated until our live launch date which was on January 4, 2021. From that point forward, the index calculation and administration were taken over by a Benchmark Administrator—Moorgate Benchmarks Ltd in London, England at the time of launch. All the historical backtests were vetted by Moorgate and are part of the published index history.

5.1 TSC Water Security Indices Financial Characteristics Through December 31, 2021

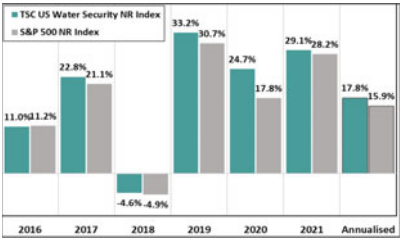
Table 5 indicates the performance and risk characteristics of the three regional water security indices compared to the traditional equity benchmarks.

While there is a lot of information in the above tables, the key takeaways are:

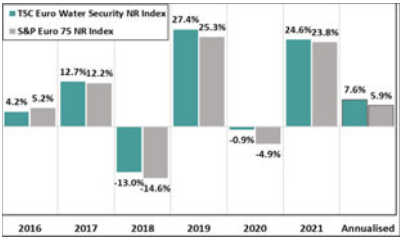
i. All the indices outperformed their traditional benchmarks over the analysis period by between 1 and 2% per year on a compound annual growth rate (CAGR).
ii. On an individual annual basis, each of the indices demonstrated the best outperformance over the past few years which may be indicating that water risk is beginning to attract more investor focus.

Table 5 TSC Water Security Index performance characteristics

Oct. 30 2015 - Dec 31 2021	TSC US Water Security NR Index	S&P 500 NR Index
Cumulative Return	175.5%	149.0%
CAGR	17.8%	15.9%
Volatility Overall	18.8%	18.2%
Volatility LTM	13.7%	13.0%
Dividend Yield	1.19%	1.26%
Correlation	99.7%	
Tracking Error (Ann)	1.62%	



Oct. 30 2015 - Dec 31 2021	TSC Euro Water Security NR Index	S&P Euro 75 NR Index
Cumulative Return	57.0%	42.8%
CAGR	7.6%	5.9%
Volatility Overall	18.3%	19.3%
Volatility LTM	14.0%	14.1%
Dividend Yield	2.24%	2.28%
Correlation	99.1%	
Tracking Error (Ann)	2.71%	



Oct. 30 2015 - Dec 31 2021	TSC Global Water Security NR Index	MSCI World $ NR Index
Cumulative Return	124.0%	112.7%
CAGR	14.2%	13.2%
Volatility Overall	16.0%	15.2%
Volatility LTM	11.8%	11.1%
Dividend Yield	1.57%	1.66%
Correlation	99.7%	
Tracking Error (Ann)	1.47%	

The TSC US and Euro Water Security Indices went live on January 4, 2021 and the TSC Global Water Security Index has not yet been launched and was in development at the time of this publication. All performance data prior to the live date was retrospectively calculated by Moorgate Benchmarks using the Index Methodology and by Anatase for the Global Index. For further information, please see Moorgate Benchmarks (2022). Past performance whether live or simulated is not indicative of future results. Returns include reinvestment of dividends net of local taxes and do not include product fees or transaction costs.

Source Anatase Ltd, Refinitiv, MSCI, Standard & Poor's

iii. All indices have correlations greater than 99% and relatively low tracking error indicating that risk exposures to the benchmarks were minimized.

iv. The overall risk (volatility) of each index is within tolerance of the benchmarks on both the past eighteen months as well as the entire

period. This means that investors can meaningfully reduce water and carbon risks without taking additional unintended risk.

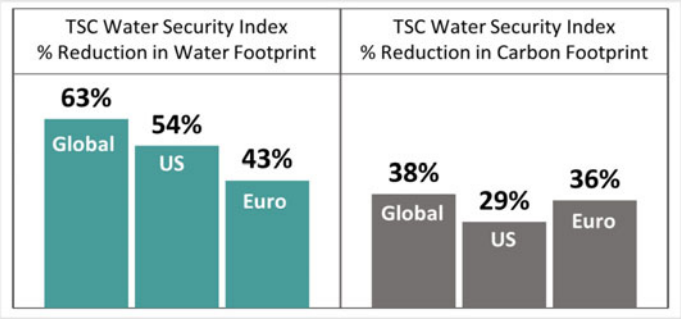
v. Each index offered a similar dividend yield to its benchmark suggesting that investors do not have to forego income to have lower water risk.

vi. Investment in water security doesn't need to come at a detriment to performance.

5.2 TSC Water Security Indices Water and Carbon Footprints on December 31, 2021

By examining the Table 6, each of the TSC Water Security Indices was able to generate significantly lower water and carbon footprints, despite taking very little benchmark risk. The Global Index has the greatest overall reduction in water footprint (63%) as well as a carbon footprint reduction of 38%. The footprint reduction numbers have been relatively stable over the last few years, so this is not a recent phenomenon. Logically speaking, reducing the weighting of constituents with the highest water footprints should result in a basket of stocks that has a lower aggregate water footprint.

Table 6 Water Footprint and carbon footprint percent reductions



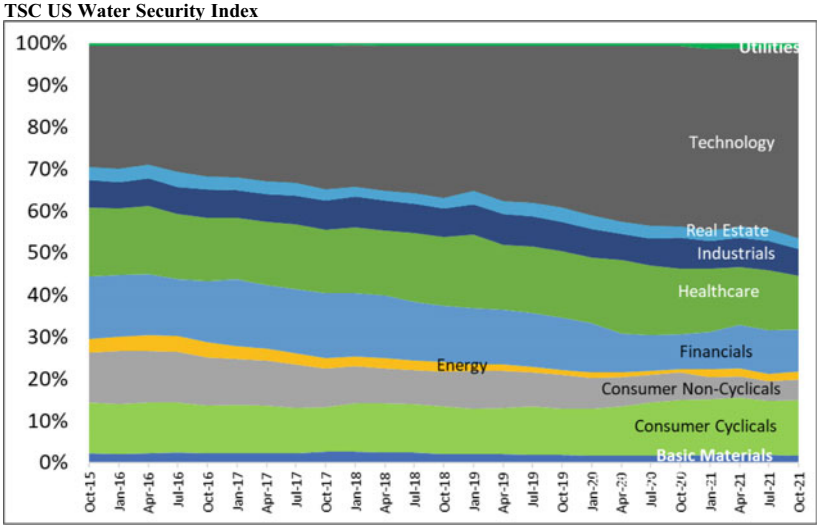
Source Anatase Ltd, Refinitiv as of December 31, 2021 based on the current constituents and weights of the TSC Indices and Market Benchmarks

5.3 TSC Water Security Indices Sector Exposure on December 31, 2021

The charts in Table 7 illustrate the sector and country and regional exposures of each TSC Water Security Index back through 2015.

Table 7 TSC Water Security Index historical sector exposures

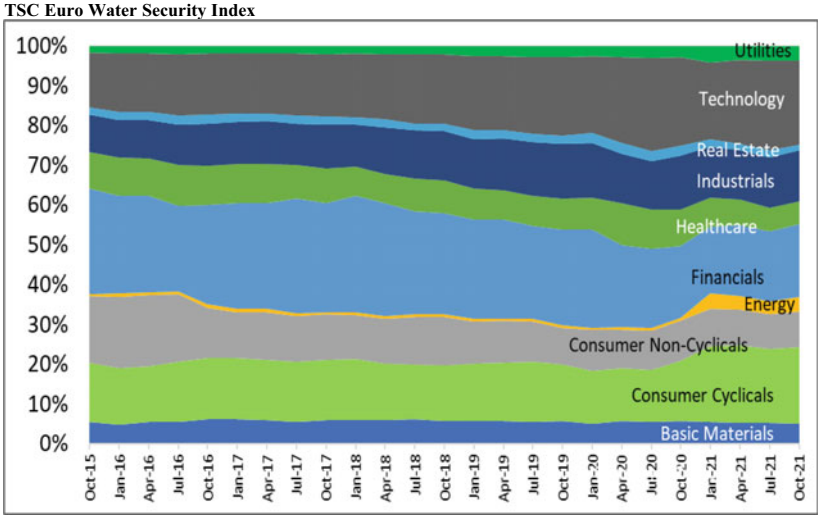
TSC US Water Security Index



TRBC Economic Sector	TSC US Water Security Index	Over / Under vs. Benchmark
Basic Materials	1.7%	-0.6%
Consumer Cyclicals	13.2%	-2.2%
Consumer Non-Cyclicals	3.4%	-3.9%
Energy	1.9%	-0.9%
Financials	10.7%	1.7%
Healthcare	12.8%	0.2%
Industrials	7.8%	0.2%
Real Estate	2.5%	-0.2%
Technology	44.8%	6.8%
Utilities	1.1%	-1.3%

(continued)

Table 7 (continued)



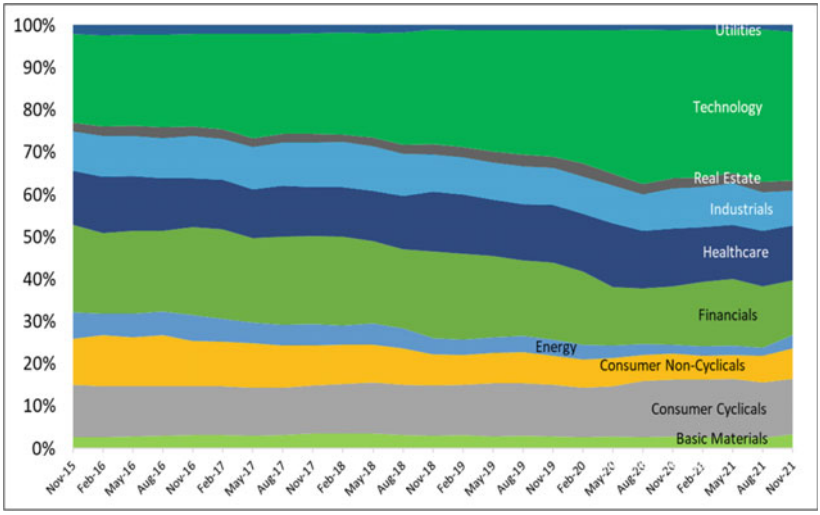
TRBC Economic Sector	TSC Euro Water Security Index	Over / Under vs. Benchmark
Basic Materials	4.9%	-5.1%
Consumer Cyclicals	19.2%	0.2%
Consumer Non-Cyclicals	8.7%	-2.8%
Energy	3.6%	-0.7%
Financials	17.9%	4.2%
Healthcare	5.7%	0.1%
Industrials	12.6%	2.9%
Real Estate	1.5%	0.2%
Technology	21.8%	0.6%
Utilities	3.6%	-0.2%

(continued)

Clearly the indices have been broadly diversified across all sectors and countries through time and as the tables showing the exposures on December 31, 2021, vs. the benchmarks suggest, there is minimal deviation in exposures compared to the benchmarks. This explains why the correlations are so high and the tracking errors are so low. This

Table 7 (continued)

TSC Global Water Security Index



TRBC Economic Sector	TSC Global Water Security Index	Over / Under vs. Benchmark
Basic Materials	3.3%	-0.9%
Consumer Cyclicals	13.0%	-0.4%
Consumer Non-Cyclicals	7.2%	-1.4%
Energy	3.2%	0.1%
Financials	12.9%	0.6%
Healthcare	12.9%	0.3%
Industrials	8.3%	-1.4%
Real Estate	2.5%	-0.3%
Technology	35.0%	4.6%
Utilities	1.6%	-1.1%

Source Anatase Ltd, Refinitiv as of December 31, 2021 based on the current constituents and weights of the TSC Indices and Market Benchmarks. The TSC US and Euro Water Security Indices went live on January 4, 2021 and the TSC Global Water Security Index has not yet been launched and was in development at the time of this publication. All performance data prior to the live date was retrospectively calculated by Moorgate Benchmarks using the Index Methodology and by Anatase for the Global Index.

also provides further historical evidence that investment in a water security index constructed across a broad universe of stocks across markets and economic sectors should have a considerably lower risk exposure for investors than a concentrated basket of stocks that are solely in the water purification industry.

6 Conclusion and Next Steps

6.1 Conclusion

The purpose of this report is to provide insight on the importance of water risk in investment space—a focus that has been sorely lacking in light of the overwhelming focus on CO_2 emissions as the relevant source of climate risk. While it is clear that CO_2 emissions are part of the climate issue, the financial services industry has largely ignored water risk in its reporting on climate and provision of climate-based investment products. It is compelling that over the past few years, more and more climate experts have written about water scarcity and its impact on the environment, and yet there is a dearth of commentary about the impact of water scarcity on corporate earnings and future security prices.

The work that has been done in quantifying water risk into an investment strategy as explained in this chapter is groundbreaking and can enable investors to reduce their exposure to water risk in their portfolios, however, it is only a first step. The lack of water metric reporting standards and regulatory requirements for all public companies to report their water metrics hinders investors from truly understanding the inherent water risk when investing in equities.

6.2 Next Steps

The author states that the most important way forward is to develop a framework for consistently and accurately measuring water risk. This requires regulated standards for all listed companies in the same way that there are financial reporting standards for publishing income statements, balance sheets, and other financial statement content in annual reports. The problem with this approach is that there are numerous ESG data providers who claim to have the "best" data available when in fact all of these providers source their data from company annual reports. So, they all source the same data but each processes it in their own "special" way

to create a unique water measurement. The question that comes to mind is "do investors really need so many different water risk metrics?" When investing in bonds, people often look to a bond rating for a measure of credit risk. There are really only two bond rating agencies, do we really need more? The author would propose the same argument holds true for water risk ratings and hope that at some point in the future, companies are required to follow regulatory standards when reporting their water metrics and ESG data, and ratings providers are reduced in number.

While these next steps may take years to appear, what can investors do in the meantime? The TSC Water Security Indices are available for investment, and while they are a first generation of water security investment, they are currently the only means (short of individual company analysis by investors) to hedge portfolios against water risk.

Overall, the relevance of water challenges in investment portfolios will further increase, and information about water risk and water scarcity will become more prominent in theory and practice (see for example Foster [2022] as a recent cover story in the Barron's magazine).

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