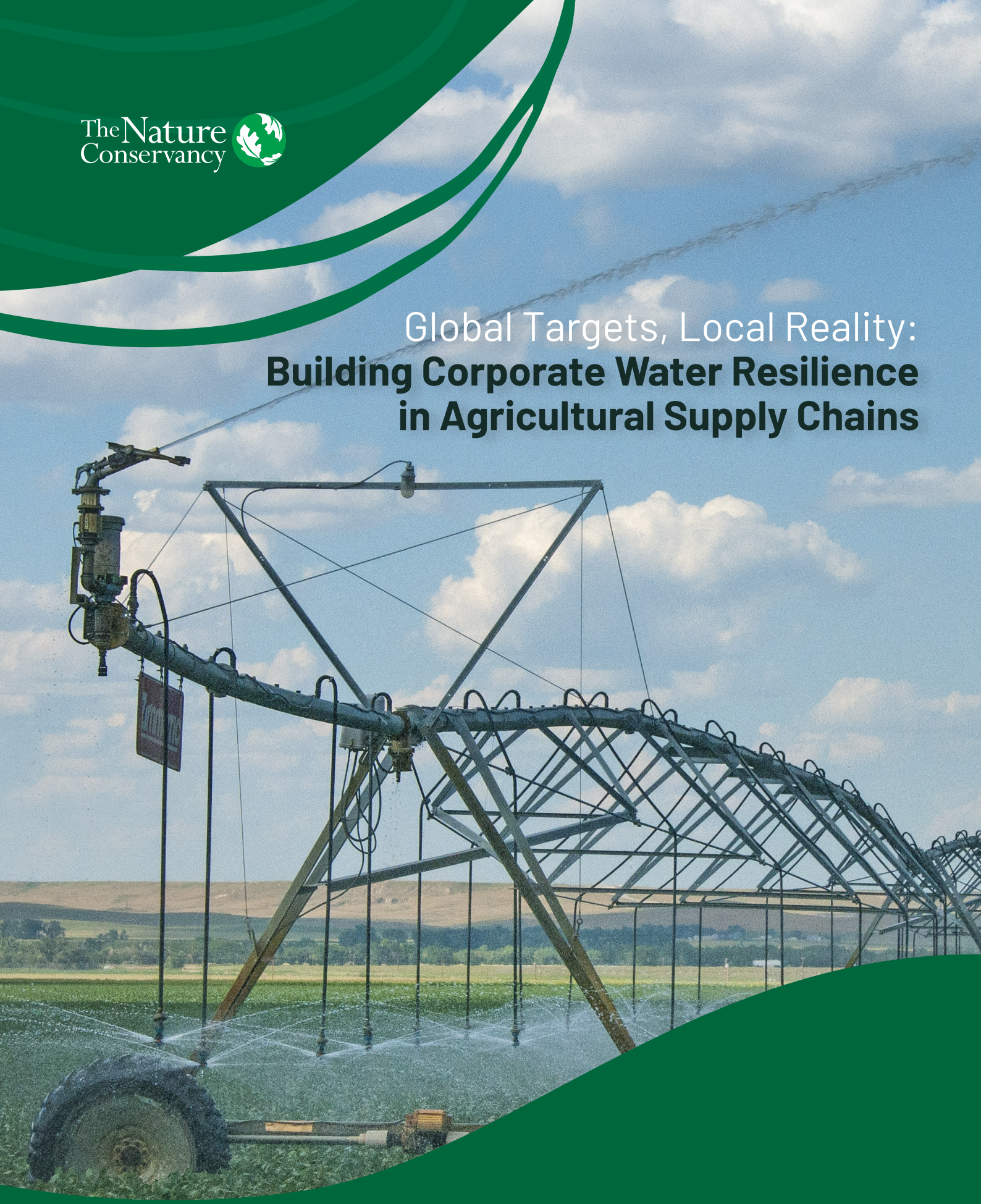
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Global Targets, Local Reality: **Building Corporate Water Resilience in Agricultural Supply Chains**



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Executive Summary

Corporate water strategies in the agricultural sector increasingly rely on global risk frameworks to set targets and prioritize action. These tools are valuable for portfolio-level screening, helping companies identify where water-related risks are most likely to disrupt business operations. However, because these frameworks combine hydrology, governance, infrastructure, and other local dynamics into comparable indicators, they are often insufficient on their own for deciding what to fund, where, and with what expected outcome. When companies mistake portfolio-level comparability for investable interventions, they risk overlooking the highest-value opportunities to improve water resilience.

We propose a structured learning loop that converts global risk signals into locally validated, decision-grade action. Global risk screening tools identify where to look, local context determines what is worth doing, and implementation generates the evidence needed to improve future decisions. The result is a disciplined and capital-efficient approach to reducing corporate water risk. A hypothetical case study in the U.S. Great Plains illustrates this dynamic. Two sourcing regions that appear similar under global screening diverge materially under local analysis. These differences fundamentally change which interventions are effective, how impact should be measured, and where capital produces material risk reduction.

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The Challenge

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Water risk is financially material for agricultural supply chains (Gustafsson et al., 2024) and emerges from the interaction of biophysical conditions, governance systems, infrastructure, and social dynamics that together shape how much water is available, to whom, when, and under what constraints (Mekonnen & Hoekstra, 2016). For decades, complex system feedbacks and geographically diversified sourcing helped multinational agricultural firms buffer local shocks, giving agricultural production a remarkable degree of aggregate stability at the global scale. But that stability appears to be weakening as diets shift, populations grow, and biophysical volatility intensifies (Bezner Kerr et al., 2022). In some regions, local yield stability appears to be weakening as drought and dry spells become more frequent and severe (Wang & Ren, 2025; Cornejo et al., 2026). The result is a world in which companies have less capacity to absorb local disruption simply by shifting sourcing elsewhere.

To manage this complexity at scale, multinational agricultural companies are turning to global screening tools such as World Resources Institute's Aqueduct Water Risk Atlas (Kuzma et al., 2023) and WWF's Water Risk Filter (WWF, 2021). These tools are effective for triage across large sourcing portfolios, helping companies identify where deeper attention is warranted. However, they do not determine what actions will reduce risk within a given basin. By design, they translate complex hydrologic, governance, and infrastructure realities into comparable signals, which enables prioritization at the portfolio level but does not provide a basis for intervention design, cost estimation, or expected impact.

Water systems are particularly sensitive to this issue because local conditions determine both the magnitude and direction of an intervention (Ward et al., 2008). Hydrologic connectivity, water law, infrastructure constraints, and farmer behavior all shape how water moves through a system (Gillespy et al., 2017; Uhlenbrook et al., 2022). When those factors are ignored, risk-mitigation interventions that look beneficial in an aggregate model may fail on the ground. For example, improving irrigation efficiency can either reduce consumptive use or simply alter return flows in ways that change downstream availability, depending on surface-groundwater dynamics and basin rules governing withdrawals. Likewise, basins with similar composite risk scores may be facing entirely different problems, such as groundwater quality constraints in one place and long-term aquifer depletion in another.

Global water risk layers are therefore best interpreted as a first-pass signal to identify basins that merit deeper analysis relative to the rest of a portfolio. The moment a company asks what it should fund in a specific watershed to reduce risk and contribute to enterprise targets, additional forms of context become necessary: hydraulic connectivity between surface water and aquifers, engineered storage and transfer dynamics, local water law and enforcement, irrigation systems and constraints, and the social dynamics that shape management practice adoption. These factors determine whether a proposed intervention will change outcomes in practice and, consequently, improve a company's water risk profile.

Agricultural companies are therefore left with a real trade-off: the information needed to make better local decisions is valuable, but it is not free. How they manage that trade-off will shape whether water investments become a source of genuine risk reduction or just another layer of reporting logic. The opportunity is not to replace global screening with bespoke basin studies everywhere, but to become more strategic about when and how local context is gathered and used as a complement to those global analyses.

A basin identified as high risk tells a company where to look.

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Path Forward: From Risk Signals to Decision-Ready Action

We propose a four-part process that enables companies to move from risk identification to effective, context-specific intervention while continuously improving strategy over time. This approach retains the consistency and scalability of global screening while incorporating the local specificity required for effective intervention design and capital allocation.

1. **Signal:** Identify Priority Basins

Companies should begin by combining global water risk screening with sourcing importance to identify a manageable set of priority basins. Tools such as the Aqueduct Water Risk Atlas and WWF Water Risk Filter can be overlaid with sourcing footprint, volume, revenue exposure, strategic crop importance, or other business-relevant data to generate a portfolio-level heat map of water risk.

From there, companies can rank basins and select a focused subset for deeper analysis, such as the highest-risk and highest-relevance 5–10% of basins, or another threshold appropriate to the company's portfolio. The purpose of this step is triage: to identify where local diagnosis is most warranted before capital is committed.

2. **Diagnosis:** Rapidly Scan Local Context

Once priority basins are identified, a rapid assessment of local context is used to validate risk drivers and identify the factors that will shape intervention outcomes. This scan should focus on a minimum set of decision-relevant variables, including:

a. Hydrologic dynamics (e.g., groundwater-surface water connectivity, recharge patterns),

b. Governance structures (e.g., water rights, enforcement mechanisms, collective management systems),

c. Infrastructure constraints (e.g., irrigation systems, storage, conveyance), and

d. Agronomic and behavioral factors (e.g., cropping systems, farmer incentives, adoption barriers).

The objective of the diagnosis step is to achieve decision-grade clarity on what is driving risk and which types of interventions are likely to be effective. Even a modest set of locally grounded insights from a brief desk review can materially improve decision quality relative to reliance on global indicators alone.

3. **Intervention:** Instigating Change on the Ground

Interventions should be designed around the results of the diagnosis step. In some basins, the highest-value action may be reducing nutrient loading, sediment loss, or other water quality pressures. In others, it may be reducing consumptive water use, changing irrigation practices, shifting crop rotations, or supporting demand reduction. The intervention should follow the diagnosis rather than a standardized practice menu.

This step also requires explicit choices about implementation: whether to work through existing local institutions or build a new bespoke program, whether to prioritize speed or depth of engagement, and how much measurement precision is needed to support internal claims and enterprise targets. The aim is to select actions that are locally coherent, operationally feasible, aligned with internal decision needs, and capable of producing a defensible contribution to water resilience.

4. **Feedback:** Learn and Refine

Effective implementation should both address immediate water challenges and contribute to a flywheel of learning, so that future implementation is progressively improved. Companies should track which practices are adopted, where expected outcomes materialize, where they fall short, and whether the limiting factors are technical, economic, institutional, or social.

This feedback can then be used to refine both basin-level strategy and enterprise-level prioritization. Over time, such a process improves diagnosis, sharpens assumptions about intervention effectiveness, and helps companies allocate capital toward the basins and practices most likely to produce durable risk reduction. Even imperfect measurement can improve decision quality when it is captured systematically, its uncertainty is documented, and it is used to guide the next investment cycle.

Taken together, these steps allow companies to retain the consistency and scalability of global frameworks while incorporating the local specificity required for effective intervention and ongoing learning. In doing so, they can expand their water risk mitigation strategy from a static exercise in target-setting to a dynamic system capable of adapting to evolving conditions and improving performance over time.

Case Study

To make this concrete, we applied the approach above to a simplified hypothetical case study. Our aim is to show how a comparable starting point can lead to materially different strategies once local conditions are taken into account, and how those differences shape well-designed corporate water interventions.

1 Signal: Identify Priority Basin

We selected two agricultural commodity growing regions in the U.S. Great Plains (Figure 1) that appear similar under global risk screening (Figure 2A) but diverse once local context is incorporated. Both regions are important agricultural production areas that likely warrant deeper analysis in many multinational agricultural sector corporate sourcing portfolios. This creates a comparable starting point for examining how local diagnosis changes intervention design.

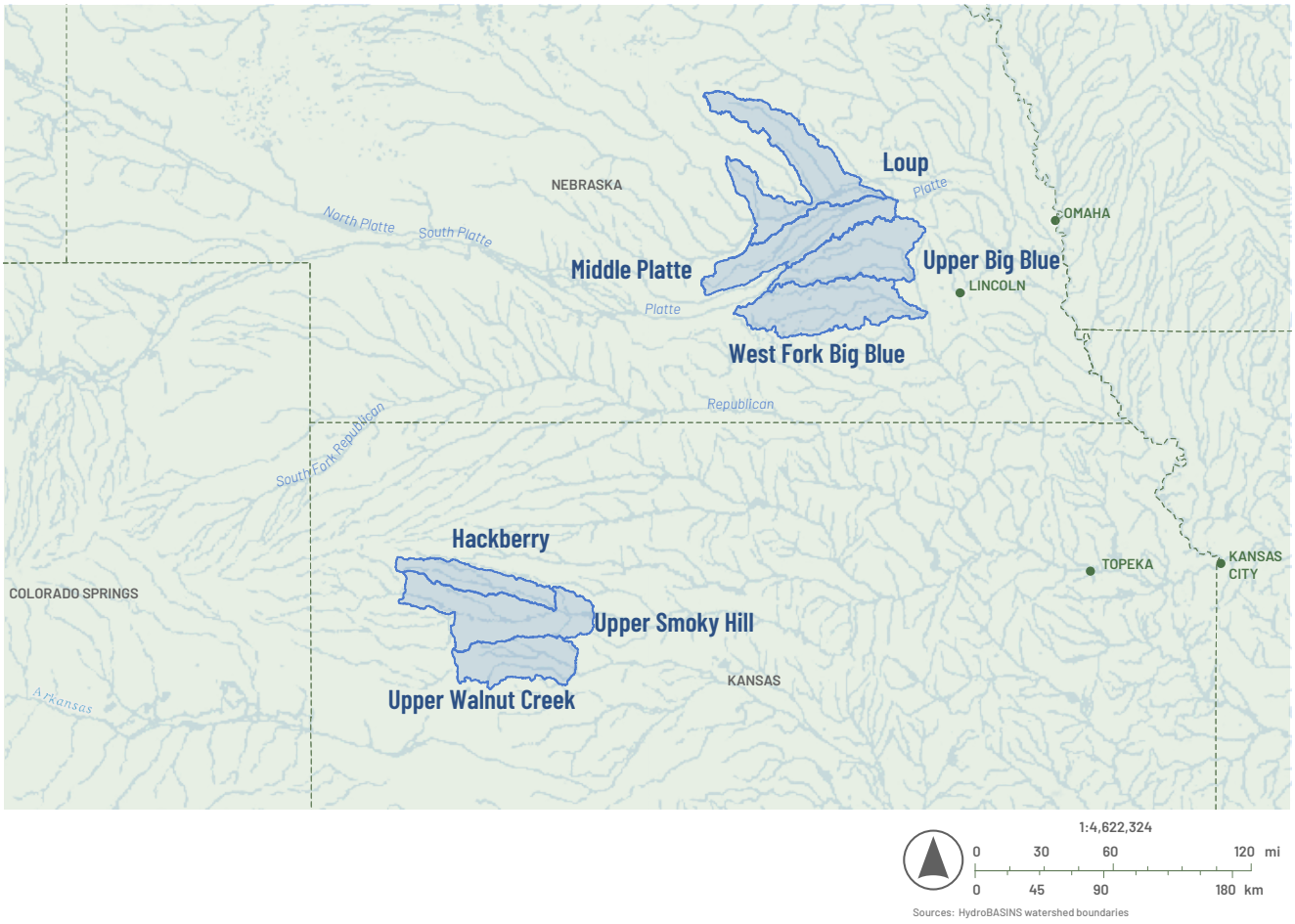


Figure 1. Agricultural sourcing regions used in the case study: east-central Nebraska (Loup, Upper Big Blue, Middle Platte, and West Fork Big Blue basins) and west-central Kansas (Hackberry, Upper Smoky Hill, and Upper Walnut Creek basins).

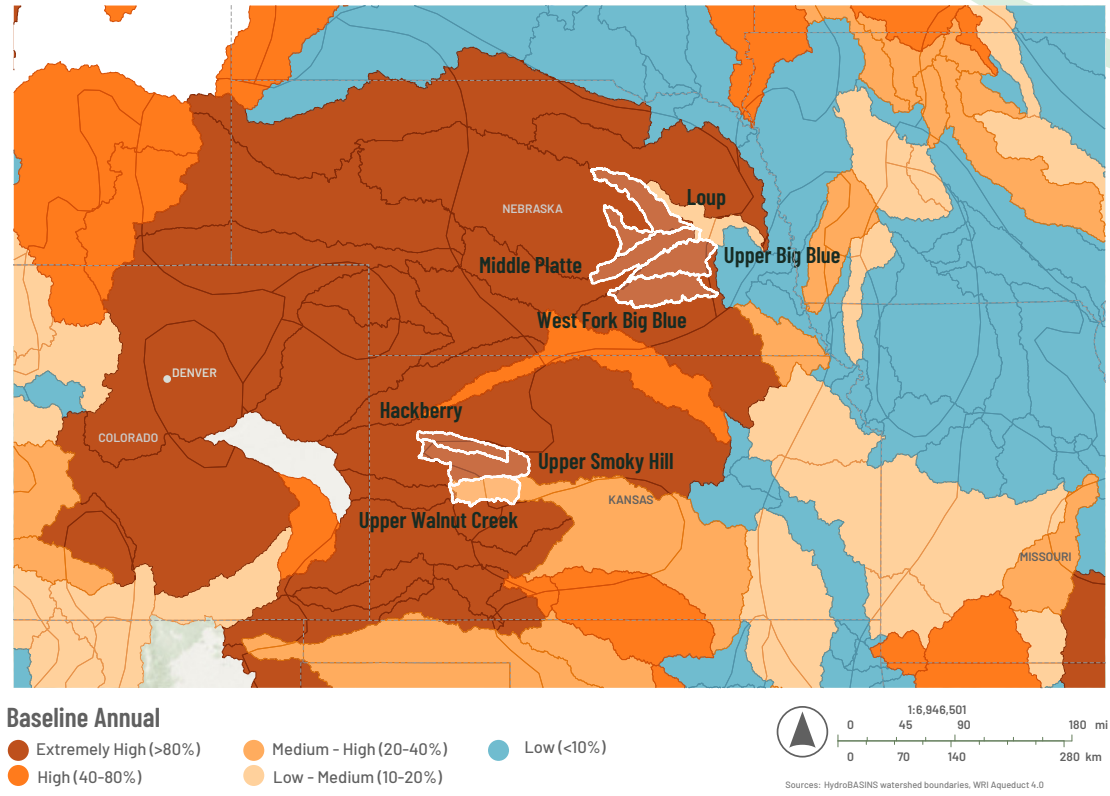


Figure 2A.

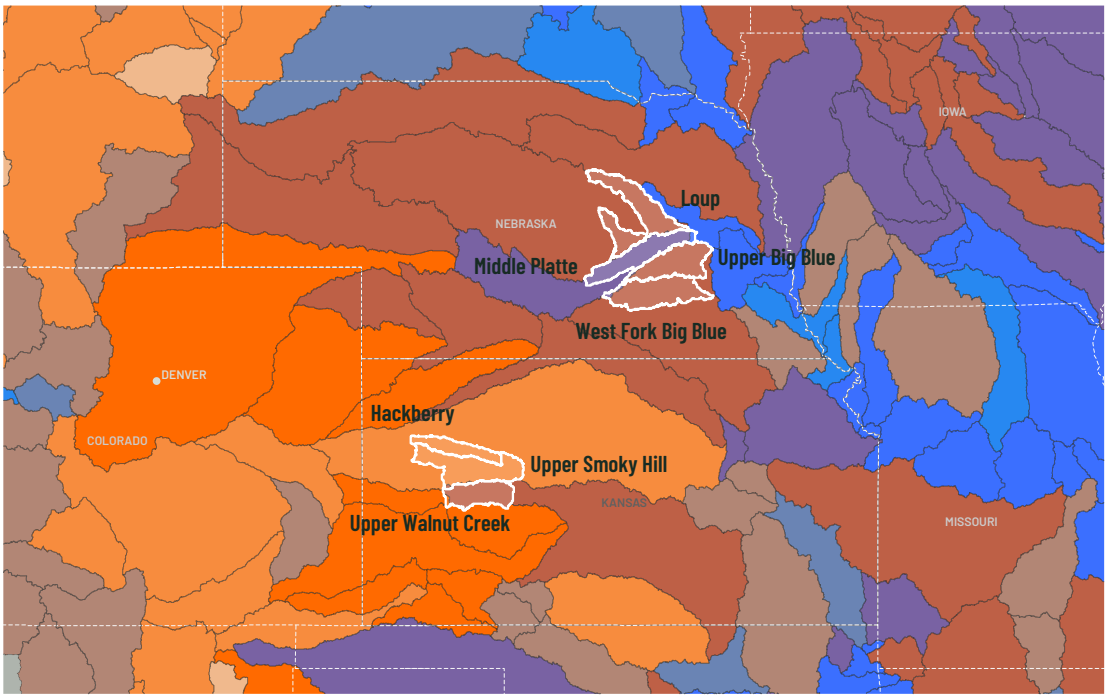


Figure 2B.

Figures 2A and 2B. Aqueduct 4.0 overall water risk in the case-study basins under baseline and future conditions. Figure 2A. shows baseline annual overall water risk. Figure 2B. shows projected future annual overall water risk under Aqueduct's business-as-usual scenario. "Overall water risk" is a composite index derived from multiple quantity, quality, and regulatory/ reputational indicators. From World Resources Institute, Aqueduct 4.0.



2 **Diagnosis:** Rapid Local Context Scan

At the portfolio level, basins in both regions register as "Extremely High" baseline (estimated in 2019 based on data from 1979-2019) water risk using the Aqueduct 4.0 screening tool (Figure 2A) but with divergent future risk profiles (Figure 2B). Both operate under a prior appropriation governance framework for surface water rights, where water rights are allocated on a "first in time, first in right" basis. While Kansas groundwater rights are similarly governed by prior appropriation, Nebraska manages groundwater based on correlative rights ("share and share alike"). Both are also major agricultural production regions with extensive irrigation and established local management institutions. A rapid local context scan, including desk review and interviews with local water managers, revealed that this apparent similarity masks materially different risk structures. Eastern Nebraska's persistent constraint is water quality, while western Kansas faces a more fundamental water availability constraint.

In Nebraska, irrigation is predominantly sourced from a portion of the Ogallala Aquifer that is relatively thick compared to the rest of the Aquifer and is regularly replenished by precipitation and surface water interactions, particularly from the Platte River system (Figures 3 and 4). Non-consumptive water (i.e., water not lost to crop uptake [evapotranspiration] or direct evaporation) often re-enters the system within relatively short timeframes, supporting downstream freshwater ecological flows, municipal use, and additional agricultural withdrawals. As a result, groundwater declines tend to be episodic rather than persistent, and constraints on irrigation are typically felt when rainfall is insufficient (i.e., in more arid zones or during drought). Coarse-textured soils, shallow water tables in parts of the region, intensive tillage practices, and widespread fertilizer use contribute to nitrate, phosphorous, and sediment loss to ground and surface waters. These biophysical conditions interact with agricultural practices to create a system where water availability is relatively stable, but water quality is under pressure. In this context, the persistent risk is water quality.

In the Kansas basins, by contrast, water availability is the central constraint. Many areas rely on thinner alluvial aquifers that are recharged primarily by local precipitation and are more sensitive to sustained withdrawals. Even where the Ogallala Aquifer is present, it is often less thick and less resilient than in Nebraska (Figure 4). Higher evapotranspiration rates and lower annual precipitation in the Kansas basins we selected for our investigation further increase dependence on groundwater. These biophysical constraints are not readily ameliorated through existing by management dynamics. Groundwater Management Districts and Locally Enhanced Management Areas (LEMAs) provide mechanisms for collective action, but they operate within systems where water scarcity is already structurally embedded. In many areas, groundwater levels have been in long-term decline, agricultural production is tightly coupled to water availability, and governance solutions are limited.

These distinctions determine not only the magnitude of potential impact, but its direction. Interventions that improve irrigation efficiency, for example, may reduce consumptive use in one system but primarily alter return flows in another, depending on groundwater–surface water connectivity and local governance constraints. Likewise, nutrient management strategies that are highly relevant in one basin may have limited impact in another where water quantity dominates.

Another critical investment implication emerges from the diagnosis step. Under Aqueduct's future business-as-usual scenario screening, the Nebraska basins appear to remain high risk, while the Kansas basins appear to decline in overall water risk (Figure 2B). Local diagnosis suggests the opposite interpretation for intervention planning. The Nebraska sourcing area overlies a thicker and more buffered portion of the High Plains aquifer, where groundwater availability is less likely to become the binding constraint on agricultural production in the near term. Kansas, by contrast, depends more heavily on thinner, locally recharged, and capacity-limited groundwater systems, making it more vulnerable to production disruption even where the future composite risk score appears lower. For capital allocation, this distinction matters: Eastern Nebraska may warrant investment primarily to reduce water quality impacts, while western Kansas may warrant investment to reduce exposure to water availability constraints that are not fully captured by the screening result.

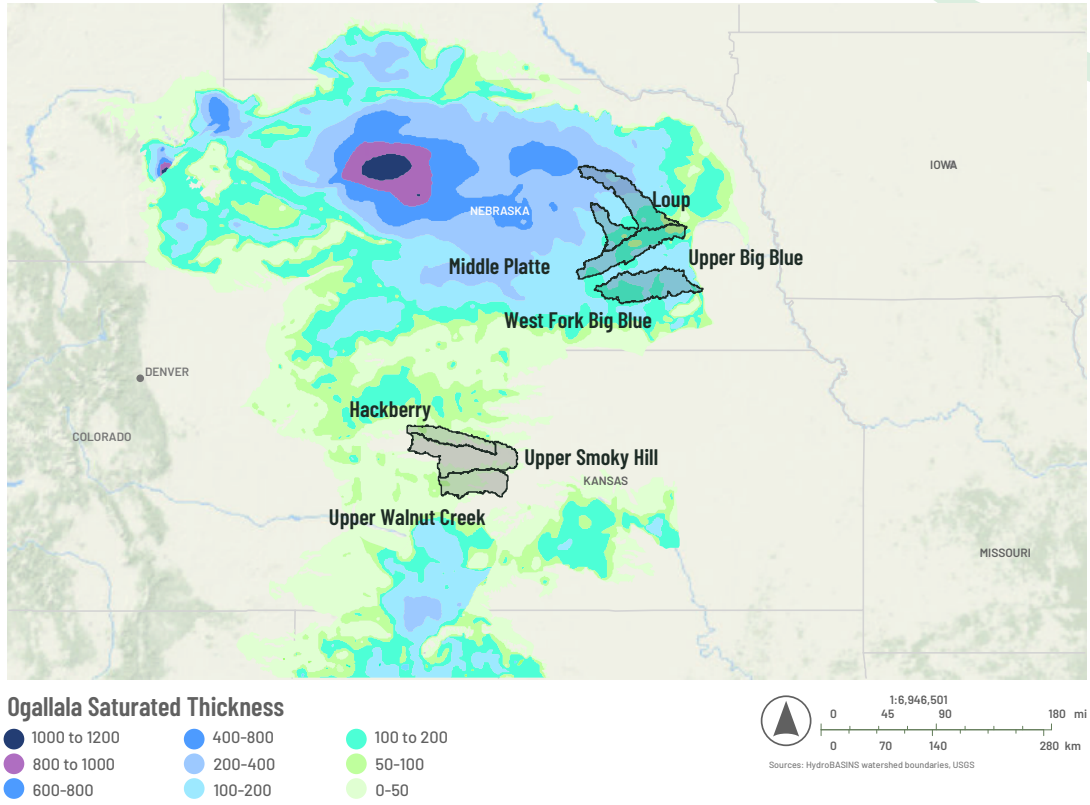


Figure 3. Case-study basins overlaid on saturated thickness of the High Plains/Ogallala aquifer. The Nebraska sourcing area overlies a thicker and generally more buffered portion of the aquifer system, while the Kansas sourcing area includes thinner or more locally constrained groundwater supply. From U.S. Geological Survey, 2022.

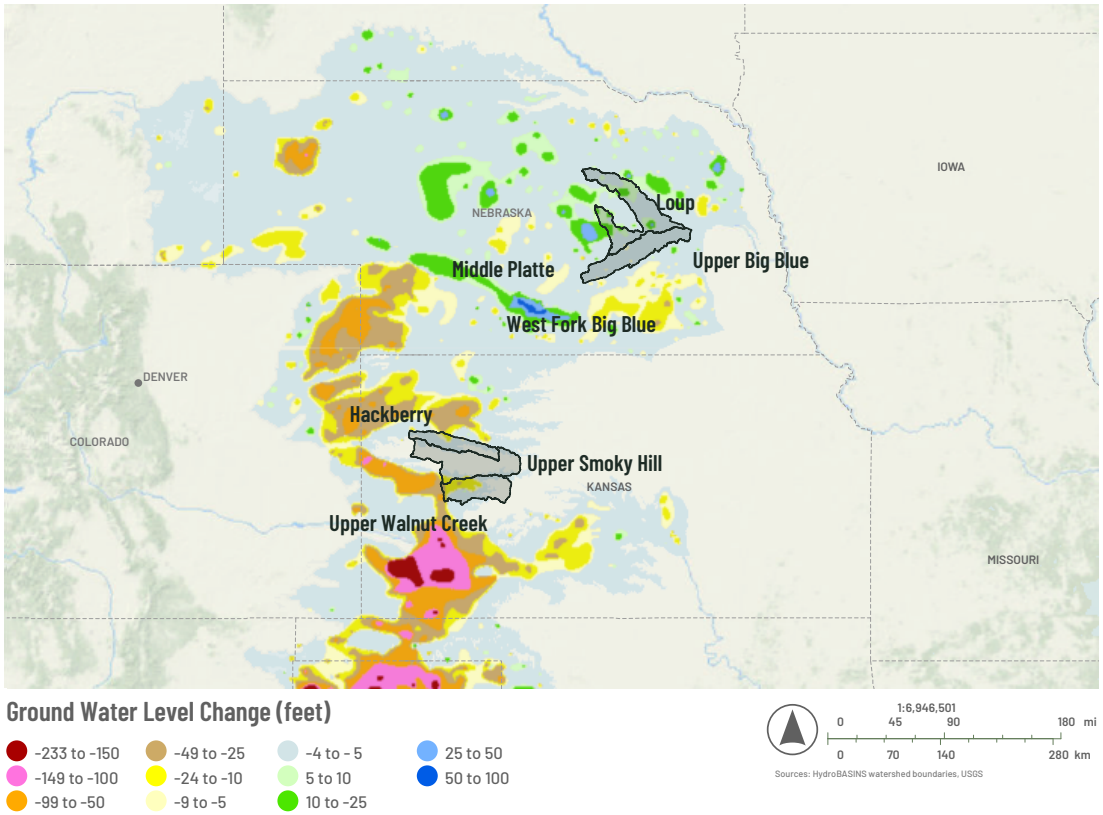


Figure 4. Groundwater-level change in the High Plains/Ogallala aquifer from pre-development to 2015, illustrating greater long-term groundwater decline in the Kansas portion of the case study relative to the Nebraska portion. From U.S. Geological Survey, 2018.

3 **Intervention:** Instigating Change on the Ground

At a high level, effective intervention design comes down to aligning on the risk driver a company wants to abate (e.g., quality versus quantity or both), and the physical behavior of the system (how water and pollutants move through the system).

In the Nebraska basins, where water availability is relatively stable, but water quality is under pressure, the risk driver is water quality. In the US Great Plains cropland context, that leads to a fairly specific set of priorities, including improved fertilizer application (rate, timing, placement, type), use of cover crops and improved tillage management to reduce leaching and erosion, using soil biologics or other amendments where supported by the best available evidence, and managing irrigation to reduce leaching and runoff.

The specific interventions change in the Kansas basins, where the priority shifts to reducing consumptive water use. In practice, that means a combination of improving irrigation efficiency and introducing deficit irrigation, both through technology and scheduling; possibly shifting cropping systems to include more water-efficient crops in rotation (e.g., sorghum); introducing periods of fallowing; and/or reducing tillage to retain soil moisture and limit evaporative loss.

These practices are well-established, but their impact depends heavily on context. For example, improving irrigation efficiency in a system with strong groundwater–surface water connectivity may primarily alter the timing and location of return flows rather than reduce total consumptive use. In contrast, in more hydrologically isolated or capacity-limited systems, the same intervention can result in a direct and durable reduction in water withdrawals. This distinction depends on ground–surface water connectivity and local governance rules around withdrawals, and is where local context in the design of interventions becomes decisive.

In these basins, engaging existing local systems is likely the fastest route to impact. These entities already have trusted relationships with farmers and a working understanding of what is feasible. They know where adoption will stall and where it can move quickly. Partnering with them allows companies to operate inside that existing infrastructure, rather than trying to recreate it. For more details on practice identification and impact estimates, see the Appendix.

4 **Feedback:** Learn and Refine

Even well-designed interventions will not behave exactly as predicted because water systems are inherently dynamic. The real value of implementation is what the system reveals about how the intervention behaves under real conditions. This is where static, target-centric corporate strategies tend to break down, because measurement is treated as the end goal rather than as a source of learning.

Focusing on surprise and uncertainty as sources of learning is how companies build capacity to adapt faster than water risk compounds.

In practice, that means paying attention to patterns that emerge across interventions: which practices farmers feasibly adopt, under what conditions, where expected outcomes materialize, and where they do not. When results fall short, the key question is whether the constraint is technical, economic, institutional, or social. Those observations do more than improve the next round of implementation. They also sharpen future estimates of likely target contribution, cost-effectiveness, and durability. Over time, this is how a company moves from generic basin prioritization to more efficient investment linked to demonstrated impact.

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Conclusion

Global water risk frameworks are essential tools for corporate water strategy, but they cannot determine on their own what a company should fund, where it should act, or what outcomes it can reasonably expect. Their value is strongest at the portfolio level to help companies identify where water-related risk may be material and where deeper attention is warranted. Once a company moves from prioritization to investment, however, local hydrology, governance, infrastructure, agronomy, and adoption dynamics determine whether an intervention will reduce risk in practice.

Our Great Plains case study illustrates why that distinction matters. East-central Nebraska and west-central Kansas can appear broadly similar under global water risk screening, yet local diagnosis points to materially different strategies. In Nebraska, the more durable constraint is water quality, particularly nutrient loss to groundwater. In Kansas, the constraint is water availability, shaped by thinner and more locally constrained groundwater systems, lower precipitation, higher evapotranspiration, and long-term depletion risk. These differences change which interventions are appropriate, how impact should be measured, and where corporate capital is most likely to produce defensible progress toward water resilience.

For companies, the practical implication is not to abandon global targets or screening tools. It is to use them for what they do best, then connect them to a structured process of local diagnosis, intervention design, implementation, and feedback. Targets can still provide direction, consistency, and accountability, but the path toward achieving them should become more precise with each cycle of learning. In this way, corporate water strategy can move beyond static target-setting toward an adaptive investment and learning system: one that identifies material risk, tests locally coherent interventions, learns from implementation, and directs capital toward the places and practices most likely to build durable water resilience in agricultural supply chains.

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Appendix

This appendix provides the technical scaffolding behind the case study. Its purpose is to show how basin-specific hydrologic, agronomic, and management conditions can be translated into indicative estimates of likely intervention fit, target contribution, and measurement needs. In other words, how the approach outlined above can achieve a "both/and" of meeting enterprise target setting goals while developing the conditions necessary for learning and long-term adaptive capacity to manage water-related risks in corporate sourcing footprints.

Additional technical notes on the basins

In the Nebraska sourcing area, irrigation water is predominantly withdrawn from a portion of the Ogallala Aquifer[1] that is deep and replenished through precipitation and runoff from the Rocky Mountains into the Platte River. Any non-consumptive returns (i.e., water applied in excess of crop use) to the system typically return to the Ogallala and adjacent Platte River in a matter of months to years, where they can be used for additional agricultural withdrawals, municipal and industrial use, and to provide for aquatic ecosystems. In years of heavy irrigation and light rainfall, this area will experience ephemeral declines in the groundwater table, with subsequent average rainfall years typically restoring those declines so that, overall, declines are marginal in each ten-year window with average precipitation. Rarely is in-season irrigation limited by aquifer levels and/or pumping capacity. The predominant crops grown are corn and soy. Across the Great Plains (which encompasses our entire study area), future precipitation patterns under climate change are expected to shift. While the total amount of growing season rainfall is predicted to increase slightly, it will likely occur in fewer, but more intense, storm events. This means longer dry periods between rainfalls, punctuated by heavier downpours (Shulski, 2019).

The Kansas sourcing area falls both within and outside of the Ogallala Aquifer. Those basins outside of the Ogallala rely on thin, capacity-limited alluvial aquifers, i.e., groundwater that is directly recharged (i.e. replenished) by precipitation in the immediate area, with surface stream flow seeping into the ground where it is stored or emerges above ground as springs. Because the alluvial aquifer is thin and recharged only by precipitation, delays in return flows from nonconsumptive use (i.e., water not consumed by the crop), coupled with heavy groundwater pumping and low stream flows, means the aquifer is regularly in decline. Saline groundwater is also present in the Kansas areas, which further limits irrigation. The marginal areas in the Kansas sourcing basins that do fall over the Ogallala are in zones where the aquifer is thinner (i.e. less storage) relative to those in Nebraska.

Both the Ogallala and alluvial aquifer groundwater sources in the Kansas basins rely on seasonal precipitation for recharge. Growing season groundwater available for withdrawals is directly linked to growing season precipitation, a much tighter linkage than is observed in Nebraska, where declines are less sensitive to withdrawals and precipitation on a local, annual basis. In other words, in these two areas, Nebraska farmers are more able to rely on groundwater for irrigation in a dry year than Kansas farmers. Additionally, evapotranspiration rates are higher, and annual precipitation is lower, in Kansas sourcing areas, leading to greater reliance on groundwater to make up precipitation deficits for the same crop compared to Nebraska.

Since 2000, there has been a consistent linear decline in withdrawals across the Kansas overlay of the Ogallala aquifer. At existing annual depletion rates, it is estimated that some areas in Kansas may have less

1 While the Ogallala Aquifer has become synonymous with groundwater stress, it is part of an aquifer system (the High Plains Aquifer) that stretches from Texas to South Dakota and not all parts are created equal. The aquifer itself changes significantly in depth and thickness across its extent, as do surface-level conditions that influence the aquifer's depth, thickness, and depletion rate.

than 50 years' worth of water supply if current pumping continues, while other areas are projected to experience significant aquifer loss within the next 50 to 100 years (Steward et al., 2013). Predominant crops grown in the region are corn, alfalfa, wheat, sorghum, and, more marginally, triticale.

To estimate the specific water use needs in each area, we relied on public data sources and scientific literature to understand approximate field-level water use. Individual and aggregate farm management data on water and nutrient application are not publicly available. For these estimates, crop evapotranspiration (ET) can be used as a proxy for water use. Crop ET occurs whether a crop is irrigated or not. In the basins of interest in eastern Nebraska, ET of irrigated corn can be estimated at 19 inches per growing season while irrigated soybean ET rates are around 17 inches per growing season (Sharma & Irmak, 2012). This equates to approximately 1.95 million liters of water use per acre of irrigated corn and 1.75 million liters[2] of water use per acre of irrigated soybean fields in these basins. Because these fields receive insufficient precipitation, a portion of the crop's water use includes irrigation water that producers directly apply to fields. Approximate per-field irrigation requirements in the basins of eastern Nebraska are 7.7 and 6.2 inches of irrigation for irrigated corn and soybean, respectively, or 790,000 liters and 640,000 liters of water use (Sharma & Irmak, 2012; Figure 5). These values indicate that irrigation can make up ~35-40 percent of crop water use in the irrigated corn and soybean fields in eastern Nebraska, with the rest coming from rainfall during the growing season.

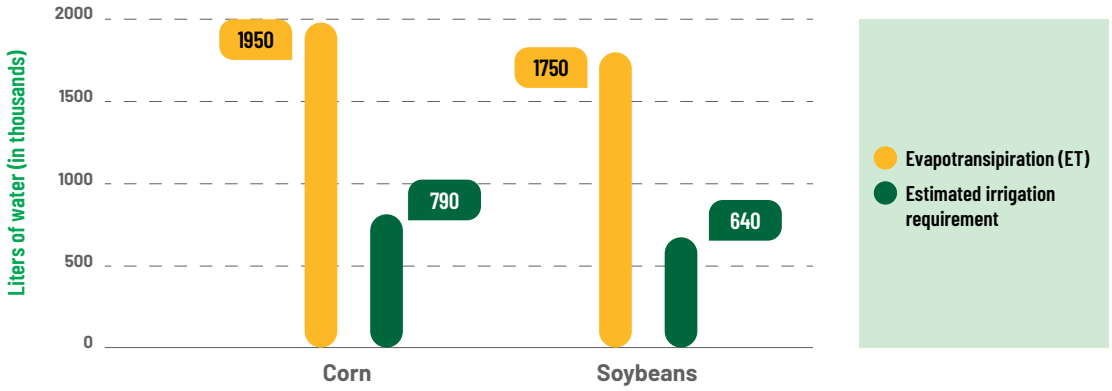


Figure 5. Approximated evapotranspiration (ET) and irrigation water requirement for corn and soybeans in Nebraska. With data from Sharma and Irmak (2012).

The wheat and sorghum fields that dominate the landscape of the basins of interest in Kansas are almost entirely rainfed systems. Average growing season ET totals estimated from studies in the area are 19 inches for rainfed wheat and 20 inches for rainfed sorghum, equivalent to 1.95 million liters per acre of water use for wheat and 2.0 million liters per acre of seasonal water use for sorghum (Rogers et al., 2015). The majority of corn in the western basins in Kansas is irrigated with average ET totals of 29.5 inches, or 3.0 million liters per acre of water use of which some portion is from irrigation water (Rogers et al., 2015). The estimated field-level irrigation requirement for corn in the selected basins in Kansas is 15 inches, equivalent to 1.5 million liters per acre of water use coming from irrigation – roughly 51 percent of the total water use (Presley et al., 2012; Figure 6).

2 Liters and inches are both used here because each are distinctly commonplace for their individual use cases, i.e., liters for corporate targets and inches for discussing on-farm irrigation in the US.

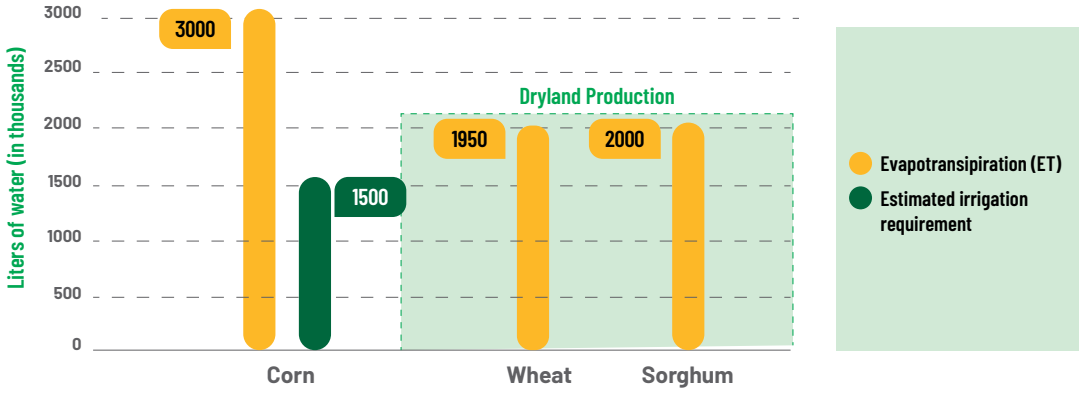


Figure 6. Approximated evapotranspiration (ET) and irrigation water requirement for corn, wheat and sorghum in Kansas. With data from Presley et al., 2012.

It is imperative to note that this simplified approach to ET estimates assumes no over or under-application of water by the farmer in irrigated fields and is purely a rough approximation rather than a precise account of what occurred on each field.[3] In most cases over or under application occurs, either because farmers are hedging against risk (over-application), lack precision irrigation tools (over-application), hit their specific irrigation allocation (under-application) or are intentionally using a management technique called deficit irrigation to reduce consumptive use (under-application). Additionally, ET rates vary significantly across geographies and crop types, and annual and seasonal variations in precipitation have a profound impact on water use and irrigation applications.

Water quality degradation due to loss of topsoil from agricultural areas is also a source of material risk to agricultural production. Such erosion is driven by a combination of factors, including on-farm management practices and climatic factors like timing, amount, and intensity of precipitation and wind. In the basins of interest in Kansas, which receive comparatively less precipitation than those in Nebraska, wind is the primary climatic driver of sediment loss. Sediment loss estimates for this part of Kansas are roughly 1.5 tons per acre per year from sheet and rill erosion caused by rainfall and surface water runoff and 3 tons per acre per year from wind erosion (USDA, 2020). Eastern Nebraska receives more annual precipitation and is characterized by the presence of rolling hills, contributing to more significant sheet and rill erosion. Sediment losses here are estimated at 3-4 tons per acre per year from sheet and rill erosion and 1 ton per acre per year due to wind erosion (USDA, 2020). Where local, field-level data is available, calculations such as the Universal Soil Loss Equation can be used to precisely estimate sediment loss (Figure 7).

3 Open-source data platforms like OpenET, although limited in geographic coverage, provide more precise estimates of field-level water use. OpenET provides satellite-based evapotranspiration data for agricultural land west of the Missouri River in the continental United States. This data can be combined with publicly available precipitation data to estimate field-level irrigation requirements in addition to utilizing the ET estimates for each field and crop type. OpenET and similar remotely-sensed data sources are not a substitution for field-level in-situ measurements but offer an increased degree of accuracy over state or region-wide estimates or data from limited field studies.

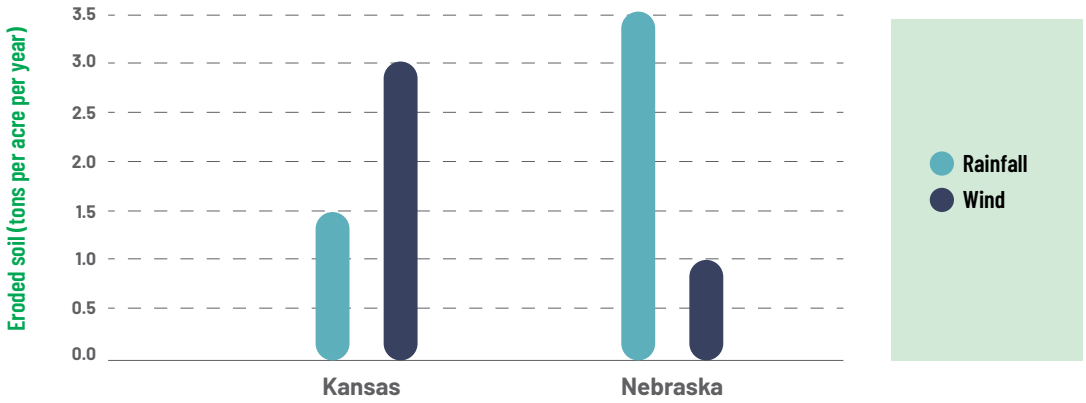


Figure 7. Estimated soil erosion in Kansas and Nebraska, differentiated by its cause: rainfall or wind. Using RUSLE2 data from USDA, 2020.

While water use and sediment loss are highly dependent on local conditions and field management, nutrient loss in agricultural landscapes is governed by even more complex environmental and biophysical interactions. Because of this, there is a major gap between coarse, regional or catchment-level estimates of nutrient loss, and many studies that are highly localized at the field or plot level require extensive measurement and modeling.

In irrigated and rainfed cropland in Kansas and Nebraska, nitrogen and phosphorus are the most applied nutrients. Nitrogen fertilizer is predominantly lost via leaching to groundwater, which can be exacerbated by soil type, nitrogen fertilizer type, precipitation or irrigation patterns, application amounts, and application timing (e.g., fall application or pre-plant application). Phosphorus fertilizer is more commonly lost due to surface runoff and sediment loss, with the magnitude of loss varying based on surface topography, soil type, application amount and timing, and precipitation and irrigation events. Phosphorus binds to clay-organic matter complexes and can accumulate in soils, whereas nitrogen tends to be more readily lost. Estimates of nitrogen loss from cropland in Nebraska and Kansas reflect the wide range of variables, with some estimates ranging from 40-80 lbs per acre of nitrogen loss (Thapa et al., 2018; Nouri et al., 2022; Rogovska et al., 2023).

Additional technical notes on the interventions

Water quality impacts from interventions can be particularly difficult to measure when groundwater is involved due to the lag between surface activities and residence time of nutrients in the vadose zone before reaching groundwater. Additionally, impacts of implementation of any on-farm practice will be heavily impacted by variables such as local soil type, drainage system, cropping rotation, type of implementation (e.g. specific cover crop planted), planting dates, seasonal variation in precipitation, etc. Global studies on cover crops and reduction of nitrate leaching show a wide range of results but several studies indicate potential nitrate leaching reductions of around 40-50 percent when cover crops are implemented (Thapa et al., 2018; Nouri et al, 2022; Rogovska et al., 2023). A study in Nebraska indicated corn-soybean crop rotation may reduce nitrate leaching by 40% compared to continuous corn cropping (Wortmann et al., 2020). Additionally, use of cover crops was shown in a Kansas study to reduce sediment loss by ~67 percent compared to no cover crop (Carver et al., 2022). The same Kansas Carver et al. (2022) study reported a 19 percent reduction of total phosphorus loss by switching fertilizer application from fall broadcast application to



subsurface, spring application of phosphorus fertilizer. Other studies have indicated that conventional rules around fertilizer applications often result in over application of fertilizer and underestimation of existing residual nutrient availability in the soil (Singh et al., 2025) and reducing excess fertilizer application may have a greater impact on reducing nitrate leaching than irrigation rates.

For illustrative purposes, a 25 percent reduction in nutrient and sediment losses provides a reasonable directional estimate for evaluating potential target contribution, while recognizing that actual outcomes would depend on practice mix, baseline conditions, adoption rates, and measurement design. If a company has a 500,000 acre sourcing footprint in each location, for example, that would equate to a roughly estimated 562,500 tons (562,500,000 kg) of topsoil saved in the Kansas basins per year and 625,500 tons (567,500,000 kg) of topsoil in the Nebraska basins saved per year.[4] It could also yield a roughly estimated 7,500,000 lbs (3,401,943 kg) per year of nitrogen fertilizer saved in each location,[5] although this number is variable based on application rate/timing/placement and conditions like rainfall, winter soil conditions, and other factors outside of a farmer's immediate control. A water quality program in the Nebraska sourcing area, assuming a 500,000-acre sourcing footprint, could therefore plausibly avoid hundreds of millions of kilograms of sediment loss and several million kilograms of nitrogen loss annually, though the share reaching surface water or groundwater would depend on local soils, hydrology, practice design, and measurement approach.

Both Nebraska and Kansas have robust, specialized local agencies to manage water resources: Natural Resources Districts in Nebraska, and Groundwater Management Districts in Kansas. These programs present an opportunity for corporate partnership to create a bespoke program to address the primary water challenges within the Kansas sourcing basins: water scarcity. Costs for establishing a joint program could be $500,000 or more depending on the type of program and resources needed to collect data, engage with farmers, provide cost-sharing, and measure impact. Because a company would be able to contribute substantially to the program execution, there is potential for a high degree of contribution to enterprise water targets as well as high direct impact on the ground from having partners engaged locally. Potential practices that could be implemented as part of a program in rainfed areas of the Kansas sourcing basins include incentives and cost-sharing to encourage more diverse cropping practices to improve soil health such as encouraging no-till or reduced tillage and potentially cover crops to build soil health. In irrigated basins, similar practices may be implemented as well as cost-sharing for conversion to more efficient irrigation systems and improvements to existing irrigation systems to decrease consumptive use.

4 Assuming figures listed in text above, i.e., an average of 4.5 tons/ac/yr lost in the Kansas sourcing area and 5 tons/ac/yr in the Nebraska sourcing area.

5 Assuming the estimate listed in text above, i.e., an estimated 60lbs/ac/yr of nitrogen is lost. This value is highly variable and benefits from additional data collection, e.g., farmer surveys about application rates, seasonal rainfall data, and potentially soil testing in support of defensible corporate claims.

Potential impact

Long-term studies in western Kansas indicate potential for reduced water use and increased water productivity by diversifying crop rotations and utilizing three to four-year cropping rotations of wheat, sorghum, and fallowing. Specifically, rotations of wheat-wheat-sorghum-fallow and wheat-sorghum-sorghum-fallow show increased water productivity, grain yield, and available soil water compared to continuous wheat rotations (Schlegel et al., 2016). Additional studies have illustrated that sorghum is more drought tolerant than winter wheat and has higher water productivity, demonstrating 75 percent greater yield response per unit of water use than winter wheat making the case for increased production of sorghum instead of winter wheat in water stressed areas such as western Kansas (Moberly et al., 2017). A conservative planning assumption for an agricultural sector company would be a minimum 15 percent water savings from a typical intervention program (and up to 50 percent if crop rotations and a landscape scale initiative was undertaken), which equates to a conservative estimate of roughly 225,000 liters saved per acre in the Kansas basins, and slightly lower (~200,000) liters per acre saved in the Nebraska basins. If a company has a 500,000 acre known sourcing footprint in west-central Kansas, that would equate to a rough estimate of 112 billion liters saved per year.

Both reduced tillage and no-till practices have been shown to retain more soil moisture. Studies in western Kansas found that fields with crop residue completely covering the soil surface (typically indicative of conservation tillage or no-till) had 50-65 percent less surface evaporation compared to bare soil (Presley et al., 2012). In a rainfed system, this decreased surface evaporation can translate into actual water savings. However, water savings are more complex to quantify in an irrigated cropping system as only a portion of excess irrigation is lost from the system (i.e. via consumptive use) while the rest remains in the watershed via recharge or runoff to surface water.

Grants supporting existing local programs

There are already many existing programs in both the Kansas and Nebraska sourcing areas that are effective and in need of additional funding. A company could contribute funding ranging from $10,000-$200,000 to support these existing programs and fund activities like experimental practices, promotion of nutrient management and cover cropping, and additional technical support to drive new practice adoption. Funding these programs would result in a high degree of direct impact but would be accompanied with more difficulty in translating outcomes to enterprise water targets.

Basins in Kansas are managed under a prior appropriation governance framework, in which water rights are based on a "first in time, first in right" principle, i.e., the earliest users have senior rights to water usage over later users. Nebraska basins are managed under a mix of prior appropriation and correlative rights, with surface water resources falling under the prior appropriation doctrine and groundwater resources following correlative rights. Correlative rights to groundwater allow all landowners who own property above the shared aquifer to have coequal rights to access and use the resource. In both systems, water withdrawals (from streams or groundwater) are regulated by local governance entities empowered to manage groundwater decline by limiting withdrawals. These agencies consist of 23 Natural Resources Districts in Nebraska covering the entirety of the state, and 5 Ground Water Management Districts in Kansas covering select portions of western and central Kansas. In Nebraska,

the State's Department of Water, Energy, and Environment collaborates with the Natural Resources Districts to develop an Integrated Management Plan to ensure that the two water resources, surface and groundwater, can be managed unilaterally despite their differing water rights framework. The Kansas basins have an additional optional management program in place, called a Locally Enhanced Management Area (LEMA), designed to empower local stakeholders to more proactively manage water depletion in their area by proposing a management plan enforced by the state. The management districts in both states were established in the early 1970s and are uniquely robust and mature examples of locally-managed resource management frameworks. There has been a concerted effort to manage/measure groundwater usage across both states, and parts of both states have groundwater allocations (meaning users have restrictions on how much they are allowed to pump) and local regulations to protect groundwater quality. Both the Nebraska and Kansas central basins are significant agricultural areas for the nation in terms of economic contribution and agricultural productivity.



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