Applying AI For Smart Soil Management

MANAGING RISK AND UNEARTHING OPPORTUNITY

THE 2023 GUIDE

ClimateAi

Contents

Introduction

MANY BUSINESSES ARE IGNORING A SIGNIFICANT MATERIAL RISK RIGHT AT THEIR FEET — OR UNDER IT. THE HEALTH AND QUALITY OF SOIL, OR LACK THEREOF, CAN QUICKLY JEOPARDIZE THE OPERATIONS, SUPPLY CHAIN, AND PROFITABILITY OF ANY COMPANY THAT DEPENDS ON NATURAL RESOURCES.

Today, climate change, deforestation, urbanization, and intensive farming practices erode, pollute, and degrade the soil, a precious resource. Already, about one-third of the Earth's topsoil has been severely degraded, according to the United Nations, with an estimated 90% of global soil likely to be at risk by 2050. The impact of soil degradation could total $23 trillion in losses — of **food, drinking water, medicine, manufactured goods, and ecosystem services at large** — worldwide by 2050, according to the United Nations.

As climate change accelerates, accounting for soil becomes an increasingly important part of future-proofing any company's ongoing operations and long-term strategy. Soil health, especially in agricultural systems, is crucial as companies, investors, and consumers increasingly look to protect productivity in a climate-changing future. Left unmanaged, or managed in the wrong way, it can quickly become a material physical risk and a financial liability. Plus, soil risks directly intersect with two other top business risks: water risks and climate change risks.

Well-planned soil management strategies secure supply chains and are crucial for regulatory, reputational, and market reasons. Businesses need to show that they have these strategies in place to access land from local communities, receive resources from investors and other stakeholders, and stay ahead of certain national and local regulations. Companies must ensure that land they are responsible for is not facing regulatory action.

Today's AI-driven technology can empower businesses with advanced analytics, predictive capabilities, and real-time monitoring to make data-driven decisions, optimize soil utilization, and adopt sustainable practices for soil management.

What businesses are most at risk?

The impacts of poor soil health are first and foremost felt by companies that produce or source land-intensive goods, such as foods, fiber, timber, and other medicines and materials.

FOOD AND AG SECTORS

The world relies on soil for 95% of our food production, so agribusinesses (and food security at large) are directly exposed to a number of risks that could happen when soil is not properly managed. Food production faces risks from the loss of soil function — and at the same time, farming practices can accelerate these factors.

FARMING PRACTICES THAT ACCELERATE THE LOSS OF SOIL FUNCTION:

- **Slash and Burn** - the burning and clearing of forests to make way for farmland
- **Conventional Tillage** - tilling with a V-plow, spring-toothed harrow, chisel plow or field cultivator, and double-disking
- **Monocropping** - growing a single crop (often corn, soybeans, and wheat) year after yearn on the same land (for short-term profitability, but can kill nutrients and leave the soil weakened)
- **Overgrazing** - excessive livestock grazing can cause damage to grassland
- **Excessive fertilization or irrigation**
- **Excessive use of pesticides**

IMPACTS ON SOIL	CONSEQUENCES OF LOSS OF SOIL FUNCTION	BUSINESS IMPACTS
Wind and water erosion	Lack of biodiversity	Lower land productivity
Soil pollution	Crop damage	Higher input prices, for fertilizer, pesticides, and water
Compaction	Increased pest and disease incidence	Lower profits from lower quality and decreased yields of crops
Soil salinity	Decreased yields	Rising commodity prices
Soil oversaturation	Lower quality crops	Disrupted operations
Poor soil moisture, quality, structure, and/or health	Less nutritious crops	Greater regulation and reputational risk

CONSIDER: **According to the U.N., soil erosion may reduce up to 10% of crop yields by 2050, which is the equivalent of removing millions of acres of farmland. Global food production might be reduced by up to 33.7 million tons.**

APPAREL AND TEXTILES

The apparel value chain — raw-material production, material preparation and processing, and end of life — is both a culprit and a victim of soil risks and intersecting risks, like biodiversity and water. Apparel supply chains have been directly linked to soil degradation, the conversion of natural ecosystems, and waterway pollution.

RAW MATERIALS	RISKS
Cotton	Water and insecticide-intensive
Wood-based natural fibers	Created from cellulose, mainly derived from wood; more than 150 million trees are logged annually to create it
Natural fibers from wild animals	Can lead to food chain disruptions and trap non-target species and overexploit certain species for their skins, fur, and wool
Synthetic fibers	Can lead to destruction of natural habitats for mining of coal and petroleum for polyester, as well as land and water pollution
Livestock	Can cause deforestation from land use for grazing and feed grain production, releasing excess emissions, and also cause water pollution from livestock breeding

CONSIDER: **Kering, the parent group of the fashion brands Gucci and Puma. The company reported in 2015 that 45% of its environmental impacts were associated with producing raw materials such as wool, cotton, and leather. The biggest contributor, land-use change, totaled $202 million in damages per year, and the effects of soil degradation are hidden in this cost.**

WOOD INDUSTRY

Forestry, logging, the timber trade, and the production of primary forest products and wood products (e.g. furniture) and secondary products (e.g. wood pulp and paper) depend on the health of forest soils, which are very unique ecosystems. They have high activity and diversity of microbes, soil fauna, vegetation, and plant roots, though different tree species thrive in different soil structures, porosities, and pH balances. This soil is vulnerable to compaction, drought, pests, and deforestation. Wood products are borne of either tree plantations — which are productive but use monocropping which can hurt soil quality — or natural forests — which means deforestation, and erodes soil and releases GHG emissions.

ADDITIONAL INDUSTRIES

Medicine also relies on soil for developing new antibiotics. Bacteria that produce antibiotic compounds that are highly toxic to other bacteria can help develop new drugs to fight increasingly antibiotic-resistant infections. When soil dies, this lifeline to new medicine and pharmaceuticals is at risk. Additionally, the real estate sector is vulnerable to soil contamination, because it determines the feasibility of the location for development and also could risk regulatory action. Plus, the mining industry faces serious reputational risk due to the potential for destruction of the soil structure of lands and vegetation restoration on post-mining lands.

What are companies doing today to manage soil risks? Where are current practices falling short?

TODAY, APPROACHES TO SOIL MANAGEMENT VARY BY INDUSTRY. NO CONSISTENT UNIVERSAL FRAMEWORK EXISTS DUE TO SEVERAL CHALLENGES: an absence of a standard soil quality baseline (because soils vary spatially and seasonally); a lack of a universal soil quality metric (different stakeholders monitor different soil indicators in different ways, as it can be labor, time, and cost-intensive); and uncertainty around the impact climate extremes on soil systems.

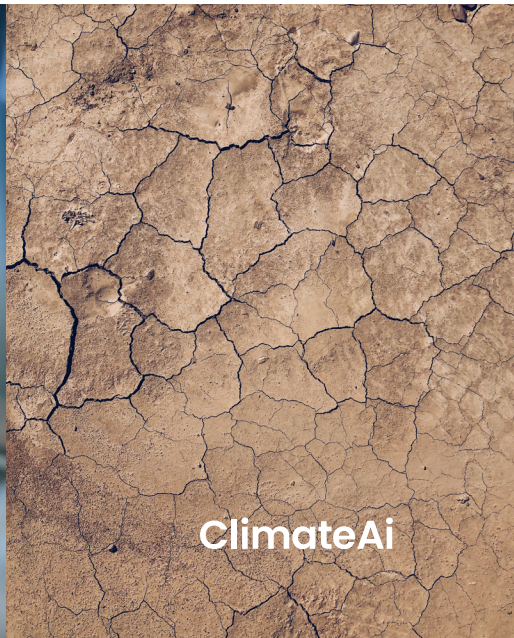
Despite this, game-changing new forms of climate-smart technology are providing forward-thinking companies with data-driven insights. With advancements in digital tools like sensors and satellites, soil assessments are becoming more spatially and temporally accurate.

With this data, artificial intelligence and machine learning models that also take climate change into account can identify emerging risks to soil. With this actionable information, businesses can improve their soil strategies to enable higher yields, grower profitability, and climate resilience.

This enables companies to answer critical questions about their business operations and strategies:

+ **Resource Planning/Sourcing**
  Are current soil-dependent resources reliable and sufficient to meet production goals currently? What about with the changing climate and changing production goals?
+ **Cost Management**
  Are soil risks becoming material financial risks, and are there opportunities to source from cheaper and less risky regions, or buy/apply inputs more efficiently?
+ **Sustainability Reporting**
  What are the evaluated potential risks for protected regions and biodiversity hotspots?
+ **Investment Planning**
  What will pricing dynamics look like in the future? Are there opportunities to invest early in future soil risk-proof, high-yield regions?
+ **Catastrophic (i.e. Wildfire) Risks**
  What are the soil-affecting catastrophic risks to key sourcing regions? Are these risks changing in time? Are there tipping points at which lesser risks will become catastrophic?

Technological advances can help growers and those along the agricultural value chain to grow more sustainably and efficiently, protecting both yield and soil while improving resource use and animal welfare. **Food, Ag, and Forestry Sectors** have a massive opportunity in the sector to both better understand growers' soil risks and to shift farming practices to improve soil health. **Apparel and Textile Sectors** can also use climate-smart technologies to create and use more resource-efficient materials that increase ecosystem health and combat global warming by sequestering carbon in the soil.



What is the better solution?

BECAUSE SOIL IS SO INTERCONNECTED TO OTHER VARIABLES LIKE WATERSHEDS, WEATHER, AND CLIMATE, BUSINESSES THAT RELY ON SOIL NEED A TECHNOLOGICAL SOLUTION THAT TAKES INTO ACCOUNT THE DISPARATE SOIL DATA THAT EXISTS AND COMBINES IT WITH MORE VARIABLES TO HAVE A HOLISTIC UNDERSTANDING OF IN-SITE CURRENT RISKS AND FUTURE RISKS.

Advances in AI can accomplish this. They can connect data from public and private remote sensors and on-site samples — like watershed risks and water availability, altitude, soil temperature, anticipated precipitation, wind, humidity, sunny day changes, and pest pressures — and incorporate other local and global weather and climate models. Powerful computer models can create spatially continuous data maps even for inaccessible locations, as the data can be downscaled and understood.

These models can also be tied to yield, so that growers and businesses can understand how soil, water, and climate variables all affect the ultimate crop yield. These actionable insights inform key decisions for soil, like what and when to plant, when and how much to irrigate, how much to fertilize, and when to harvest. Weather-optimal timing of planting, input applications, and harvesting boosts productivity and it can do so with far greater resource efficiency i.e. less wasted fertilizer, pesticides, less time running fossil fuel-powered tractors in slow, sub-optimal, muddy conditions, etc.

Companies along the value chain, from growers to retailers to investors, can understand their exposure to intersecting soil, water, and climate risks along the parameters that matter to them. They can feel confident to make data-driven decisions to secure the supply chain, find alternative production locations, and justify investment in new locations.

Climate risk and mitigation is another area in which businesses under-appreciate soil's potential. It is the largest global reservoir of organic carbon, and understanding how much carbon soils sequester can help businesses meet their climate and sustainability goals while building resilience.

Companies leading the way in soil management

McCain Foods, the Canada-based food company that is the world's largest manufacturer of frozen potato products, understood that the soil that its main product was growing in faced new risks from climate change. It turned to ClimateAi to identify the risks to its current growing areas and to identify new potential growing locations with similar soil parameters, including bulk density, sand concentration, clay concentration, silt concentration, gravel concentration, cation exchange capacity of clay fraction, dominant soil type carbon content, area-weighted carbon content, organic carbon, and pH level. ClimateAi was also able to translate these factors into other important risks like emerging pest and disease potential, which helped determine which sourcing areas to prioritize.

Nuveen, one of the world's largest land asset managers, was looking to determine if certain regions would maintain high yield in the climate-changing future and so if they were worthy of investing in. It was interested in highly specific variables such as water availability in root zones in soil, which coincides with precipitation patterns, drought risks, extreme heat risks, flood risks, and more. ClimateAi's platform was able to provide the probabilistic chances of these occurring at several timescales (10 years, 20 years, 30 years) to help inform these long-term investment decisions.

Driscoll's
Only the Finest Berries™

Driscoll's, the California-based berry seller that is one of the biggest produce companies in the world, wanted to understand long-term climate risks to its sourcing regions to minimize climate-driven volatility in yield and quality and potentially diversify regions if needed. Berries are as a category especially vulnerable to temperature shifts and soil changes. The company used ClimateAi's platform to understand climate change's impact on soil temperature to determine that certain regions that relied on optimal microclimates would experience changes that could make the regions unviable in the coming decades. Especially when combined with other climate risks like a projected future low clean water availability in the region, the company went forward in its decision to begin diversifying its sourcing regions.

ClimateAi's Soil Management Tools: Insights That Matter

ClimateAi gives businesses unprecedented insights into the soil risks facing their operations and supply chains, from this year to 50 years out. Using publicly and privately available soil and agronomic data, cutting-edge weather forecasts, and advanced climate and hydrological models, users can access actionable, reliable insights for their fields, operating sites, and portfolios.

MONITOR FOR SHORT-TERM DECISION MAKING

+ Support key decisions like:

  What are the crop- and location-specific risks facing my operation this year? (drought, extreme heat, pest incidence, etc)?

  How will these key risks impact yield, quality, and timing — and what actions can I take to mitigate them?

  What are the best varieties or crops to plant in our existing locations with our soil parameters and expected conditions?

  When should we sow, apply inputs, and harvest to maximize yield/quality this year to minimize pesticide, fertilizer, and water runoff?

  Where are the new locations (microclimate level and soil type) that can optimally grow our focus crops?

  When will these crop-specific climate risks really start to hurt our bottom line?

  What does soil moisture, surface water, and groundwater for recharging of water and water stress look like over the next 6 months?

+ Help evaluate soil moisture, surface water, and groundwater for recharging of water and water stress for the next 6 months.

ADAPT FOR LONG-TERM STRATEGY:

+ Evaluate potential new sites and improving business continuity plans through climate stress testing.
+ Assess the long-term risks of exposure to extreme weather such as droughts and floods with hazard maps.
+ Conduct annual trend analysis over the coming decades at a resolution of 50km x 50km.
+ Determine the risk tipping point for surface water, groundwater, and soil moisture.
+ Answer the question: "what locations around the world today, look like my production locations will look 10-20 years from now?" or "in 10-20 years, what locations will look like my top production sites today?" (in terms of soil type and soil, climate, and water risks) to inform climate-smart breeding, trial siting, production siting, etc.

ClimateAi's smart soil technology enables management and mitigation of environmental risks for businesses and governments. The platform identifies industry- and company-specific risks to soil, water, and commodities. This technology is revolutionizing sustainable soil management practices by optimizing in-season decision-making in terms of variety choice, input application, and more that directly impact soil quality, all while preventing losses and boosting profits.

Beyond this, by better understanding the intersecting nature of soil, water, and climate risks in the coming seasons, users can make informed decisions to adapt and plan investments in current locations and alternative locations accordingly.

Past weather patterns are no longer indicative of future patterns, because of climate change's impacts, so machine learning is a necessity to be able to understand what's coming. Continued technology advancements and more expansive industry-specific data will set the stage for the standardization of soil assessments across supply chains to help businesses adapt and bring climate resilience to our global economy.

Healthy soils are the foundation of successful business. In a warming world, healthy soil will be all the more valuable because it stands up better to drought, floods, and other extreme weather events, while also sequestering carbon and mitigating climate change. ClimateAi strives to make soil sustainability better for everyone by controlling climate change and soil changes through data. Managing soil health allows us to work with the land – not against it.

About ClimateAi

ClimateAi is pioneering the application of artificial intelligence to help businesses and governments build climate resilience. By applying AI to climate risk modeling, its ClimateLens platform provides short and longterm insights into weather and climate impact, helping businesses identify the actions needed today to adapt to the climate change disruptions of tomorrow, as well as new opportunities that may arise as a result. Its client roster includes The Wonderful Company, Advanta, Driscoll's, Nuveen, and Ocean Spray.

FOR MORE INFORMATION OR TO SCHEDULE A DEMO
PLEASE VISIT CLIMATE.AI

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Appendix

HOW COMPANIES MEASURE SOIL HEALTH

For years, growers have relied on site-specific soil sampling and historical knowledge to make seasonal crop-specific decisions like what and when to plant, irrigate, fertilize, apply pesticides, and harvest to optimize yield and quality.

More and more agricultural companies have adopted technologies that monitor key indicators of soil health, such as moisture, pH balance, and nutrient levels. Satellites, drones, and connected sensor technologies collect information, and data maps are generated with the help of geospatial data, geographic information system (GIS) technologies, and software.

KEY ELEMENTS OF SOIL MANAGEMENT

To take stock of soil risks, companies first must understand the current conditions of the soil at relevant sites. Companies currently approach soil by quantitatively and qualitatively analyzing it along a few dimensions:

- **Capability:** what functions can a given soil perform — given its characteristics like texture (type of soil), porosity (aeration and drainage), pH, cation exchange capacity (CEC), altitude — and in doing so, produce?
- **Condition:** what is the current state of a given soil — moisture, contamination, compaction, erosion — compared to its reference condition?
- **Capital:** what are the economic values produced by various services supported by soil?
- **Connectivity:** do managers have the right knowledge and resources to manage the soil according to its capability?
- **Codification:** what policies are in place that need to be taken into account?

Some characteristics of soil are inherent and hard to change (like texture, if it's sandy or clayey or silty), while others are dynamic (like amount of soil organic matter, soil structure, soil depth, and water and nutrient holding capacity). These dynamic properties respond differently to management depending on the soil's inherent properties and ongoing climate changes.
Understanding these qualities by assessing soil indicators, mentioned above, which contribute to an overall measure of soil quality and thus land productivity and yield, is important for businesses that rely on the soil.

Additionally, a number of regions have a level of regulation around soil contaminants, including PCBs, PAHs, petroleum products, heavy metals, pesticides, microplastics, and more.

FOR MORE INFORMATION, VISIT CLIMATE.AI