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Spotlight

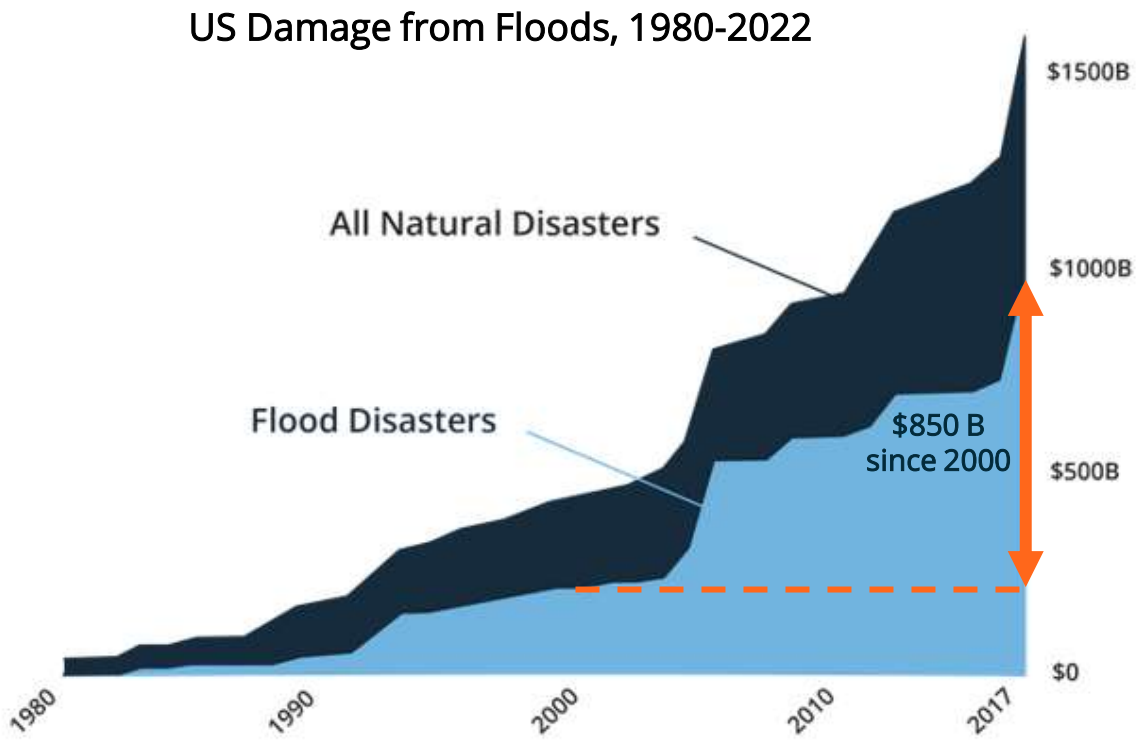
Resources & Environment

Flood Resilience

March 2023

Flood resilience: Executive summary

- Climate change is increasing the frequency and severity of precipitation and elevating sea levels, especially in the Northern Hemisphere
- While Asia has embraced the urgency of adapting flood infrastructure, North America and Europe are falling dangerously behind in financing improvements
- **Research shows that that proactive approaches are 5x more effective at mitigating flood damages than responsive approaches such as water pumps and barriers**
- New innovations offer proactive approaches: **alternative physical solutions** (artificial reefs, alternative concrete) that decrease severity of flooding as well as **software** and **hardware** solutions that predict a flood's behaviour and impact on infrastructure
  - New physical solutions offer long-term, ecologically positive answers to issues of coastal erosion (artificial reefs) and urban drainage (permeable pavement)
  - Sensors rapidly detect flow rates in stormwater systems to prevent catastrophic blockages and provide software companies the data collection needed for infrastructure analysis
  - Software solutions simulate flood events to inform preparations – new autonomous image recognition tools reduce labour costs in repairing stormwater systems from thousands of dollars a day to just $1
- Precise flood sensing and analysis tools are solving problems before they happen, offering value far beyond generalist risk mapping – these **solutions are fragmented today, but soon will be vertically integrated and scaled**
- Insurance, civil engineering, and construction sectors provide startups channel partners, **acquisitions will consolidate solutions and create a tipping point for proactive flood resilience innovation to take hold in the market**



Source: Flooddefenders.org (chart), U.S. Billion-Dollar Weather and Climate Disasters, 2023, NOAA National Centers for Environmental Information (data)

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Flood resilience: Setting the stage

Description

- Novel sensor data applications and AI assisted analysis deliver proactive insights that reduce damage to infrastructure, property, and loss of life
- Primary Driver: Economics of flood avoidance not well understood by public, response and recovery are the mainstream approaches
  - Incumbent technologies center on localized weather monitoring / reactive flood controls - Current tech also **fails to assess pluvial (extreme rainfall) flooding**
  - **Incumbent technology can only predict floods four hours ahead of time – cannot inform proactive decisions and take true loss prevention action**

Impact

- Adopting just the digital stack of flood resilience innovation tools, **flood-prone areas can reduce financial losses by nearly 70%**
  - Innovative software identifies infrastructure's weak points through simulated floods and automated asset health analysis
  - Image recognition technology removes the need for labor-intensive analysis of stormwater systems and expedites infrastructure repairs
  - Sensor-informed flood prediction software provides localized insights on how a flood will behave and map where damages will occur
- **Coastal regions avoid losses further with artificial reef systems** - reducing wave impacts, slowing erosion, reducing coastal floods long-term
- Nearly every major urban area in Europe and North America in need of flood infrastructure upgrades –flood risk analysis technology in city operations will extend the lifetime of infrastructure and avoid need for future upgrades

Proactive Risk Analysis within Flood Management

Figure 2: Non-Structural Flood Management in European Rural Mountain Areas—Are Scientists Supporting Implementation?, 2021, Felix Conitz et al in *Hydrology*

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Flood Resilience: From reaction to risk reduction

Reactive responses to flooding are failing

- Current flood analytics do not model flood behavior, instead relying on traditional forecasting to predict flood events a maximum of four hours before they occur
- Analytics insights then inform disaster responses to redirect water with portable flood barriers and pump systems in hopes of minimizing mounting damages
- To prepare urban environments for pluvial (rainfall) flooding, cities needs tools to proactively model how future floods will behave and impact infrastructure

Proactive approaches to flooding are 5x more effective

Innovation in flood prevention has two themes: **infrastructure** (artificial reefs, permeable concrete, failure detection) and **assisted mapping/modelling** (Artificial Intelligence, Machine Learning, sensors, GIS, visualization tools).

- **Hardware:** Placing sensors and controllers in stormwater systems to precisely trace waterflow, predict blockages, detect failing infrastructure

  Predictive maintenance, early evacuations, traffic / logistics re-routing capabilities of newer software is enabled by the recent innovations in sensing

- **Software:** Improvements focus on data aggregation, Artificial Intelligence (AI), and Machine Learning (ML) use

  AI image recognition of faulty stormwater systems and precise risk analysis to inform rapid evacuation or property loss mitigation

- **Physical Solutions:** CCell's recent artificial reef innovations incorporate controllable electrical currents to deenergize waves, a novel means of fighting erosion

Increasing specificity of innovation and granularity of data in the flood technology sectors allows cities to analyze impacts of flooding and act on pressing issues with surgical precision

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StormSensor's Terrapin® decision making system

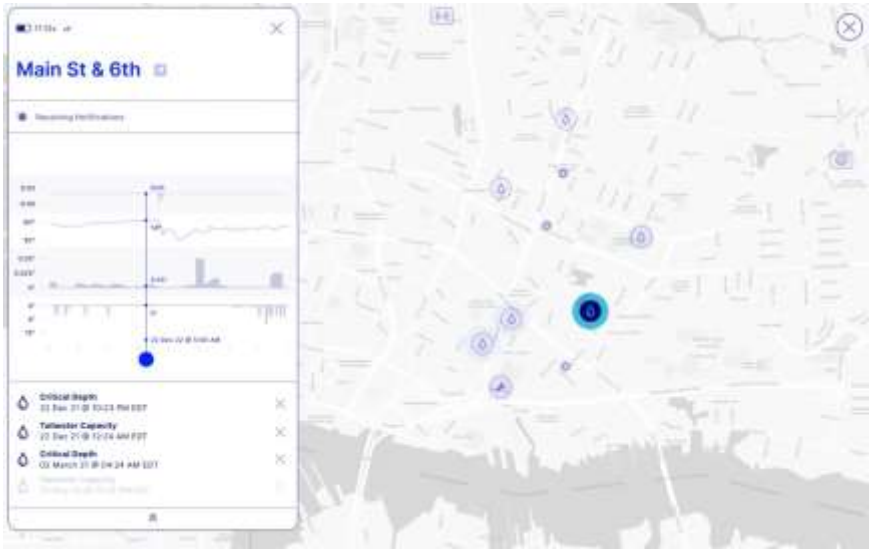


Figure 3: Terrapin® Solutions Demonstration, 2021, StormSensor

SewerAI's AutoCode image recognition & CCell's Digital Reef

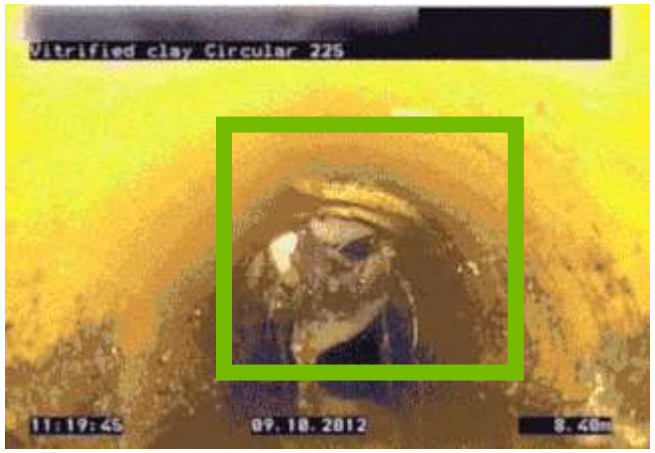
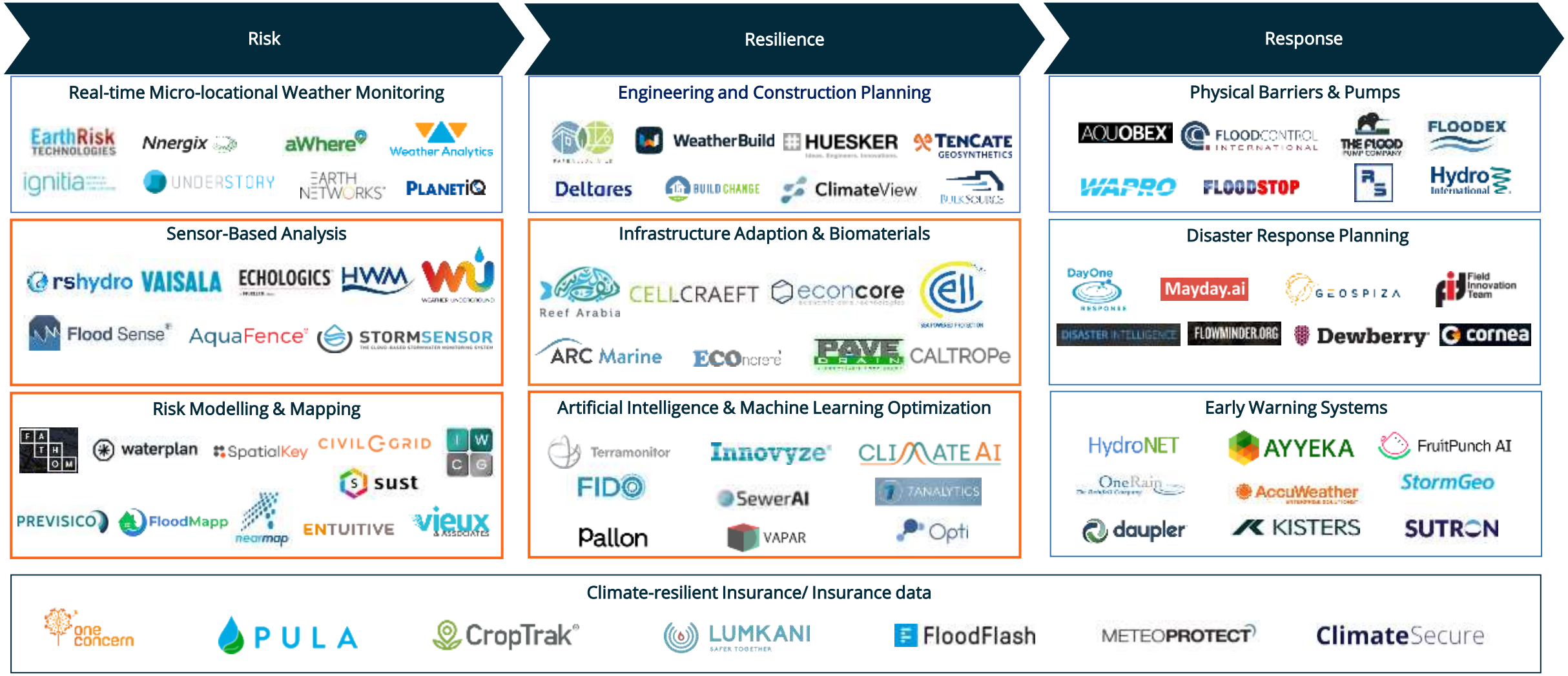


Figure 4 & 5: (Left) AutoCode footage, 2021, SewerAI (Right) The Digital Reef, 2021, CCell

Flood resilience: Value chain



Focus of current Insight

Flood Resilience: Investment/corporate activity

Venture Investments

September **$5 M Series A**, Geographic expansion

September **$2.09 M Seed**, Sensor development

October **$1.5 M Growth Equity**, Geographic expansion

November **$2.39 M Series A**, Geographic expansion

December **$10 M Series A**, Geographic expansion

April **$6 M Series A**, Product development and expansion

April **$7 M Seed**, International market expansion

June **$1.68 M Seed**, International market expansion

September **$7.64 M Series A**, International growth

September **$2.5 M Seed**, Model development

February **$3 M Follow-On**, Geographic expansion

2021 2022 2023

Corporate Activity / M&A

January **Incubation**, Develop go-to-market

February **Partnership**, Develop global flood model

September **Partnership**, Develop national flood model for Japan

February **Acquisition**, Application of flood forecasting to BulkSources' construction platform

June **Acquisition**, Enables rapid scaling in Europe and abroad

September **Partnership**, Develop real time flood damage assessments

Investment Activity Partnership Acquisition

Flood Resilience: The ABC's

Discussion

Attractiveness

- The global flood prevention and protection market is currently worth $19.17 billion and is expected to grow 5.85% annually over the next four years, eventually reaching a market size of $24.4 billion in 2027 - **this market expansion will be led by government contracts for innovative solutions**
- Flood technology market is currently undervalued due to high risk of company failure and challenging launch path in a fragmented market but has a high economic potential for companies able to successfully scale their solutions
- Despite physical solutions catering strictly to public clients, governments are slow to adopt alternative physical solutions due to caution over **expensive product testing** and **lengthy rollout periods** required to validate new ideas
- **Large engineering and construction companies are buying into disruptive startups through mergers and acquisitions, creating a healthy ecosystem that taps into large firms' abilities to scale and startups' edge in innovation**

Business Models

- **Physical Solutions** are sold outright as assets, with relevant upkeep and maintenance often included in sale price
- **As-a-service**: CAPEX-light solutions that offer flood detection / planning benefits where an infrastructure upgrade may not be required
  - Hardware companies lease sensors and gauges that provide clients measured data, but charge subscription fees for assisted decision-making services that are tailored to the device in question
  - Software (risk analytics) companies offer subscription-based models for decision-making tools and mapping services - Image recognition tools are often supplied through usage fees or licensing models.
- Some innovators require channel partners to access adjacent markets, this trend is exemplified in the flood mapping space where data providers are partnering with insurers and brokers to provide flood risk informed insurance products. E.g. Previsico

Competitive Trends

- Software companies focusing on a specific and geographically transferable market segment (E.g. SewerAI's stormwater infrastructure analysis) are expanding rapidly while **general flood mapping companies' scaling is limited by the localized nature of their datasets** and the time it takes to construct them – use-case specialization is the key to competitive advantage in this subsector
- Hardware solutions, particularly sensors focused on analyzing water flow and drainage, are scaling rapidly and quickly becoming n operational prerequisite for software companies who require localized and specific data
- Insurance sectors vary in their participation, depending on geography and value of assets being protected (E.g. UK is leading flood mapping innovation while Asia's insurance innovation is minimal)

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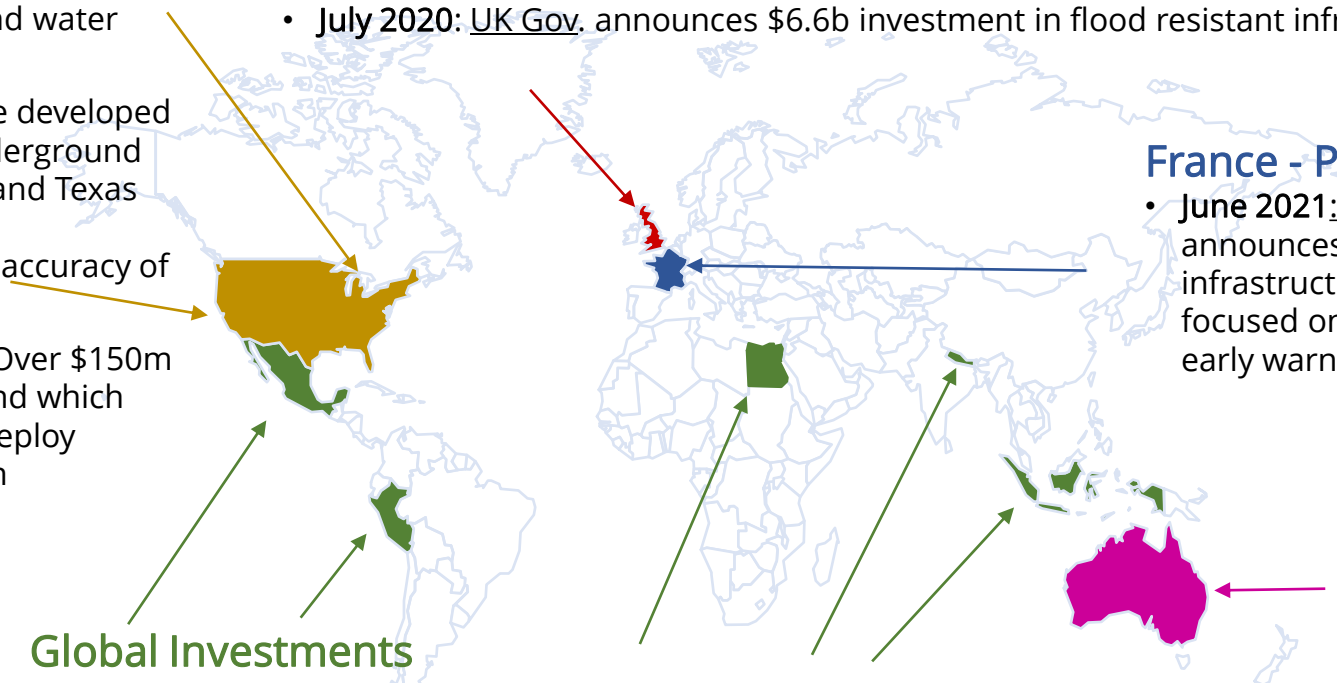
Flood Resilience: Regional drivers, sources of innovation, pilots

United States – Private innovation and finance

- Pave Drain's permeable pavement pilot significantly reduced flood risk and improved underground water storage in Milwaukee
- CivilGrid and SewerAI have developed robust digital maps of underground utility assets in California and Texas that will increase speed of infrastructure repairs and accuracy of flooding predictions
- **2022**: WaterEquity raised Over $150m for their Global Access Fund which promotes microloans to deploy solutions to water crises in developing economies

The United Kingdom - Public finance

- **September 2021:** Innovation Fund invests $181m in 25 projects addressing flooding and coastal resilience
- **May 2020**: $4.72b expansion of the New Roads and Street Works Act (NRSWA 1991) to digitized subsurface infrastructure and release it to start-ups like Previsico
- **July 2020**: UK Gov. announces $6.6b investment in flood resistant infrastructure and software



France - Public finance

- **June 2021**: French government announces $1.4b flood infrastructure modernization plan focused on physical defences and early warning/mapping software

Global Investments

- **2010-2022**: The UN's Adaptation Fund committed $998 million for climate change adaptation and resilience through 139 projects in developing countries, received additional pledges worth $230m in Egypt
- **2018:** The Zurich Flood Resilience Program has partnered with Wharton Business School and Zurich Insurance to deliver $35.6m in flood warning systems and infrastructure in Peru, Mexico, Indonesia, and Nepal

Australia – Public finance

- **January 2021**: New South Wales' government announces $1.2b in funding for flood mitigation and resilience projects
- **September 2019**: NSW MVP grants scheme provides $25,000 to several startups including sewer and stormwater management software company Vapar

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Flood Resilience: Innovator Examples

Positioning: Pluvial flood prevention analysis and precise 48-hour early warning system for insurance companies. Utilize software modeling and sensors.

Market insight
- Traditional flood forecasting ignores pluvial (stormwater) flooding, 70% of total flooding damages
- Pluvial flooding will increase - accurate and precise forecasting mitigates losses for insurance companies through informed planning

Company Insight
- Product was created in collaboration with several UK insurance companies, providing Previsico several immediate clients and foothold in the insurance industry
- Continuing work with current UK insurance clients' North American divisions, may partner with regional risk analysis companies to license or acquire their data sets and training models

Milestones:
- Lloyd's Lab partnership connected company with insurance majors (Liberty, MunichRe, HM underwriting)
- **2022**: Contract won in Northern Ireland, expanding to Boston, NYC, DC
- **September 2021**: Raised $2.4 million in seed funding
- **June 2020**: $700,000 loan for international expansion.

Capital: $3 million, next round finalized in March

Contact: Jonathan Jackson, CEO

Positioning: Artificial reefs that reduce wave impacts, coastal erosion, and flooding for hotels, coastal communities, and governments.

Market insight
- Changes in coastal climates and poor land management practices are increasing coastal erosion
- Current solutions are very expensive (sea walls, replenishment) or just a short-term fix (geotubes)

Company Insight
- Company struggled to gain wide-spread market traction with each client/site posing unique challenges
- Initially focusing on the coastal hotels and hospitality sector, the company pivoted to governments / wealthy costal communities
- CCell's artificial reefs deenergize wave currents, while stimulating natural reef development, creating both a short- and long-term solution to coastal erosion

Milestones:
- 6 pilot programs in various locations (MX, UK, IL)
- Success in stimulating rock growth to rebuild reefs and create new ones; able to revive fish stocks in certain areas
- **January 2020**: Raised $650,000 in seed funding

Capital: Undisclosed

Contact: Will Bateman, CEO

Positioning: Road and sidewalk concrete that increases groundwater absorption for residential communities and governments.

Market insight
- Traditional concrete fails to deal with heavy rains, increased pluvial flooding necessitates new solutions that utilize subsurface draining
- Other permeable concrete exists but often as a company's niche or secondary product

Company Insight
- Footholds in several urban centers, wide product availability, want to find right investors as ROI will be slow until they reach high market share and industry approval from civil engineers
- Targeting older, flood-prone cities as partners to show tangible benefits of their product
- Issues dealing with new climates (had difficulty in clay soils and icy conditions)

Milestones:
- Partnership with HydroCAD-10 used to expand digital modeling capabilities
- Milwaukee pilot and expansion reduced pluvial flooding and related damages in low-lying urban center
- Successful pilots and retrofits in Athens, Cincinnati, Richmond, and Newark

Capital: Undisclosed

Contact: Doug Buch, CEO

Flood Resilience: Innovator Examples

STORMSENSOR
CREATING SMART URBAN WATERSHEDS

Positioning: Flood risk and analysis platform that doubles as an early warning and assisted decision-making system for cities

Market insight
- Current infrastructure was not designed to handle the increased rain urban areas are now experiencing
- Securing the asset health of public infrastructure requires both real-time monitoring and predictive risk assessment, necessitating the need for both sensor and software technology

Company Insight
- Large data sets needed to train its algorithms, growth dependent on public partnerships or lengthy studies
- Company offers three separate flood risk and analysis tools but each operate in a very crowded market and are currently restricted to northeast US

Milestones:
- Successful pilot partnerships in Detroit, Boston, and Norfolk
- **December 2021**: Raised $10 million in series A round
- **August 2021**: Raised $12 million in growth equity
- **August 2018**: Raised $1.2 million in seed round

Capital: $28 million

Contact: Jeff Plymale, CEO

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ARC Marine

Positioning: Producer of 98% recycled material sea walls, marinas, and artificial reefs to prevent coastal flooding and erosion

Market insight
- Climate change has altered ocean current behavior and damaged coral reefs, leading to increased coastal erosion and subsequent flooding
- Traditional solutions are very expensive (carbon intensive sea walls, replenishment) or just a short-term fix (geotubes)

Company Insight
- Partnered with several off-shore wind farms as their concrete provider and erosion prevention solution
- Significant competition in the artificial reef/erosion defense market so company has diversified products and customers (oil pipeline protection, aquaculture)
- Product was designed to offer an ecologically positive concrete that would not require additional clean-up efforts once it erodes

Milestones:
- **November 2021**: Raised $2.39 million in seed funding
- **February 2020**: Began commercial trial with Vattenfall's offshore wind farms
- **July 2019**: Included in a $2 million research fund hosted by the University of Plymouth to prove that their products increase marine biodiversity

Capital: $2.5 million

Contact: Tom Birbeck, CEO

SewerAI

Positioning: Sewer/drainage assessment platform utilizing AI image recognition to reduce repair cost and assessment time for city governments

Market insight
- Maintaining adequate water infrastructure prevents floods, reduces water waste, pollution, and damage
- European governments are investing heavily in this technology to update their dated subsurface infrastructure in urban areas

Company Insight
- Company's image recognition software reduces assessment costs from thousands of dollars a day to ~$1 per day
- Similar baseline technology as startups WinCan, Cuds while incumbents AECOM and Jacobs also produce a similar tool catered toward civil engineers

Milestones:
- **March 2023**: Raised $3 million in growth equity
- **April 2022**: Raised $6 million in series A round
- **October 2021**: Raised $1.5 million in growth equity
- **August 2020**: Raised $2 million in seed funding

Capital: $12.5 million

Contact: Matt Rosenthal, CTO

Flood Resilience: Incumbent Examples

Positioning

Engaging Innovation

AECOM

- AECOM is a global infrastructure consulting firm operating in over 150 countries that generated $13.2 billion in revenue in 2022
- Mission statement focuses on constructing sustainable infrastructure solutions for today and future generations
- AECOM has recently expanded its dedicated flood prevention sector to meet both growing client demand and environmental risk of flood
- The company's size and range of expertise allows them to engage entire communities, cities, government agencies, or private clients

- **February 2022**: AECOM awarded $300 million Risk MAP contract with FEMA to map flood hazards and risk data for the entire US
- **2020**: AECOM develops internal AI image recognition software to identify faulty infrastructure
- **October 2014**: Acquired software company URS corporation for $6 billion to expand water resources engineering and flood management systems
- **July 2014**: AECOM acquires ACE International Consultants and launches their flood risk management services

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RSK / **BLACK & VEATCH**

- Black & Veatch is a global engineering and construction firm with a focus on flood risk mapping and infrastructure protection that generated $3.3 billion in revenue in 2022
- Black & Veatch joined both the NEXT Coalition and CEMEX Ventures to identify and promote innovative technology in construction
- RSK Group is a UK based engineering firm that provides water management services in both Asia and the UK

- **December 2022**: Contracted by the city of Charleston to develop a 25 year framework for flood mitigation strategies and technology
- **January 2021**: RSK Group acquires Black & Veach's UK and Asia operations to focus both firms' services geographically
- **March 2018**: Black & Veach establishes the Center of Excellence in Houston to research and deliver stormwater solutions for low-lying coastal regions

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Munich RE

- Global reinsurance firm, which providers insurance to insurers
- Munich RE provides coverage for catastrophic events such as floods and hurricanes and work with their clients to mitigate their exposure to losses, which proactive flood protection technologies can do
- Munich RE is mandated to disclose its climate related risk-exposure in the EU, Singapore, Canada, Japan and others

- **June 2022:** Participated in Salient's $5.4 million seed round, provider of weather forecasting services using machine learning and ocean data
- **February 2022:** Invested in parametric flooding insurance provider, FloodFlash's $15 million Series A round to fuel its US expansion

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Flood Resilience: Keep an eye out for…

Market milestones

- Insurance companies will continue to invest in and support solutions that help clients take a proactive role to mitigate flooding risks (E.g. Munich RE investing in FloodFlash, Prevsivo's UK insurance partnerships)
- Construction and engineering companies will replicate or acquire technologies to eliminate licensing costs, E.g., AECOM acquiring flood risk mapping software developer URS
- Construction and engineering companies will acquire or partner with innovators to tackle entire geographic markets and win contracts (AECOM addressing flood mapping and digital tools for entire American Northeast)
- Majority of total adaptation financing in 2019/2020 was from the public sector (86%), 37% of which was for the water sector - as adaptation budgets increases to meet the challenges of climate change, we expect public financing for water tech to increase even further as a percentage of adaptation financing

Innovator milestones

- **Hardware** providers will vertically integrate, enter the software market themselves
  - Increased centralization of data will improve flood risk models
  - Advancements in remote sensing (e.g. satellite data) will improve granularity and value
- **Software** providers will consolidate to create regional disaster data powerhouses:
  - As urban areas centralize data collection, climate, storm, and infrastructure data predictions will become more precise
  - Companies will scale geographically by acquiring other companies with specific regional data insights (E.g. CivilGrid's subsurface mapping of western US)
- **Physical solutions** providers will work alongside government agencies to customize solutions - Success with a pilot and government partnership will position these solutions as standard public infrastructure

Regulatory/Policy Milestones

- New building and zoning requirements will reduce number of residential properties in flood prone areas, potentially slowing the need for investment in physical solutions
  - FEMA offers a voluntary buyout program to relocate people in flood prone areas (USA)
  - The Flood Re scheme provides discounted flood insurance and relocation stipends for residents in flood-prone areas (UK)
- Expect increased public financing of pilot programs focused on infrastructure mapping, repair, and diagnostics
  - US EPA Water Infrastructure & Innovation Act (WIFIA) has financed over $17 billion in loans to update water infrastructure to meet rising risks
  - Issues are treated on a local market by market basis, national programs are exceptionally rare

Resources & Environment: Sector research

Cleantech Group tracks the start-ups, scale-ups, investors & multinationals

from across the region & the world shaping the future of the Resources & Environment industry

Recent Published Research

- **Spotlight Insight:** Digital Water (Q1)
- **Sector Insight:** Carbon Offsets & Markets (Q4)
- **Sector Insight:** Corporate Sustainability Monitoring (Q3)
- **Sector Insight:** Water & Cleantech (Q2 2022)
- **Spotlight Insight:** Climate Risk Analytics (Q2 2022)
- **Spotlight Insight:** Methane Monitoring in the Oil & Gas Industry (Q1 2022)
- **Sector Insight:** Sustainable Construction Design (Q1 2022)

Upcoming Topics

- **Sector Insight:** Mining Exploration (Q2)
- **Spotlight Insight:** Insurance & Climate Risk (Q2)

Upcoming Events

- **Cleantech Forum Asia** – *Meet the top innovators, investors & incumbents driving cleantech in Asia – Singapore – June 6 - 7, 2023*

Analyst – Parker J. Bovée

- Focused on emerging innovation & trends across the resources & environment sectors, including water, waste, circular economy, natural resources & corporate sustainability.
- Prior to joining Cleantech, Parker developed wildfire prevention technologies with VegaMX and researched socioeconomic implications of gambling legalization at the RXN Group.
- Parker earned a Bachelor's degree in History and Public Policy from the University of California, Berkeley where he specialized in the history of American environmental entrepreneurship.

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