Sensory Experiences of Environmental Data

The SEED Toolkit

Version 4.02

Revised August 2026 | This version is a stable release. The toolkit is published as an open resource for others to use and develop.

A practice-based resource for turning environmental data into sensory experience. It is designed for artists, researchers, scientists, technologists, educators, policymakers and other informed non-specialists who want to communicate environmental information in ways that people can hear, smell, touch, taste and feel, as well as see.

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How to use this toolkit

The three layers

The toolkit is organised into three layers. Each answers a different question, and together they form the basis of an integrated practice.

Conceptual Layer	**Why?**	Values, ideas and ethical commitments. What the work is for, who it is with, and what responsibilities it carries.
Methodological Layer	**How?**	The working process. Reviewing data, developing ideas with others, designing the sensory translation, and choosing materials.
Technical Layer	**With what?**	The practical infrastructure. Datasets, sensors, software and output devices, from free and open-source to specialist.

The integrated workflow

The workflow is not a fourth layer. It is the sequence a project moves through, drawing on all three layers as it goes. Ethical reflection is present at every stage, not only at the end.

W1 Data foundation	**W2** Ideation & collaboration	**W3** Software application	**W4** Hardware implementation	**W5** Ethics & ecology review

Where to start

You do not have to begin at the beginning. Find the description that best matches you.

I hold data but do not know what to do with it.	Start at the Methodological Layer (2.1 and 2.2), then read the Conceptual Layer to frame the question.
I want to commission someone but cannot write the brief.	Start at the Conceptual Layer, then use the Integrated Workflow to structure the commission.
I have an idea but do not know what is technically possible.	Start at the Technical Layer, then return to 2.3 to test whether the translation holds.
I am a practitioner and want to place my existing work in the framework.	Read the Integrated Workflow first, then use the layers as a checklist.

Reading the table

Each row of the toolkit table has four parts. The Sub-Component names the different parts of the layer. The Description sums up the meaning or application of the Sub-Component. The Tools column gives concrete examples, which are illustrative rather than exhaustive or prescriptive. The Rationale explains why the element earns its place, and is the column to read if you are deciding whether something is relevant to you.

Unfamiliar terms are defined in the Glossary at the end of this document.

(Sensory Experiences of Environmental Data)Toolkit Components

Component Category	Sub-Component Category / Stage	Description	Examples of Specific Tools / Technologies	Rationale for Inclusion (Value)
1. Conceptual Layer	Values, intellectual foundations, and ethical commitments underpinning all subsequent work.			
	1.1 Interdisciplinary Thinking	Bridging scientific knowledge with artistic interpretation.	• Collaboration between artists, scientists and technologists • Interdisciplinary advisory boards	Ensures balance of creativity and accuracy.
	1.2 Ecological Awareness	Framing tools as mediators of ecological relationships.	• Critical ecological frameworks (Gabrys 2016; Parikka 2015; Morgan 2020)	Making invisible processes (air quality, pollinators, e-waste, microplastics) tangible.
	1.3 Participation & Engagement	Empowering audiences and communities to co-create.	• Citizen science platforms (iNaturalist / GBIF) • Community biodiversity surveys	Enhances accessibility, agency and cultural relevance.
	1.4 Ethical Considerations	Transparency, sustainability, safeguarding and accessibility.	• Consent forms • GCC sustainability guidelines • Accessibility audits	Fosters responsible, inclusive practice as a condition of the work, not an addition to it.
2. Methodological Layer	A working process from data review through creative translation to fabrication and reflection.			
	2.1 Reviewing Environmental Datasets	Identifying and contextualising data.	• Marine Institute • Met Éireann • EPA Air Quality • iNaturalist / GBIF • CPR Database • SFPA	Provides a reliable foundation for sensory translation.
	2.2 Workshopping & Ideating	Conceptual development and planning.	• Artist–scientist workshops • Interdisciplinary dialogues • Co-design sessions	Fosters innovation, defines sensory approach (sound, smell, touch, taste, vision).
	2.3 Designing Creative Strategies	Artistic data translation: deciding which sensory modality suits which data, and why. The pivotal decision of the workflow.	• Sonification • Olfactory translation • Gustatory (taste-based) approaches • Tactile and proprioceptive design • Cross-modal mapping	Transforms abstract data into embodied experience. Decisions here determine the artistic and communicative character of the finished work.
	2.4 From Digital to Material: Considerations &	Choice of materials, media and technologies that reflect both	• 3D printing • Laser cutting • CNC fabrication	Ensures deep consideration of media and their socio-environmental impact.

Component Category	Sub-Component Category / Stage	Description	Examples of Specific Tools / Technologies	Rationale for Inclusion (Value)
	Fabrication	conceptual intent and ethical stance.	• Fablabs and makerspaces	
	2.5 Ethical & Ecological Frameworks	Guidelines and sustainability reflection applied throughout, not only at the end.	• GCC resources • Sustainable materials guides • Cultural consultation protocols	Reduces ecological footprint and ensures cultural sensitivity.
3. Technical Layer	Tools to enable the gathering, processing and translation of ecological data in innovative ways.			
Environmental Datasets				
	Public Data Repositories	Sources of pre-existing environmental data for review and inspiration.	• Marine Institute • Met Éireann • EPA Air Quality • iNaturalist • GBIF • CPR Database • SFPA	Provides scientific accuracy and a tangible starting point, grounding artworks in reliable information.
	Citizen Science Data	Data collected by non-professional scientists, often community-sourced.	• Community environmental monitoring projects • Local biodiversity surveys	Fosters community engagement and allows for localised, relevant environmental narratives.
Data Acquisition Hardware				
	Acoustic Sensors	Microphones to capture sound, including underwater (hydrophones) and ultrasonic frequencies.	• Hydrophones • Ultrasonic microphones • Parabolic microphones	Captures imperceptible environmental sounds (marine life, ice melt, natural processes) for sonification.
	Chemical / Olfactory Sensors	Devices that detect and quantify chemical compounds or scent profiles in the environment.	• MQ-series gas sensors • Air quality analysers (PM2.5, VOCs) • Electronic noses • Gas chromatographs	Makes invisible pollutants and subtle ecological smells tangible.
	Thermal / Climate Sensors	Sensors measuring temperature, humidity and other atmospheric conditions.	• Thermocouples • Thermistors • Humidity sensors • Barometers	Translates climatic change into tactile (heat or cold) or subtle sensory feedback.
	Bio-Sensors	Devices that detect biological indicators or activity.	• Soil moisture sensors • Photosynthesis sensors • Microplastic detection kits (FTIR spectroscopy)	Connects audiences to microscopic ecological processes and hidden contaminants.
	GPS / Location Devices	Devices that record geographical	• GPS trackers	Enables site-specific installations grounded in particular places

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		position and movement.	• Mobile phone location data	and movements.
Data Processing & Creative Software				
	Data Analysis & Visualisation	Software for statistical analysis, data cleaning and initial visual representation.	• Python (Pandas, NumPy, Scikit-learn) • R • HTML / CSS / JavaScript • Excel	Essential for understanding raw data and preparing it for sensory translation, ensuring scientific rigour.
	Real-time Interaction	Platforms for building interactive, responsive installations that integrate live data feeds.	• Processing • p5.js • OPENRNDR • openFrameworks • Three.js • TouchDesigner	Facilitates dynamic and immediate responses to environmental data, creating immersive experiences.
	Audio Production & Sonification	Software for manipulating and generating sound, central to data sonification.	• SuperCollider • PureData (Pd) • Ableton Live • Max/MSP	Transforms numerical data into emotionally resonant and perceptible auditory experience.
	3D Modelling & Immersive Environments	Software for creating virtual spaces and interactive simulations for XR experiences.	• Blender • FreeCAD • Unity • Unreal Engine • ZBrush • Cinema 4D • Fusion 360	Creates virtual objects and environments where multisensory data can be spatially explored.
	AI / Machine Learning: Generative Tools	Ready-made platforms generating visual or sonic material from prompts or data inputs. Usable without programming.	• Stable Diffusion • ComfyUI • Hugging Face (hosted models)	Enables generative visual and sonic outputs that adapt responsively to environmental data, with a low technical barrier.
	AI / Machine Learning: Custom Model Frameworks	Libraries for building and training bespoke models. Requires programming expertise.	• TensorFlow • PyTorch	Allows sophisticated data interpretation and adaptive sensory outputs responding to complex environmental shifts.
Interactive Hardware & Output Devices				
	Microcontrollers & SBCs	Small programmable computers that interface with sensors and control output devices.	• Arduino • Raspberry Pi • ESP32 • Micro:bit	Provides the physical brain for interactive elements, connecting software outputs to sensory experience.

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			• Repurposed phones / computers • Solar power	
	Visual Displays	Devices for displaying visual components of the artwork.	• LED matrices • Optical fibres • LED screens • Interactive screens • OLED displays • Projectors	Supports visual representation alongside multisensory elements, offering complementary understanding.
	Audio Output Systems	Equipment for delivering sound experiences.	• Multi-channel speaker arrays • Spatial audio systems (Ambisonics)	Creates immersive and directional soundscapes allowing audiences to spatially experience ecological data.
	Olfactory Diffusers	Devices that release controlled scents into an environment.	• Digital scent emitters • Vapour diffusion devices • Custom scent delivery systems	Translates invisible environmental data (pollution, plant health) into immediate, evocative olfactory experience.
	Haptic Feedback Devices	Devices that create tactile sensations.	• Vibrotactile actuators • Pneumatic feedback systems • Wearable haptic suits (e.g. Teslasuit)	Provides direct physical sensation corresponding to environmental data, fostering embodied empathy.
	Precision Culinary Equipment	Tools to prepare food and beverages based on specific data parameters.	• Fermentation systems • pH meters • Infusion devices	Enables taste-based experiences allowing participants to literally taste environmental conditions or changes.
Ethical & Practical Considerations				
	Sustainability Guidelines	Best practices for minimising the environmental footprint of artistic production.	• Gallery Climate Coalition (GCC) resources • Sustainable materials guides	Encourages critical reflection on the ecological impact of tools and processes.
	Interdisciplinary Collaboration	Partnerships with scientists, engineers, community members and other artists.	• Workshops • Joint research projects • Advisory boards	Ensures scientific rigour, cultural sensitivity and technological innovation.
	Participant Safeguarding & Accessibility	Measures ensuring the comfort, safety and informed consent of participants, with attention to sensory difference, allergy and disability.	• Clear communication about sensory content • Consent forms • Careful sensory calibration • Accessibility audits	Upholds ethical responsibilities towards the audience, ensuring safe engagement with potentially intense sensory experiences.

Component Category	Sub-Component Category / Stage	Description	Examples of Specific Tools / Technologies	Rationale for Inclusion (Value)
Integrated Workflow	Not a fourth layer. The operational sequence running through the three layers above.			
	W1 **Data Foundation**	Reviewing and contextualising datasets.	• Environmental repositories • Open APIs • Citizen science platforms	Establishes a credible baseline.
	W2 **Ideation & Collaboration**	Interdisciplinary planning.	• Workshops • Joint projects • Co-design sessions	Bridges science and art.
	W3 **Software Application**	Processing and translation: from data to sensory output via digital tools.	• Analysis tools • Sonification platforms • Real-time environments • 3D and XR software	Creates interactive and multisensory experiences.
	W4 **Hardware Implementation**	Delivering experiences.	• Sensors • Microcontrollers • Visual, audio, olfactory, haptic and culinary outputs	Connects audiences with tangible outputs.
	W5 **Ethics & Ecology Review**	Reviewing and documenting the ethical and ecological decisions taken throughout, rather than making them for the first time.	• GCC sustainability audit • Safeguarding documentation • Accessibility review	Embeds responsibility and trust as demonstrable outcomes.

References

The toolkit is grounded in the following work. Morgan (2020) is the research project on which SEED is based.

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Parikka, J. (2015)	A Geology of Media. Minneapolis: University of Minnesota Press.

Glossary

Terms used in the toolkit, defined for readers coming to this material for the first time.

Ambisonics	A method of recording and reproducing sound in full three dimensions, so that listeners perceive sound as coming from specific directions and heights around them.
CNC fabrication	Computer Numerical Control: manufacturing in which a computer directs a cutting or milling machine to shape material precisely from a digital design.
Citizen science	Scientific data collection carried out by members of the public rather than professional researchers, often through apps or organised local surveys.
Cross-modal mapping	Deciding how information in one form (a number, a rate of change) should be represented in another sensory form (a pitch, a temperature, a scent intensity).
FTIR spectroscopy	Fourier Transform Infrared spectroscopy: a laboratory technique identifying materials by how they absorb infrared light. Used here principally to identify microplastics.
GBIF	Global Biodiversity Information Facility: an international open-access database of species occurrence records.
GCC	Gallery Climate Coalition: an arts-sector body providing guidance on reducing the environmental impact of exhibitions and artistic production.
Gustatory	Relating to taste. A gustatory artwork asks the audience to taste something as part of the experience.
Haptic	Relating to the sense of touch, particularly through vibration, pressure or force applied to the body.
Hydrophone	An underwater microphone, used to record sound beneath the surface of water.
Microcontroller	A small, inexpensive programmable computer (such as an Arduino) that reads sensors and controls devices. The component that makes an installation respond to its environment.
Olfactory	Relating to smell.
PM2.5	Airborne particles smaller than 2.5 micrometres. Small enough to enter the lungs and bloodstream, and a standard measure of air pollution.
Proprioceptive	Relating to the body's sense of its own position and movement in space, distinct from touch, sight or balance.
SBC	Single-Board Computer: a complete small computer on one circuit board, such as a Raspberry Pi.
SFPA	Sea-Fisheries Protection Authority: the Irish state body publishing annual fisheries statistics.
Sonification	Turning data into sound, so that patterns and changes can be heard rather than seen. The auditory equivalent of data visualisation.
Vibrotactile	Producing sensation through vibration against the skin.
VOCs	Volatile Organic Compounds: carbon-based chemicals that evaporate readily at room temperature. Many are air pollutants and many carry a detectable smell.
XR	Extended Reality: the collective term for virtual reality, augmented reality and mixed reality technologies.