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D4.2-Report on low-cost sensors viable for citizen science activities

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V 0.2	Luca Baldini, CNR Filippo Giannetti, UNIPI	24/02/2023	Updated draft internally reviewed

V 0.3	Saul Crowley, UCD Tasneem Ahmed, ATU	27/02/2023	Updated draft after contribution from partners
V1.0	Salem Gharbia, ATU	28/02/2023	Final version

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Meaning / Full text
CCLL	Coastal City Living Lab
EBA	Ecosystem-Based Approach
WP	Work Package

BACKGROUND: ABOUT THE SCORE PROJECT

SCORE is a four-year EU-funded project aiming to increase climate resilience in European coastal cities.

The intensification of extreme weather events, coastal erosion and sea-level rise are major challenges to be urgently addressed by European coastal cities. The science behind these disruptive phenomena is complex, and advancing climate resilience requires progress in data acquisition, forecasting, and understanding of the potential risks and impacts for real-scenario interventions. The Ecosystem-Based Approach (EBA) supported by smart technologies has potential to increase climate resilience of European coastal cities; however, it is not yet adequately understood and coordinated at European level.

SCORE outlines a co-creation strategy, developed via a network of 10 coastal city 'living labs' (CCLLs), to rapidly, equitably and sustainably enhance coastal city climate resilience through EBAs and sophisticated digital technologies.

The 10 coastal city living labs involved in the project are: Sligo and Dublin, Ireland; Barcelona/Vilanova i la Geltrú, Benidorm and Basque Country, Spain; Oeiras, Portugal; Massa, Italy; Piran, Slovenia; Gdansk, Poland; Samsun, Turkey.

SCORE will establish an integrated coastal zone management framework for strengthening EBA and smart coastal city policies, creating European leadership in coastal city climate change adaptation in line with The Paris Agreement. It will provide innovative platforms to empower stakeholders' deployment of EBAs to increase climate resilience, business opportunities and financial sustainability of coastal cities.

The SCORE interdisciplinary team consists of 28 world-leading organisations from academia, local authorities, RPOs, and SMEs encompassing a wide range of skills including environmental science and policy, climate modelling, citizen and social science, data management, coastal management and engineering, security and technological aspects of smart sensing research.

EXECUTIVE SUMMARY

This document is a deliverable of the SCORE project, funded under the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003534.

The aim of this document is to report on the work completed under T4.2 – the compilation of a catalogue of low-cost sensors viable for citizen science activities.

LINKS WITH OTHER PROJECT ACTIVITIES

The outputs from this deliverable are also intended to be utilised as part of the activities under T9.6 – EBA Training Schools. Under WP9 instructional materials are being developed with the aim to facilitate the training of local communities in citizen science techniques using the sensors selected under T4.2.

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1.1. Low-Cost Sensor Review

In order to prepare the catalogue of low-cost sensors, a careful review of the scientific literature was undertaken in scientific databases like the Web of Science (WoS; https://www.webofscience.com/wos/woscc/basic-search), Science Direct (SD; https://www.sciencedirect.com/) and Scopus (https://www.scopus.com/home.uri) to identify the latest low-cost sensors in the last decade for monitoring coastal hazards. Often, monitoring the coastal hazards also involves the monitoring of various forcing factors like winds, waves, water levels etc that leads to the hazards as well as the coastal zone characteristics like nearshore topography for the accurate modelling of coastal hazards like coastal flood and erosion. A total of 60 relevant papers were chosen for the final review using the PRISMA protocol [1], which includes a checklist of 27 items to identify, select, appraise, and synthesise studies mainly within the clinical context to minimise bias, however in the last few years this protocol has been applied to other fields like tourism [2],[3] and environmental studies [4]. The sensors/sensing technologies from these papers were classified into several categories like terrestrial photogrammetry, aerial photogrammetry etc. Further details of these categories is explained in [5] . These sensors monitor different variables that were mapped into specific and broad categories of hazards and systematically arranged in the Miro board for the relevant SCORE partners to collaborate, choose and deliberate on these sensors. A snippet from the Miro board [6] is shown in Figure 1.

In order to select the sensors for citizen science activities, these sensors were grouped according to broad and specific categories of hazards as shown in Table 1.

Table 1 : Mapping of coastal parameters against broad and specific categories of hazards for the selection of low-cost sensors.

Parameters	Hazards (Broad)	Hazards (Specific)
Water levels	Floods/Extreme events/coastal erosion	Coastal/pluvial/fluvial floods/hydrological drought/shoreline change
Topography (Beach, dunes, and intertidal areas)	Coastal erosion	Morphological changes/shoreline change
Shoreline	Coastal erosion	Shoreline change
Surface wind	Flood/extreme events/coastal erosion	Coastal/pluvial/fluvial floods/Storms
Surface waves	Flood/extreme events/coastal erosion	Coastal flood/morphological change
Atmospheric pressure	Extreme events/floods	Storms/water level
2m Air temperature	Extreme events	Heatwaves/meteorological drought
Sea surface temperature	Maritime pollution/extreme events	Marine heatwaves/ acidification/ecosystem shifts

Soil moisture	Extreme events	Drought (agricultural/meteorological)
Water quality	Maritime pollution	Acidification/plastic pollution/deoxygenation
Precipitation	Flood/extreme events	Pluvial/fluvial flood/drought

As seen from Table 1, for instance, against the variable 'water levels', the broad categories of hazards are floods, extreme events and coastal erosion and the specific categories of hazards are coastal flood, fluvial and pluvial flood, shoreline change, and hydrological drought. To map the sensors in a collaborative way against the parameters and the hazards as seen from *Table 1*, the Miro board has been used as it offers great flexibility for collaborative work (Figure 1) .

The relevant sensors found from the literature were accordingly mapped. It was found that more sensors (spanning different sensing technologies) can map similar variables as shown in Figure 2. Same colour has been used to highlight similar parameters to visually emphasize that there are wide categories of low-cost sensors for monitoring the same parameters, creating opportunities to not only select but also combine different techniques to meet specific monitoring objectives. This leads to a large number of options to choose low-cost sensors suitable for citizen science activities. Clearly the scientific literature review was not exhaustive of all the possible forcing factors relevant for coastal hazards, especially within the context of SCORE's urban coastal city living labs. For instance, in the systematic literature review precipitation was neglected because the review strictly focused on climate induced coastal hazards and as such the changing climate, for instance, affects coastal flood hazards due to changes in the sea level more than rainfall [7]. However, rainfall is an important parameter for the coastal city living lab from the context of fluvial and pluvial flood. Thus, attention was turned to the grey as well as scientific literature for the identification of low-cost sensors for citizen science DIY activities. This search was not conducted according to the PRISMA protocol for a systematic review. Relevant sensors for parameters like rainfall, and water quality for the SCORE CCLL's were selected and shortlisted. The relevance of these sensors for DIY activities were deliberated with the relevant score partners and the CCLLs. A few sensors from the selected list of sensors from the sensor catalogue have already been pilot tested in the frontrunners, specifically the 'MINKE advanced water quality kit' in Dublin and Sligo and the Kite KAP Foil in Sligo. This initial pilot is intended to test the applicability of the sensors for activities with local stakeholders and communities, with the findings being used to refine how the other sensors on the catalogue will be presented through the digital web catalogue that is also being developed.

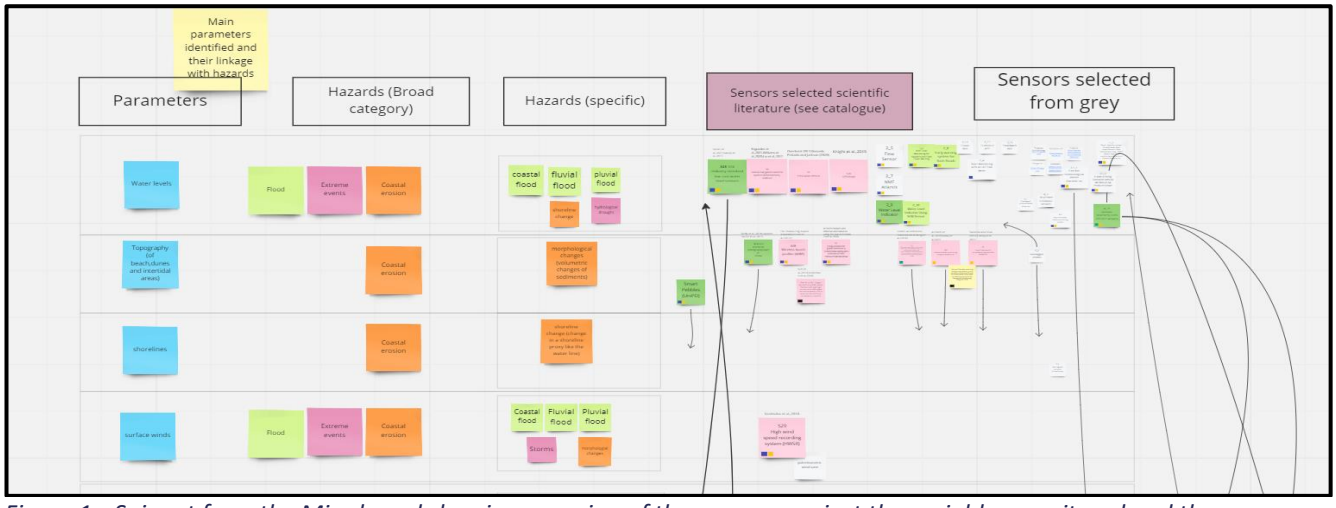

Figure 1 : Snippet from the Miro board showing mapping of the sensors against the variables monitored and the corresponding hazards

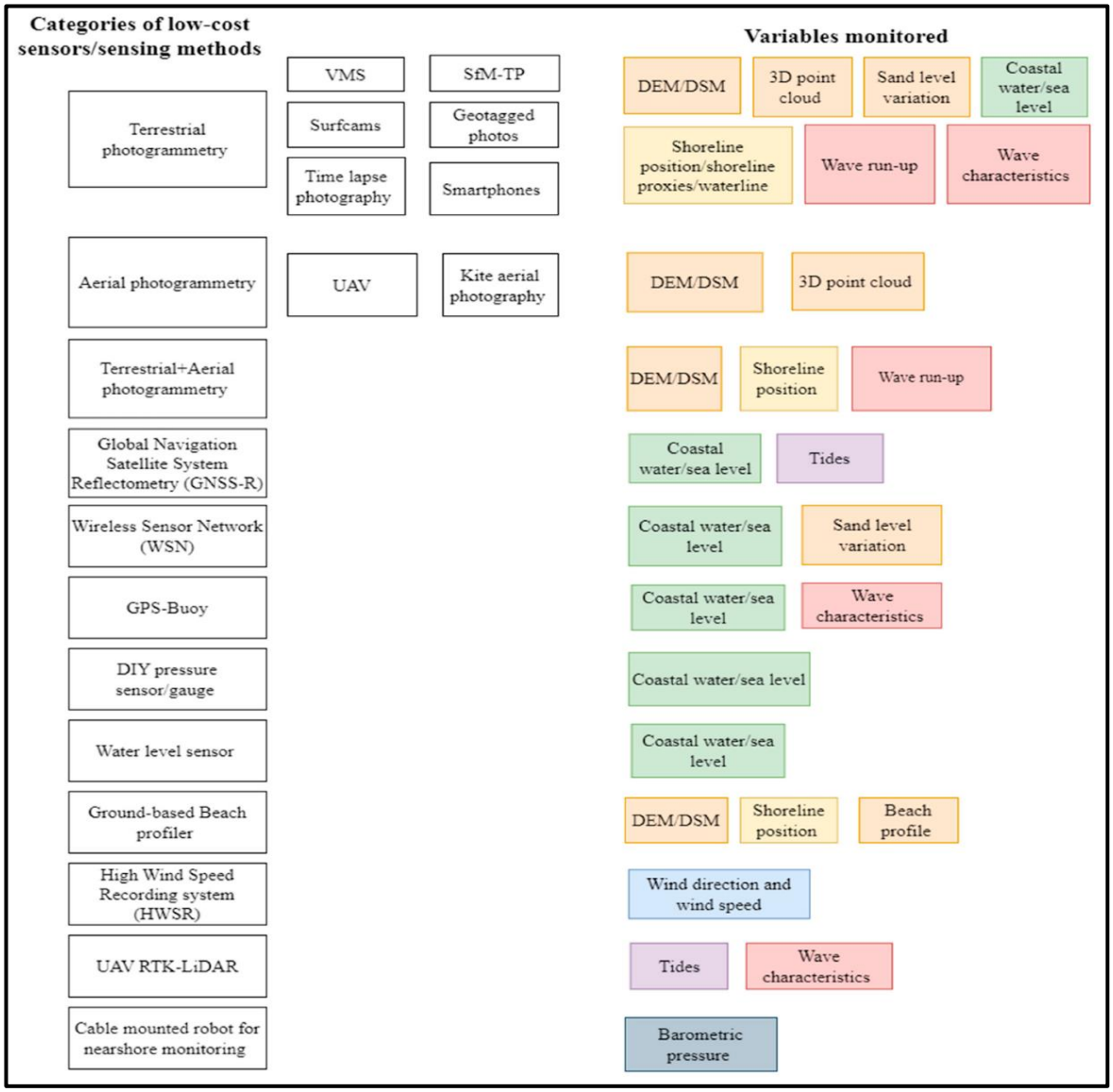

Figure 2 : The different variables obtained from the sensors/sensing methods ; variables have been colour coded, with similar variables being coloured the same.

1.2. DIY Citizen Science Activities

Onboarding processes are currently being developed for a number of sensors to enable citizens to assemble and deploy sensors either independently or as part of SCORE workshops. The outputs generated from this are also being intended to be utilised as part of the activities under T9.6 – EBA Training Schools, which aims to facilitate the training of local communities in citizen science techniques. These materials will likely be developed into an online platform to further streamline the process. Drafts of the onboarding steps involved for a number of sensors have also been prepared on the Task Miro board as seen in Figure 3.

The onboarding materials being developed will provide clear, concise instructions for citizens to assemble and deploy sensors. These materials will also cover troubleshooting techniques for any issues that may arise during the process. Small scale sensor deployment is currently underway in the Frontrunner cities of Dublin and Sligo to pilot this approach, with the aim of identifying any technical or practical needs that may be required by other CCLLs to successfully implement citizen science activities. The team in Dublin is working to create partnerships with local

community groups and schools to test and further refine these materials across a number of demographic groups (school children, adults, technical staff, etc.).

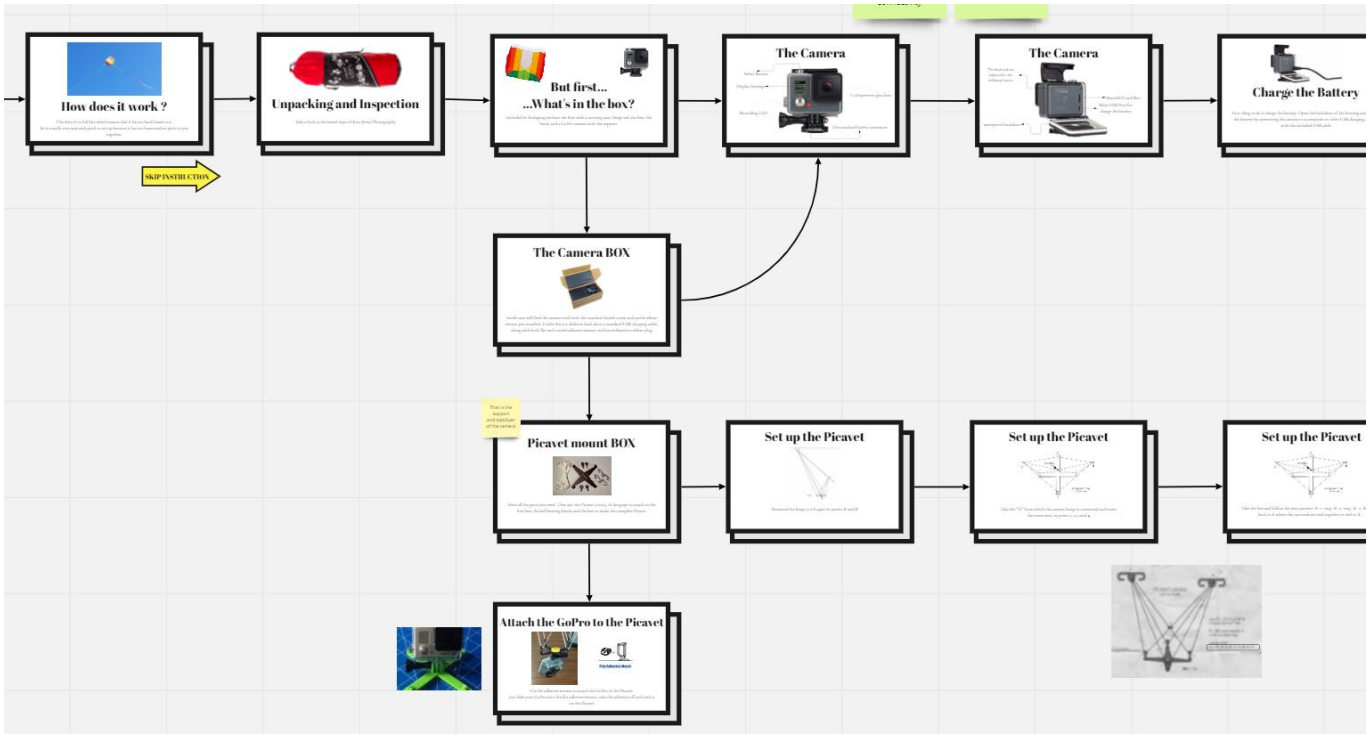

Figure 3 : : Snippet from the Miro board showing steps involved in assembling a KAP Foil for kite aerial photography. Direct link: https://miro.com/app/board/uXjVOn9dNrs=/?moveToWidget=3458764531081840946&cot=14

1.3. Low-Cost Sensor Catalogue

An online platform has been developed to assist CCLLs in planning, selecting and deploying the sensing technologies included in the catalogue. The website will function similarly to an online shop for CCLL members to fill a 'basket' with selected sensors based on criteria such as cost, technical expertise required, parameters monitored, assembly difficulty, etc. Sensing technologies will be chosen by citizens, associations and other stakeholders in each CCLL with the help of the SCORE technological partners to better fit the local needs of each community. A mockup of the website layout including possible future features has been created [8], further development of the website will be conducted based on feedback from users in the CCLLs. See Figure 4 for a breakdown of how the database of the catalogue itself is structured.

The website is available at https://score-sensor-catalogue.spatialdynamicslab.xyz

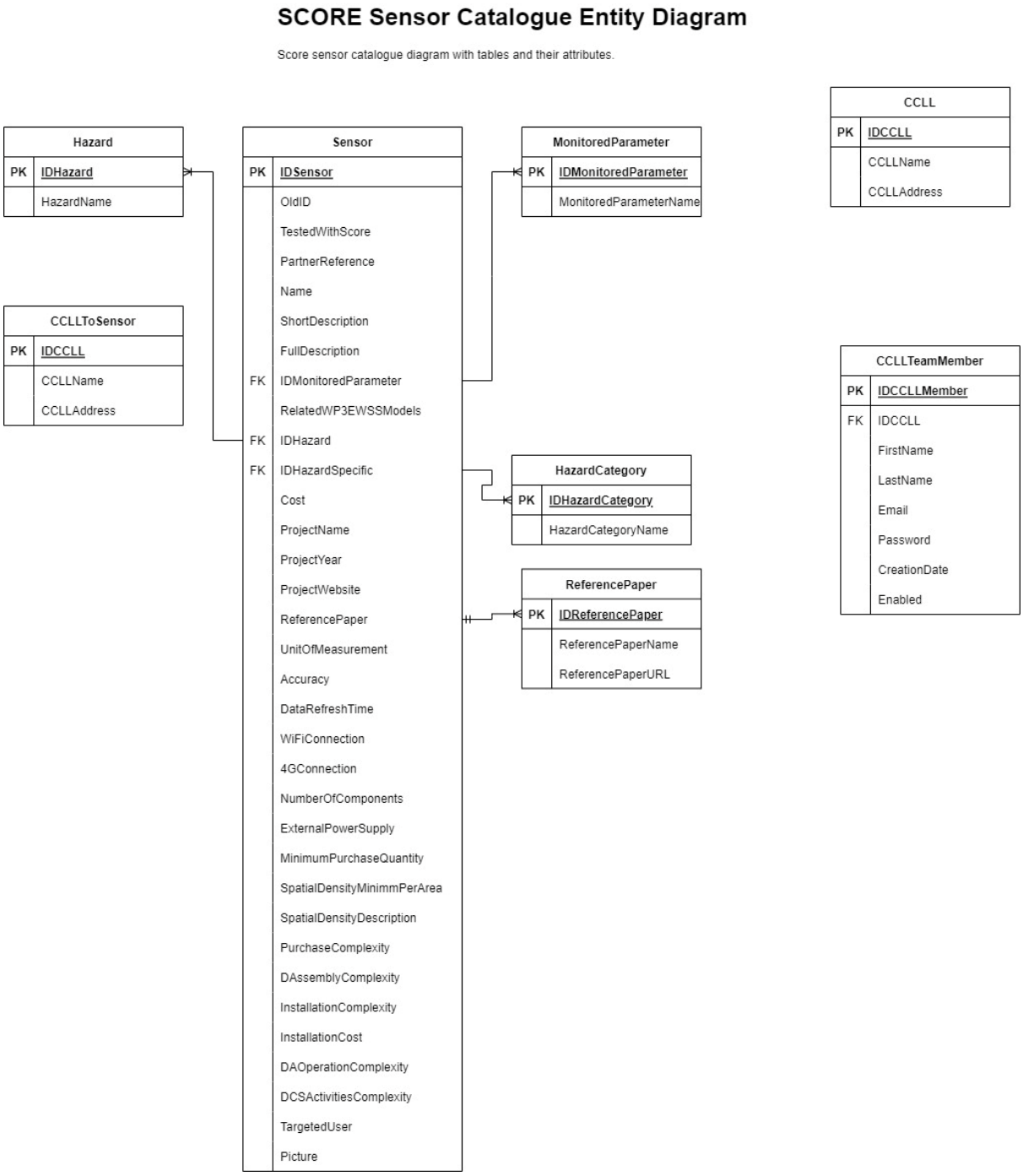

Figure 4: Sensor Catalogue Data Model - Draft Entity-Relationship Diagram

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APPENDIX

Link to catalogue of low-cost sensors for citizen science (Excel)