SUMMARY OF PhD THESIS

Research on applications of environmental informatics for soil protection

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INTRODUCTION

Unprecedented scientific and technological developments, over the last 30 years, have brought to the fore new opportunities for data acquisition, information processing, and knowledge dissemination about the environment, including soil. These opportunities include the emergence of relatively new disciplines, that have materialized as research areas since 1990. In this context, *environmental protection*, i.e. *soil protection*, and *environmental informatics*, i.e. *environmental information systems*, stand out. These fields are grafted onto the classical sciences, namely soil science, and informatics.

Soil protection and environmental informatics have matured out of the need to meet the specific requirements of the information and conceptual consumer society, which specialists in various fields need. As a result, the present research has endeavored to complement knowledge in the field by configuring, creating, and using a mobile application dedicated to soil protection.

My PhD thesis starts from delimiting the current state of knowledge on the use of mobile applications for soil protection, and continues with the creation of a dedicated mobile application - *My Soil Protection App*.

The first chapter, titled *Soil - from resource-support to scientific concern*, starts with the importance and functions of soil in society, summarises the current state of the use of soil resources, and discusses scientific concerns for soil protection. In addition, the most significant legislative provisions concerning soil protection in the EU and in Romania have been considered.

The second chapter - *Soil protection, environmental information systems and environmental informatics* - begins by stressing the importance of environmental data processing, at the same time presenting the evolution and typology of environmental information systems. We discuss environmental informatics and a series of research on applications for soil protection, a field at the border between Environmental Sciences and Information Technology.

Chapter three summarises the objectives of the research based on a literature review. We have organized the current state of knowledge on the use of mobile applications dedicated to soil protection in relation to the 7 research milestones that we considered necessary, namely the comparison of the application with other applications dedicated to soil protection, the establishment of the framework for conducting field research, the selection of ecopedological indicators of interest, the creation of the application, the calibration, validation, and evaluation of the application created in relation to the conditions in the experimental area.

Chapter four describes the specifics of the natural environment in which the experimental research was conducted, while chapters five and six present the working methodology used, including the MIT App Inventor® development environment, going through the creation, testing, validation, and use of the mobile application titled *My Soil Protection App*.

The last two chapters briefly present the conclusions, proposals, and recommendations in relation to the app created, in which we have focused on 11

ecopedological indicators selected from the *Methodology for the Elaboration of Pedological Studies* and on real-time connections with functional platforms, thus supporting the specialists in the field, i.e. farmers, agricultural area managers, local public administrations, representatives of other public and private entities, etc.

1. Soil - from resource-support to scientific concern

Chapter 1 comprises four sub-chapters presenting data on the importance and functions of soil (§1.1), scientific concerns about soil protection (§1.2), and the current state of soil resource use (§1.3). It also reviews the most relevant legislation on soil protection (§1.4).

2. Soil protection, environmental information systems and environmental informatics

Chapter 2 comprises three sub-chapters detailing the importance of environmental data processing (§2.1), illustrating the evolutionary typology of Environmental Information Systems (§2.2) and introducing Environmental Informatics for soil protection (§2.3).

3. Research objectives

Chapter 3 comprises seven sub-chapters that summarise the objectives of the research based on a consultation of the literature on soil protection and environmental informatics (§3.1). The current state of knowledge on the use of soil protection mobile applications (§3.2), the comparison of the application with other soil protection mobile applications (§3.3), the establishment of the field research framework (§3. 4), the selection of ecopedological indicators of interest and the configuration, creation, and testing of the application (§3.5), the calibration and validation of the application in relation to the conditions in the experimental area (§3.6), as well as the evaluation of the application (§3.7) provide important additions to the thesis and delimit the current state of knowledge.

4. The particularities of the natural environment in which the experimental research took place

Chapter 4 comprises seven sub-chapters describing the features of the natural environment in which the experimental research was carried out, reviewing general aspects (§4.1), elements of geology and geomorphology (§4.2), elements of hydrography, hydrology and hydrogeology (§4.3), climatic and meteorological features (§4.4), pedological features (§4.5), wild flora (§4.6) and the current state of land use (§4.7).

5. Material and method

Chapter 5 comprises seven sub-chapters describing the working methodology, i.e. tools, technology, and materials used in the foundation of the current state of knowledge (§5.1-§5.3), with a focus on soil protection and comparison with other dedicated applications (details in Fig. 5.2). In addition to all these, we have established the experimental area and created a mobile application for soil resource protection, which we named *My Soil Protection App* (§5.4-§5.7) (details in Fig. 5.9).

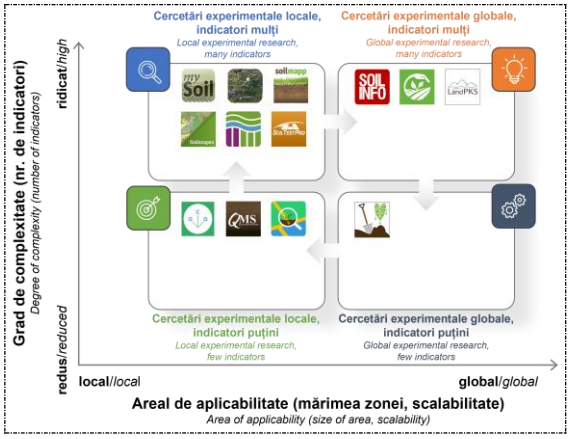

Fig. 5.2. Typology of mobile applications dedicated to soil protection activities

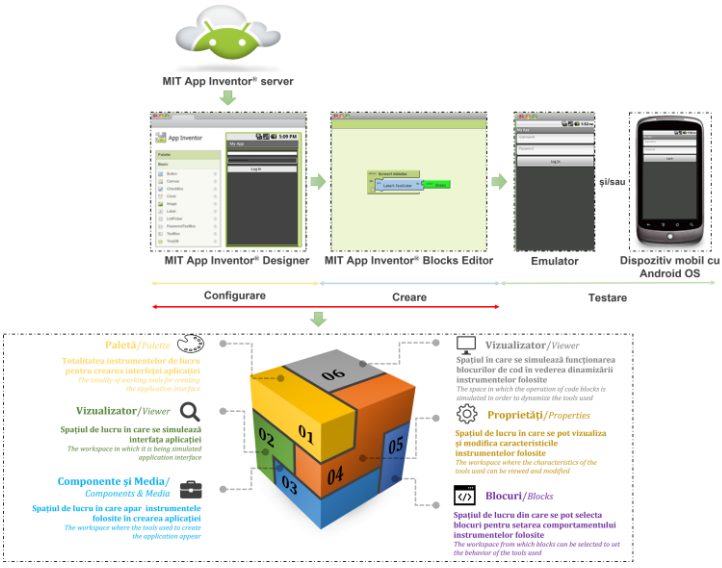

Fig. 5.9. How to configure, *build, and test a mobile app in MIT App Inventor®*

6. Results and discussion

Chapter six comprises seven sub-chapters in which results and discussions are presented in relation to the current state of knowledge in the field (§6.1-§6.3), but also in relation to the establishment of the experimental area and the creation of the *My Soil Protection App* mobile application for soil resource protection (§6.4-§6.7).

To begin with, a series of infographics have been developed, both on the definition of soils and the evolution of soil protection concerns at international level, and on the typology of environmental information systems and the evolution of environmental informatics, of which we reproduce for example Fig. 6.3, Fig. 6.4 and Fig. 6.8.

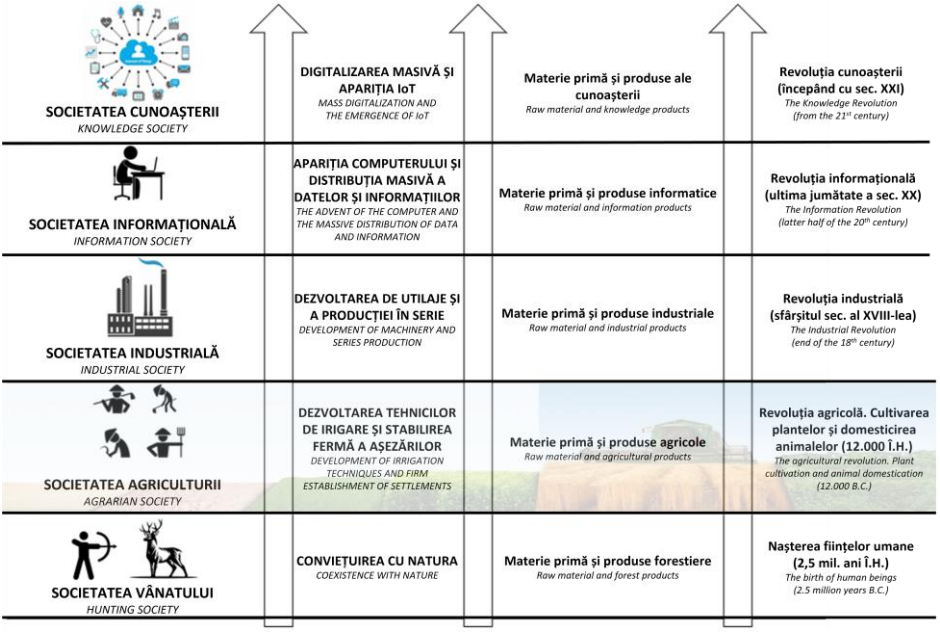

Fig. 6.3. The soil is seen in relation to the development of society (HARARI, 2017; CIORUȚA și COMAN, 2021; CIORUȚA și COMAN, 2022a,g)

The first step is to have a good understanding of the role of soil in society, as a production agent (Fig. 6.3), and then to know the evolution of approaches to soil and soil resource protection (Fig. 6.4). As far as soil protection is concerned, it should be carried out in addition to, not separately from, other activities involving environmental protection. It must also be combined with approaches specific to the development and use of environmental information systems.

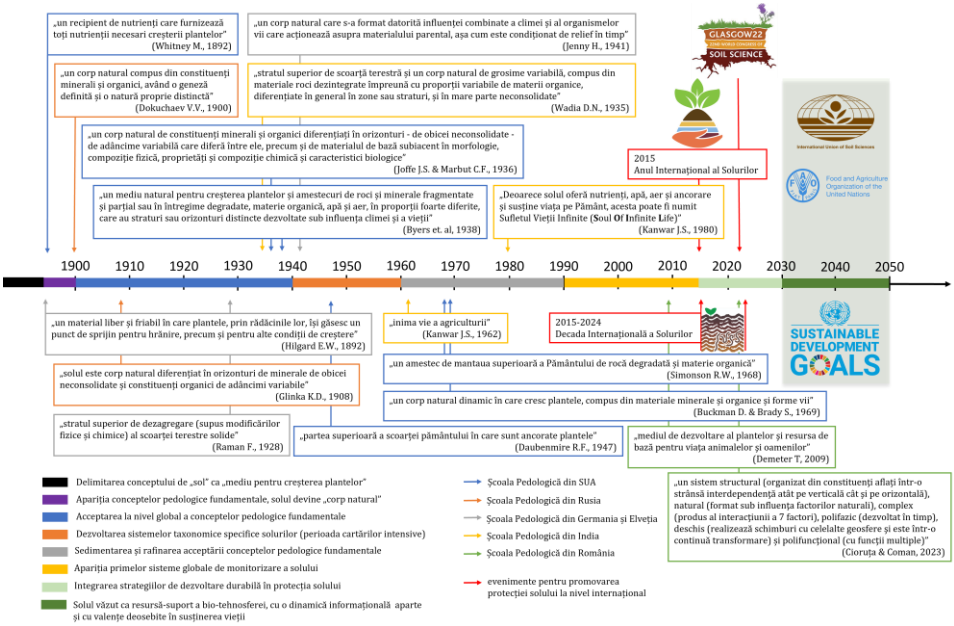

Fig. 6.4. Different perceptions of the importance and functions of soil in society over time

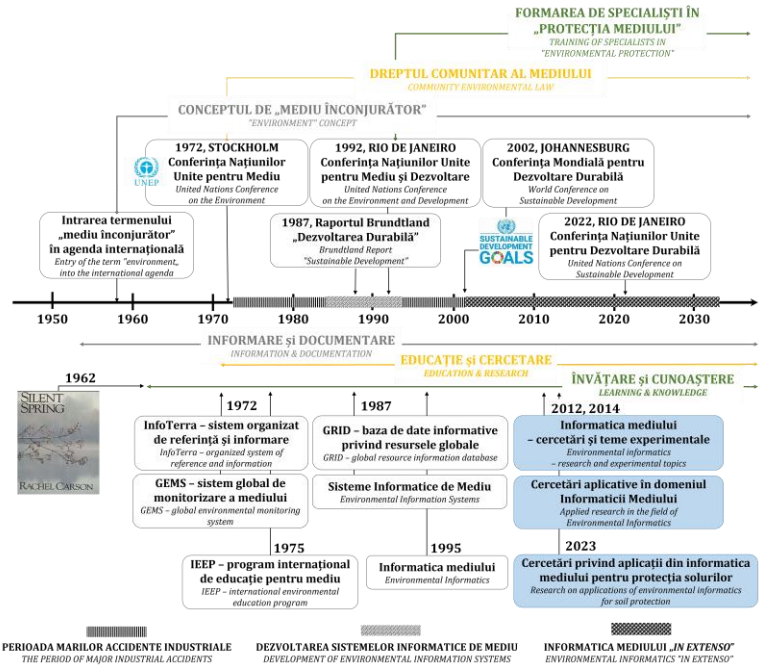

Fig. 6.8. Diagram of the emergence and development of Environmental Information Systems

In order to establish the framework for the experimental research we identified and selected seven areas of interest, with and without a known history of soil quality, land use, degradation factors, nature and type of pollution, etc. These areas are within the Someș-Tisa Hydrographic Basin.

Subsequently, considering the representativeness and depth of the research, we opted for a number of four sites, shown in Fig. 6.21, namely the Jibou - Someș Odorhei site (grid 2), Benesat - Ulmeni - Șomcuta Mare (grid 3), Tăuții Măgherăuș - Seini - Negrești-Oaș (grid 5) and Satu Mare (grid 6).

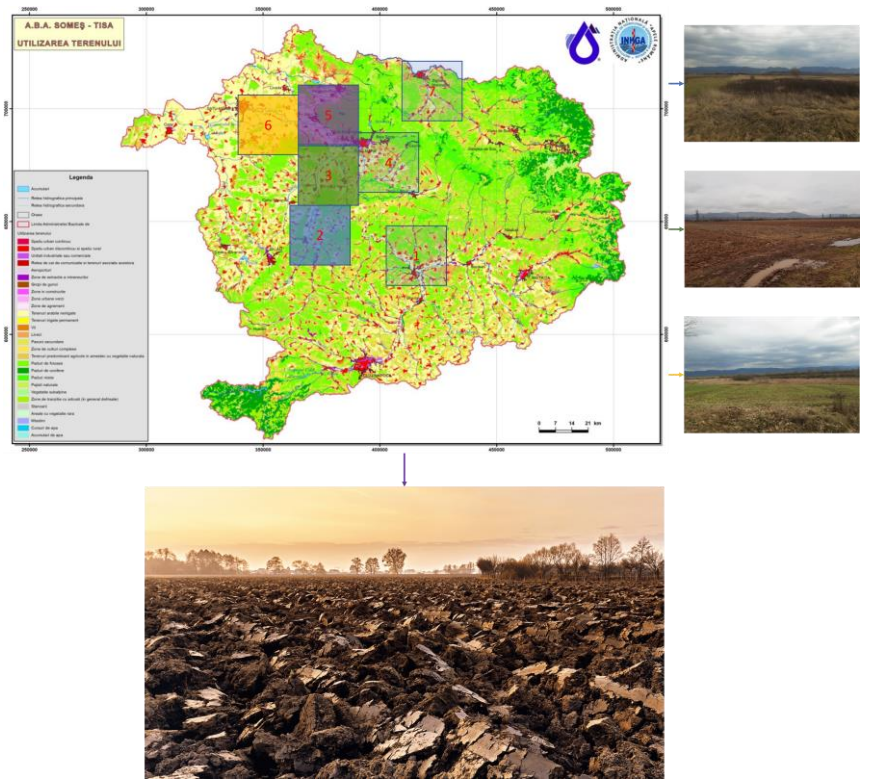

Fig. 6.21. Aspects of the natural setting of the experimental research perimeter

For the creation of the mobile application, we identified several scenarios (development environments), from which we finally selected the MIT App Inventor® platform as the optimal variant for our needs. The implementation of the app's functionalities required the consultation of the scientific literature, the *Methodology for the Elaboration of Pedological Studies* (MEPS, part III) being chosen as the fundamental basis of the work.

From the category of ecopedological indicators (details in Fig. 6. 23) we have selected seven basic indicators for the characterization of the relief-climate-vegetation unit, namely the main characteristics of the climatic zones and the main relief

categories (indicator 1), the average annual temperature classes (indicator 3), the average annual precipitation classes (indicator 4), the absolute altitude classes (indicator 6), land unevenness classes (indicator 8) and geological structures of special interest (indicator 9), plus 4 indicators dividing soil units, namely class groups, textural classes and subclasses (indicator 23), use categories and subcategories (indicator 26), soil pollution types - by nature and source (indicator 28) and degree of soil pollution (indicator 29).

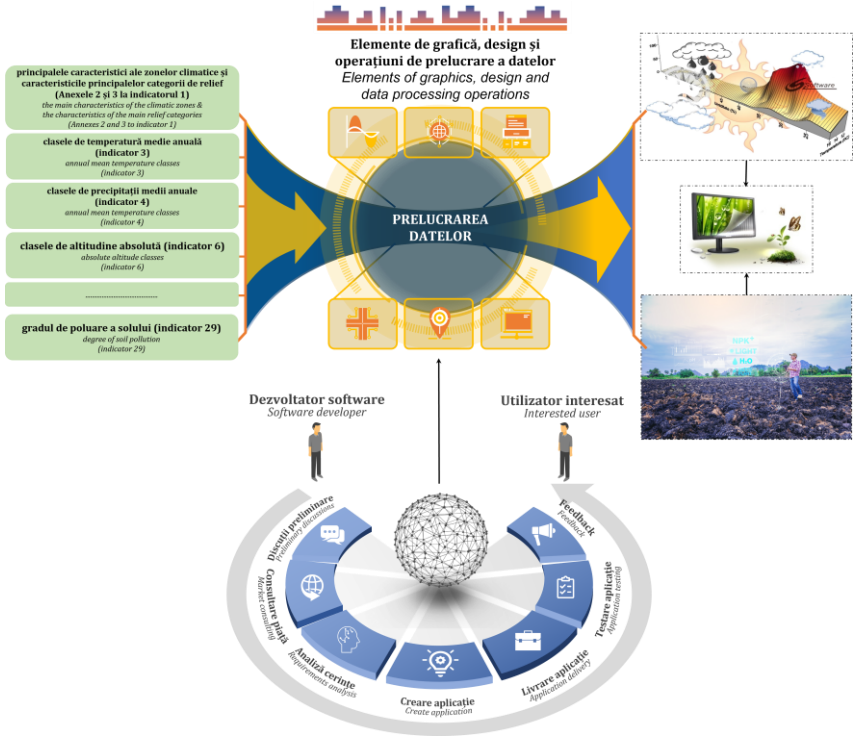

Fig. 6.23. Selection and integration of ecopedological indicators in the application

The combination of these in the *My Soil Protection App* is certainly a useful tool for users interested in soil resource protection and land use monitoring. Moreover, the app is relevant for indicating and tracking forms and types of pollution at the level of a selected area, therefore any further experimental research can be directly linked to the reporting mechanisms of the app, which have a special significance in making decisions and tracking the evolution of soil remediation measures.

7. Conclusions and recommendations

A comparison of the application created with other soil protection applications available internationally shows that there is a wide range of such applications. Some are more complex in content, others are unidirectionally developed, but all show the involvement of multidisciplinary teams of specialists in their creation.

Establishing the ecopedological indicators of interest for the present research proved to be by far the most difficult task to accomplish, both in terms of the large number of ecopedological indicators (275), of which we selected 11 and in terms of the effort involved in setting up, creating and testing the application.

The application that we created and tested (i.e. *My Soil Protection App*) fits in terms of functionality in the field of soil protection. The novel elements brought to the fore are the selection and use of basic ecopedological indicators and soil unit dividers, the configuration suitable for large experimental areas, and the real-time connection with data on soil quality and weather conditions.

The research results were validated in the four sites of the Someș-Tisa River Basin perimeter, and by extrapolation, we consider that they can be applied to any river perimeter of our country. The application supports soil protection activities by warning of a negative environmental impact, monitoring the natural mitigation capacity of a polluted area, and complementary monitoring of a potentially polluted area, while contributing to comparative studies on soil resources, and various public or private investigations.

For the accurate characterization of an area, we recommend stepwise exploration, with details of the seasonal investigation, to understand the local agroecological specificities and to confirm the documentation benchmarks. We also recommend the selection of a minimum of 5 ecopedological indicators, thus satisfactorily covering the basic needs for characterizing an area.

The use of the application *My Soil Protection App* will be free of charge after obtaining the intellectual property certificate.

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