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## LAND USE WEB MAP OF MOLDOVA CREATING USING WEB-BASED MAPPING SOFTWARE ARCGIS ONLINE

Ioana Chiriac \*, ORCID: 0000-0003-4684-0243

Technical University of Moldova, 168 Stefan cel Mare Blvd., Chisinau, Republic of Moldova

\*Corresponding author: ioana.chiriac@gmail.com

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**Abstract.** The motivation for creating of an interactive map for school is the desire to collect all the necessary information from different sources into one web map to facilitate and standardize the process of teaching geography of the Republic of Moldova, and due to the interactivity of the map to increase student academic achievement and motivation. In the article the methodology of the research, which is carried out within scientific project, the creation of Land Use Web school map of Moldova is considered. The content of the Land Use Web Map and interface screenshots showing functions of interactive map are presented in the article. In the main part of the article, the technology of the creation of Land Use map is described developed by means of work with spatial data of Laboratory of Geomorphology and Ecopedology of Institute of Ecology and Geography and using tools of Web-based mapping software ArcGIS Online. The first result of the study is the description of the technology by which any other thematic web map can be created. The second result is the Land Use web map of Moldova, which through the Internet can be used in any country of the world by students and school teachers.

**Keywords:** *Interactive map, Geographic Information System, secondary school education.*

**Rezumat.** Motivarea în realizarea unei hărți interactive pentru școală este dorința de a colecta toate informațiile necesare din diferite surse într-o hartă web pentru a facilita și standardiza procesul de predare a geografiei Republicii Moldova, iar datorită interactivității hărții - a motiva pe elevi de a multiplica cunoștințele în domeniu. În articol se ia în considerare metodologia cercetării, care se desfășoară în cadrul proiectului științific, realizarea hărții interactive Utilizarea terenurilor în Republica Moldova. În articol dat este descrisă tehnologia de creare a hărții web utilizând datele spațiale din Laboratorul de Geomorfologie și Ecopedologie al Institutului de Ecologie și Geografie și folosind instrumentele ArcGIS Online. Conținutul hărții tematice și capturile de ecran ale hărții web sunt prezentate în articol. În urma cercetării au fost stabilite două rezultate. Primul rezultat al cercetării este descrierea tehnologiei pentru crearea altor hărți tematice interactive. Al doilea rezultat al cercetării este harta web de utilizare a terenurilor în Republica Moldova, care poate fi accesată prin intermediul Internetului în orice țară de către elevi și profesori.

**Cuvinte cheie:** *Hartă interactivă, Sistem Informațional Geografic, învățământ secundar.*

## 1. Introduction

For centuries, maps were routinely printed on paper. Although useful and aesthetically pleasing, paper maps were not always easily accessible and were often too expensive for the map consumer. In many cases, university libraries were the best places to locate paper maps. But the Web has fundamentally changed how maps are accessed, distributed, and produced [1, p.442]. According to Michael Peterson, the Web has evolved over three distinct periods that have fundamentally changed how maps are distributed. During the Web's early years, existing paper maps were digitally converted into .jpg or .gif images that were stored and retrieved via Web. As the Web matured, developments in technology and the evolution in computer languages allowed interactivity and animation to take place via the Web. In its current state, the Web has potential to deliver a considerable range of mapping products [2, p. 357].

Web map is an interactive display of geographic information that can be used in school education successfully. Using specific mapping-based Web site, teachers can individually tailor data sets, symbolization, data classes, color schemes and to produce maps to suit their individual mapping requirements in real time. In addition, an interactive school web map maybe used on the white board. To clarify, organize and prioritize learning, teacher can resize map, pan, zoom in or zoom out, highlight some objects in different ways, select areas, add or hide geographical elements, create geospatial tests for students. Students can search geographical objects on digital maps using spatial data tools, measure distances on interactive map, to color digital contour maps, to analyze statistics data from different sources, to create thematic map using geospatial analyze, to save digital map, to export it like an image or to print it.

Thanks to the presence of interactive maps at school, students will grow up with the understanding that GIS is an information and scientific complex for studying the dynamics and predicting landscape changes and its main components - relief, climate, soil, water and forest resources; impact anthropogenic impact on the landscape. [3, p. 82].

Currently, at the secondary education institutions (gymnasiums, high schools) of the Republic of Moldova on the Geography lessons only paper Geography Atlases are used. These atlases do not correspond to modern GIS (Geographic Information System) and are not convenient for online lessons in quarantine or homeschooling [4].

For example, "Physical and Social Geography of Republic of Moldova" Atlas is available to students during their grade 8 year. This Atlas been elaborated with the participation of the author of this article, published in 2015 by Institute "INGEOCAD", consists of two sections: physical geography and social geography of Republic of Moldova. Of particular interest is the map of the structure of the land fund, because agriculture has traditionally been and remains the main pillar of the economy of Moldova. This map shows by diagrams the percentage of arable land, orchards, vineyards and pastures in each district of Republic [5, p. 23]. The Land Use map [6, p. 149] from Atlas of History and Geography of Romania was used as an example. There is one more map from another section of Atlas, the cartogram [7, p. 248] in which districts are coloured by means of erosion degree. The impact of soil loss is one of the most pressing environmental problems. With a very slow rate of soil formation, any soil loss above 1 ton/ha/year is considered irreversible within a time span of 50-100 years. The main causes of soil erosion remain inappropriate agricultural practices, deforestation, overgrazing, forest fires and construction [8, p.16]. Because erosion is a serious problem for productive

agricultural land, an idea was born to combine these two paper maps into one interactive for better visual spatial analysis.

Based on previous experience in creating physical and thematic maps for the above-mentioned atlas, it can be hypothesized, that the spatial data and geovisualization tools [9, 10] previously used to create paper maps can be used to build an interactive map too. To support this hypothesis, the detailed technological scheme of the atlas creation was also studied [11]. In general, the creating a paper map lifecycle consists of four steps: page design, mapping, preparing for printing and printing on a printing house [12, p. 92]. The Page Design includes determination of mapping territory boundaries, its placement relative to page frames, legend and, if it is required, additional small-scale maps, explanation text, graphs and diagrams. During this process, technical conditions are taken into account too. It means that standard paper sizes for printing, visual equilibrium of page elements are carefully studied. Besides especially important requirements aimed at correctly displaying of idea and usability of map [13, p. 119]. The next step GIS mapping refers to the process by which geo-located data are charted onto maps using different cartographic methods. The most frequently used cartographic methods from Salichev classification [14] are cartogram, carto diagram, qualitative background method, linear method and Map Icons. Preparing for printing require some processing before printing or electronic distribution. For example, preparing of text and graphic elements of pages that meet output requirements. The last step of creating of a paper geographical atlas is printing on a Typography printing house. This process is the shortest from all the paper map lifecycle, but is the most responsible one. This is because errors that editors did not notice earlier can be identified on Typography's specimen, corrected and not replicated for many hundreds or thousands of copies.

Mapping is the only one common step for web mapping and creation of paper map. Page design may be replaced with creation of dashboards. At the first stage, there is a need to add the creation of a geodatabase, at the last - data sharing relationships.

So, it became necessary to determine the methods, procedures and principles for creation of thematic web maps for schools, because, for example, various spelling for a place-name always present a problem [15, p. 62]. It is hypothesized that names from web base map can be used for mapping.

The aim of this paper is to explore the methods of creating and sharing of interactive web map of Moldova using ArcGIS Tools.

## 2. Materials and Methods

There were used tools from ArcGIS Data Management Toolbox to develop, manage, and maintain feature classes, datasets, layers, and raster data structures. To simplify the task for data storage, a decision was made to use cloud-based mapping ArcGIS Online. With cloud storage, there is no need to rack and stack servers. In the cloud, businesses can scale workloads based on certain metrics as needed - in literally a few clicks - using built-in features. In the course of work, a free version of ArcGIS Online was used to test the map.

Table 1 gives an overview of the applications and tools used for Land Use map creation.

The first phase of the data lifecycle is the creation of Geodatabase in ArcCatalog Application with two types of data: Feature classes and Tables.

Next step is to relate attribute table of polygon layer of Moldova's districts with Excel Table which contains Land Use information using tool Join Field from ArcToolbox. As a result, automatically indicators of Land Use are added to be marked on the map at the next step.

Table 1

Applications and tools used for mapping		
	Application/Tools	Purpose
1	ArcCatalog 10.4.1	Collect data to Geodatabase
2	ArcMap 10.4.1, ArcToolbox, Representation	Map Design
3	ArcGIS Online	Create cloud-based interactive map
4	ArcGIS API for JavaScrip	Create and customize Dashboard

Next step is Map Design. Taking into account the fact that base map has been provided on ArcGIS Online by Esri free of charge, there is no need to create Layers of cities, hydrography, etc. For the Land Use of Moldova map there was created only one feature class with area objects of the Moldova's districts, each of which in its table of attributes keeps information on the percentage of land damaged by erosion, percentage of vineyards, arable land, orchards and pastures in the total area of the district (Figure 1).

Raion_Name	ravene	arabil	Livezi	Vii	pasuni
Anenii Noi	1	65.28	5.44	6.89	11.89
Basarabasca	3	67.49	2.02	10.14	19.76
Briceni	1	78.38	9.33	0.24	11.47
Cahul	4	74.29	2.07	14.06	8.45
Călărași	5	47.19	11.29	21.77	18.65
Cantemir	4	67.28	3.91	10.25	15.89
Căușeni	3	74.66	5.46	6.25	12.89
Cimișlia	3	71.68	2.92	8.98	15.67
Criuleni	2	74.4	5.07	4.19	9.9
Criuleni	2	74.4	5.07	4.19	9.9
Dondușeni	1	71.2	10.65	0.16	16.89
Drochia	2	82.42	2.62	0.26	13.55
Dubăsari	2	77.14	6.44	3.56	11.71
Dubăsari	2	77.14	6.44	3.56	11.71
Edineț	1	79.58	6.21	0.16	13.81

**Figure 1.** Attribute table of Thematic Layer.

All this information from the attribute table has been indicated on the map by two different cartographic methods. To indicate the degree of damage to the land of the district by erosion, the cartographic method of cartogram was selected. Also there was created the carto diagram with land use structure on districts. Chart shares are percentages of area used for arable agriculture, area used for orchards, area used for vineyards and area used for pastures.

In Table 2, data and data sources for Land Use map are presented, followed by a discussion on how these are represented on map.

When the attribute table is filled with all necessary information, cartogram and carto diagram are created, it is time to transfer the data to the online ArcGIS space and to add the created thematic layer to the base map. Next step is to create ArcGIS Online account and to indicate the purpose of it. For free it is easy to get account to test the web map.

Next step is to add the map from computer to Gallery (Figure 2) and to click Apps – Dashboard on the left side panel.

Table 2

Sources and types of data				
	Data	data format	data display	data source
1.	Number of population	numeric	numeric	Wikipedia
2.	Soil erosion data	1-4	colour	Laboratory of Geomorphology and Ecopedology, Institute of Ecology and Geography of Republic of Moldova
3.	Share of land area used for arable agriculture	%	chart pie	
4.	Share of land area used for orchards	%	chart pie	
5.	Share of land area used for vineyards	%	chart pie	
6.	Share of land area used for pastures	%	chart pie	
7.	Settlements	-	point	
8.	Administrative districts	-	polygon	
9.	Roads	-	line	
10.	Railroads	-	line	
11.	State borders	-	line	

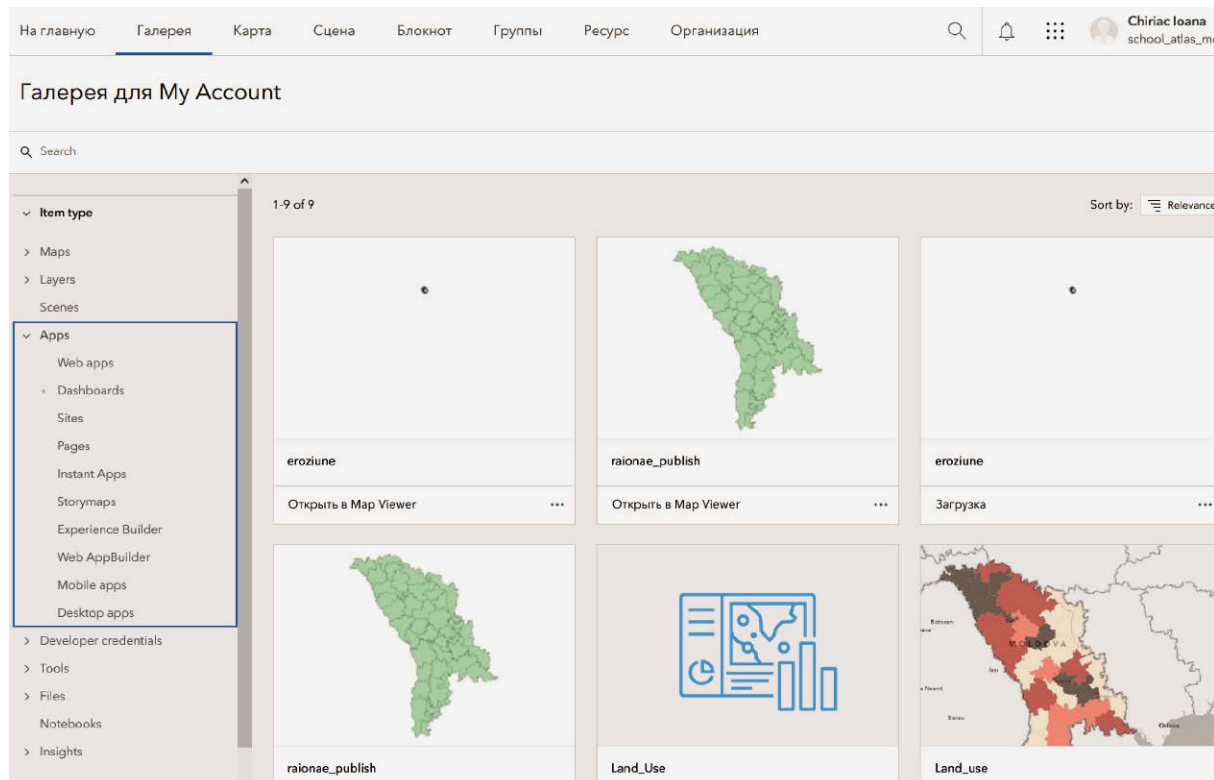


Figure 2. ArcGIS Online Gallery.

Dashboard is the app builder of map. It is very convenient that Dashboards are designed to display multiple visualizations that work together on a single screen.

Configurable elements include [maps](#), [lists](#), [charts](#), [gauges](#), [indicators](#), and [tables](#), and occupy 100 % of the application browser window.

### 3. Results

The results of the study include Land Use Web Map of Moldova and methodology suitable for creating any other thematic interactive map. In Table 3 there is made an attempt to present steps based on the workflow previously described.

Table 3

Overview of ArcGIS components and their functions	
Component of ArcGIS	Purpose
1. ArcCatalog	Creating a new file geodatabase. Import or creation of feature class.
2. ArcToolbox	Adding data to attribute table.
3. ArcMap	Mapping. Geovisualization of data using different cartographic methods.
4. ArcGIS Online	Account Creation. Downloading data on ArcGIS Online.
5. Dashboard	Dashboard design. Data sharing.

The process of map abstraction includes at least five major (interdependent) steps: creating of Personal Geodatabase, adding data to attribute table, geovisualization of data using different cartographic methods, downloading data on ArcGIS Online and data sharing. A personal geodatabase is a Microsoft Access database that can store, query, and manage data. Using right-click on the file folder in the ArcCatalog tree, there is a possibility to select the place, where new file geodatabase will be created. Data with Moldova's districts was imported from another geodatabase. Using the geospatial tool "Join" information about erosion and land use was added to attribute table of feature class of districts. Next step is geovisualization of data in ArcMap using classification in proprieties of selected Layer. After the design of the map is ready, it is possible to publish the map.

The result of the study in the form of an interactive map is presented in Figure 3. The cartogram with its intensity of the color indicates the degree of damage to the land by erosion processes. On the left side there is presented list of districts of Moldova. By clicking on the name of the district in the list or on its configuration on the map, the Land Use diagram appears. The chart includes the percentage of arable land, pastures, orchards and vineyards in the selected district. The name of land use and its percentage in total area of district appears when the mouse pointer comes over the share of the diagram. This way of displaying information was selected not to overload the map interface with text information.

On the right side of the interactive map (Figure 3), there is a Land Use graph of Moldova. This graph clearly shows that most of the land in Moldova is used for growing crops. If Full Screen for Republic of Moldova is selected, then entire territory of Moldova fits on the monitor screen and only names of countries and districts are presented on the map.

Zooming in reveals more details on the map (Figure 4). For example, communes, localities and their names, hydrography, and road networks. Thus, a very detailed informative map at one scale can also become very concise at another scale. This is one of the main advantages of an interactive map over a paper one, which usually shows only the largest geographic features.

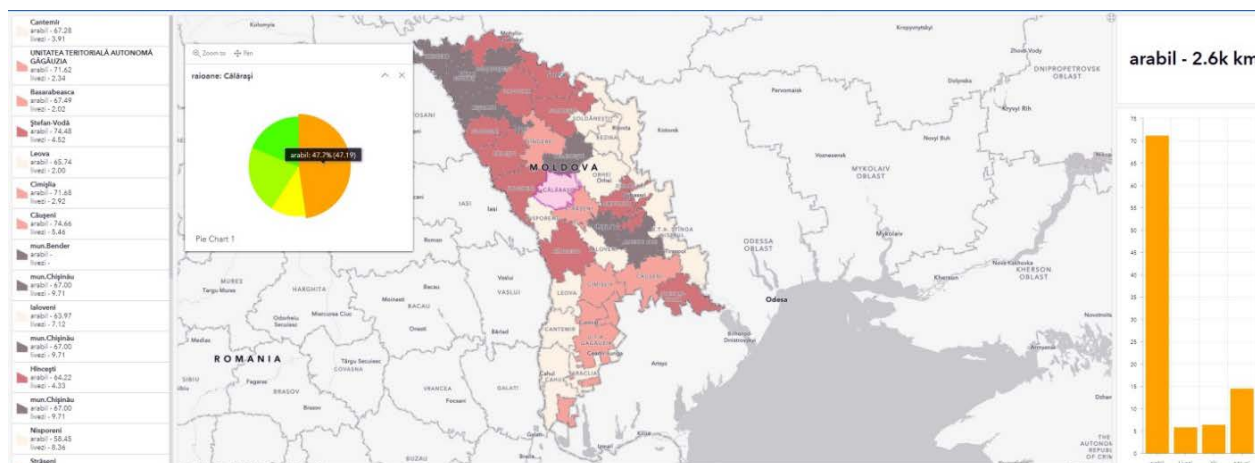


Figure 3. Land Use web map of Republic of Moldova.

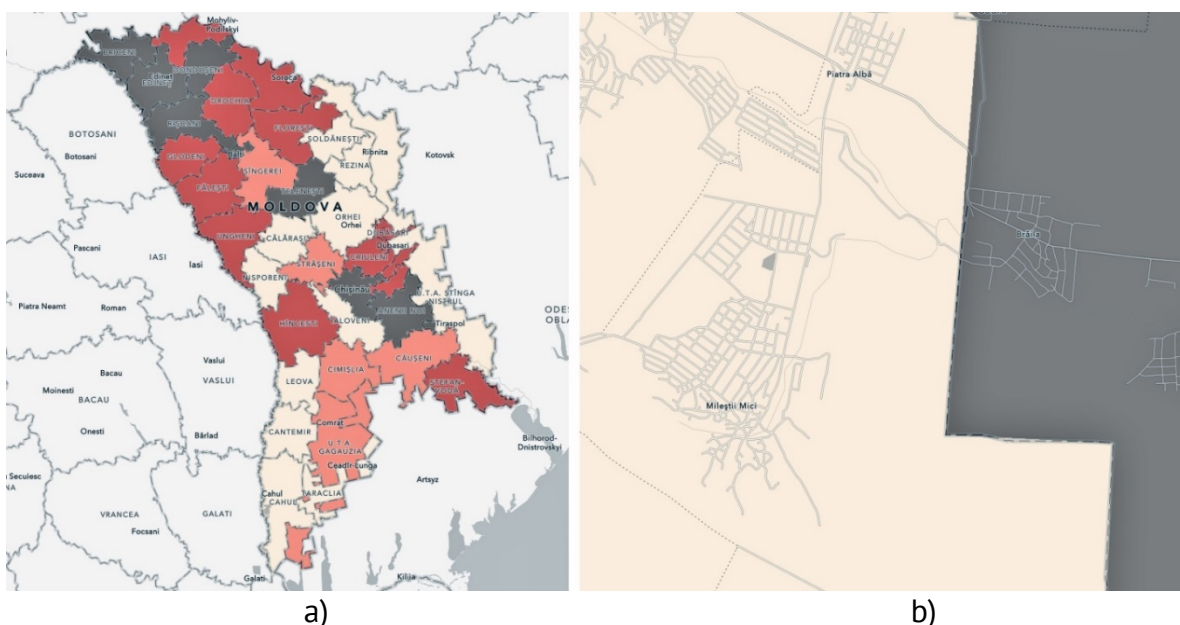


Figure 4. Land Use Map at different scales: a) scale 1:1500000; b) scale 1:10000.

Internet-based GIS have been developed in which all the individual layers are separated thus allowing many students to access and visualize the geo-data at the same time. Data editing on Geography lessons should not be available to students. However, on the lessons about geodatabase, it makes sense to demonstrate the fact that data changes by one student will be displayed on all computers in the class in real time.

The application has been designed in such way that information is easy to find, quickly to access and available for students whenever they require it. All the tools offered does help the secondary school student to find what they need for their objectives of lesson.

#### 4. Discussion

The long way to the applying of Geographic Information System Mapping Technology in school education in Republic of Moldova began 15 years ago. In 2008, the possibilities and prospects of using GIS for paper atlas producing in Republic of Moldova where proposed [3]. During 2013-2016, the production of paper atlases using GIS technologies was launched at State Enterprise “INGEOCAD” [5]. In this period of time, it was found that ArcGIS is a mapping platform that enables to create interactive maps and apps to share within organization or publicly. Based on above-mentioned experience in paper maps production, there were

proposed methods for creation of interactive maps [12]. As a logical consequence, the paper you are reading, provides step-by-step instruction for interactive map creation. It should also be noted that this instruction can be used to create other interactive thematic maps.

Future research directions include the study of results after the integration of interactive maps in school education. The significant improvement in grades would be a positive outcome of this study. It would be useful to explore the possibilities of other mapping software, except ArcGIS. There perhaps exists free GIS software, which is also fully compatible with the school education. It would also be interesting to explore how interactive maps can be assembled into a coherent atlas system.

## 5. Conclusions

There will be a significant increase in the use of the Internet by schools over the next five years. Young geography teachers and school students who grew up with gadgets in their hands will obviously find paper atlases irrelevant. New system of education with faster paced and interactive learning is required. Interactive maps are suitable for these purposes. WebGIS is a special GIS tool that uses the Internet as a means to access and transmit data, present GIS results and conduct analysis. Similar to web maps and web layers, dashboard is the part of the ArcGIS geo informational model. In addition, dashboards offer filtering capabilities, which enable a refined set of data to be presented to the intended audience.

The transition from the use of paper atlases to interactive ones will save printing costs and will reduce the financial costs of the parents. However, the budget item must be included for information technology so that the expenditure for acquisition is part of the scholar planning process. Every organization using the ArcGIS platform can take advantage of ArcGIS Dashboards for a fee.

The main conclusion, based entirely on the results of the research is the fact that the data, geospatial tools and flowsheet used before to create paper maps, now can be used to create interactive thematic maps of Republic of Moldova. Compared to the process of creating paper atlases, the web mapping is much simpler. The development environment for web based GIS application is greatly simplified with easy-to-use ArcGIS tools. A dashboard's [layout](#) can be configured in various ways to be as effective as possible. Page format, map scale, geographic projection are no longer limiting factors for the amount of geographic information added to a map. In addition, the line features (boundaries, rivers) and labels accepted in the international geographical community are used as a base map and exclude errors. Various spelling for a place-name is not a problem anymore. On ArcGIS Online names are spelled according to official practice in the local language. For names in language written in non-roman alphabets, the U. S. Board of Geographic Names transliteration system were followed as well as local official systems where they exist.

The methodology of Land Use Web map creating described by steps in this article maybe used to create any other thematic interactive maps. Creating a cartogram is the best way to map contiguous geographic phenomena. For example, Land Use Web map gives a good overview of the structure of the Moldovan land fund by its diagrams and degree of soil damage by erosion by its cartogram. The dark colours of the cartogram, covering more than half of the territory of Moldova, indicate that agricultural activities in these areas are under threat. Soil erosion by water, wind and tillage affects both agriculture and the natural environment.



Getting an access to workflow-specific apps, maps and data from around the globe and tools gives an opportunity for being equally mobile in the classroom and at homeschooling or in quarantine.

**Conflicts of Interest:** The author declares no conflict of interest.

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[jes@meridian.utm.md](mailto:jes@meridian.utm.md)