

# **A Mobile Application to Visualize Historic Land Use along Hiking Trails in Southern Germany**

Christian Sommer<sup>1,2</sup>, Andreas Braun<sup>1</sup>, Markus Hanold<sup>1</sup>, Hans-Joachim Rosner<sup>1</sup>  
and Volker Hochschild<sup>1</sup>

<sup>1</sup>University of Tübingen, Germany

<sup>2</sup>Heidelberg Academy of Sciences and Humanities, Germany

## **Abstract**

Land-use and land-cover change is a global phenomenon that poses great challenges to people, who often oppose changes in the familiar landscape (Foley et al., 2005). However, it needs to be recognized that humans have continuously shaped and intensively intervened in the landscape throughout history, creating the 'Kulturlandschaft' (cultural landscape) we see today, and leading to the scientific preoccupation with the 'Anthropocene' (Ellis, 2011). By enriching locations with digital content, this knowledge can be better conveyed, since so-called 'augmented places' not only convey information, but also allow the embodiment of what has been learned through increased immersion (Chang, Hou, Pan, Sung & Chang, 2015). We present an application that combines historical landscape change and the legacies of early mechanization through a mobile WebGIS designed with tourists in mind to convey information about historical land use in a playful way (<http://gdi.geographie.uni-tuebingen.de/echaz/map.html>). Historical map material for the region of the river Echaz in southwest Germany was digitized and georeferenced, organized in a framework of geoservices, and finally made available together with further content in a web app. Ultimately, the aims are to show alternatives to current land use and to address the variability of the landscape, and thus to achieve participation in and acceptance of landscape planning.

## **Keywords:**

WebGIS, land use, augmented places, Anthropocene

## **1 Background and motivation**

Nearly every landscape on earth is the result of centuries of anthropogenic use and transformation. Accordingly, landscapes are a valuable archive of human activity on the planet. In many parts of the world, historical land use is well documented or can be reconstructed. However, this information is rarely made accessible to the public.

Digitizing historical land use and its organization in a GIS can help to increase understanding of past land-management practices and raise awareness of traditional methods of cultivation

and husbandry (Knowles & Hillier, 2008). This has been demonstrated by Bender, Boehmer, Jens & Schumacher (2005), who collected and digitized cadastral maps, land registers and aerial photos dating from 1827 to 2001 to quantify the changes in cultural landscapes in the Bavarian Forest and the Franconian Alb. This information can be used for the restoration of historical habitat aggregates or the development of sustainable land-management plans. Rosner (2000) and Nowatzki & Rosner (2016) analysed century-scale landscape changes in the nearby Schönbuch area using the landscape metrics approach. While geospatial techniques are already increasingly used to integrate historical data in plans for the conservation of natural resources, the aspects of remembrance and cultural heritage are still widely neglected. However, the availability of such data is not the major constraint in most cases, but rather their accessibility for people from outside public administration or without the technical know-how. As one possible solution, Burggraaf et al. designed an online platform for the collection and cartographic representation of cultural heritage sites to assist their preservation and remembrance, as well as their consideration in official planning applications (Burggraaff, Knieps, Schulteiß, & Tempel, 2017).

Hasse (1996) recognized that tourism is strongly linked to the human desire for an unspoiled state of the environment and that outdoor-enthusiasts especially show great interest in the stories behind the landscapes through which they hike. Accordingly, the location-based provision of historic land-use information can increase awareness of historical forms of land use, the morphogenesis of landforms, and cultural heritage.

This article proposes a way to prepare and organize, in a user-friendly manner, openly accessible historic land-use data along hiking trails in the Echaz valley in southwest Germany. To further attract people who are not primarily interested in landscape history, this information is enriched with information about land-use changes, and selected socio-cultural content, such as photographs or historical descriptions of administrative divisions and their cultural peculiarities. Consequently, our target group includes all people, from young adults to the elderly, who show an interest in landscape and nature, have at least a minimal affinity for technology, and can handle everyday mobile apps. Using elements from familiar mobile map applications, we augment historical maps and aim to facilitate access to the wider public.

## 2 Data and methods

### 2.1 Data and preparation

#### Local primal cadastral map: *Urflurkarte*

As a starting point of the land-use analysis, we used the earliest cadastral maps ('Urflurkarte') of the kingdom of Württemberg, which were created between 1818 and 1840 by a decree of King Wilhelm I. These maps show parcels of land, landforms, settlements and buildings at the scale 1:2,500 and were made publicly available as a web mapping service (WMS) by the federal archive of the state of Baden-Württemberg (Naumann, 2014).

## Historic topographical maps

Topographical maps from 1908, 1936, 1963, 1977, 1987 and 1999 are provided in paper form by the State Office for Land Information and Development, Baden-Württemberg (LGL) at a scale of 1:25,000. They contain the most relevant forms of land use and land cover related to urban areas, traffic, energy, infrastructure, vegetation and topography, and use predominantly consistent legends.

## Hiking trails

We selected hiking trails in the area from among those officially designated as such by the municipality of Pfullingen and retrieved them from Open Street Map. The chosen trails stand out for being waymarked, and for having trailside information on nature and culture as well as works of art. Additionally, maps and route descriptions were available on the town's homepage (Stadt Pfullingen, 2020), so that the online map can directly refer to these materials.

## Cultural descriptions of communes

As additional content for the online map, the 'Württembergische Oberamtsbeschreibungen' were used. Compiled between 1820 and the early 20<sup>th</sup> century, these contain descriptions of the historic administrative units, their geographical characteristics, living conditions in the towns and villages, the characteristics and habits of residents, linguistic peculiarities, and various amusing anecdotes (Memminger, 1824). A collection of over 60 texts is available and attracts several thousand page-views per month (Wikisource, 2020). The document dealing with the Reutlingen area dates back to 1824 and includes a topographical map with a scale of 1:100,000. A digital version of a reprint from 1971 is available free on Wikisource (2020).

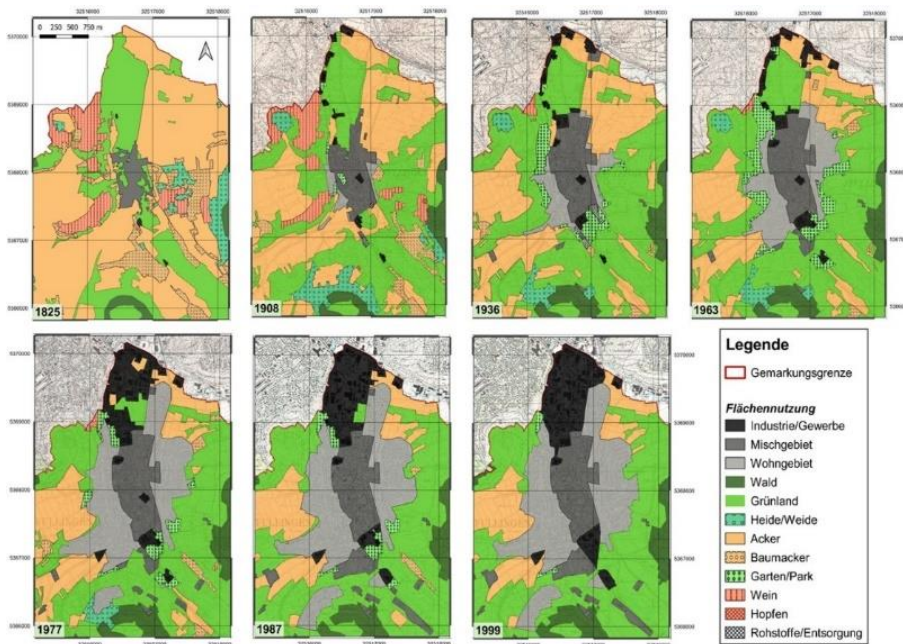
## Historic POIs

Points of interest (POIs) include the historic water mills on the Echaz and other historic buildings, and the artificial Echaz canal. Some of the mills can be traced back to at least the 11th century and are living monuments with functioning equipment. As they were of great importance for the economic development of the region and are also in a good state of repair, the 'water experience path' provides information about them on boards (Pustal, 2018). Parts of the mills are also included in the Milldatabase, which features technical aspects of the milling equipment (Milldatabase, 2020). Further tourism-related information, such as opening hours and entrance fees for museums and lookout towers, was obtained from Pfullingen's homepage (Stadt Pfullingen, 2020).

## Processing

The maps were available only in paper form, so topographical maps were georeferenced using the coordinates (Gauß Krüger Zone 3) at the map margin and subsequently reprojected to the current system (UTM Zone 32). In the absence of a usable map margin, the historic maps were georeferenced using persistent buildings (e.g. churches), elevation points and other control points that could be cross-checked with those on modern maps. When inaccurate localizations occurred in the historic maps, these were excluded through an analysis of the residuals. The thin plate spline method proved to be best suited for the transformation process, which was carried out (as was the whole procedure) using the 'Georeferencer' plugin in QGIS 3.8. All land-use information in the maps was digitized and classified into the following harmonized

classes: industrial/commercial, mixed, residential, forest, grassland, meadow, cropland, cropland with trees, orchard, garden/park, viticulture, hop cultivation, disposal (Figure 1). The classes meadow (‘Heide/Weide’), cropland with trees (‘Baumacker’), meadow orchard (‘Streuobstwiese’) and hop cultivation (‘Hopfenanbau’) especially have strong cultural connotations, as they are linked to particular periods of German history and traditional forms of cultivation. In the second step, changes in the land-use classes over the period being investigated were identified using a pair-wise approach, as proposed by Herold, Hecht & Meinel (2011). The results show an increase of built-up areas from 34 to 493 hectares between 1820 and today. More importantly, traditional land-management techniques, such as viticulture, or cropland with trees, vanished almost entirely from the area. This underlines the importance of the digital conservation of knowledge of these for hikers in the present landscape. In many cases, remnants of historical land use become visible once pointed out to the viewer, for example the shape and sizes of parcels, characteristic landforms, or the remains or transformations of buildings (Eberle, Eitel, Blümel & Wittmann, 2017; Morrissey, 2015)



**Figure 1:** Change in land use in the study area around the city of Pfullingen (Brand, 2019)

## 2.2 Online Application

The web application is based on a framework of web services, local data and sensor information, which are merged and executed on mobile devices using a JavaScript interface. The background data include geodata from Maps4BW (the freely accessible official map service of the state of Baden-Württemberg) and the map service of the OpenStreetMap project. The two datasets are integrated as interchangeable basemaps via standardized Web Map Services (WMS) or Web Map Tile Services (WMTS), as defined in ISO 19128. Other

records are linked via the same standardized interface, but these are self-hosted by a Geoserver instance on a web server of the University of Tübingen (Geoserver, 2020). They include primarily raster data, such as the georeferenced historical maps. The relevant vector layers, such as land-use data, hiking trails and POIs, are kept on the web server together with linked attributes, such as additional information, external web links, or picture URIs, as feature collections in the open format geojson.

All these data sources are bundled, styled and displayed in a WebGIS application based on HTML5, CSS3 and the JavaScript library Leaflet 1.6.0 (Leaflet, 2020). The Leaflet library is an open source software for generating interactive web maps, which, thanks to its responsive design, is particularly suitable for display on both desktop and handheld devices, and is, furthermore, accessible through a broad range of web browsers.

The individual time steps are represented by layer groups that bring together the various geo layers of each time period. Each layer group consists of a contemporary basemap and an overlying land-use layer. Since the geo-referenced basemaps have defined scales and are therefore not freely scalable, several basemaps with varying scales were integrated and only the most suitable one is displayed for each zoom level. For example, the map of the ‘Oberamtsbeschreibung’, featuring an overview at 1:100,000, is displayed at zoom level 14. This is replaced by the ‘Urflurkarte’ at higher zoom levels. Finally, the maps are overlaid by an opaque land-use layer in vector format, which is colour-coded for land-use classes. POIs and hiking trails are also symbolized and integrated as a simple overlay layer, on top of all the other layers.

Auxiliary information about the POIs, hiking trails and land-use classes can be called using the pop-up functionality of Leaflet. The additional information is read from the attribute fields of the corresponding geojson files and displayed in an output window. Depending on the layer, external content such as web links or images are included in this output using HTML5 syntax.

The user’s precise location is identified by the device’s GPS sensor via the HTML5 Geolocation API once the localization of the device has been activated. For reasons of privacy, the user is asked to confirm access to the position, although the application does not track any information about users.

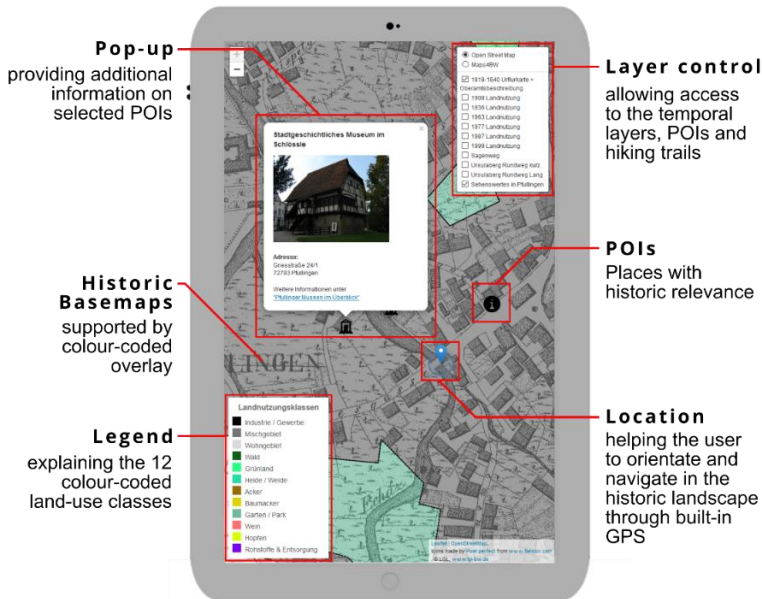
The application’s user interface comprises several basic cartographic elements of the Leaflet library, which allows the user to interact with the map. These include an interactive legend, a zoom-dependent scale, and essential gesture control.

## 3 Results and discussions

### 3.1 User Interface

In order to make access as barrier-free as possible and to make the software accessible to as many people as possible, the application can be loaded directly into the browser. Navigation in the map, with gestures for pane, zoom and click, is identical to that found in common map applications, so that the user instinctively finds his/her way around. Since some content is integrated via web services, a constant internet connection is required.

If the user opts in to having their GPS location displayed on the map for better orientation, the map can be underlain by recent topographic background maps showing landmarks and walkable paths. Waymarked hiking trails and themed trails with information boards can be displayed as a separate layer; information about trail length, names and further links can be displayed using pop-ups.

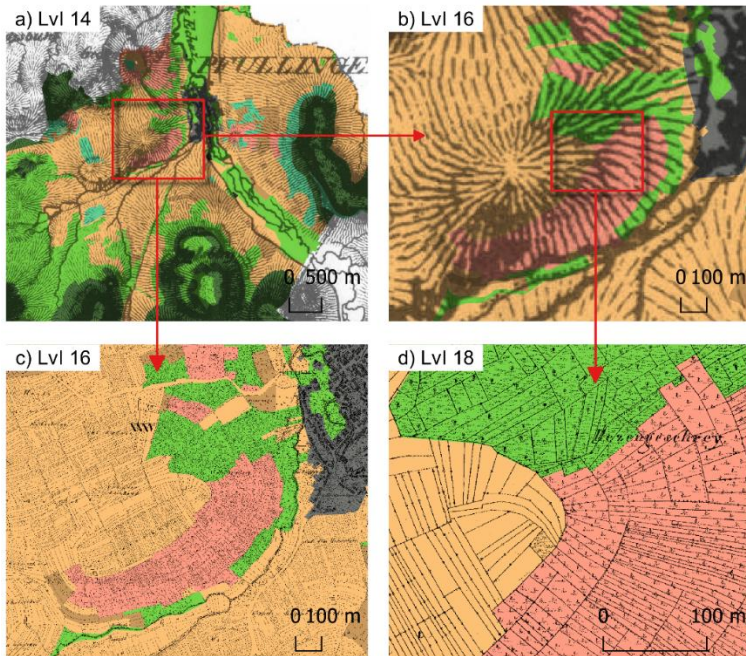


**Figure 2:** User interface of the mobile application

The historical land use is presented as a contemporary background map that uses colour-coding to distinguish between classes, as the historical symbolism alone is difficult to read. Since the land-use classes are standardized across all time steps, the user can see directly the development of the landscape over time and, for example, experience the growth of the urbanized area. They can also see the replacement of special crops by industrial agriculture and the loss of landscape diversity that goes along with that at concrete locations. At the same time, however, the example of the mills also shows that the landscape was subject to constant change even in historical times and was actively shaped by human activity through intensive interventions.

Displaying contemporary maps is intended to increase immersion, a concept from augmented and virtual reality (Milgram & Colquhoun, 2014), which refers to the ability to translate reality into a non-physical world through various stimuli. In this case, the historical maps represent a visual stimulus, which is the result of the (nowadays unfamiliar) symbology, old-fashioned fonts, and the printing technique of the time. Earlier studies indicate that such location-based access to information fosters embodiment of historical places, not only conveying knowledge but also creating an emotional attitude towards place (Chang, Hou, Pan, Sung & Chang, 2015; Oleksy & Wnuk, 2016)





**Figure 3:** Screenshot of historic land-use maps with colour-coded overlay at different zoom levels. The overview map of 'Oberamtsbeschreibung' serves as background in (a) and (b), while the background map switches to the 'Urflurkarte' (earliest cadastral maps) at the higher zoom level (b). Note that the 'Urflurkarte' was excluded from low zoom levels due to poor readability (c).

## 3.2 Challenges and Outlook

The project was carried out largely in the context of final dissertations and practical seminars by geography students at the University of Tübingen. The collaborative work on the web map was greatly facilitated by the use of the developer platform GitHub, which enabled planning, programming and code reviews (<https://github.com/sommergeo/echaz-histo>). Furthermore, the open source programming allows high reproducibility of the mobile application. However, programming skills are required. With regard to the map material, the increasing policy of governmental agencies to make (historical) geodata freely available, partly even as web services, is very much in line with our approach. With the growth of portals like <https://www.leo-bw.de>, the need to host one's own WMS-Servers will be progressively reduced, so that Web Services can be integrated directly into the application, thus simplifying portability to other regions or use cases.

The heterogeneity of the input data posed particular challenges – for example the development of a consistent classification for land use, because the topographic maps were created using different scales, surveys, classification systems and mapping techniques.

Since historical symbolism and changes in it over time are difficult for most users, the transparent colour-coded overlay of the harmonized classes has proved to be a good choice. This method of representation corresponds to the thematic maps which are common today

and allows for continuity when comparing different points in time, while maintaining the aesthetics and thus the immersion of historical maps.

A further expansion of the application within the scope of student research projects provides for the following modules, each corresponding approximately to the time required for a group term paper:

- The enrichment of additional locations with elements of augmented or virtual reality, such as pictorial representations of buildings or landscape views, which are included in some historical sources (e.g. panoramas in the ‘Oberamtsbeschreibung’ or contemporaneous copper-plate engravings).
- A stronger link between the physical world and the app. This can be implemented relatively easily using mobile tagging applications on information boards etc.
- The creation of additional content for children. This not only appeals to a new target group, but also involves prospective geography teachers on the development side, bringing them into contact with geomeia in creating educational content.
- The possibility for users to add information themselves and thus increase participation.
- Developing the app further with possible future land uses or planning scenarios, including the expansion of urban development. The app could thus have a positive influence on citizen participation and acceptance of planning measures (Bishop, 2015).

Finally, we aspire to a scientific evaluation of the application and of the educational effect on the user. To date, feedback has been provided mainly by participating and non-participating students and lecturers of geography, who cannot be considered representative of the target group because of their extensive prior knowledge. Feedback could be gathered by means of a questionnaire, for example, which could be accessed directly via the app, or by a personal survey of representative users. It would be particularly interesting to compare users’ knowledge about the variability of the landscape before and after using the app, as well as their attitudes towards, and acceptance of, interventions in the landscape.

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