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Research Article

Conversion of agricultural soils in Austria—a case study for a community in Upper Austria

Bodenversiegelung in Österreich – eine Fallstudie für eine oberösterreichische Gemeinde

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Summary

We have analyzed the loss of agricultural land in a case study of the community Eggelsberg in the Innviertel in Upper Austria. The trigger for the project was the attribution of Austria as Europe's leader in soil sealing. We compared the results of the Austrian agricultural soil survey of the 1970s with the actual land use and quantified the land use change. Within half a century, 15% of the agricultural area was converted to settlement area or to other forms of infrastructure. According to the original soil assessment, 96 ha of high-quality cropland, 1,220 ha of medium-quality cropland, 121 ha of low-quality cropland, and 409 ha of grassland were converted. The forest cover remained stable. The highest share of soil sealing was owed to the expansion of the settlement area and the construction of a successful enterprise. Minor contributions were expansions of farm buildings. The loss of agricultural land was reasonable and reflected the needs of the local population. A special protection status because of the future relevance of the agricultural land was not communicated to land managers and is not reflected in the market prices of agricultural products. The relevance of the agricultural land beyond the regional level is not fully recognized.

Keywords: soil protection, soil loss, food security, soil value, structural change, cropland

Zusammenfassung

Wir haben den Verlust an landwirtschaftlicher Nutzfläche am Beispiel der Gemeinde Eggelsberg im Innviertel in Oberösterreich untersucht. Anlass der Untersuchung war die Bezeichnung von Österreich als Europameister der Bodenversiegelung. Die Landnutzung der fünf Jahrzehnte zurückliegenden landwirtschaftlichen Bodenkartierung wurde mit GIS-Werkzeugen mit der aktuellen Bodenverwendung verglichen. Die Veränderung der Landnutzung wurde quantifiziert. Wir haben festgestellt, dass in einem halben Jahrhundert insgesamt 15 Prozent der landwirtschaftlichen Nutzfläche verbaut worden sind. Davon waren 96 Hektar hochwertiges, 1220 Hektar mittelwertiges und 121 Hektar geringwertiges Ackerland und 409 Hektar Grünland betroffen. Die Umwandlung zu Wald spielte im Untersuchungsgebiet keine Rolle. Der größte Teil der Nutzungsumwandlung erfolgte aufgrund der Vergrößerung des Siedlungsgebietes und zur Ansiedlung eines Industriebetriebes. Außerdem wurden Zubauten an Höfen vorgenommen. Insgesamt ist die Veränderung der Bodennutzung gut begründet und entspricht den Bedürfnissen der regionalen Bevölkerung. Die Erhaltung der landwirtschaftlichen Nutzfläche der Region wurde an die Landbewirtschafter nicht explizit diskutiert und ist in den Preisen der landwirtschaftlichen Produkte nicht reflektiert. Allerdings hat sich die Bewertung der Qualität des Landes durch den kontinuierlich stattfindenden Klimawandel geändert. Der Bedeutung des Bodens für eine künftige Versorgung mit landwirtschaftlichen Produkten wurde nur teilweise Rechnung getragen. Die überregionale Bedeutung des Bodens als Produktionsfläche wurde nicht ausreichend kommuniziert.

Schlagworte: Bodenschutz, Bodenverlust, Ernährungssicherheit, Bodenwert, Strukturwandel, Ackerland

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1. Introduction

The annual soil loss in Austria is high. The Environment Agency Austria reports, since several years, that the daily soil conversion amounts to more than 10 ha, which is by a factor of 5 above the sustainable soil conversion rate (https://www.umweltbundesamt.at/umweltsituation/raumordnung/rp_flaecheninanspruchnahme/). The majority is potential cropland and grassland that is converted into area for buildings and streets, thereby being permanently lost as productive land. The soil loss is often memorably compared with multitudes of areas of soccer pitches (approximately 0.5 ha) in order to emphasize the extent of the challenge of soil protection. The topic raised political attention, and efforts toward soil conservation were prominently placed in the Government Program 2017, the National Climate and Energy Program (#mission2030, BMNT 2018), and the Bio-economy Strategy (BMNT 2019) in order to facilitate a growing supply of biomass and to sustainably ensure the provision of soil ecological functions. The relevance of productive and functional soils was emphasized in the Environment Control Report (UBA, 2019).

On top of soil loss as a consequence of structural change of the society, climate change is posing an additional challenge. At present, sites in the North-East of Austria have the highest production potential. Scenarios for the future productivity of grassland and cropland suggest that the productivity of grassland in mountain regions may increase and benefit from climate change, whereas cropland in low elevation will become less productive. Within a few decades, the productivity potential of agricultural sites in central Austria (e.g., Innviertel in Upper Austria) will exceed the productivity of other regions, mostly as a consequence of higher temperatures and a sufficient soil water supply (Haslmayr et al., 2018). In order to provide for future food security, experts suggest to define soil conservation sites (in German: Boden-Vorbehaltsflächen) that should enjoy a certain protection status in order to preferentially maintain them for crop production (Baumgarten, 2019).

We analyzed the extent of soil conversion for a community in Upper Austria where agriculture plays an important role. We used the data from the Austrian Agricultural Soil Survey (https://bodenkarte.at/) in order to quantify the soil conversion during approximately 40 years.

2. Material and methods

2.1. An agricultural community in Upper Austria

As a case study, we selected the community Eggelsberg that is located in the Innviertel in Upper Austria. The village is located at 531 m a.s.l. and comprises the cadastral communities Eggelsberg, Gundertshausen, Haimhausen, Haselreith, and Ibm. The total area is 24.2 km². About one-fifth of the area is forest, and more than two-thirds are used as agricultural land. The agricultural soils are mostly Cambisols (Braunerde) derived from quaternary gravel and moraines. The village is intersected by a few main roads that connect local centers.

2.2. Assessment of the land use change for 50 years

The soils of the area have been mapped between 1963 and 1976 within the program of the Austrian Agricultural Soil Survey (BVA, 1976). A field crew assessed the soil quality for agricultural use, among others, by means of soil type, soil depth, soil texture and gravel content, and the soil's water-holding capacity. In addition, soil material from reference profiles was collected and chemically analyzed for pH, organic carbon, and additional chemical soil parameters. As the surveyor has also assessed the value of the mapping units regarding arable land and grassland, it is possible to identify "high-value cropland", "medium-value cropland", "low-value cropland", and "grassland" in the soil map. The spatial extent of soil forms was transferred to the Austrian map at a scale of 1:25,000. The Austrian agricultural soil maps were digitized between 1995 and 2000 and were published as e-bod (https://www.data.gv.at/anwendungen/digitale-bodenkarte-ebod/). The digitized soil map was saved as a layer in the geographical information system QGIS (http://www.qgis.org) and used as reference for the previous land use.

The current land use was derived from the most recent orthophoto that was available as a basemap (https://www.basemap.at/). The last update of the used data was made on December 5, 2019. The actual extent of cropland was digitized on the orthophoto and was saved as individual layer in QGIS.

The forest cover was obtained from the results of an ongoing remote sensing project conducted at the Austrian Forest Research Center (https://bfw.ac.at/rz/bfwcms.web?dok=7222; Schadauer et al., 2019). The shapefile was available from a public data hub (BMLFUW, 2017).

The map of soils with a high yield potential was created within a project on scenarios of food security for Austria and was obtained from the INSPIRE data repository (Haslmayr, 2018, Inspire 2020). The yield-potential map was overlaid on the basemap of Austria (Grundkarte; http://www.basemap.at).

The e-bod soil map and the digitized land-use map derived from the orthophoto were intersected. Tracts of land that have been previously classified as cropland but were not cropland on the orthophoto were identified. A visual inspection of the orthophoto allowed the distinction of "new buildings," "new roads," and "other infrastructure." In addition, the converted land was classified into "village growth" for sites within 200 m beyond the boundaries of the settlements in 1965 and "other soil development."

The forest land has not been changing over time. The intersection of agricultural land with the layer showing the forest cover in the region did not indicate a relevant transfer of land area between agriculture and forestry.

3. Results

Figure 1 shows an example of the soil map according to the agricultural soil map (BVA, 1976). The map shows the roads, settlements, and the forest area according to the Austrian map with a scale of 1:50,000. The agricultural soils are stratified according to the expertise of the field crew of the soil mapping exercise at the time of the survey. In Figure 2, the cropland that has been converted to other types of land use is indicated as high-quality cropland (brown), medium-quality cropland (blue), low-quality cropland (magenta), and grassland (yellow). The forest area that is represented in light green shades has not changed. The white areas represent cropland remaining as cropland.

Table 1 presents a loss of agricultural land of 15% in approximately half a century. The development of surface took place irrespective of its value as an agricultural production site and was equally distributed among the site-quality classes.

Figure 3 shows the evaluation of land of the community Eggelsberg according to the recent data that are based on the evaluations of the administration (Haslmayr, 2018). The evaluation of soil half a century after the soil survey shows that 36% of the area is evaluated as valuable cropland and 11% as valuable grassland. This land is recommended to be spared from soil sealing in order to secure the nonrenewable resource soil and to ensure food security in Austria (Table 2). Almost half of the agricultural land of the community Eggelsberg is considered to be highly valuable and should be spared from soil sealing.

4. Discussion

In a recent assessment of communities by the Center for Public Administration Research, the village Eggelsberg had a highly favorable ranking in an Austrian comparison based on the criteria on its financial management (KDZ, 2020). Despite the pull factor of nearby towns (Braunau and Salzburg), the village Eggelsberg is maintaining its size. More persons are coming to the village for work as persons are going out. The population of the community Eggelsberg is slowly yet constantly increasing (https://www.statistik.at/blickgem/G0201/g40406.pdf). Traditionally, Eggelsberg has been an agriculturally dominated village with several local businesses and a large tannery. A decisive moment in the development of the village was the foundation of an industrial enterprise in 1979 that has developed favorably since then and led to a lasting increase and diversification of job opportunities. Structural change in the society was reflected in the demand for the development of surface area. Schools, recreation and shopping areas, residential areas, a sewage plant, and streets were built. This economically favorable development was possible at the expense

Table 1. Quantity of lost agricultural surface in 50 years in the community Eggelsberg
Tabelle 1. Bodenverlust in der Gemeinde Eggelsberg in 50 Jahren.

	Area in the year 1970 (ha)	Soil loss until 2020 (ha)	Proportion of soil loss (%)
High-productivity cropland	96	11	11.5
Medium-productivity cropland	1,220	190	15.6
Low-productivity cropland	121	18	14.9
Grassland	409	63	15.4
Agricultural land	1,846	282	15.3

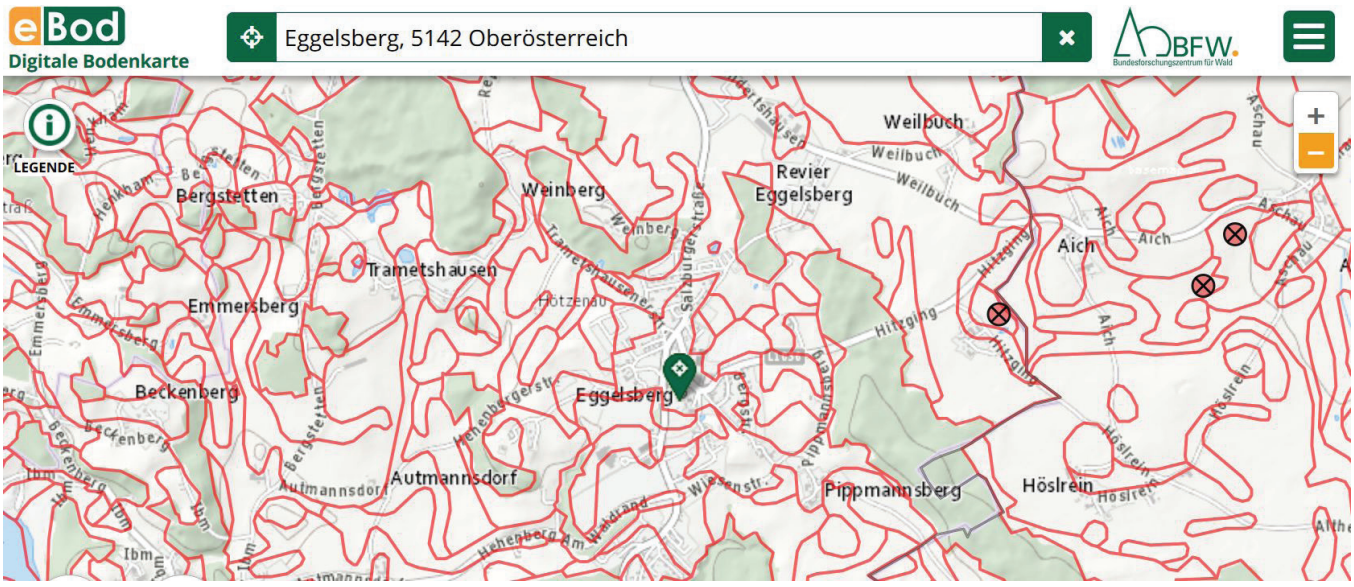

Figure 1. Original map of the Agricultural Soil Survey in the community Eggelsberg. Red lines delineate strata with similar soils (https://bodenkarte.at/).
Abbildung 1. Bodenkarte der landwirtschaftlichen Bodenkartierung der Gemeinde Eggelsberg. Die roten Linien bezeichnen Zonen mit gleichen Bodenformen (https://bodenkarte.at/).

of agricultural soil (Haberl 2015). Overall, the converted agricultural land was put to use that meets the life style and infrastructure expectations of the regional population. Two-thirds of the agricultural soils in the area had been qualified as medium quality in 1970 (Table 1). Owing to its origin from glacial and fluvial deposits, the soils have a lower productivity compared with the classical agricultural top soils in the east of the country. Soil quality has apparently not played a major role in the land-use change in the past 50 years. The main share of agricultural soils lost was soils of medium quality, according to the soil evaluation of 1970. Most of the now-sealed former agricultural land is close to the center of villages, where the demand for new residential houses was satisfied. The village of Eggelsberg has grown considerably in the past 50 years, and the area of sealed surfaces for buildings and traffic space has doubled. In the studied area, a similar development took place in the village Ibm and, to a slightly lesser extent, in the village Gundertshausen. Evidently, there was no indication for unconstrained sprawl of the villages. Rather the villages grew gradually, and the claim of productive agricultural land was undisputed by the local population.

Table 2. Distribution of the area of the community Eggelsberg according to a recent evaluation of soils.
Tabelle 2. Rezente Einschätzung der Bodenqualität in der Gemeinde Eggelsberg.

	Area (ha)	%
Forest land	500	21
Valuable cropland	861	36
Valuable grassland	257	11
Area of the community	2,412	

The forest cover of approximately 20% of the area was mostly retained. The forests are owned by local farmers, and timber is used for the local demand of wood products, bioenergy, and the traditional reserve for unexpected expenses. Heating systems based on wood chips are abundant. A decentralized energy supply based on regionally available renewable resources is commonly found in farm houses, because the fuel is available from silvicultural interventions. Forests traditionally occupy sites that are unsuitable for agriculture, because of either the steepness of slopes or the low soil fertility. A peculiarity of the region is the forest cover of moist sites adjacent to peatland.

As commonly found, there is not a sudden loss of soils because of a single large project. Instead, the loss is gradual. A new house is built and, within a couple of years, both sides along a street are developed into residential areas; the old school is too small for modern demands, a new unit is erected with a school, a kindergarten, and retirement homes; a new supermarket outlet opens up.

Soil scientists suggest reserving the productive agricultural land in the region in order to ensure a sustainable food production in Austria under warmer conditions. The agricultural sites in Upper Austria are presumingly less vulnerable

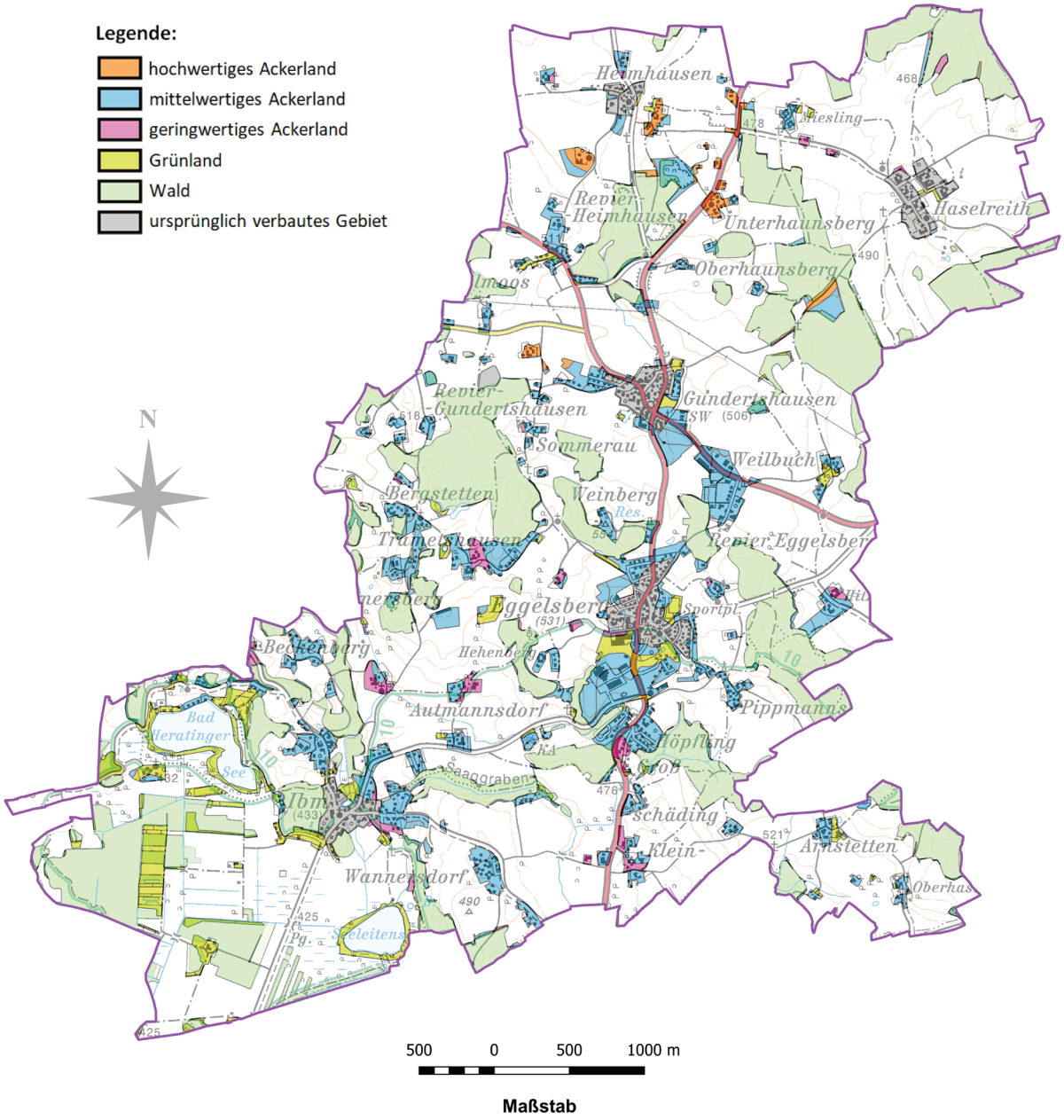

Figure 2. Map of the village Eggelsberg. The grey shades represent the historic area of settlements and light green shades forest. The orange, blue, and magenta shades represent now-sealed areas of high-, medium-, and low-productivity cropland, respectively, and the yellow shades represent now-sealed areas of grassland.

Abbildung 2. Karte der Gemeinde Eggelsberg. Die grauen Zonen geben das Siedlungsgebiet von 1970 wieder. Die hellgrünen Flächen sind Wald. Die Farbtöne Orange, Blau und Magenta repräsentieren jetzt verbaute Gebiete mit Ackerland mit hoher, mittlerer und niedriger Produktivität, und die gelben Farbtöne repräsentieren jetzt versiegeltes Grünland.

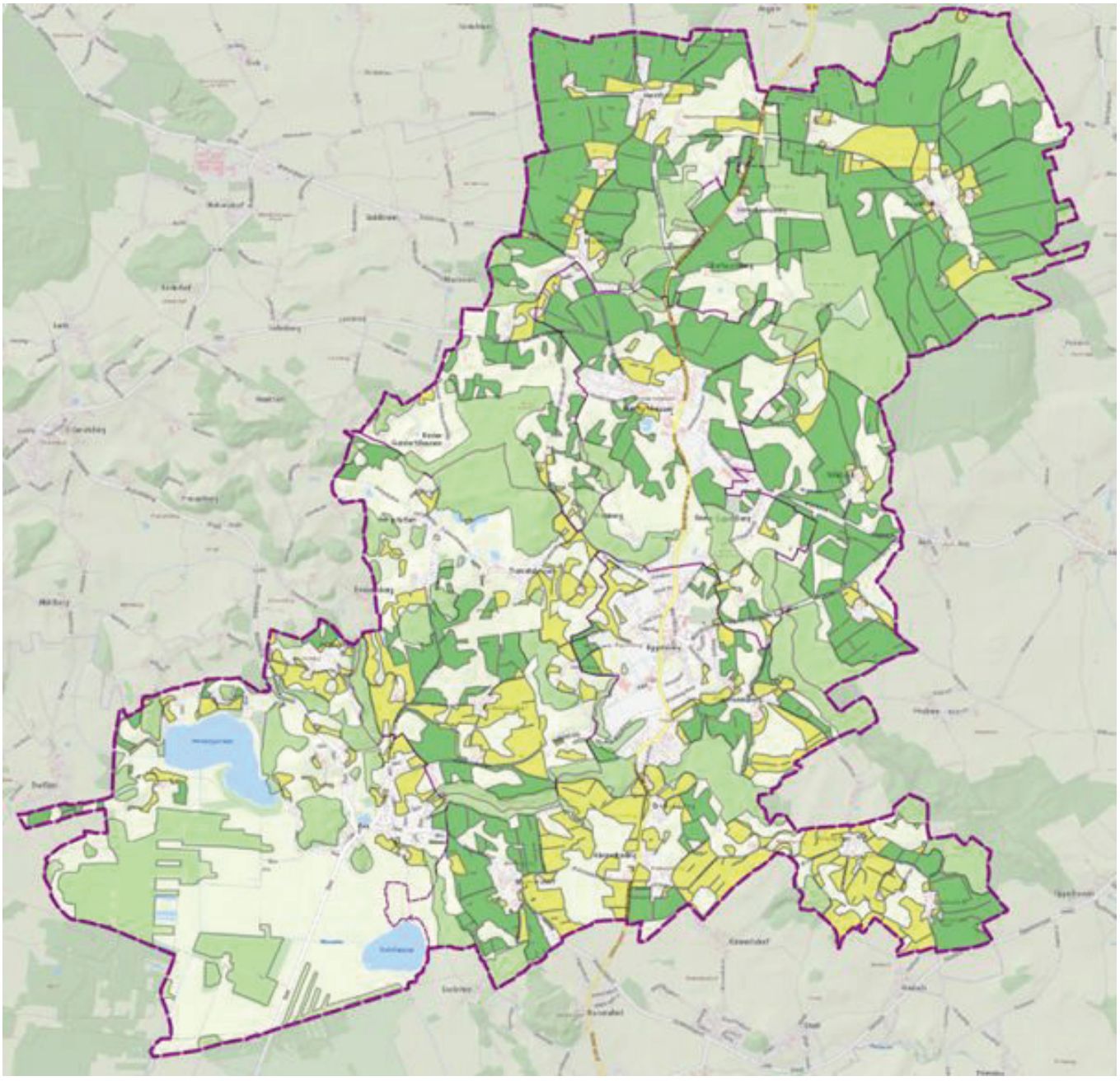

Figure 3. The evaluation of land of the community Eggelsberg according to the recent data. The light-green shades represent forest land, dark-green shades highly productive agricultural land, and the yellow shades highly productive grassland.
Abbildung 3. Die Bewertung der Böden in der Gemeinde Eggelsberg auf Grundlage der rezenten Daten der Finanz-Bodenschätzung. Die hellgrünen Flächen zeigen die Waldfläche, die dunkelgrünen Flächen zeigen wertvolles Ackerland und die gelben Flächen zeigen wertvolles Grünland.

to the effects of climate change than the agricultural sites in the East of Austria, where water shortage is expected to pose considerable problems in the future. A comparison of Figure 3 and Tables 1 and 2 shows that the appreciation for the land quality in the region has changed. While the land was classified mostly as medium-quality agricultural land before 50 years, the recent map shows high-quality cropland mostly in the north and east of the community of Eggelsberg. Valuable grassland was identified mostly in the south of the community. So far, valuable agricultural land has been spared from soil sealing.

While the concerns about the future availability of agricultural land are at the agenda at the national level, it has not fully conveyed to the local actors. From the perspective of

local residents and farmers, a critical shortage of fertile soils is not conceived. The land demand for residential buildings, enterprises, shopping, and parking is given priority over abundant agricultural land. The high valorization of the agricultural land from the viewpoint of scientists is not evident for local farmers. The enterprise structure in the areas follows the general trend in Upper Austria with a slow decrease in the agricultural enterprises. Yet, the area of the agriculturally managed land remains almost unchanged because remaining farmers are buying or leasing the available agricultural land and are increasing their area of managed land (LWF, 2017). The potential future relevance of the agricultural soils is obviously not creating a credible stimulus for actors in agriculture.

The focus on local demand for land in order to build infrastructure and residential areas is not accounting for concerns on possible future shortages of productive land for the provision of food, fodder, and fuel that is clearly expressed in a meta level (Foley et al, 2011, Gaupp et al., 2020). The societal demand for the production of biomass from regional land resources is not sufficiently reflected in land use regulations.

5. Conclusion

We assessed the change of land use during half a century in a community in Innviertel, Upper Austria. On the basis of the chemical and physical properties of soil, the land was mostly evaluated as medium productive 50 years ago. In the meantime, the effects of climate change have changed that view and have placed about 50% of the area of the community under the category of preferential agricultural land. Yet, societal demands have led to a loss of approximately 15% of the agricultural land in the 50 years. Selling the land for settlement expansions was obviously more attractive than maintaining agriculture and conserving agricultural land in order to meet future demands. Although the expansion of the village was sensible and responsible, a considerable part of potentially valuable agricultural land was sacrificed.

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