Assessing the Reliability of Land-Use Data in Slovenia: A Case Study of Terraced Landscapes

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Abstract. Land use relates to the exploitation of land through human activity in the landscape. Land use is also one of the best indicators of a landscape’s structure and processes. Land cover comprises manmade surfaces, agricultural areas, forest and semi-natural areas, wetlands, and bodies of water. In Slovenia more than half of the land (63%) is forested. Manmade surfaces represent less than 5%. A large proportion of relatively inaccessible forest is the main reason why society had a less critical impact on forests in the past in Slovenia in comparison to the majority of central European countries. Regarding the high-quality landscape in the country, Slovenia’s natural features are characterized by a mix of forest and farmland. These land categories (i.e., complex cultivation patterns and land principally used for agriculture with significant areas of natural vegetation) cover 23% of Slovenia. Land-use data for farmland are gathered and provided to the relevant institutions by landowners, who are not specialists in land-use data. In addition, land use is only a two-dimensional tool, which does not recognize elevation differences and terraced slopes. Terraced areas are either omitted from the inventory of land-use data because landowners do not report them, or they are included in the inventory because landowners do not realize that their land is not terraced. Consequently, the differences between the official data on vineyards, orchards, and olive groves on terraces and actual terraced slopes with such land use may differ significantly.

1. Introduction

In Slovenia more than half of the land (63%) is forested. A large proportion of relatively inaccessible forest is the main reason why society had a less critical impact on forests in the past in Slovenia in comparison to the majority of central European countries. Regarding the high-quality landscape in the country, Slovenia’s natural features are characterized by a mix of forest and farmland. These land categories (i.e., complex cultivation patterns and land principally used for agriculture with significant areas of natural vegetation) cover 23% of Slovenia. Manmade surfaces represent less than 5%.

Land use relates to the exploitation of land through human activity in the landscape. Land cover comprises manmade surfaces, agricultural areas, forest and semi-natural areas, wetlands, and bodies of water. Land use is also one of the best indicators of a landscape’s structure and processes. It is therefore important that information about land use be precise. For some data, government institutions that collect these data highlight the differences arising from different methodologies for recording. The data collected on vineyards are such an example. According to orthophoto maps, there are almost 19,300 ha of vineyards in Slovenia, although the Register of Grape and Wine Producers (RPGV) lists...
only about 16,000 ha [1] (table 1). This difference occurs because not all winegrowers are also members of the Register of Grape and Wine Producers (RPGV). There is much more vineyards than is registered in the Register of Grape and Wine Producers (RPGV).

Relevant institutions also publish information on how much terraced land is planted with vineyards in the three wine-growing regions in Slovenia (table 2). and in nine wine districts in Slovenia (table 3). In 2007 in Slovenia, 37% of vineyards were located on terraces (in 2017 only 31%): in the Drava Valley 24% (1,757 ha), in the Sava Valley 27% (824 ha), and in the Littoral 55% (3,759 ha).

Table 1. Comparison of vineyard land in Slovenia according to orthophoto maps and according to the Register of Grape and Wine Producers (RPGV).

| Years | Orthophoto maps (ha) | Register of Grape and Wine Producers (RPGV) data (ha) | Difference between data (ha) |
|-------|----------------------|------------------------------------------------------|-----------------------------|
| 2007  | 22,951               | 17,192                                               | 5,759                       |
| 2011  | 21,265               | 15,973                                               | 5,292                       |
| 2016  | 19,300               | 16,000                                               | 3,300                       |

Table 2. Comparison of vineyards on terraces in the three wine-growing regions in Slovenia (Sources: 2007: [2]; 2017: RPGV).

| Wine growing regions | 2007 (%) | 2007 (ha) | 2017 (%) | 2017 (ha) |
|----------------------|----------|----------|----------|----------|
| Drava Valley         | 24       | 1,757    | 20       | 1,254    |
| Sava Valley          | 27       | 824      | 20       | 533      |
| Littoral             | 55       | 3,759    | 49       | 3,035    |
| Slovenia             | 37       | 6,340    | 31       | 4,822    |

Table 3. Comparison of vineyards located on terraces in nine wine districts in Slovenia (Sources: 2007: [3], 2011: [4], 2017: RPGV).

| Wine districts       | 2007 (%) | 2011 (%) | 2017 (%) |
|----------------------|----------|----------|----------|
| Prekmurje            | 4        | 4        | 2        |
| Styria               | 35       | 24       | 21       |
| Bizejško-Sremič      | 42       | 34       | 27       |
| Lower Carniola       | 27       | 18       | 15       |
| White Carniola       | 27       | 23       | 20       |
| Gorizia Hills        | 81       | 80       | 80       |
| Vipava Valley        | 66       | 65       | 59       |
| Karst Plateau        | 14       | 13       | 10       |
| Slovenian Istria     | 30       | 21       | 20       |

The premise is that in the case of identifying terraced vineyards in Slovenia similar errors occur as in the case of vineyard land in Slovenia. However, these errors are not published because there is no precise layer of terraced areas made for Slovenian regions to compare it with. The research question will be verified in the selected landscape framework for the Gorizia Hills, for which a precise layer of terraced vineyards has been created and updated.

2. Data and methodology
The Gorizia Hills was chosen as a pilot area because research on terraced landscapes in this region—which is poorly accessible, rural, and hilly, with small villages on the ridges crisscrossing the entire land—has been extensively published, and data on land use, terraced areas, and other relevant
information is readily available. In the Gorizia Hills, agricultural land is primarily cultivated on slopes, and agricultural terraces cover about 29% of the overall area of the Municipality of Brda. Therefore, terraces are the predominant landscape element in the region. Terraces include a full 99.4% of the categories of agricultural land use; the majority (nearly 70%, or 1,446.4 ha) is vineyards, nearly one-tenth (186.4 ha) is extensive orchards, as is the share of permanent meadows (182.2 ha), 5% (113 ha) is intensive orchards, and 3% (70 ha) is forest. All other categories of land use represent less than 1% of the land [5]. The selected landscape framework was chosen in such a way as to cover both the valley area and the slope area.

Data chosen for the study were:

- The ortophoto of the selected landscape framework.
- The layer of land use on terraces in the selected landscape framework as inventoried by Slovenia’s Ministry of Agriculture in 2017.
- The layer of vineyards on terraces in the selected landscape framework as inventoried by Slovenia’s Ministry of Agriculture in 2017.
- The map of cultivated terraces on open terrain in the selected landscape framework inventoried in 2016. To identify the terraces, digital ortophoto maps were employed as well as records on the actual utilization of agricultural and forest land and a digital elevation model (DEM). These desk data were supplemented with field observations and mapping.
- The layer of Lidar (Laser Scanning or Light Detection and Ranging) in the selected landscape framework. In addition to its greater accuracy, the advantage of Lidar is the penetration of the signal through vegetation. This is especially important in identifying terraced landscapes because it makes it possible to register terraces already overgrown.

Differences in and reliability of the land use data were determined by the overlapping of different data. The methodology used is a comparative method, which brings into focus similarities and differences between layers and shows their influence on the representative data.

3. Results and discussion
The selected landscape framework covers 527 ha. The ortophoto map is not very useful for checking terraced areas of slopes, but it is a very suitable tool for verifying land use. The layer of land use on terraces in the selected landscape framework as inventoried by Slovenia’s Ministry of Agriculture shows that 205 ha of terraced areas have different land use (figure 1). This is 45 ha less than indicated on the map of cultivated terraces on open terrain inventoried in 2016 (250 ha, or 22% more; figure 2). Looking at the maps, it becomes obvious that the difference in calculation arises because the terraces inventoried by the Ministry of Agriculture are also defined on flat terrain, but at the same time, much of terraced land on the slopes is not marked as such.

| Table 4. Comparison of numerical values of areas represented in figures 1 to 5. |
|-----------------|-----|-----|
| Area            | (ha)| (%) |
| Selected landscape framework | 527 | 100 |
| Figure 1        | 205 | 39  |
| Figure 2        | 250 | 47  |
| Figure 3        | 165 | 31  |
| Figure 4        | 197 | 37  |
| Figure 5        | 192 | 36  |

Even a comparison of the map of cultivated terraces from 2016, which has been carefully verified in the field, and of the Lidar layer, which is very reliable data, shows that it would be possible to identify some additional slopes as terraced (although abandoned) land. The reason for these
The difference between the land use layer for terraces in the selected landscape framework as inventoried by the Ministry of Agriculture and the real situation represented by the map of cultivated terraces from 2016 is in fact much greater than it seems at first glance. By creating a cross-section of land use on the terraces by the Ministry of Agriculture and the map of cultivated terraces from 2016 (figure 3), it is seen that actual terraced areas marked by the official data comprise only 165 ha, which is 31% of the entire sample. These are terraced areas that are recognized by both inventory methods. The error of marking agricultural plots in the valley as terraced areas, and of omitting agricultural plots on slopes that are terraced, balances the numerical difference between layers of the determined and actual state of terraced landscapes.

![Image](image_url)

**Figure 1.** The layer of land use on terraces in the selected landscape framework as inventoried by the Ministry of Agriculture and the Lidar layer (prepared by Tomaz Berčič)

As this experiment has shown, differences arising with regard to land use of terraced vineyards (figure 4; figure 5) are conditioned by precision regarding what is terraced land and what is not (table 4). It can be concluded—and the premise confirmed—that errors occur when identifying terraced vineyards across Slovenia because there is no precise layer of terraced areas made for Slovenia for comparison.
Figure 2. The map of cultivated terraces on open terrain in the selected landscape framework inventoried in 2016 and the Lidar layer (prepared by Tomaž Berčič)

Figure 3. A cross-section of land use on terraces by the Ministry of Agriculture and the map of cultivated terraces from 2016 on the Lidar layer (prepared by Tomaž Berčič)
**Figure 4.** The layer of vineyards on terraces in the selected landscape framework as inventoried by the Ministry of Agriculture and the Lidar layer (prepared by Tomaž Berčič)

**Figure 5.** The layer of vineyards on the map of cultivated terraces on open terrain in the selected landscape framework inventoried in 2016 and the Lidar layer (prepared by Tomaž Berčič)
However, the question remains whether there is any need at all to create a precise inventory of terraced landscapes in Slovenia. If these data are not produced, it will not be possible to monitor changes in terraced landscapes, global and local influences on terraced areas, production issues, changes of cultural significance, and other changes. Consequently, strategic planning, careful evaluation, and future visions for terraced landscapes can fail because of the inaccuracy of the analytical data [7].

4. Conclusion
Land use is only a two-dimensional tool, which does not recognize elevation differences and terraced slopes. Terraced areas are either omitted from the inventory of land-use data because landowners do not report them, or they are included in the inventory because landowners do not realize that their land is not terraced. Consequently, the differences between the official data on vineyards, orchards, and olive groves on terraces and actual terraced slopes with such land use may differ significantly.

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