# Supplementary Information for Crowdsourcing LUCAS: Citizens Generating Reference Land Cover and Land Use Data with a Mobile App

**Juan Carlos Laso Bayas[1*], Linda See[1], Hedwig Bartl[1], Tobias Sturn[1], Mathias Karner[1], Dilek Fraisl[1,2], Inian Moorthy[1], Michaela Busch[1,3], Marijn van der Velde[4], and Steffen Fritz[1]**

[1]Ecosystems Services and Management Program, International Institute for Applied Systems Analysis, Schlossplatz 1, 2361 Laxenburg, Austria; {lasobaya, see, bartl, sturn, karner, fraisl, moorthy, **fritz**}**@iiasa.ac.at**;
[2]University of Natural Resources and Life Sciences (BOKU), Vienna, Austria
[3]Fritsch, Chiari und Partner ZT GmbH, Marxergasse 1B, 1030 Vienna, Austria; **michaela.busch@gmx.at**;
[4] European Commission, Joint Research Centre (JRC), 21027 Ispra, Italy; **marijn.van-der-velde@ec.europa.eu**;

## 1. LUCAS Land Cover Classes

Table S1 contains the complete set of LUCAS LC classes organized into three main levels.

**Table S1.** LUCAS LC classes for levels 1, 2, and 3. Source: [1]

| LC level 1 | LC level 2 | LC level 3 |
|---|---|---|
| Artificial land | Roofed built-up areas | Buildings with one to three floors |
| | | Buildings with more than three floors |
| | | Greenhouses |
| | Artificial non-built up areas | Non built-up area features |
| | | Non built-up linear features |
| | Other artificial areas | |
| Cropland | Cereals | Common wheat |
| | | Durum wheat |
| | | Barley |
| | | Rye |
| | | Oats |
| | | Maize |
| | | Rice |
| | | Triticale |
| | | Other cereals |
| | Root crops | Potatoes |
| | | Sugar beet |
| | | Other root crops |
| | Non-permanent industrial crops | Sunflower |
| | | Rape and turnip rape |
| | | Soya |
| | | Cotton |

| | | |
|---|---|---|
| | | Other fiber and oleaginous crops |
| | | Tobacco |
| | | Other non-permanent industrial crops |
| | Dry pulses, vegetables and flowers | Dry pulses |
| | | Tomatoes |
| | | Other fresh vegetables |
| | | Floriculture and ornamental plants |
| | | Strawberries |
| | Fodder crops | Clovers |
| | | Lucerne |
| | | Other leguminous and mixtures for fodder |
| | | Mixed cereals for fodder |
| | | Temporary grasslands |
| | Permanent crops: Fruit trees | Apple fruit |
| | | Pear fruit |
| | | Cherry fruit |
| | | Nuts tree |
| | | Other fruit trees and berries |
| | | Oranges |
| | | Other citrus fruit |
| | Other permanent crops | Olive groves |
| | | Vineyards |
| | | Nurseries |
| | | Permanent industrial crops |
| Woodland | Broadleaved woodland | |
| | Coniferous woodland | Spruce dominated coniferous woodland |
| | | Pine dominated coniferous woodland |
| | | Other coniferous woodland |
| | Mixed woodland | Spruce dominated mixed woodland |
| | | Pine dominated mixed woodland |
| | | Other mixed woodland |
| Shrubland | Shrubland with sparse tree cover | |
| | Shrubland without tree cover | |
| Grassland | Grassland with sparse tree cover | |
| | Grassland without tree/shrub cover | |
| | Spontaneously re-vegetated surfaces | |
| Bare land and lichens/moss | Rocks and stones | |
| | Sand | |
| | Lichens and moss | |

| | | |
|---|---|---|
| | Other bare soil | |
| Water areas | Inland water bodies | Inland fresh water bodies |
| | | Inland salty water bodies |
| | Inland running water | Inland fresh running water |
| | | Inland salty running water |
| | Transitional water bodies | |
| | Sea and ocean | |
| | Glaciers, permanent snow | |
| Wetlands | Inland wetlands | Inland marshes |
| | | Peatbogs |
| | Coastal wetlands | Salt marshes |
| | | Salines and other chemical deposits |
| | | Intertidal flats |

**2. The near real-time quality assurance system**

The near real-time quality assurance system was built as one branch within the Geo-Wiki application [2] called FotoQuest Quality Check. The interface is shown in Figure S1. On the right hand side of Figure S1 is a map interface that shows three points for each quest made: the *Target* is the location of the LUCAS survey point; *Lucas* is the actual location where the LUCAS surveyor did their survey, which already provides a good visual impression of the small discrepancy between the two locations; and *FotoQuest* is the location of the person who made the quest during the campaign. In the example provided in Figure S1, one can see that the FotoQuest Go Europe user was on the edge of the field. Users were told to get as close to the point as possible but not to enter private properties or agricultural fields unless they had permission. After comparing the 2015 LUCAS pictures displayed in the app with the current location, the user then decided if there was a change compared to the LC present. The first level of LU chosen by the user matched the LUCAS point, i.e., Agriculture, but the type of agriculture has changed, i.e., instead of maize, the field is now being used to grow sunflowers, which the user has determined from the decision tree built into the app showing the photographs.

The objective of the near real-time feedback system was to provide advice to each user within 24 hours of receiving a completed quest. Feedback was always personalized and included four main types as outlined in Table S2. The first three types of message were issued when the user successfully completed the quest and earned 1 to 3 Euros but with increasing feedback in the form of suggestions for making improvements in future quests. For example, the second type of agreement message provides minor suggestions such as urging the user to get closer to the point in future quests if possible, while the third type provides stronger advice about future improvements. The final type of message issued was in situations where the quest was unsuccessful along with the reasons why, such as being too far from a point or the poor quality of the photographs. In this way, the users could learn from their mistakes, make better quests and ultimately earn 1 to 3 Euros for each point. In general, feedback could be qualified as: 1) Motivational, when there were some encouraging words in the message sent; 2) Neutral, when the quest was accepted and the corresponding reward was stated; and 3) Recommendations, when there was additional feedback text that contained specific indications to improve the quest. These additional recommendations were roughly classified into three groups including: 1) recommendations to improve the quality of the pictures taken; 2) encouragement to get as close to the point location as possible; and 3) recommendations on how to describe the LC at the actual location.

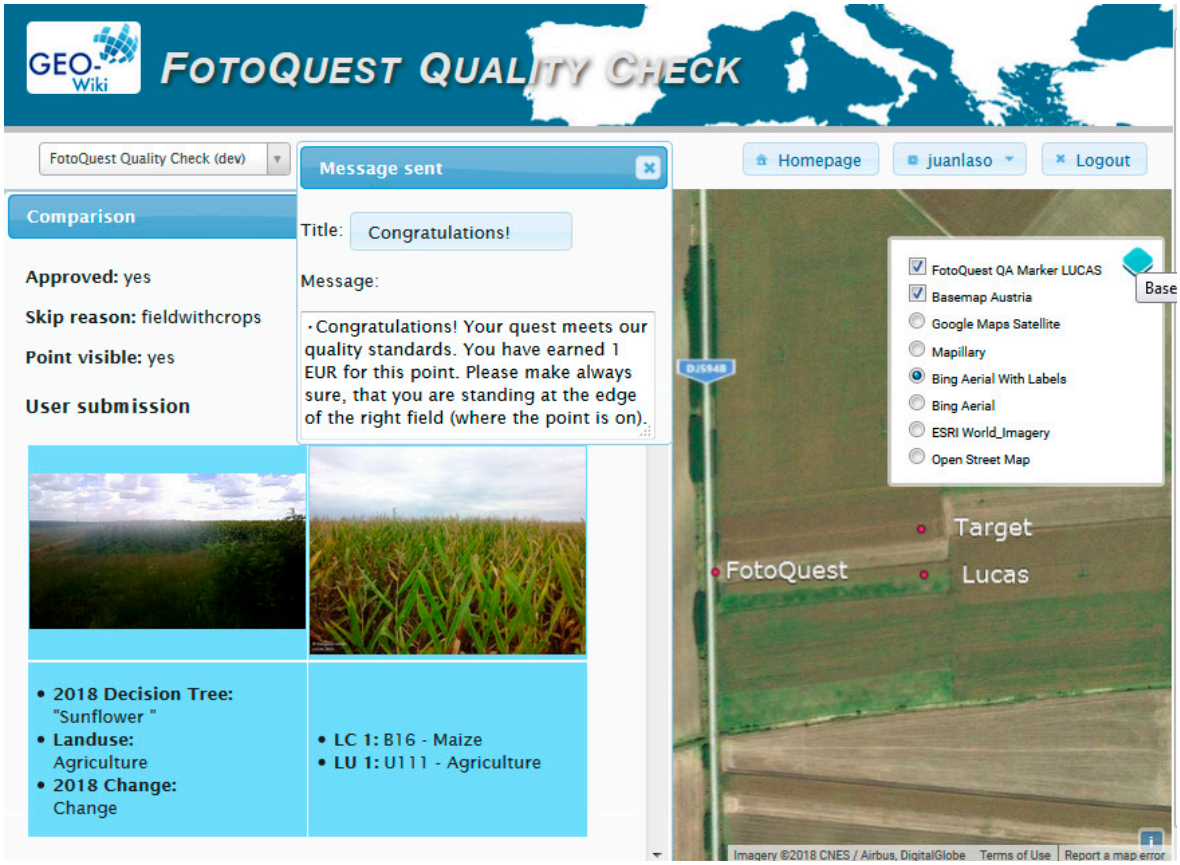


**Figure S1.** The FotoQuest quality branch in the Geo-Wiki platform showing the actual LUCAS point (Target), the location where the LUCAS surveyor did their survey in 2015 (Lucas) and the location of the FotoQuest Go Europe user (FotoQuest). Pictures from the LUCAS 2015 survey are displayed along with those submitted by the user. A messaging system allows the FotoQuest team to deliver feedback directly to the user in almost real-time as shown in the 'Message sent' box.

**Table S2.** Types of feedback provided to the users from the near real-time quality assurance system.

| Type of feedback provided | Total quests | Subtype | Example messages |
|---|---|---|---|
| Motivational | 622 (39%) | Standard | Congratulations! Your quest meets our quality standards. You have earned 1 EUR for this point. Keep up the good work! |
| | | High quality | Perfect! Your quest meets our quality standards. You have earned 1 EUR for this point. |
| Recommendations | 326 (20%) | Distance to the point | Congratulations! You have earned 1 EUR for this point. However, you marked the point as unreachable, although we can see from the map that you could have gotten closer. Next time, please go to the exact point. If the point is unreachable, please get as close to the point as possible. |
| | | LC / LU accuracy | Congratulations! Your quest meets our quality standards. You have earned 1 EUR for this point. When answering the questions for land use, always describe the point itself and not its surroundings. This time you chose residential, but since it is directly on the street, you should have chosen transport. Keep up the good work! |
| | | Picture quality | Congratulations on your first quest! Your quest meets our quality standards. You have earned 1 EUR for this point! For your next quest, please keep in mind that when taking the photo, there should be one third sky and two thirds of land/ground in the picture! Have fun! |
| Neutral | 662 (41%) | | Congratulations! Your quest meets our quality standards. You have earned 1 EUR for this point. |

A total of 94 users received recommendations as feedback. Table S3 summarizes the types of recommendations sent as feedback and how these were distributed. Recommendations regarding the quality of the picture was the most common type of feedback provided, which also had the highest number of most useful recommendations.

**Table S3.** Recommendations sent as feedback disaggregated by type of feedback.

| Type | Number of users that received at least one recommendation | Total # of quests with most useful* recommendations | Percentage of quests with recommendations Mean (min-max) | Range of recommendations per user |
|---|---|---|---|---|
| Distance to target | 31 (22%) | 31 | 3 (0-33) | 0 to 5 |
| Quality of picture | 48 (34%) | 56 | 6 (0-66) | 0 to 12 |
| Quality of answer (LC) | 27 (19%) | 23 | 3 (0-50) | 0 to 5 |

*Recommendation sent before the user proceeded to complete another quest, i.e., at least one day before

### 3. Results from the user surveys

A total of 87 users participated in the survey carried at the end of the FotoQuest Go Europe 2018 campaign, with 56 users filling in the German language survey and 31 the English language one. Of the German language respondents, 60% had not participated in FotoQuest campaigns before, whereas this

was 90% in the English language survey. Almost 90% of the German language respondents had not participated in any citizen science project before whereas that number was 70% for the English language respondents.

Table S4 shows the main innovations and characteristics of the FotoQuest Go Europe 2018 campaign liked by the respondents of the German and English language surveys. Regarding the motivations that drove the users of FotoQuest Go Europe, enjoying being outdoors was the highest ranked motivation in both surveys (4.7-EN and 4.3-GE out of 5 stars). Additionally, "helping science", "interest in the project", "improve knowledge" and "discover new landscapes" were also well ranked. Furthermore, some users also commented that the gaming or competing-against-others element of the game was quite an incentive for them, although this was not a pre-selected motivation in the surveys.

**Table S4.** Results from the survey regarding which features of the FotoQuest Go Europe 2018 campaign were liked by the users. An intense green color means a higher number of respondents, whereas pale blue colors represent the lowest number of respondents.

| App feature | Number of respondents (%) | |
|---|---|---|
| | German survey | English survey |
| Points located across the whole of Europe | 24 (43%) | 17 (55%) |
| Rewards | 21 (38%) | 16 (52%) |
| Landcover specific pictures and information | 21 (38%) | 15 (48%) |
| App design | 11 (20%) | 18 (58%) |
| Feedback | 14 (25%) | 1 (3%) |
| Time period (summer) | 14 (25%) | 1 (3%) |
| Challenge points | 4 (7%) | 7 (23%) |
| Expert information (on a point) | 7 (13%) | 2 (7%) |
| Other | 2 (4%) | 1 (3%) |

When the users were asked to rate some characteristics of the app itself, the user-friendliness of the app (8.8/10), and the LC specific pictures with links to identify LC at the point (8.7/10) were the highest features rated by the respondents of the English language survey, whereas the feedback and the reward systems (8.1/10 each) as well as the user-friendliness of the app (8.1/10) were the highest for the German language respondents. One recurring recommendation was to provide better navigation by linking to an existing map application such as Google Maps. Another request was to provide offline maps, especially for points that are difficult to reach, e.g., in the mountains, where the mobile signal is not available or intermittent. The lowest rated feature of the campaign was the weekly €30 challenge (7.8-EN and 5.3-GE /10). The reasons cited included that the point made little sense because it was too far away to reach or that the information about the challenge was simply missed, because, e.g., it was only advertised in Facebook and did not appear as a push notification in the app.

Recommendations made to the team to improve future campaigns are shown in Table S5. In the category "Others", it was often recommended to create a version with offline maps and to improve the navigation as mentioned above. It was also suggested that the project could be better described, and to show the results more openly so that people who have participated in the project as well as new potential users could better understand the aims of the project. Although some participants found the time period a positive feature (i.e., running of the campaign during the summer), others found this an aspect that could be improved, possibly because this is also a holiday period for many.

**Table S5.** User-recommended improvements for future FotoQuest Go Europe campaigns. An intense green color means a higher number of respondents, whereas pale blue colors represent the lowest number of respondents.

| Recommendations for improvement | Number of respondents (%) | |
|---|---|---|
| | German survey | English survey |
| Information about the project | 25 (45%) | 13 (42%) |

| | | |
|---|---|---|
| Time period (summer) | 22 (38%) | 10 (33%) |
| Social Media | 6 (11%) | 11 (36%) |
| Rewards | 14 (23%) | 4 (13%) |
| App design | 11 (20%) | 6 (19%) |
| Others | 10 (18%) | 2 (7%) |
| Feedback | 4 (7%) | 5 (16%) |
| Website | 5 (9%) | 2 (7%) |

**References**


1. Eurostat *LUCAS 2015 (Land Use / Cover Area Frame Survey). Technical reference document C3 Classification (Land cover & Land use)*; Eurostat, 2015;
2. Fritz, S.; McCallum, I.; Schill, C.; Perger, C.; See, L.; Schepaschenko, D.; van der Velde, M.; Kraxner, F.; Obersteiner, M. Geo-Wiki: An online platform for improving global land cover. *Environmental Modelling & Software* **2012**, *31*, 110–123, doi:10.1016/j.envsoft.2011.11.015.