# Engaging Citizens in Environmental Monitoring via Gaming*

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## Abstract

Citizen science is quickly becoming one of the most effective tools for the rapid and low-cost collection of environmental information, filling a long recognized gap in in-situ data. Incentivizing citizens to participate, however, remains a challenge, with gaming being widely recognized as an effective solution to overcome the participation barrier. Building upon well-known gaming mechanics, games provide the user with a competitive and fun environment. This paper presents three different applications that employ game mechanics and have generated useful information for environmental science. Furthermore, it describes the lessons learnt from this process to guide future efforts.

**Keywords:** Crowdsourcing, citizen science, gaming, land cover, land use

## 1. INTRODUCTION

Citizen science is increasingly being recognized as an important new component of environmental monitoring. There are many different examples of successful ongoing citizen science projects (http://scistarter.com/) but many of these projects are focused on biodiversity, species identification and nature conservation. There are fewer examples of citizen science projects that involve citizens in the collection of data for the calibration and validation of Earth Observation (EO)



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products, yet the potential clearly exists. One example of such a project is Geo-Wiki (Fritz et al., 2012), which is an online tool that is focused on gathering calibration and validation data on land cover from high-resolution satellite imagery. A number of crowdsourcing campaigns have been organized in the past, where crowdsourced land cover data have been used to produce hybrid land cover products and to validate existing products (see e.g. Fritz et al. (2013, 2015); See et al. (2015)). Although these campaigns were successful in terms of both the quality of data collected and the involvement of people in science, we wanted to investigate methods for attracting larger numbers of participants and thereby to develop a much larger training and validation database. One way to achieve this goal is via gaming and the use of mobile devices, since games are the most frequently used application on smartphones (dotMobi, 2013).

## 2. GAMIFICATION OF ENVIRONMENTAL MONITORING

The use of serious games (or games with a scientific purpose) is not new and has been steadily gaining prominence. There are many good examples, some of which have shown impressive scientific results. For example, FoldIt is a game in which players (i.e. 230,000 players) fold proteins and has led to discovering new protein structures (Khatib et al., 2011). A game to help map the neurons in the brain, called EyeWire (Kim et al., 2014), is being played by more than 160,000 people. A further citizen science project with game-like mechanics, Galaxy Zoo 1, was able to collect over 50 million classifications done by more than 150,000 users (Clery, 2011). Numerous examples also exist of games specifically for environmental monitoring. For example, Cropland Capture managed to collect 4 million classifications from over 3,000 players identifying images with and without cropland present (Salk et al., 2016).

Although the games described above are good examples of incentivising players, they do not always guarantee correct data. Players are sometimes wrong even when the majority of people agree on the answer. One reason for this is that the players are not trained sufficiently in understanding exactly what the task is. Another reason is that the game mechanics in some cases allow a strong influence of some players who play the game frequently but who are sometimes wrong. In this paper we present three serious games in the context of land cover / land use monitoring that have been developed as part of the current set of available Geo-Wiki (geo-wiki.org) tools (Table 1). From the three games described below, we summarize the lessons learnt to be applied in future gamification of environmental monitoring.

**Table 1: Description of Geo-Wiki Environmental Monitoring Games (as of 16.12.15)**

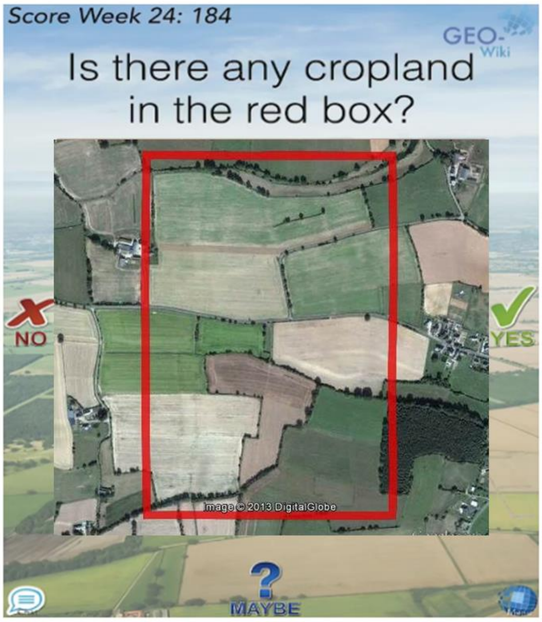
| *Game* | *Platform* | *Players* | *Classifications* |
|---|---|---|---|
| **Cropland Capture** | Cross-platform | 3,314 | 4.5 million >185000 unique |
| **FotoQuest Austria** | Mobile devices | 200+ | 12000 >2000 quests |
| **Picture Pile** | Cross-platform | 533 | 600K |

## 2.1. Cropland Capture

Cropland Capture was launched in mid-November 2013 and ran until the beginning of May 2014 as a multi-platform game running in a browser, on a smartphone or a tablet for both the Apple and Android operating systems (Figure 1). As part of the game, the players were presented with a red rectangle placed on top of satellite imagery or photographs. Players were then asked to determine if there was any evidence of cropland in the image. The mobile device interface was designed so that players swipe the images into three possible categories of Yes, No or Maybe. For each correct answer, the player received a single point while one point was deducted for incorrect answers. Correctness was determined through majority agreement, although there was an option to challenge the crowd. The leader boards were reset each week and the top three players in terms of the number of classifications were added to a prize draw that took place at the end of the six-month period.

At the end of the game, more than 4.5 million images and photographs had been classified. Of these, there were around 170,000 unique images. This means that each image has a frequency distribution, which has allowed us to examine the performance of the crowd. Overall, users disagreed with the crowd less than 10% of the time, with low bias toward identification of cropland or non-cropland. This implies that identifying cropland from the images and photographs is a task that the crowd can easily do with high accuracy. There was also no significant difference in performance based on background or experience, implying that a background in remote sensing is not required for satisfactory performance in this task. Other patterns found in the data are described in Salk et al. (2016).

**Figure 1: Screenshot of Cropland Capture**




## 2.2. FotoQuest Austria

IIASA launched FotoQuest Austria in July, 2015, running for three months (Figure 2). The app has the EU LUCAS (Land Use and Cover Area frame Survey) protocol built in and asks players to locate points on the ground, classify the land cover based on the LUCAS categories, and then take pictures in 4 directions and on the ground. The game-like app, which is aimed at a German-speaking audience of all ages, allows participants to take geo-located photographs of landscapes for science.

The project aims to gather information about land use change in Austria that is important for research on climate change and flood risk. It also aims to spark a sense of adventure and exploration, encouraging participants to get outside and enjoy nature. Participants can also compete for points and prizes. In particular, we are interested in gathering data on urban expansion and the preservation of wetlands, which store large amounts of carbon dioxide and are therefore important for limiting climate change.

The game collected a total of over 12,000 photos, with more than 2000 locations visited or 12% of total available locations. Approximately 200 persons downloaded the app and collected a minimum of one observation. We are currently working with the TD1202 COST network Mapping and the Citizen Science, to use the app in other European countries. More information can be found at: http://fotoquest.at/ (as of January 29, 2018 renamed to FotoQuestGo).

**Figure 2: Screenshot of FotoQuest Austria**

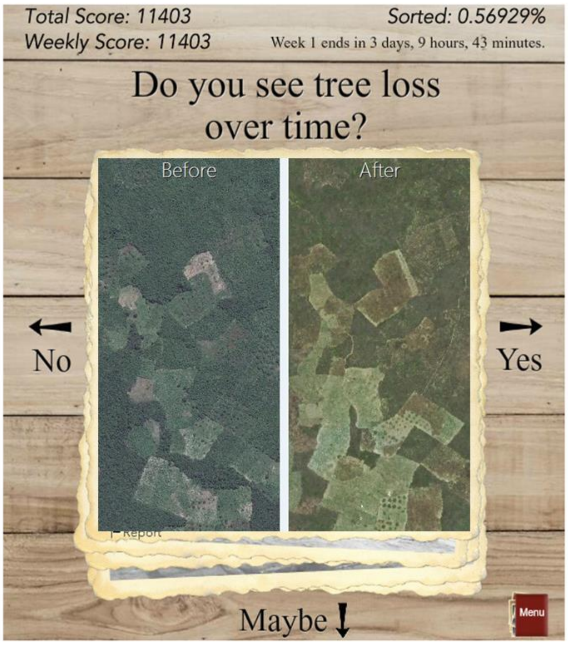

## 2.3. Picture Pile

The Picture Pile game is the successor to Cropland Capture (Figure 3). The game has been made more generic, i.e. other land cover types have been added and it will also collect information on land use as well as change over time. The idea is that players classify piles of pictures, where a pile represents one task or theme. By having different tasks, more variety will be embedded in the game to help retain players for longer. The game mechanics are similar to Cropland Capture, i.e. the player swipes images to the Yes, No or Maybe categories to classify them.

Some other planned tasks include the following: 'Do you see evidence of human impact in this picture?' and 'Are the trees oil palms?' For change detection, players will be presented with a pair of images and asked to determine whether they can spot any evidence of deforestation. Other tasks will be embedded as the game progresses. Each pile has an associated leader board and a chat channel, which makes it very easy for players and the organizers to communicate and will foster the formation of a community.

The scoring mechanism that will be employed in Picture Pile is one of the main changes from the Cropland Capture game. Instead of a majority agreement approach, more use of controls or reference data will be implemented within the game. The reference data will be images that experts have interpreted and are therefore treated as correct. Reference data will be provided to the players throughout the game and incorrect answers will be heavily penalized. This mechanism will also be used to provide feedback to the players so that they learn over time as the game runs. The game was launched in November 2015 and more information can be found at: http://geo-wiki.org/games/picturepile.

**Figure 3: Screenshot of Picture Pile**



## 3. LESSONS LEARNT

One of the most challenging aspects of citizen science includes overcoming the barriers to participation. From the gaming applications described above, a variety of lessons have been learnt, which could apply generally to game applications across numerous themes. These include the need to develop a good, professional-looking app, which provides personal satisfaction to the user and has a fun feel to it. However, a good-looking app alone is not sufficient; it must be a part of a holistic approach that contains stimulating, scientific ideas, allows for good communication with the community and provides appropriate incentives for participation.

Testing the app is critical, so a reliable testing strategy should be built into the app development. For researchers entering this field, the amount of testing needed should not be underestimated. Moreover, developing for Android can be challenging as there are many different Android versions and phones available. However, the app should be as bug-free as possible or users will not engage further. Testing is critical not only for the first release, but for all subsequent updates as well, since new bugs can be introduced.

Campaigns require considerable thought when using volunteers to do the work of expert (authoritative) data collection. There must be a lot of tips and helpful hints on how to do what is needed without overburdening the users (and thereby losing their interest).

The timing of a campaign launch should be carefully chosen to match the target audience, e.g. if targeting schools, then campaigns should be integrated within the school year. Media launch events, i.e. press conferences, interviews and video for high-level media distribution, are important for initial and ongoing recruitment and outreach. Another key to success is to be well connected to grassroots organizations (e.g. the Alpenverein in the case of Foto Quest Austria). Outreach via social media is also an effective channel. Including a budget line for Facebook-targeted campaigns that generate direct website clicks, mobile installs, etc. can yield additional participation.

## 4. CONCLUSIONS

This paper has briefly described three game applications that have generated considerable amounts of in-situ data for terrestrial environmental monitoring. Not only is the volume of data impressive, but the cost at which it is obtained is far less than collecting authoritative data. In addition, the nature of crowdsourcing or citizen science means that information can be obtained over time, allowing for new forms of change detection.

In conclusion, engaging citizens in environmental monitoring via gaming, as demonstrated by the three examples given here and numerous other activities underway, has great potential to change the way we collect in-situ data. Nevertheless, pitfalls exist, with lessons learnt from previous game development being applicable across many domains. In spite of the challenges outlined here, gaming applications offer the possibility to generate large amounts of timely, cost-efficient high quality information that was previously unavailable.

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