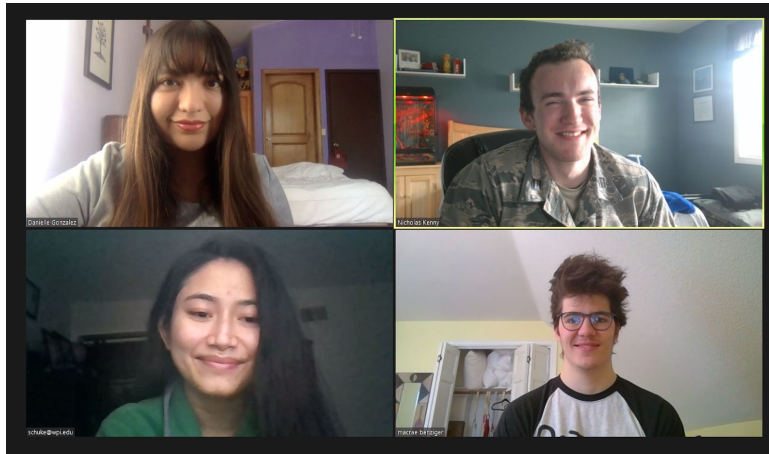


WORCESTER POLYTECHNIC INSTITUTE

Investigating the Sources of Artificial Light Pollution Utilizing Citizen Science

Supplemental Materials



Macrae Benziger
Sreeshti Chuke
Danielle Gonzalez
Nick Kenny

Advisors:
Professor Katherine Foo
Professor Sarah Stanlick

Sponsor:
GFZ Potsdam



Table of Contents

Part A - Authorship	2
Part B - Sponsor Description	3
Part C - Training Guideline Sheet	8
Part D - Survey Questions	10
Part E - Survey Results	15
Part F - Infographic	22

Part A - Authorship

Macrae Benziger	Sreeshti Chuke	Danielle Gonzalez	Nick Kenny
Meeting note taker	Weekly Schedule Maker	Sponsor/Advisor Communication	Weekly A3 Report
Developed python script to analyze the data collection	Survey graph designer	Infographic designer	Designed the training guidelines for citizen scientists
Survey Writer	Survey Writer	Survey Writer	Survey Writer
Slide Writer/Editor	Slide Writer/Editor	Slide Writer/Editor	Slide Writer/Editor
Primary Methodology Writer	Primary Background Writer	Primary Background Writer	Primary Methodology Writer
Primary Objective 1 Writer	Primary Objective 3 Writer	Primary Objective 3 Writer	Primary Objective 2 Writer
Secondary Objective 2 Writer	Secondary Objective 1 and 2 Writer	Secondary Objective 1 and 2 Writer	Secondary Objective 1 Writer
Abstract Editor	Abstract Editor	Abstract Editor	Abstract Writer
Recommendations and Conclusion Editor	Recommendations and Conclusion Writer	Recommendations and Conclusion Writer	Recommendations and Conclusion Editor
Mandatory Fun Host	Primary Mandatory Fun Creator/Host	Secondary Mandatory Fun Creator/Host	Mandatory Fun Host
Secondary IRB	Secondary IRB	Secondary IRB	Primary IRB
Primary Booklet Designer	Daily Team Meeting Scheduler	Daily Report	Secondary Booklet Designer

Part B - Sponsor Description

German Research Centre for Geosciences (GFZ)

The German Research Centre for Geosciences, abbreviated as GFZ, is Germany's national research center for Earth Science. Located in Potsdam, Germany, the GFZ is known for its expertise in understanding how the planet functions, and how humans impact their environment. In their own words, the mission of the GFZ is to “deepen the knowledge of the dynamics of the solid Earth, and to develop solutions for grand challenges facing society.” The organization currently employs 1281 people and is funded largely by the German Federal Government, with an annual budget of 95 million euros in 2018 (GFZ). The GFZ works with multiple universities within Germany and internationally, with their main clientele being the University of Potsdam, Freie Universität Berlin, and the Technical University of Berlin.

GFZ's vision is to understand the systems and processes of the Earth as a whole in order to address global change and its impact. Their main goal is to minimize risks that are associated with natural hazards and to determine the impact humans have on System Earth (GFZ Profile). Geoscience is a complicated field of study, and as such the organization is structured into four departments, each focusing on a different part of Geoscience as a whole. As illustrated below, the GFZ is divided into the Geodesy, Geophysics, Geochemistry, and Geosystems departments.

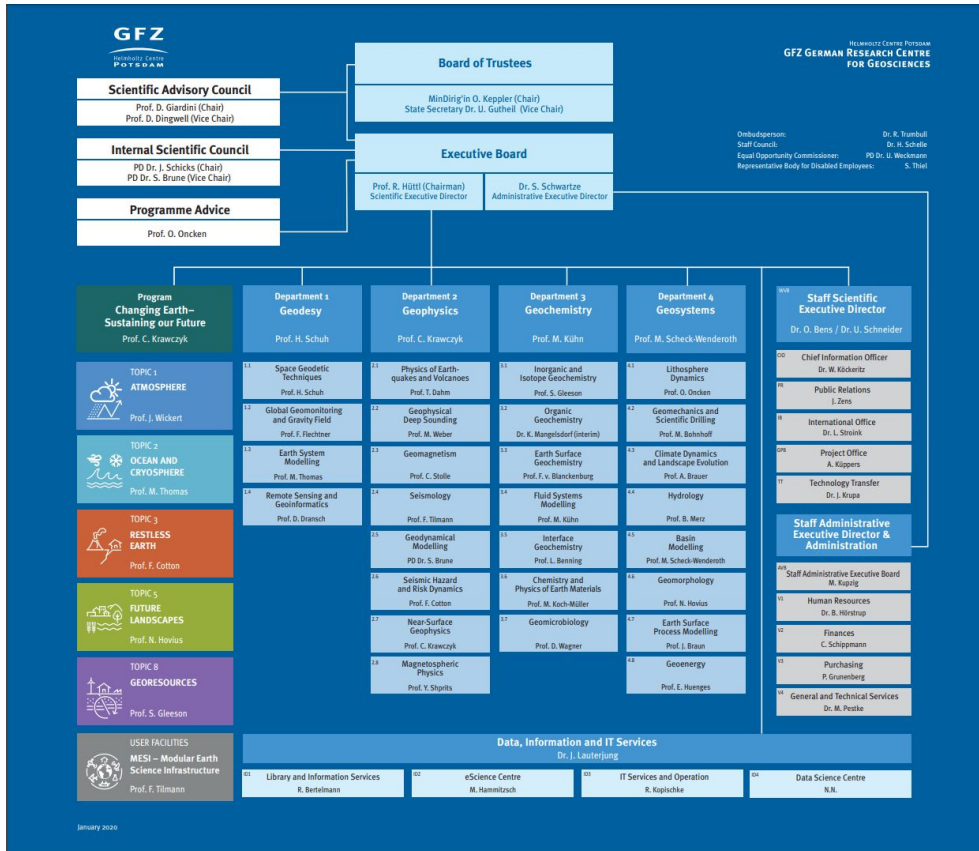


Figure 1: Organizational Chart of GFZ

The GFZ has a rich history. Founded in 1992, the GFZ is located on the Telegrafenberg, one of the most well known hills in the German scientific community. Located on this hill is the Albert Einstein Science Park which includes many observatories, one of which is the world's first Astrophysical Observatory as well as the birthplaces of German meteorology. Many research institutions including the GFZ have their headquarters in Telegrafenberg (Albert Einstein).

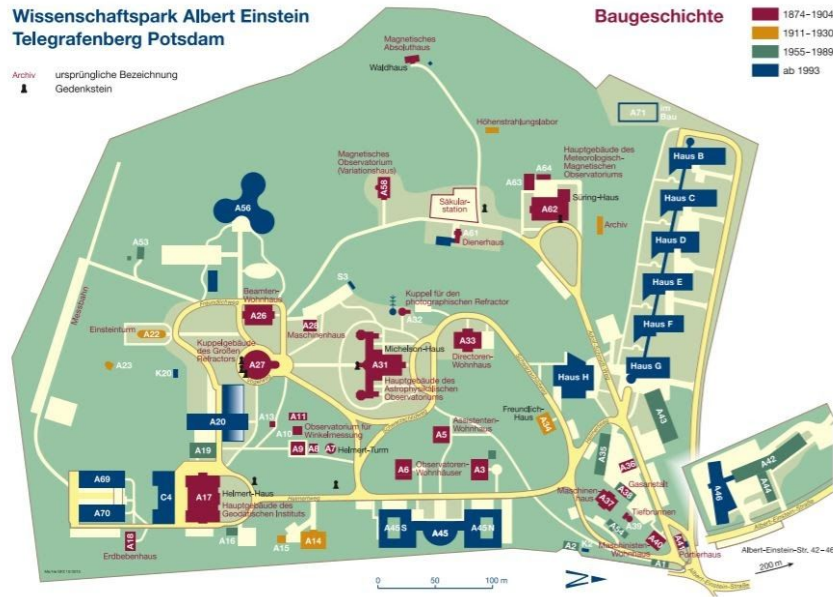


Figure 2: Map of the Albert Einstein Science Park

The GFZ is a talented organization with multiple projects spanning the entire geoscience field. One specialty of the GFZ is analyzing seismic activity along with plate tectonics around the globe. A recent example of this was when the GFZ were able to detect the formation of an underwater volcano off the shore of the East African island of Comoros recently (GFZ). This example, while specific, shows the GFZ’s ability to adapt to global environmental problems. Thus, they aim to analyze and reduce night-time light pollution not only in their home country, but on a global stage.

Within GFZ’s team of researchers in the Remote Sensing and Geoinformatics department, which is one of the major contributors towards light pollution research papers, is Dr. Christopher Kyba (GFZ). Throughout his career, he has written various pieces such as “Artificially lit surface of Earth at night increasing in radiance and extent”, where geographic light patterns are observed to record major changes in the area and radiance of artificial lights (Kyba et al., 2017).

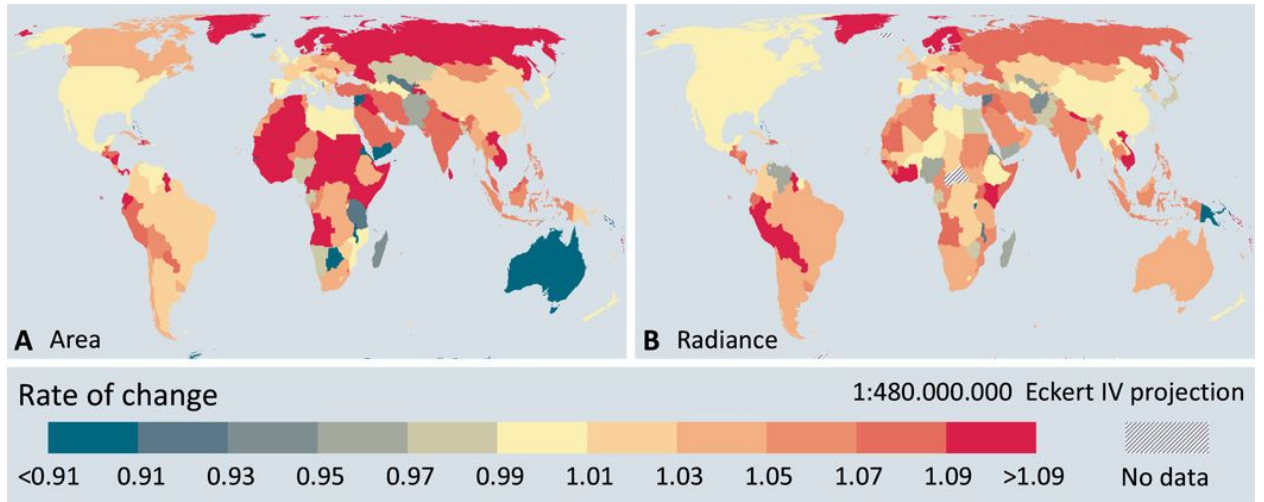


Figure 3. “Geographic patterns in changes in artificial lighting.”

Retrieved from <https://advances.sciencemag.org/content/3/11/e1701528>

In his personal blog, Kyba acknowledges that studies involving artificial lighting inventories have a great need of contribution through public participation. This is why he encourages citizen science research through the app “Loss of the Night”, for which he has a separate blog (Christopher Kyba).

“Loss of the Night” works by taking a user’s location, and guiding them to stars that should be in clear view. It is then that a user indicates whether or not the star(s) are visible to them. This mostly serves to have a more accurate tracking history of urban light pollution, with a final goal of creating a database that records the increasing lighting throughout the years (Christopher Kyba, 2015). With this previous research and app in mind, valuable information can be taken into account during the research and implementation of the “Night-time Light Emissions” project.

The German Research Centre for Geosciences is a complex, talented organization leading the German field of Earth Science. Located in the center of a scientific community with a rich history, they motivate young citizen scientists to further research within their field and encourage the general public to be mindful of their environment. They are a global analytical organization which is perfectly suited for collecting data on the global night-time light pollution problem.

References:

GFZ. *Christopher Kyba*. Retrieved from www.gfz-potsdam.de/en/staff/christopher-kyba/?

Kyba, Christopher C. M., et al. (1 Nov. 2017) *Artificially Lit Surface of Earth at Night Increasing in Radiance and Extent*. Retrieved from advances.sciencemag.org/content/3/11/e1701528.

Kyba, Christopher. *Christopher Kyba*. Retrieved from userpage.fu-berlin.de/~kyba/.

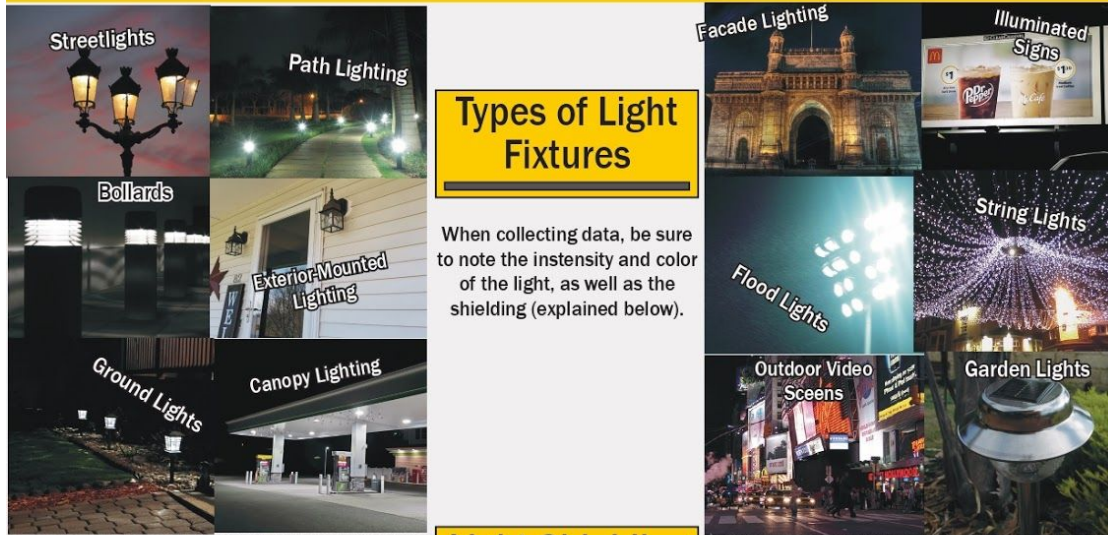
Kyba, Christopher. (14 Jan. 2015) *Brief Introduction to the Loss of the Night App Project*. Retrieved from lossofthenight.blogspot.com/2015/01/brief-introduction-to-loss-of-night-app.html.

“Albert Einstein Science Park.” *OMICs International*, Open Access Publisher, www.omicsonline.org/universities/Albert_Einstein_Science_Park/.

“GFZ Profile.” *GFZ German Research Centre for Geosciences*, Helmholtz Centre Potsdam, www.gfz-potsdam.de/en/about-us/organisation/gfz-profile/.

Part C - Training Guideline Sheet

Data Collection Guidelines



Types of Light Fixtures

When collecting data, be sure to note the intensity and color of the light, as well as the shielding (explained below).

Light Shielding Explained



Counting Windows



Residential Windows

Lit residential windows are counted in a standard fashion, with 1 window equalling $2m^2$ (~ $2yd^2$) or about how much space one person takes up. When counting multiple windows, try to estimate how many "standard" windows there are.



Commercial/Shop windows are typically much larger than residential windows, often with whole walls of glass. Counting them is as simple visualizing how much space 4-6 people take up, which counts as 1 commercial window. This equals about $8-12m^2$ (~ $8-12yd^2$)

Image Attribution

Vijay Sharma / "Gateway of India at night" / CC BY-SA 2.0

Atomic Taco / Pillars (3568940445) / CC BY-SA 2.0

jamesunvala / Full moon through Christmas lights in January / CC BY-SA 2.0

"NYC Times Square Street/Night Life" by derluckyucas is licensed under CC BY-NC-ND 2.0

Leon Brooks / Solar garden light / CC BY-SA 2.0

Léna / Streetlight on the pont des Catalans (Toulouse, France) at sunset / CC BY 3.0

Prateek Karandikar / Path near floating restaurant, with moon, Infosys Mysore / CC BY-SA 4.0

Leon Brooks / stadium, lights / CC0 Public Domain

Part D - Survey Questions

Personal Experience with Night Sky

Thank you for taking an interest in our survey, this will help our Interactive Qualifying Project team further understand light pollution's causes and effects.

Have you ever seen a clear night sky (Stars, Milky Way)?

- Yes
 - No
 - Unsure
-

Do you enjoy stargazing?

- Yes
 - No
 - I've never done stargazing
-

Why have you never done stargazing?

- It is not possible to do so where I live
- I don't have an interest in stargazing
- Other:

Understanding of Light Pollution

Do you know what light pollution is?

- Yes
- Somewhat

No

What do you think are some factors that could increase light pollution?

How concerning do you think light pollution is in relation to other environmental issues?

- Not at all
- A little
- A moderate amount
- A lot
- A great deal

Place-Based Understanding of Light Pollution

How much light pollution do you think there is in your town/city?

- None at all
- A little
- A moderate amount
- A lot
- A great deal

Do you think that light pollution has had any effects on your health?

- Yes
- No
- Unsure

What do you think those effects could be?

Have you ever had problems with excessive outdoor lighting?

Yes (feel free to write your experience)

No

What are some things you have done to help reduce the level of light pollution at night?

I have done:

I have not taken actions to reduce light pollution at night

Other:

How safe do you feel walking around your neighborhood at night?

- Always
 - Most of the time
 - About half the time
 - Sometimes
 - Never
-

How comfortable would you be taking data at night using an application on your phone?

- Extremely comfortable
 - Somewhat comfortable
 - Neither comfortable nor uncomfortable
 - Somewhat uncomfortable
 - Extremely uncomfortable
-

Citizen Science

Do you know what Citizen Science is?

- Yes
 - No
-

Citizen Science is when the general public participates in research, usually as a way of collecting data on a massive scale.

For example:

The application iNaturalist allows users to record both common and rare organisms such as plants and animals. With this information, researchers are able to gather data about different species.

With this definition in mind, answer the following questions:

Would you consider participating in Citizen Science?

- Yes
 - No
-

What do you think could be a possible incentive for people participating in Citizen Science?

What do you think is a major barrier that would keep someone from participating in citizen science?

Contact Interest

Would you be interested in entering a raffle for a \$15 Dunkin' gift card?

- Yes!
 - No thanks
-

Please enter your name and email to enter the raffle:

My name is:

My email is:

Would you be interested in having a 15 minute phone interview about light pollution with our IQP team, to help us further understand our research goal?

- Yes!
- No

Thank you for taking interest! Please enter your name and email so we can contact you at a later date

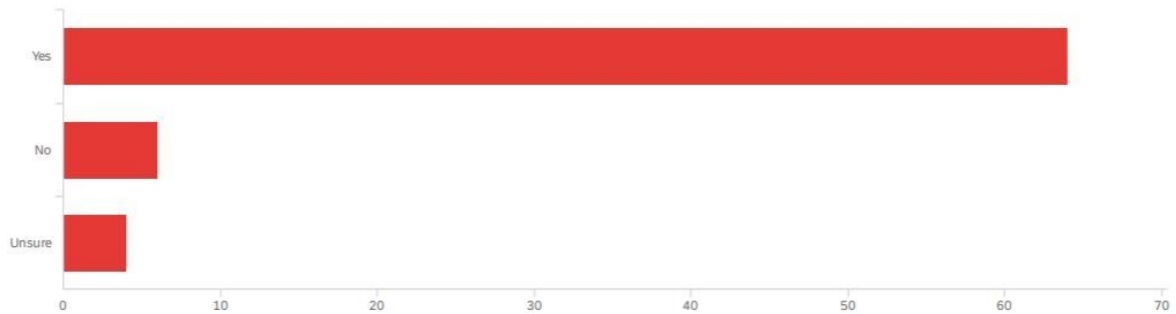
My name is:

My email is:

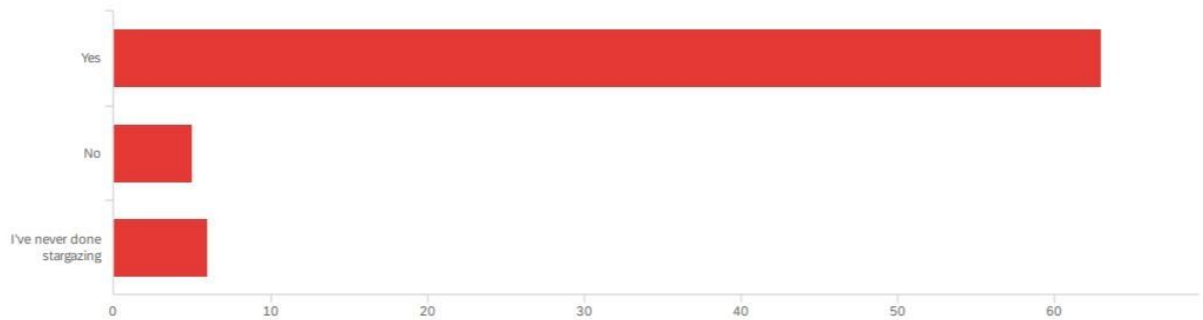
Powered by Qualtrics

Part E - Survey Results

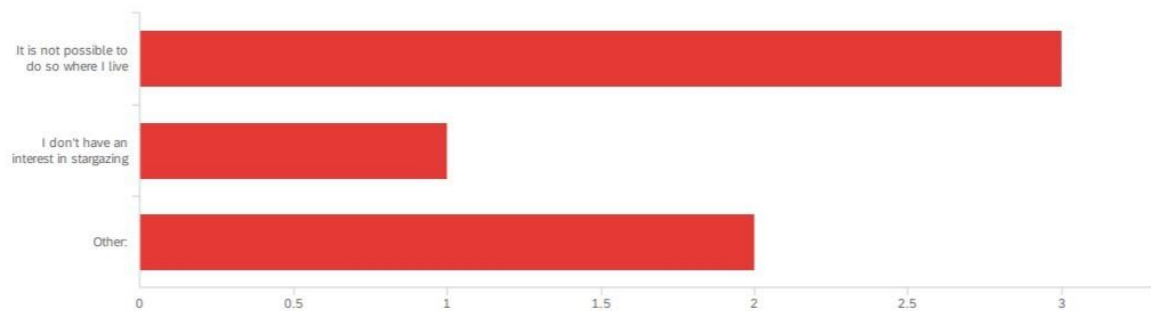
Q1 - Have you ever seen a clear night sky (Stars, Milky Way)?



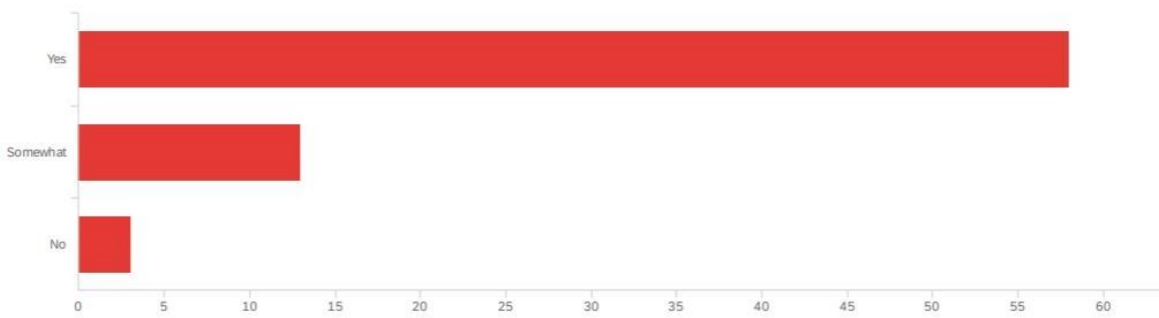
Q2 - Do you enjoy stargazing?



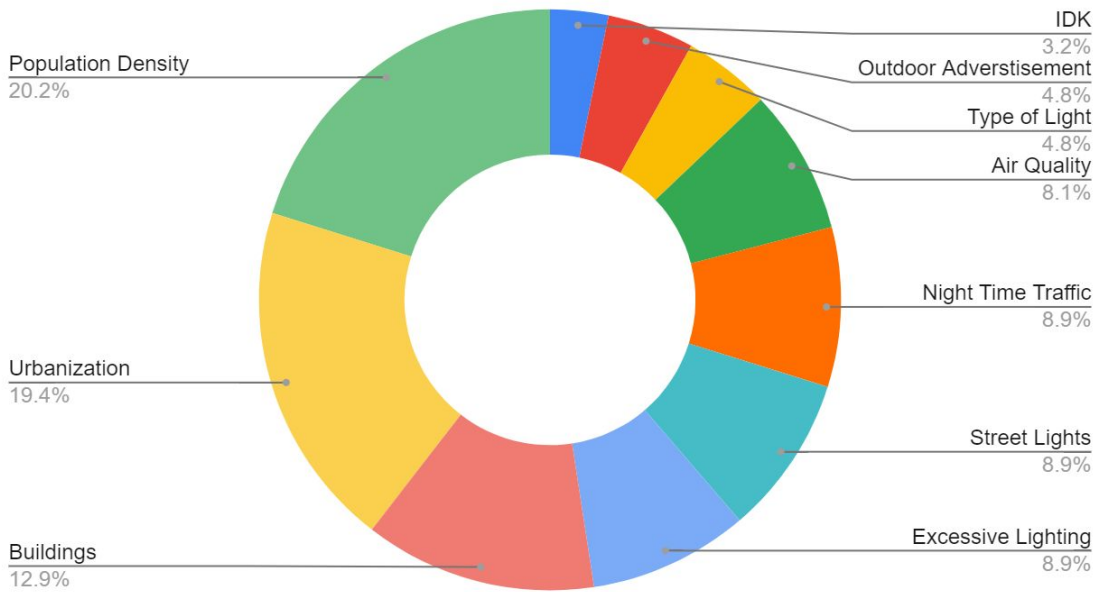
Q3 - Why have you never done stargazing?



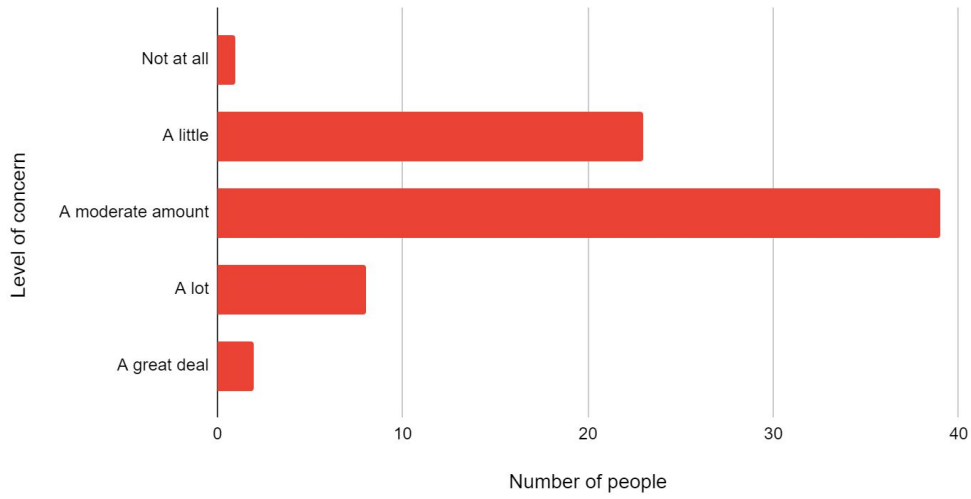
Q4 - Do you know what light pollution is?



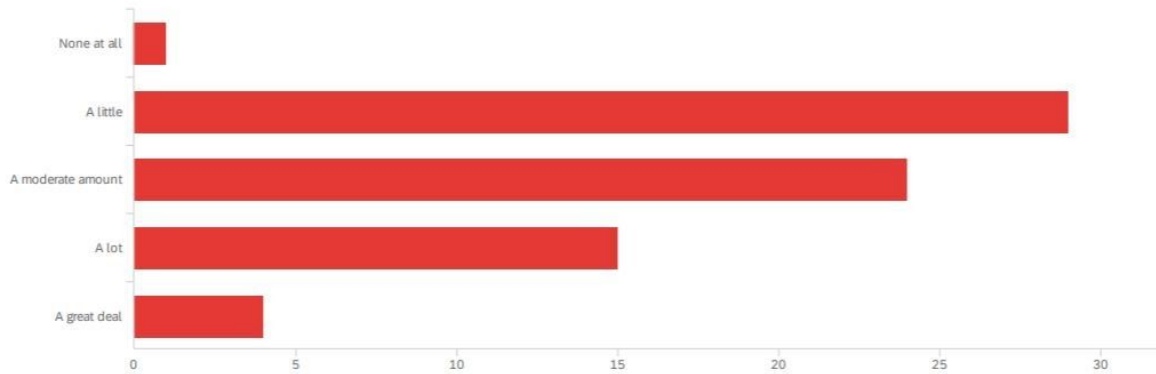
Q5 - Light Pollution Factors



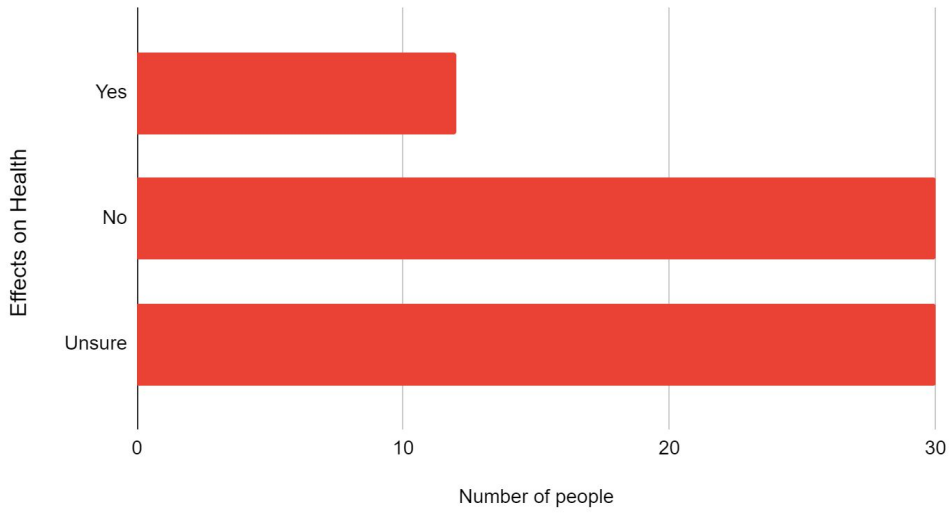
Q6 - How concerning do you think light pollution is in relation to other environmental issues?



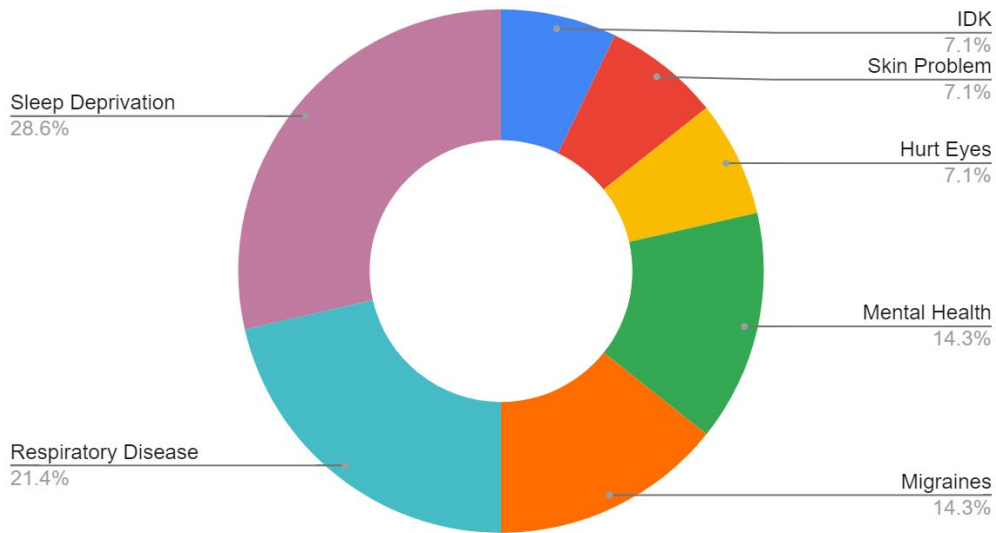
Q7 - How much light pollution do you think there is in your town/city?



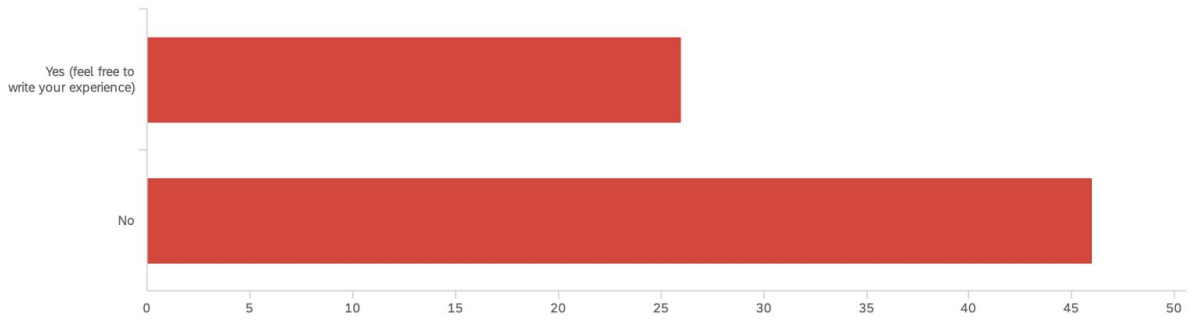
Q8 - Do you think that light pollution has had any effects on your health?



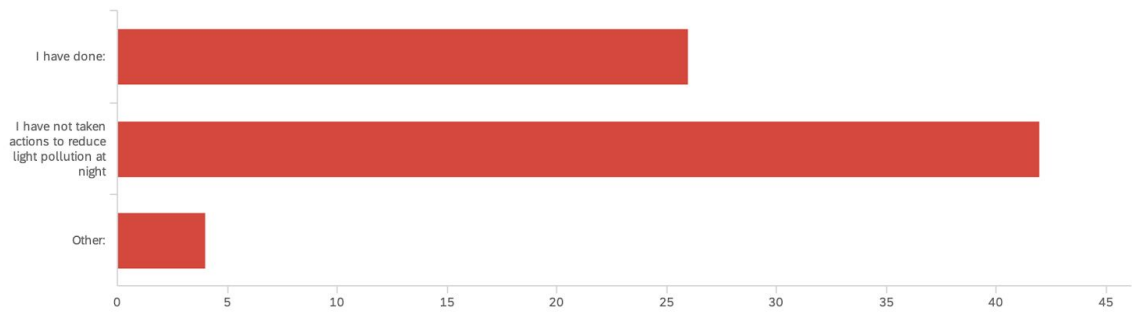
Q9 - Light Pollution Effects on Health



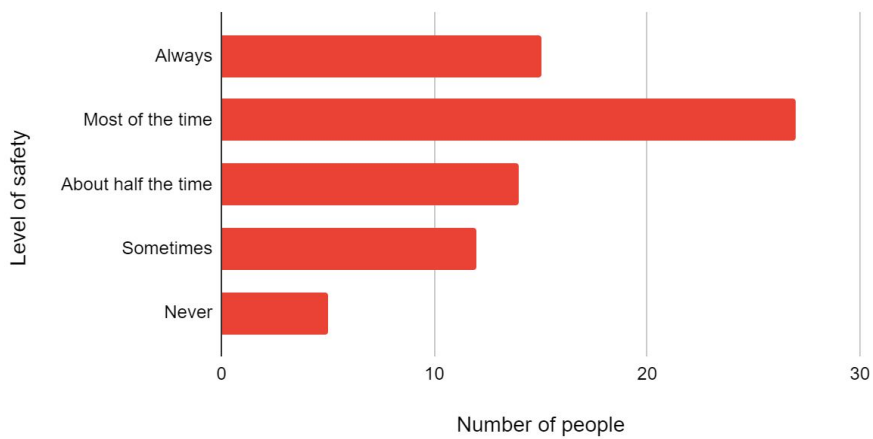
Q10 - Have you ever had problems with excessive outdoor lighting?



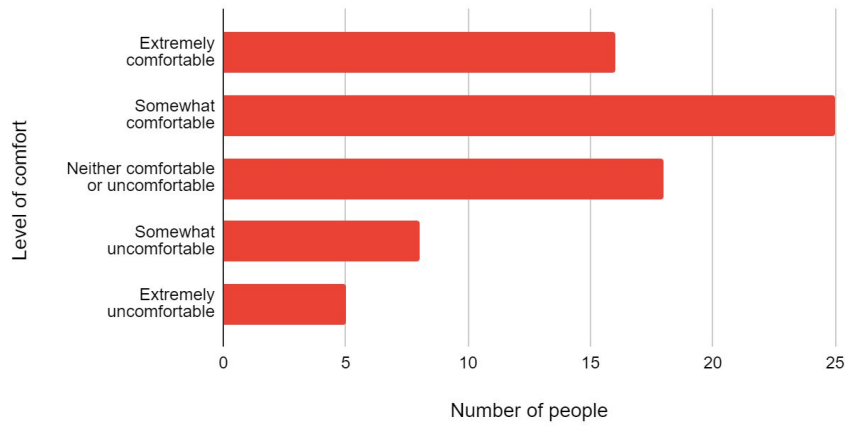
Q11 - What are some things you have done to help reduce the level of light pollution at night?



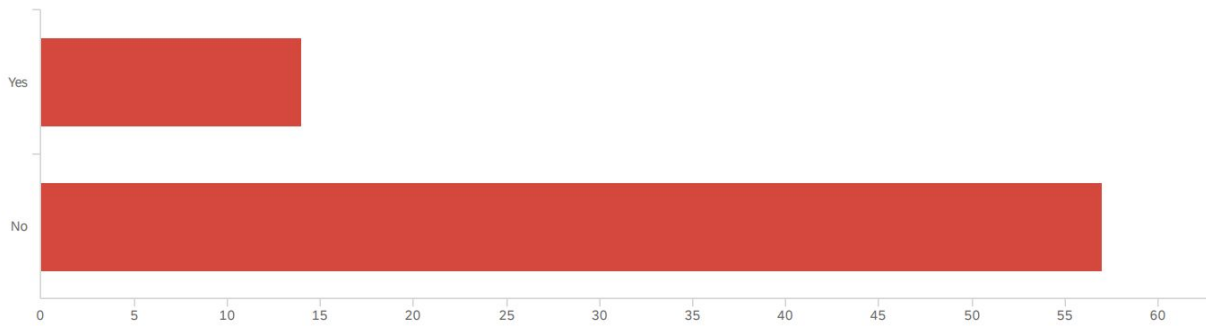
Q12 - How safe do you feel walking around your neighborhood at night?



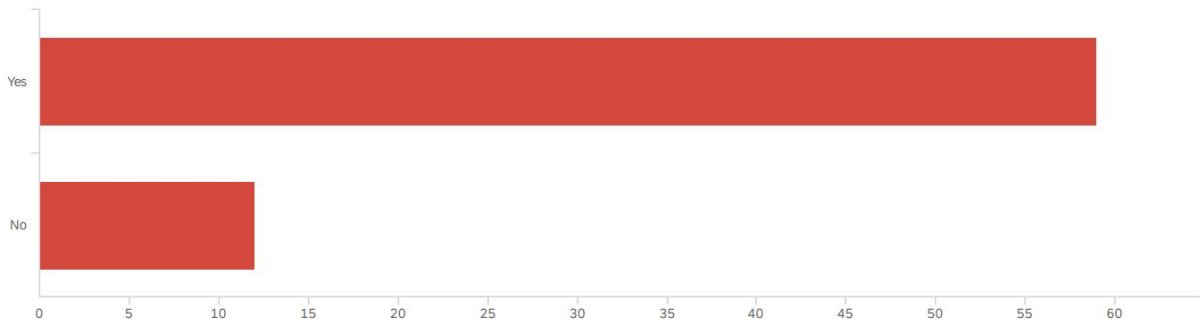
Q13 - How comfortable would you be taking data at night using an application on your phone?



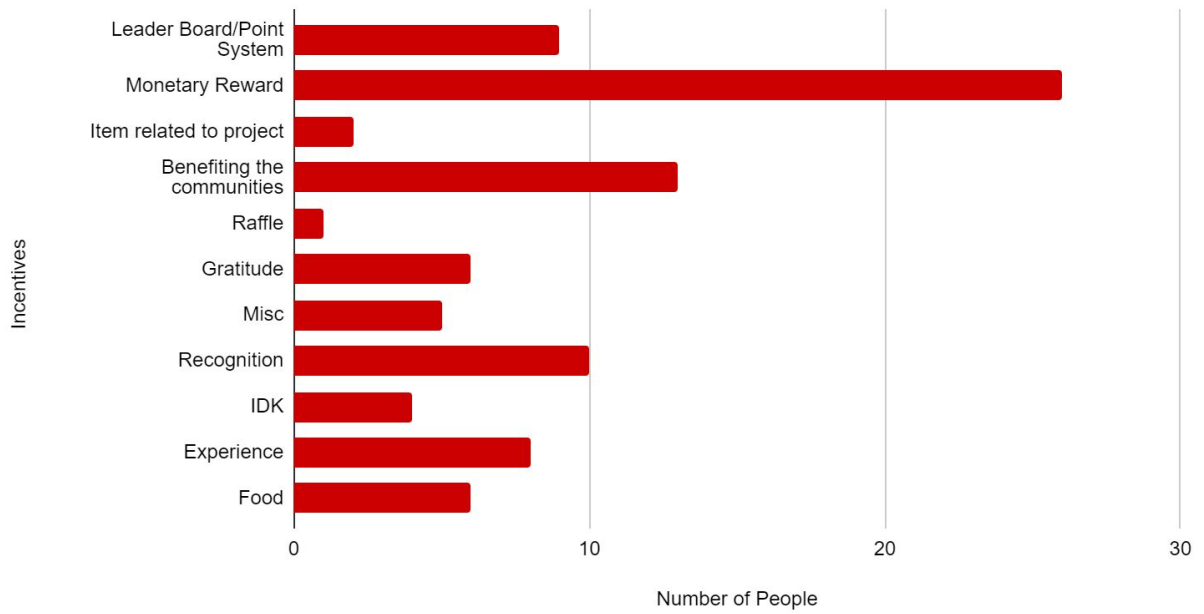
Q14 - Do you know what Citizen Science is?



Q15 - Would you consider participating in Citizen Science?



Q16 - What do you think could be a possible incentive for people participating in Citizen Science?



Q17 - What do you think is a major barrier that would keep someone from participating in citizen science?

