GLOBE IVSS Research Guide

[GLOBE Africa 2022 Document]

Acknowledgements

This GLOBE IVSS Research Guide has been developed as a resource guide to assist GLOBE Teacher and students undertaken and present their research. The Guide is premised on the GLOBE Program International Virtual Science Symposium format but can be applied on any other student research project.

The Guide has been prepared by Mr. Charles Mwangi, Coordinator GLOBE Program in Kenya with support from Mr. Mark Brettenny, GLOBE Africa Regional Coordination office. Thank you Prof Rebecca Boger, Ylliass Lawani and Francis Nsubuga for taking time to review.

It is hoped that this guide will assist in increasing the number of projects submitted to GLOBE IVSS 2023, more especially from the developing countries.

Photo credits to GLOBE Program. Most of the pictures in this document are from the GLOBE Program Website and has not been recreated.

NOTE: Almost all the information provided in this document is sourced from the GLOBE Website or related resources. All effort has been made to update and contextualize the information. In case of any discrepancy or misrepresentation, all responsibility is waved. This document is ONLY a guide to assist students who want to fast track their research process.

TABLE OF CONTENTS

CHAPTER 1: GLOBE OVERVIEW

About GLOBE

The Global Learning and Observations to Benefit the Environment (GLOBE) program is a worldwide, hands-on, primary and secondary school-based science and education program. GLOBE supports students, teachers, and scientists in collaborations using inquiry-based investigations of the environment and the earth system.

GLOBE currently works in close partnership with the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and National Science Foundation (NSF) in studies and research about the dynamics of Earth's environment.

Announced in 1994, GLOBE began operations on Earth Day 1995. Today, the international GLOBE network has grown to include representatives from 121 participating countries and 136 U.S. partners coordinating GLOBE activities that are integrated into their local and regional communities. There are more than 35,000 GLOBE-trained teachers working in over 34,000 schools around the world. To date, GLOBE students have contributed more than 165 million measurements to the GLOBE database for use in their inquiry-based science projects.

In 2003, NASA and the University Corporation for Atmospheric Research (UCAR) entered into a cooperative agreement for operation and management of the GLOBE Program and this is still in effect. UCAR is in-charge of the operations of the GLOBE Implementation Office (GIO) and is based in Boulder, Colorado in the United States. GIO works closely with the Regional Coordination Offices in SIX region; Africa, Asia & Pacific, Europe & Eurasia, Latin America & Caribbean, Near East & North Africa and North America.

Educational Elements of the GLOBE Program

GLOBE students carry out a series of investigations that scientists have designed to gather data about the Earth and how it functions as a global system. Students use instruments and their own senses to observe the environment at sites within or near their schools. They record the data they gather, save it in a permanent school data record, and send the collected data to the GLOBE Data Server (using a computer/laptop connected to Internet or using mobile devices loaded with GLOBE Data Entry/GLOBE Observer app). The GLOBE Website (www.globe.gov) contains all the GLOBE resources, including information on the different protocols and requisite learning Activities that can be adapted to the local curriculum needs.

Each Learning Activity provides the background information needed to successfully complete the activity. Each of the Protocols and Learning Activities includes a designation of recommended grade levels, in three categories:

- Primary - Ages 5-9 years.
- Middle - Ages 10-13 years.
- Secondary - Ages 14-18.

There are six key educational elements of the GLOBE program.

1. **Selecting local study and sample sites** – Students, with guidance from teachers, pick a local study sites (or numerous sites) where they collect recurring measurements.
2. **Taking measurements carefully on a regular schedule** - Students begin with taking one measurement and then, over the course of a few months, add new measurements one-by-one as they learn how to do them.
3. **Submitting the data** - All measurement data should be submitted to the GLOBE Data Server using a computer/laptop with Internet; or a mobile device loaded with GLOBE Data Entry/GLOBE Observer App. All the data collected is freely available on the GLOBE website and as such students and teachers can access and interact with data from any part of the world.
4. **Complete the Learning Activities** - Each investigation has a set of Learning Activities that help your students learn more about the science domains, the instruments and procedures for the measurements, and the ways that students and scientists can use the data collected.
5. **Using GLOBE systems on the Internet to explore and communicate** - GLOBE program has created a website which has created comprehensive (and easy to use) online resources for both training and learning. The GLOBE website offers opportunities to student and teachers to establish linkages, collaborate and communicate with other schools and with the GLOBE scientists.

6. **Promoting student investigations** - Ultimately, the aspiration of the GLOBE Program is to enable and facilitate students to undertake their own investigations at local sites. The GLOBE website avails to students and teachers learning resources as well as data collected by other students worldwide.

Currently, there are four Spheres of GLOBE scientific research. Each Sphere has numerous GLOBE investigations protocols. These spheres include:

a) **Atmosphere** - Atmospheric measurements collected by students are important for studying weather, climate, land cover, phenology, ecology, biology, hydrology, and soil. Students conduct daily measurements of cloud and contrail cover and type, air temperature, precipitation, precipitation pH, barometric pressure, relative humidity, surface ozone, and aerosol optical thickness.
b) **Hydrosphere** - Hydrosphere protocols enable us to take accurate measurements of the often changing quality of water bodies around us. Students conduct weekly measurements of water transparency, temperature, dissolved oxygen, pH, either conductivity or salinity, alkalinity, nitrate-nitrogen as well as freshwater micro-invertebrates in water bodies near or around their schools.
c) **Pedosphere** — Data collection of soil temperature, moisture and chemical properties is invaluable to scientists in many fields. Students expose a soil profile, take soil samples, and analyze them to determine the characteristics of various soil layers. They also do daily to monthly measurements of soil moisture at various depths and locations, and take daily to weekly measurements of near-surface soil temperature.
d) **Biosphere** - Biosphere Protocols offer ways to quantify seasonal change, land cover, land use, and the amounts of living and dead biomass on the land surface. Students collect data on green up/green down, land cover, fire fuel, phenology, biometry and bird migration.

In addition to these direct investigations, there are two supportive investigations included in GLOBE:

a) **Earth as a System** - Exploring Earth as a System help students understand the connections between different aspects of the natural world on a variety of scales, ranging from their own school yard to the entire earth. Earth as a System looks at bundling related protocols together despite them being in different Spheres.
b) **GPS** - Global Positioning System (GPS) is the technology that enables students to determine the latitude, longitude, and elevation, of various sites using a small hand-held receiver and a set of Earth-orbiting satellites. This information is essential so that scientists and others will always know where measurements were taken. Currently, smartphones and mobile phones can collect GPS data automatically.

The Benefits of GLOBE Program

For the GLOBE program to positively impact our society, it requires immense support from its stakeholders; that is the learners, educators, scientist, partners and volunteers. However, it also promises huge benefits to these stakeholders. Some of these benefits include:

a) **For students or learners:** The GLOBE Program provides a platform to build the capacity to do scientific research investigations – to be a scientist. Through GLOBE, learners gain an understanding of why the scientific method and data are important and how they can be used to study and understand the Earth as a system. With GLOBE, students learn the practices of science through hands-on investigations in their own communities, which sparks their curiosity and interest in science. This often leads to inquiries that help solve real-world problems and further understanding of our global environment.

b) **For teachers and educators**: The GLOBE Program involves working with an international community of teachers, scientists, students and others to achieve inquiry-based instruction and thus provides an avenue for teacher professional development. While GLOBE is not a curriculum, it is widely adaptable into many different curricula covering multiple subjects applicable to primary and secondary grade levels and beyond.

c) **For scientists:** GLOBE is a shared source of research-quality environmental data produced following a set of consistent measurement protocols using instruments that meet established specifications. These data are broadly applicable to research investigations ranging from the local to the global. GLOBE also offers a meaningful way for scientists to interact with and mentor teachers and students and provide expertise to them. Scientists also benefit from experiences with teachers and addressing the questions of students.

d) **For the international community**, GLOBE provides a framework where students, teachers, educators, and scientists can engage in connecting, sharing, and collaborating with a worldwide community of partners focused on a better scientific understanding of the Earth system. The GLOBE program also offers rich opportunities for fulfilling project and mission education, community engagement and outreach requirements and demonstrating broader impact of government funded projects.

e) **Addressing the Sustainable Development Goals:** The GLOBE Program seeks to realize a number of the Sustainable Development Goals (SDG), key one being **SDG Goal 4** which seeks to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. The program also addresses **Goal 13, 14 & 15**, which focus on aspects of climate change and the ecosystem/environment as well as **Goal 6** which deals with issues related with water management.

CHAPTER 2: GLOBE IVSS

About IVSS

The GLOBE International Virtual Science Symposium (IVSS) is Science Symposium organized by GLOBE every year since 2012 to provide students from primary school through undergraduate from all GLOBE countries with opportunity to document, discuss and share their research process and findings with their peers, earn virtual badges, and receive feedback from a team of experts and STEM professionals. The GLOBE IVSS is an entirely online annual event which is open to GLOBE students from around the world. Each year, the GLOBE IVSS focuses on a new theme determined by the organizers who constitute the GLOBE Community.

GLOBE 2023 IVSS

The theme for this year's (2023) IVSS is **Global Connections: Investigating Earth as a System Together**. Students are encouraged to explore the *Earth as a System Protocol Bundles* and use them as tools to investigate their environmental research questions. This year's theme inspires students to make connections with other students and scientific explorations around the world. Students are also advised to present their research in creative ways, for example, through storytelling tools including video, online media, storyboards, drawings, and more.

GLOBE website is a great resource for finding potential research partners. To search for other collaborators, you can use GLOBE's *Find a Project Collaborator* tool to identify teachers and other research partners from around the world.

GLOBE 2023 IVSS Timelines

The timelines for the GLOBE 2023 IVSS are as indicated in the table 1.1

Table 1.1: GLOBE 2023 IVSS Timelines

Event	Deadline
2023 IVSS Questions and Answer Session	12th October, 2022
Projects Accepted	1st January – 10th March, 2023
Due Date for all IVSS Projects	10th March, 2023
Judges Webinar	29th March, 2023
Judging Period	30th March – 9th April, 2023
Feedback and Virtual Badges Shared	Earth Day: 22nd April, 2023
Drawing for stipends	Earth Day: 22nd April, 2023

Using the Earth as a System Protocol Bundles

When forming research questions for GLOBE IVSS 2023, students are required to reference the Earth as a System Protocol Bundles. These curated protocol collections cover: *agriculture, air quality, ENSO, mosquitos, oceans, rivers and lakes, soils, urban environments, the water cycle, water quality*, and *weather bundles*.

More details on this link: https://www.globe.gov/es/web/earth-systems/community

Each bundle has an introduction explaining how the included protocols relate to one another. Additionally, these bundles contain case studies, example research questions, and other resources to help the GLOBE community understand the details of each protocol.

This guide provides highlights of selected THREE of the Earth as a System Bundles; *Mosquito*, *Soils* and *Weather*, and later gives a more detailed review on select "TWO" bundles; *Agriculture* and *Water Quality*, to assist the students better under the bundles each with a case study or sample report based on Agriculture presented in the Appendix section (*see page 40*).

NOTE: *Students are free to select any of the Earth as a System Protocol Bundles*

a) Mosquito Bundle

Mosquitoes infect hundreds of millions of people with serious diseases and kill more than a million people each year. You can make a difference in tracking and controlling the spread of mosquitoes and help protect your loved ones from contracting dengue, Zika, and other illnesses. This bundle contains a group of protocols to help you better understand how mosquito populations interact with the various Earth spheres.

More details on this link: https://www.globe.gov/es/web/earth-systems/community/mosquito-bundle

b) Soils Bundle

Soils are one of Earth's essential natural resources supporting nearly all terrestrial life by holding life, nutrients, hydration, and filtering water. This bundle contains a group of protocols to help you better understand how soil interacts with the various Earth spheres.

More details on this link: https://www.globe.gov/es/web/earth-systems/community/soil-bundle

c) Weather Bundle

Weather is highly variable around the world and can change in minutes. This variability is directly related to the energy budget of a particular area and depends on many different factors like land cover and incoming solar radiation. This bundle contains a group of protocols to help one better understand how the weather interacts with the various Earth spheres.

More details on this link: https://www.globe.gov/es/web/earth-systems/community/weather-bundle

d) **Agriculture Bundle** (*Sample Case 1*)

Taking care of our land and fields helps preserve agriculture's benefits to humanity, including food security, nutrition, and livelihoods. This bundle includes a group of protocols to help you better understand how agriculture interacts with the various Earth spheres. Agriculture also changes as you move across the globe. How land is used agriculturally is based on climate conditions, the type of crop being grown, the scale of cultivation, farming intensity, mechanization level, combinations of livestock, and much more.

The Agriculture Bundle cross cuts across all the GLOBE Spheres. Some of the protocols that impact Agriculture include;

- *Atmosphere*: Air temperature, Surface temperature, Precipitation, Wind direction, Relative humidity
- *Pedosphere*: Soil characteristics, Soil fertility, Soil moisture, Soil pH and Soil Temperature
- *Biosphere*: Land cover, Green-down and Green-up
- *Hydrosphere*: Temperature, pH, Alkalinity, Salinity, Nitrates and Electrical Conductivity

More details on this link: https://www.globe.gov/es/web/earth-systems/community/agriculture-bundle

Sample Research Question

A few examples of research questions students can explore include the following;

- Is the soil color the same or different in and around agriculture fields in your area?
- What is the relationship between the soil characteristics and choice of crops being grown by farmers in your region?
- How do weather parameters like temperature, humidity and rainfall affect the plant growth in your area?
- What is the impact of fertilizer on soil characteristics such as pH, electrical conductivity, nitrates and/or salinity?

Sample Hypothesis

A few examples of Hypothesis students can explore include the following;

- The soil color in and around agriculture fields is different from that in grazing land
- The soil characteristics in my area has made it impossible to plant YYY crops
- Temperature, humidity and rainfall has negatively impacted on farming in my area
- The use of fertilizer has increased the Soil pH, electrical conductivity, salinity, nitrates

Water Quality Protocol Bundle (*Sample Case 2*)

As water interacts with the atmosphere, soil, and the surrounding land cover bordering water bodies, its quality changes. The chemical composition, pH, transparency, and many other factors can be affected as water works its way through the water cycle. Human activity can also impact water quality in major ways through our tampering with the natural environment. Because of its influence on what can live in a body of water and how that water may be used, water quality is an important area of scientific study.

In general, the quality of water can't be measured by remote sensing from satellites. Because of this limitation, data collected from GLOBE scientists, teachers, and students are vital in helping people become better informed and engaged stewards for the water in our environment. By taking water quality measurements guided by this Bundle's protocols, the GLOBE community can learn more about the water in their local environment and collaborate with others around the world

The Water Quality Bundle focusses on THREE GLOBE Spheres namely;

- *Atmosphere*: Precipitation
- *Pedosphere*: Soil pH
- *Hydrosphere*: Water Temperature, Water pH, Alkalinity, Salinity, Nitrates and Electrical Conductivity, Water Transparency and Dissolved Oxygen

More details on this link: https://www.globe.gov/web/earth-systems/community/water-quality-bundle

Sample Research Question

A few examples of research questions students can explore include the following;

- What is the quality of the water in (*name*) river/dam/water pan?
- Is my tap water at home safe to drink, bath or water the crops?
- How does water quality on (*local name*) river affect macroinvertebrates?
- How does human activity in my area/school affect water quality?

Sample Hypothesis

A few examples of Hypothesis students can explore based on the Sample Research Questions include the following;

- The quality of the water in (*name*) river/dam/water pan is bad
- The tap water safe at home is not safe to drink, bathe in or water the crops
- The water quality on (*local name*) river has reduced the variety of macroinvertebrates
- Agricultural activities in my area/school has reduced the quality of water in the *dam*

CHAPTER 3: SCIENTIFIC RESEARCH PROCESS

The scientific research process entails asking questions, exploring the possible solutions, and using evidence to justify your answers. This is a process that anyone can undertake as long as they adhere to the commonly acceptable process of conducting science. A student can collect or access data from other source, analyze the data by performing calculations and plotting the data to gain a better understanding of the information generated from the data.

More importantly, the findings need to be communicated to peers and the public for general information. It is such findings that could easily be used to influence and guide the decision and policy making process within a community. The flowchart shown in Figure 3.1 illustrates some of the key steps in the Scientific Process.

Figure 3.1: Key Steps in the Scientific Research Process (Source GLOBE)

Steps of the Scientific Method

1. Observe Nature

The first step in any scientific research process is careful observation and being curious about what is happening around. Enjoy the process by giving yourself time to absorb anything and everything that's going on around you. Listen to the news, conversations, take a walk in the park, read the bill boards, etc.

When something catches your attention, think about what kinds of questions you could ask about how or why that thing is the way it is. Think about events or things that are different from the way they were previously.

For example, consider the images shown in *Fig 3.2* and *3.3*, what questions do they evoke:

Fig 3.2: How do cloud types differ?

Fig 3.3: How does pollution affect our water?

2. Ask a Research Question

After you've taken some time to observe the environment around you, think about some questions you could answer with a research project. The scientific method starts when you ask a question about something that you observe: *How*, *What*, *When*, *Who*, *Which*, *Why*, or *Where*?

A good research question doesn't have an obvious answer and could have more than one solution. Additionally, if your question can be answered with a simple "*yes*" or "*no*," the question probably isn't strong enough for a research project.

When you are thinking about questions to pose, try to concentrate on problems with solutions that will expand your understanding on a chosen topic. Typically, questions that begin with "*How...*" or "*Why...*" will help you dig deeper into a topic more than questions that

begin with "*Is there...*". It adds more value, if your research question addresses a problem that's significant and interesting to you and your community and could provide new insights.

Steps to a Good Research Question

The following is a guide to creating good research questions:

a) Think and list down some questions you want to investigate
b) From this list of questions, identify one or more that are:
    - Interesting to you
    - Can be answered using new/available data or GLOBE measurements
    - Can be answered within the time frame for your research project
c) Throughout the course of your project, revisit these questions as necessary. Scientists frequently refine their questions during their research as they learn more about the research topic.

3. Develop a Hypothesis

The purpose of science is to develop questions about the world around us. Discovering the answers to these questions teaches us more about how nature works and where humans fit into the equation. An important step in finding these answers is developing and testing hypotheses.

***Note**: A **hypothesis** is an initial, tentative statement that offers a possible explanation to some phenomenon, event, or scientific problem. These statements are made at the beginning of projects in order to provide an initial direction for further research.*

A useful hypothesis is both testable and measurable. This means that there is some variable you can evaluate that will either prove or disprove your hypothesis. This verification procedure is what the rest of the scientific process is all about.

A hypothesis is an educated guess about how things work. It is an attempt to answer your question with an explanation that can be tested. A good hypothesis allows you to then make a prediction: *"If _____[I do this] _____, then _____[this]_____ will happen."* State both your hypothesis and the resulting prediction you will be testing. Predictions must be easy to measure.

When you're developing your hypothesis, try to think about a reason that may explain the question you're researching. As you further investigate your problem, you'll learn more background information about your topic and create new questions to answer. These questions may refine your hypothesis throughout your project and lead you to even more questions you didn't initially consider.

4. **Plan and Conduct an Investigation**

Once you develop your hypothesis, you need to create a plan to test your idea. This plan should be thorough but achievable within your allotted timeframe. To help you create a robust research investigation, follow the following guide:

a) **Create Steps:** Creating clear steps for your research plan will help you track your progress towards completing your investigation. If you are working in a group, these steps should also include the lead and who will be responsible for each task.

b) **Determine Relevant Data:** Figuring out which data is most important to your investigation will help you focus on the measurements that have the most impact on your hypothesis. ***Note:*** *If you need to take observations that aren't covered by GLOBE protocols, you should write out the procedures you will follow and specify the instruments you will use to collect that data.*

c) **Identify Existing Data:** Once you've chosen what types of data to use, determine where any existing measurements are available and how you will access them.

d) **Establish Resources:** If you're collecting data as part of your project, identify any available scientific resources you can use to measure your chosen phenomenon. These resources can be computer programs, measurement equipment, or other supplies that will help you take accurate readings.

e) **Ask for Help:** Once you've completed the steps above, think about any areas that may require additional support from other people. Teachers, experienced scientists, and even adults and students can be a great resource when you're working through your project. Additionally, it often helps to have a mentor or coach when learning anything new.

f) **Plan your time:** Think about how long each step in your plan may take and any other relevant details. For example, you'll want to think about when and where you'll take your measurements and how you'll get other data that you need. When you're organizing your time, keep in mind that some steps may take longer than you originally planned.

Tip: *Remember that the precision and accuracy of the data you use may affect the questions that can be answered. For example, if you're looking for a change of half a degree in temperature, but your thermometer is only accurate to ±2 C.*

5. **Assemble your data**

With your investigation plan in place, you can start gathering the relevant data you want to analyze. If you're using data from other GLOBE members or external databases, make sure to keep track and record your sources and search queries to easily recall them later.

If you're taking measurements out in the field, remember to keep all your records organized. This will make reading your data during the analysis stage much more efficient. A great way of cataloging your observations is to keep a notebook of GLOBE or other data sheets so that everything is in one place. Alternatively, if you're collecting data using GLOBE protocols, you can report your measurements to the GLOBE archive with the GLOBE data entry system or GLOBE apps. This will guarantee that your measurements are saved online. Additionally, this method will enable you to view your uploaded data using the GLOBE visualization tools.

6. **Analyze & Interpret data**

Any kind of data analysis often involves comparing data from different times and places to both look for patterns and identify where those patterns vary. When researchers are

analyzing data, they typically consider measurement averages and extreme values to determine how observed phenomenon differ from place to place. When you're analyzing your data, you should:

- Think about the easiest ways to visualize your observations and perform calculations in the assembled data. These visualizations can include maps, graphs, or tables.
    - ***Tip**: Maps are often more useful for looking at spatial patterns while graphs are better for determining patterns overtime.*
- Create tables, graphs, and/or charts to illustrate and summarize your discoveries. The data analysis step of the scientific process should be focused on using your gathered data to answer your stated research question(s) in a brief way.
- Figure out if your results answer your research question(s). Is your hypothesis confirmed or disproved?
    - *Remember, even if your results disprove your original hypothesis, this is still a valuable conclusion for future work.*
- Determine if you can you clearly state your reasoning and explain it to someone else. If you can't answer your question(s) with your collected data and analysis, you might need to collect more data, do a different analysis, or revise your original questions?
    - ***Tip:** At this point of your research, teachers or mentors are valuable resources that can provide helpful feedback and point you in the right direction.*

7. **Construct Explanations from Evidence**

Now that you have finished analyzing your data, it's time to indicate what you learned from your results. When you're documenting your conclusions, you should clearly state:

a) The question(s) you investigated
b) How you conducted the investigation
c) The result and discoveries

Investigated Question(s)

Your research questions might have changed during the course of your investigation. In your conclusion, only include the final research questions your experiment or study is meant to answer. However, you can talk about how your original questions changed over time in the body of your research report if you choose to write one.

Investigation Proceedings

A cornerstone of quality scientific research is its replicability, or the ability for another researcher to reproduce your findings by using the same methods. That's why it's so crucial to provide clear and thorough descriptions of how you conducted your original research. Essentially, this section should provide a quick summary of everything you did to arrive at your stated results. Your investigation summary should answer the following questions:

- What measurements you took?
- When, where, and how did you take these measurements?
- Did you use any other data, and if so, where did you obtain it from?
- What calculations did you perform on any of the data included in your research?

Results & Discoveries

When you're explaining the results of your analysis, make sure to describe your scientific reasoning and how you arrive at your conclusions. The explanation of the thought process from the data collection to the conclusions is an important part of communicating your findings and clarifying areas of possible confusion. To help with this clarification, it is important to include visual examples of the data you used, like graphs, tables, or maps.

Remember, research is an on-going process. Be sure to share your thoughts about how this investigation could be improved, other approaches that could be taken given more time/resources, and state any new research questions you thought of during your investigation that can build on your current results.

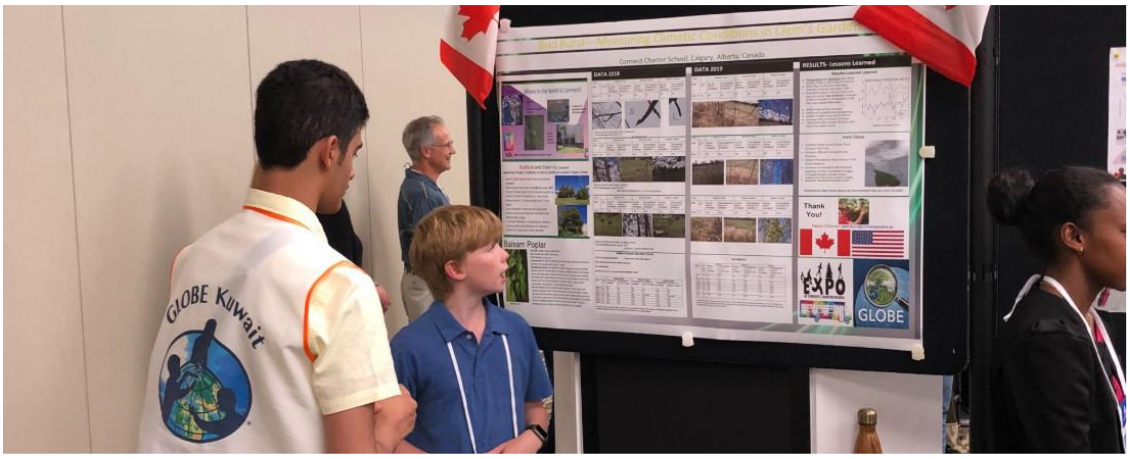
Write a Report

To complete your research, you need to communicate your results in a final research report and/or a display board. Professional scientists do almost exactly the same thing by publishing their final report in a scientific journal or by presenting their results on a poster or during a talk at a scientific meeting. The report should follow a well-structured format that clearly conveys the details of your research project as summarized under GLOBE Student Research Report Format (*Appendix 2*). Sample Research reports can be found on the following link:

***More info**: https://www.globe.gov/do-globe/research-resources/student-resources/research-report-format*

When you're finished writing, you can ask your teacher to submit your research report for publication on the GLOBE website using the upload tool on the Student Research Report page. In a science fair, judges are interested in your findings regardless of whether or not they support your original hypothesis.

8. **Communicate Conclusions**



After going through all the hard work of creating and executing a scientific research plan, it's time to share your conclusions with the world. Since this is such an important step in the scientific process, GLOBE has created several ways for you to share your discoveries with the community at large. To find a few ways to present your project to others, check out our examples below:

- Create an artifact about your project and have your teacher submit it to the *globehelp@ucar.edu* so it can be displayed on the GLOBE website. Artifacts can be images, audio, or video.
    - This is a good time to express your creativity during the scientific process, so don't be afraid to try something imaginative!
- Write a student research report and have your teacher submit it to the GLOBE website with the "Upload Tool" on the Student Research Report page.
- For a more experiential approach, you can showcase your report or presentation at a meeting or science fair.
    - GLOBE hosts several opportunities throughout the year for you to present your discoveries to the GLOBE community such as IVSS.
    - Explore other opportunities in your community to share your findings and/or outcomes

9. **Pose New Questions**

Scientists often find that their predictions were not accurate and their hypothesis was not supported, and in such cases they will communicate the results of their experiment and then go back and construct a new hypothesis and prediction based on the information they learned during their experiment. This starts much of the process of the scientific method over again. Even if they find that their hypothesis was supported, they may want to test it again in a new way.

Now that you've gone through the entire scientific process, it's time to start thinking about further research. Big science questions are seldom fully answered by just one investigation. That's why the scientific community relies on subsequent research to figure out as much as they can about the intricacies of nature. Think about all the questions your research raised and in what direction you want to take your next project

Sample Projects from Previous IVSS projects

To review past IVSS projects that relate to the Earth as a System Protocol Bundles and this year's theme, check out the example projects below:

- **Agriculture**: Agricultural soil
- **Air Quality:** How Much Do You Know About The Air Pollution of Taichung?
- **Soils:** Comparing Soil Moisture
- **Water Cycle:** Changes in the amount of rainfall runoff in the basin of Nysa Kłodzka river in the area of Nysa
- **Water Quality:** Algae Takes Over
- **Weather:** Can clouds help me predict weather?
- **Urban:** An Assessment of the Role Urban Trees Play in Modifying Weather in a City Park

More info: *https://www.globe.gov/news-events/globe-events/virtual-conferences/draft-2023-international-virtual-science-symposium-ivss-*

CHAPTER 4: REPORT LAYOUT & STRUCTURE

Guide to Report Writing

The summary of the Student Report Form is presented in appendix 2. Figure xx shows the layout of the Research Poster and summaries the different components that are essential to have in a Research Report.

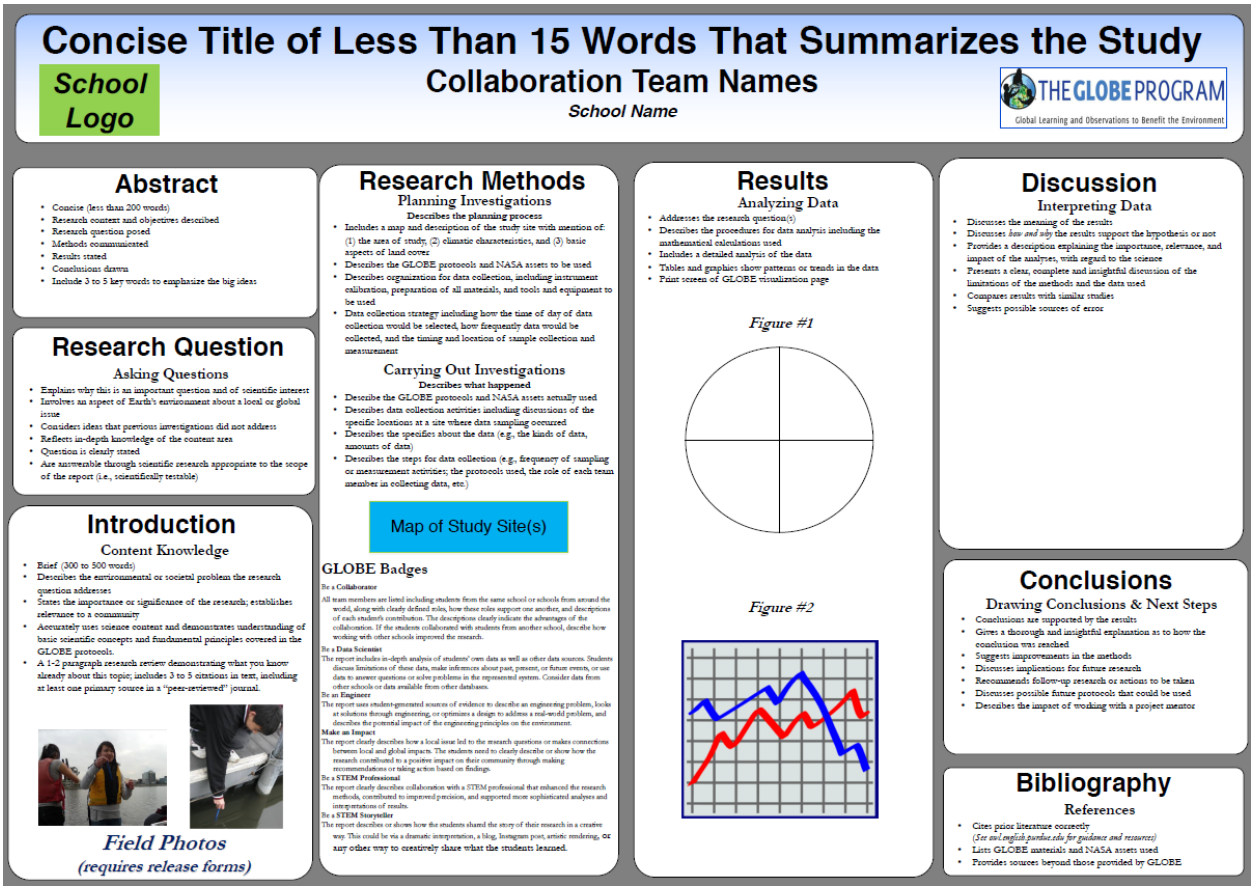


Fig 4.1: Layout of a Research Report Poster

a) Abstract

- Concise (less than 200 words)
- Research context and objectives described
- Research question posed
- Methods communicated
- Results stated
- Conclusions drawn
- Include 3 to 5 key words to emphasize the big ideas

b) Introduction (*Content Knowledge*)

- Brief (300 to 500 words)

- Describes the environmental or societal problem the research question addresses
- States the importance or significance of the research; establishes relevance to a community
- Accurately uses science content and demonstrates understanding of basic scientific concepts and fundamental principles covered in the GLOBE protocols
- A 1-2 paragraph research review demonstrating what you know already about this topic; includes 3 to 5 citations in text, including at least one primary source in a "peer-reviewed" journal.

c) Research Question (*Asking Questions*)

- Explains why this is an important question and of scientific interest
- Involves an aspect of Earth's environment about a local or global issue
- Considers ideas that previous investigations did not address
- Reflects in-depth knowledge of the content area
- Question is clearly stated
- Are answerable through scientific research appropriate to the scope of the report (i.e., scientifically testable)

d) Research Methods

- ***Planning Investigations*** (*Describes the planning process*)
  - Includes a map and description of the study site with mention of: (1) the area of study, (2) climatic characteristics, and (3) basic aspects of land cover
  - Describes the GLOBE protocols and NASA assets to be used
  - Describes organization for data collection, including instrument calibration, preparation of all materials, and tools and equipment to be used
  - Data collection strategy including how the time of day of data collection would be selected, how frequently data would be collected, and the timing and location of sample collection and measurement
- ***Carrying Out Investigations*** (*Describes what happened*)
  - Describe the GLOBE protocols and NASA assets actually used
  - Describes data collection activities including discussions of the specific locations at a site where data sampling occurred
  - Describes the specifics about the data (e.g., the kinds of data, amounts of data)
  - Describes the steps for data collection (e.g., frequency of measurement activities; protocols used, the role of each team member in collecting data, etc.)

Map of Study Site(s)

➢ ***GLOBE IVSS Badges***

In order to develop STEM professional skills and be entered in the stipend drawing for the GLOBE Annual Meeting, students need to earn a minimum of two of the optional/additional virtual badges. The 2023 IVSS Badges include any of the following Badges;

- Be a *Collaborator*
- Be a *Data Scientist*
- Be an *Engineer*
- Make an *Impact*
- Be a *STEM Professional*
- Be a *STEM Storyteller*

To earn these badges, you can select up to three badges and write about how you earned them in your IVSS report. In order to receive these virtual badges, you must display the relevant skills associated with each badge and show evidence of these skills in your IVSS report. To demonstrate these skills, you can include a summary of how you earned each badge in your report.

- ***Tip:*** *All students who submit a report to the IVSS receive a Student Research Badge, so students can earn up to four badges total.*

e) Results (*Analyzing Data*)

- Addresses the research question(s)
- Describes the procedures for data analysis including the
- mathematical calculations used
- Includes a detailed analysis of the data
- Tables and graphics show patterns or trends in the data
- Print screen of GLOBE visualization page

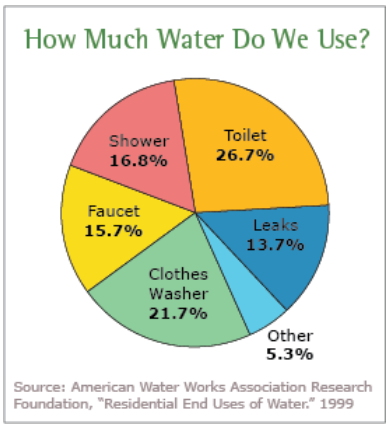


Fig 4.2: Sample pie chart

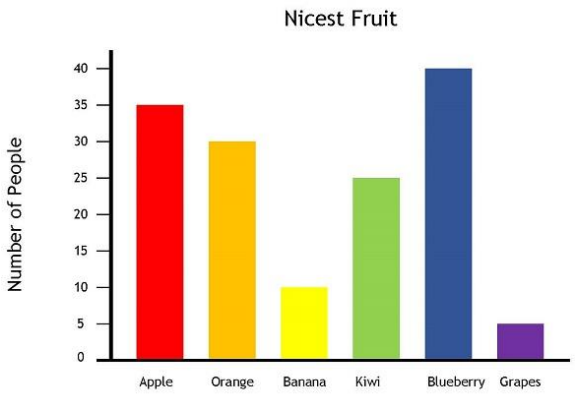


Fig 4.3: Sample bar graph

f) **Discussion** (*Interpreting Data*)

- Discusses the meaning of the results
- Discusses how and why the results support the hypothesis or not
- Provides a description explaining the importance, relevance, and impact of the analyses, with regard to the science
- Presents a clear, complete and insightful discussion of the limitations of the methods and the data used
- Compares results with similar studies
- Suggests possible sources of error

g) **Conclusion** (*Drawing Conclusions & Next Steps*)

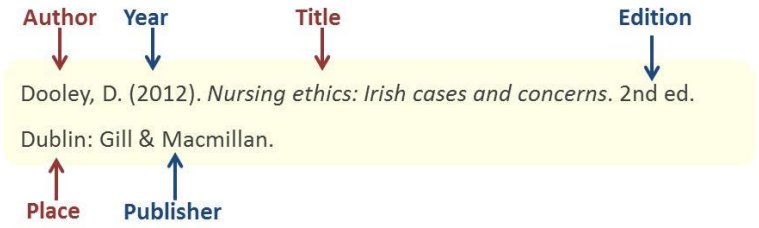
- Conclusions are supported by the results
- Gives a thorough and insightful explanation as to how the conclusion was reached
- Suggests improvements in the methods
- Discusses implications for future research
- Recommends follow-up research or actions to be taken
- Discusses possible future protocols that could be used
- Describes the impact of working with a project mentor

h) Bibliography (*References*)

- Cites prior literature correctly: See sample
- Lists GLOBE materials and NASA assets used
- Provides sources beyond those provided by GLOBE

Sample reference

- Author surname, initial. (Year) *'Article title'*, Journal Name, Volume(Issue), pagerange. Available at: URL (Accessed: Day Month Year). 2020)



GLOBE Student Research Report Template

In the table below provides an outline you should follow to complete your final report as highlighted on the Research Project Planning Guide. This outline will assist you structure your research report and present your experimental results most effectively.

Note: *The contents of the Research Report are based on the level of the students. Refer to* ***Appendix 2*** *for the overview of the* ***IVSS Student Report Templates***

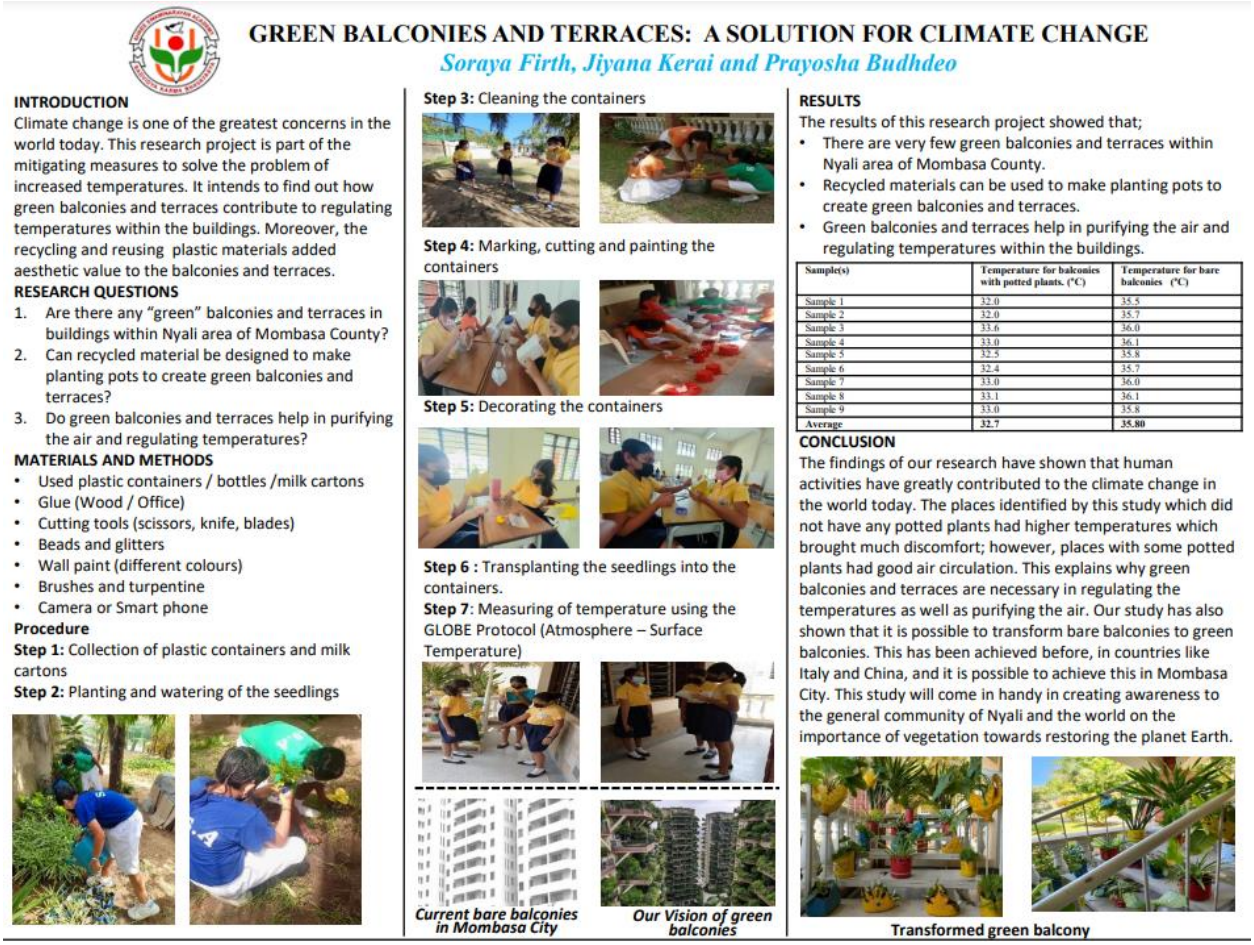
Abstract	Write a brief description of the report (maximum 250 words) that summarizes the purpose of the project, hypothesis, procedures, principal results, and conclusions.
Title Page and Table of Contents	Include the report title, names of students if parental consent has been obtained, school, teacher, and date on the title page. Include a table of contents on the second page.
Research Questions and Hypothesis	Clearly state the research problem/question and hypothesis. Explain what prompted the research, discussing the importance of the research in a greater context. Summarize background information from a literature review that helps the reader understand the research question.
Materials and Method	Describe in detail the materials and procedures used to collect data and to make observations. State what GLOBE protocols and/or data sets were used. Provide sufficient detail so that a reader could repeat the experiment from the information in the paper.
Data Summary	Present the data in tables and graphs. All plots, graphs, and tables should be numbered and include a title and a caption. All axes should be labeled and include units. Do not include the raw data in the research paper; this belongs in the research journal.
Analysis and Results	Summarize the data analysis and results. Include statistical analysis of the data. Determine and describe the experimental error. Explain any mathematics and equations that were used in the analysis. Be sure to account for, and discuss, the uncertainties present in the data set.

Conclusions	Present the conclusions reached about the research question. Explain how these conclusions were derived based on the methodology and data analysis. The results and conclusions should flow smoothly and logically from the data. Compare the results with theoretical values, published data, commonly held beliefs, and/or expected results.
Discussion	This section is to put the conclusions into context. Discuss possible improvements that could be made if the project were to be repeated; impacts of the research beyond the classroom; and suggestions and extensions for further study. Compare the findings with other research.
Acknowledgements	Credit those who assisted in the research, including individuals, businesses, and educational or research institutions.
References/Bibliography	List books, journal articles, web sites, and other communications used in your investigation or cited in your report in alphabetical order. Use the APA (American Psychological Association) format for references. **Journal article example:** Dale, V.H. (1997). The Relationship Between Land-use Change and Climate Change. Ecological Applications, 7, 753 - 769. **Book example:** Jackson, D.L. & L.L. Jackson. (2003). Farm as Natural Habitat: Reconnecting Food Systems with Ecosystems. Washington, D.C.: Island Press.

Sample Project Report Poster

The theme of GLOBE IVSS 2012 was focusing on *Engineering Solutions for a Changing Climate*. The students were encouraged to think creatively about solving environmental issues through engineering-minded solutions concerning climate change.

The following is a *sample Project Report poster* by students from Shree Swaminarayan Academy in Mombasa, Kenya with the title "*Green Balconies and Terraces: A Solution for Climate Change*" was based on the theme for GLOBE IVSS 2022.



GREEN BALCONIES AND TERRACES: A SOLUTION FOR CLIMATE CHANGE

Soraya Firth, Jiyana Kerai and Prayosha Budhdeo

INTRODUCTION

Climate change is one of the greatest concerns in the world today. This research project is part of the mitigating measures to solve the problem of increased temperatures. It intends to find out how green balconies and terraces contribute to regulating temperatures within the buildings. Moreover, the recycling and reusing plastic materials added aesthetic value to the balconies and terraces.

RESEARCH QUESTIONS

1. Are there any "green" balconies and terraces in buildings within Nyali area of Mombasa County?
2. Can recycled material be designed to make planting pots to create green balconies and terraces?
3. Do green balconies and terraces help in purifying the air and regulating temperatures?

MATERIALS AND METHODS

- Used plastic containers / bottles /milk cartons
- Glue (Wood / Office)
- Cutting tools (scissors, knife, blades)
- Beads and glitters
- Wall paint (different colours)
- Brushes and turpentine
- Camera or Smart phone

Procedure

Step 1: Collection of plastic containers and milk cartons

Step 2: Planting and watering of the seedlings

Step 3: Cleaning the containers

Step 4: Marking, cutting and painting the containers

Step 5: Decorating the containers

Step 6 : Transplanting the seedlings into the containers.

Step 7: Measuring of temperature using the GLOBE Protocol (Atmosphere – Surface Temperature)

Current bare balconies in Mombasa City

Our Vision of green balconies

RESULTS

The results of this research project showed that;

- There are very few green balconies and terraces within Nyali area of Mombasa County.
- Recycled materials can be used to make planting pots to create green balconies and terraces.
- Green balconies and terraces help in purifying the air and regulating temperatures within the buildings.

Sample(s)	Temperature for balconies with potted plants. (°C)	Temperature for bare balconies (°C)
Sample 1	32.0	35.5
Sample 2	32.0	35.7
Sample 3	33.6	36.0
Sample 4	33.0	36.1
Sample 5	32.5	35.8
Sample 6	32.4	35.7
Sample 7	33.0	36.0
Sample 8	33.1	36.1
Sample 9	33.0	35.8
Average	32.7	35.80

CONCLUSION

The findings of our research have shown that human activities have greatly contributed to the climate change in the world today. The places identified by this study which did not have any potted plants had higher temperatures which brought much discomfort; however, places with some potted plants had good air circulation. This explains why green balconies and terraces are necessary in regulating the temperatures as well as purifying the air. Our study has also shown that it is possible to transform bare balconies to green balconies. This has been achieved before, in countries like Italy and China, and it is possible to achieve this in Mombasa City. This study will come in handy in creating awareness to the general community of Nyali and the world on the importance of vegetation towards restoring the planet Earth.

Transformed green balcony

Find more projects using the link: *https://www.globe.gov/news-events/meetings_symposia/virtual-science-symposia/2022-international-virtual-science-symposium*

Note: The theme for this year's (2023) IVSS is Global Connections: Investigating Earth as a System Together. Students are encouraged to explore the Earth as a System Protocol Bundles and use them as tools to investigate their environmental research questions.

CHAPTER 5: REPORT PROJECT PLANNING GUIDE

Key Elements of IVSS Project

Some of the key elements of a GLOBE IVSS project include the following;

1. **A Complete Written Research Report**

Your report must include: Title, Abstract or Summary, Introduction, Methods and Materials, Results and Data, Discussion, Conclusion and Citations/References (*see "GLOBE Student Research Report Template" in Chapter 4*)

Important: *Requirements vary by grade level. Please check the rubrics page to see what is required for your grade level. You can find report templates in Chapter 6 of this document.*

2. **Formatting**

The complete research report must be submitted as a **.PDF or .DOCX/.DOC.** If you include more than one language, make sure the report is in a singular file for ease of access during the evaluation process

3. **Badge(s) Description**

For any of the additional badges, include a short summary of how each badge has been completed in your report. You may select up to three additional badges. ***Note:*** *Students must receive two additional badges and a four-star report to be considered for the drawing.*

4. **Presentation**

In your project, you're required to include a presentation about your work. For your presentation, you can choose one of the following:

- Provide a link to an uploaded video (10 minutes or less) hosted on an online video sharing site like *YouTube*, *Vimeo*, *TeacherTube*, or another video sharing site.
- Create a presentation poster or StoryMap that describes and outlines your research.
    - Poster files can be **.ppt**, **.pdf**, image file, or StoryMap links in the video section.

Important: *Do not upload the whole presentation video. Only upload the video link.*

5. **Thumbnail Image**

An image to be displayed with the student report.

6. **Photo Release Forms**

All individuals who appear in photos or videos must send in a photo release form in one file.

GLOBE Research Project Planning Guide

It is important to map out the timelines and milestones in order to be able to meet the deadlines provided by GLOBE and submit the IVSS Research Report within the stimulated timelines. In case of a longer or shorter time scale, this need to be adjusted accordingly.

The following is just a guide on the planning process, assuming that one has 8 weeks (approximately 2 months) before submitting the project. In this case, we will use the early January – late February 2023 Time frame (*starting **9th Jan, 2023** to **3rd March 2023***).

Detailed Guide for Project Implementation

- **7-8 weeks** prior to IVSS: *Constitute project teams*
  - Project team constituted
  - Probable Research questions explored by/assigned to student groups
- **6-8 weeks** prior to IVSS: *Research Question and Revision of Research Question*
  - Three types of Research Questions could be considered:
    - *Descriptive*: When a study is designed primarily to describe what is going on or what exists i.e. describing the characteristics of a phenomenon.
    - *Relational.* When a study is designed to look at the relationships between two or more variables i.e. *How does ___ and ___ compare?*
    - *Causal:* When a study is designed to determine whether one or more variables causes or affects one or more outcome variables i.e. *What affect does ___ have on ___?*
  - Write a one sentence HYPOTHESIS that answers your question.
- **6-7 weeks** prior to IVSS: *Plan for data collection*
  - Determine equipment need to perform field work.
  - Design data collection plan:
    - *Determine frequency of data collection.*
    - *Decide where will data be collected.*
    - *Identify who will collect data.*
    - *Identify who will enter data into GLOBE database.*
  - Alternatively, explore the data available in the GLOBE website or other sites
- **2-7 weeks** prior to IVSS: *Data Collection*
  - Field Data Collection:
    - *Field work from data collection plan*
    - *GLOBE Data Collection app and Visualization Tool*
  - Available Data:
    - *Download the requisite datasets*
    - *Clean up the different datasets needed for the project*

- **4 weeks** prior to IVSS**:** *Write Introduction*
  - Obtain GLOBE poster template or other report layout (*use PPT template*)
  - Write about the following:
    - *Describe the problem you are trying to solve.*
    - *State of the science of your topic(s).*
    - *Why is this research important to your group?*
    - *What is the community impact/connection of your research?*
- **3 weeks** prior to IVSS: *Write About Your Research Method*
  - Write about the following:
    - *Describe what you did for your research: Include number of data sets you used and any comparisons*
    - *Describe your study areas: (site, school, community)*
    - *Describe GLOBE protocols used*
    - *Justify why the data presented is sufficient to answer the research question*
  - Include a picture of your study area (e.g. from Google Earth)
  - Include an image or two of students collecting data
- **2 weeks** prior to IVSS: *Analyze Results*
  - Create a table of your results:
    - *Make sure your table has a title and is numbered.*
    - *Make sure each column and row in your table is clearly labeled.*
  - Create a visualization of your results- graph(s):
    - *Make sure your graphs and tables have titles and are numbered.*
    - *Make sure you have a legend (description of the information) in your graph.*
- **2 weeks** prior to IVSS: *Discussion of the Results*
  - Summarize (in words) your results by referring to your tables(s) and graphs(s).
  - Write about possible sources of error with your data:
    - *What errors in your data might there be?*
    - *Do your results compare with someone else's research? (research online to see if anyone else has done the similar research as you just completed.)*
- **1 weeks** prior to IVSS: *Conclusion*
  - Discuss whether the results support your hypothesis:
    - *Discuss why or why not your hypothesis was correct.*
  - Write about how you reached your conclusion.
  - Restate why it is important to know the results of your research.
  - What follow-up actions would you like to take:
    - *Continue the study?*
    - *Different protocols?*
    - *Collaboration with others?*

- Write about the impact of working with a project mentor/scientist or about any of the other badges (*if applicable*).

❖ **1 week** prior to IVSS: *Bibliography/References*

- State the books/articles/websites you used in this project.

❖ **1 week** prior to IVSS: *Abstract/Summary* (1 paragraph)

- Write down what you did in your research project.
- Write down why you did this research project.
- Write down your conclusion of your research.

❖ **Week of the IVSS**: *Practice Presentation*

- Prepare Poster(s).
- Students present to Class and Other Stakeholders.

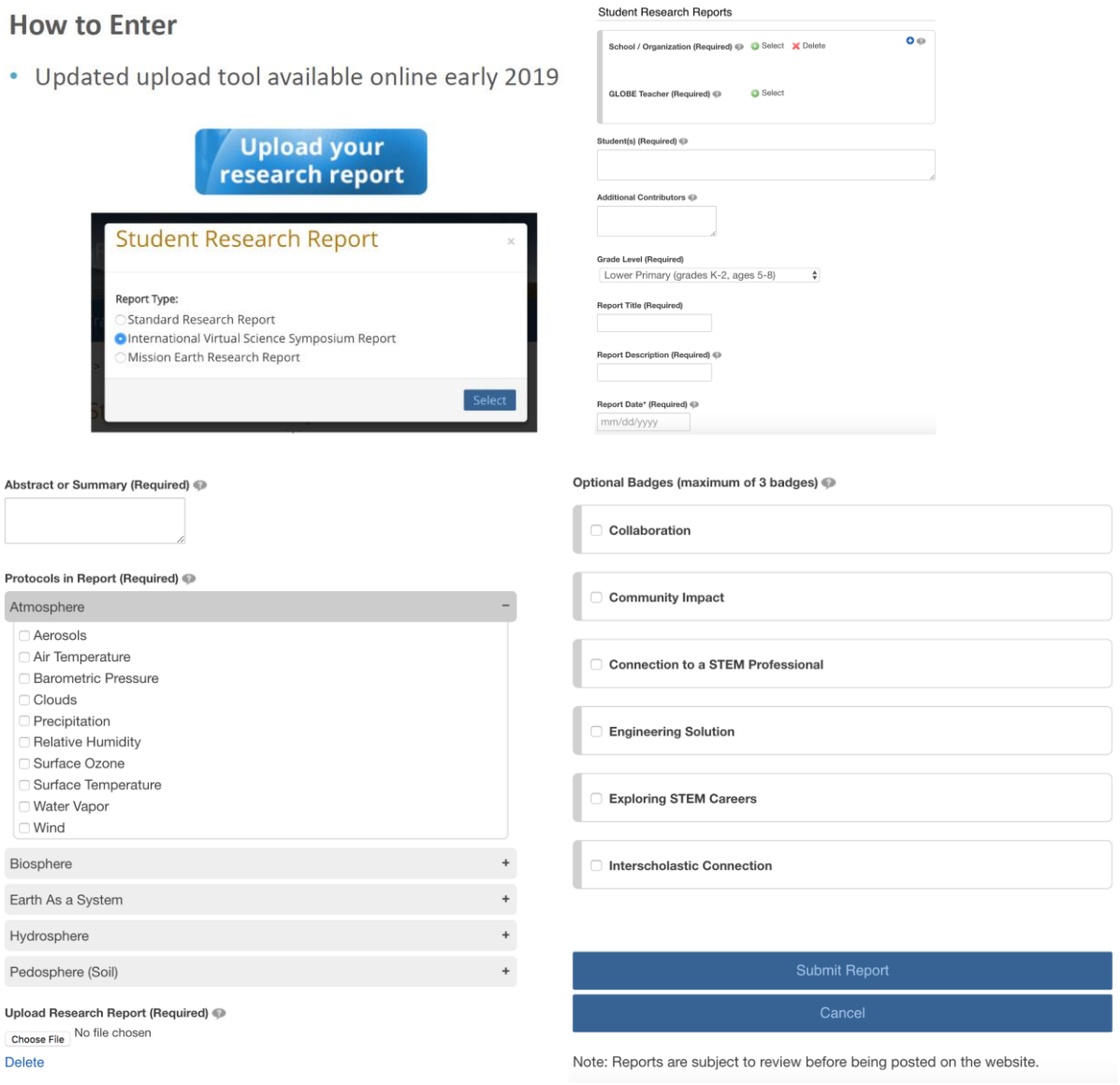
NOTE: *The Date of IVSS is* ***10th March, 2023*** *while this guide uses* ***3rd March, 2023*** *as the reference deadline date to avoid the last minute rush*

Sample template for Research Project Planning

Timelines (***prior to IVSS***)	**Actual Dates** (***filled by the Student/Teacher***)	**Activity**
7-8 weeks prior		○ Constitute teams
6-8 weeks prior		○ Research Question and Revision of Research Question
6-7 weeks prior		○ Prepare for data collection
2-7 weeks prior		○ Collection/Review of Data
4 weeks prior		○ Write Introduction
3 weeks prior		○ Write Research Methods
2 weeks prior		○ Analyze Results
2 weeks prior		○ Discuss Results
1 weeks prior		○ Write Conclusion
1 week prior		○ Write Bibliography and Abstract
2-5 days prior		○ Upload to GLOBE website and practice presentation

Submitting Research Report to GLOBE

The Research projects to be entered for the GLOBE IVSS need to be submitted using online link provided by GLOBE. The following is the general outlay of the online platform used in 2019, the current version will potentially be slightly different. Use the following



You will get an email after submitting!

CHAPTER 6: GLOBE PROJECT EVALUATION

GLOBE 2023 Evaluation Rubric

GLOBE IVSS Kindergarten - 2nd Grade Rubric (Lower Primary)

**** (Exceptional)	*** (Good)	** (Needs Improvement)	* (Insufficient)
• Report shows enthusiasm for the sciences and potential for further growth and understanding at this grade band. • Students are creative in their research/ approach to writing this report and do their best to accomplish **all** of the elements required for the IVSS. • Content is informative and has most supporting details.	• Students are creative in their research/ approach to writing this report and do their best to accomplish **most** of the elements required for the IVSS. • Students are enthusiastic about their report topic. • Content is informative and has some supporting details.	• Students do their best to accomplish **some** of the elements required for the IVSS. • Writing may be a little unclear but the report is still organized. • Report could use significant work to clarify main points and understanding for this grade band.	• Students do their best to accomplish the elements required for the IVSS but have left out significant sections or ideas. • Report is fairly unorganized, does not follow IVSS formatting, and/or writing may be unclear.

GLOBE IVSS 3rd – 5th Grade Rubric (Upper Primary)

**** (Exceptional)	*** (Good)	** (Needs Improvement)	* (Insufficient)
• Report touches on thoughtful connections between scientific concepts appropriate for this grade band. • The report is well organized and shows potential towards further development of ideas and concepts. • The report contains all of the five elements required for acceptance, clearly labeled. • The students show enthusiasm and excitement for their topic and potentially suggest ways to connect their research to their greater community.	• Writing is clear but there may be minor errors throughout the report. • Report makes clear **connections** among topics and ideas presented that are appropriate for this grade band. • The report contains **most** of the five elements required for acceptance, clearly labeled. • The students show enthusiasm for their topic.	• **Some** elements are unclear or missing. • The report is somewhat organized but the formatting may be hard to follow. • The report could use significant improvements in certain areas appropriate for this grade band.	• **Major** elements and significant sections of the report are unclear or missing. • Report writing and formatting is unclear or does not align with GLOBE IVSS report formatting standards.

GLOBE IVSS 6th-8th Grades Rubric (Middle School)

**** (Exceptional)	*** (Good)	** (Needs Improvement)	* (Insufficient)
• A "4 Star" report goes above and beyond the expectations of this project. It makes you think, "Wow!" • Report shows noticeable effort towards understanding complex scientific concepts. • The report is well organized, neat and well presented. • The writing is **clear** and concise. • The report contains the five elements required for acceptance, clearly labeled, and includes an in depth discussion of each. • Report demonstrates the ability to draw insightful conclusions.	• Report contains **all** of the elements and **most** of the criteria listed below however some **minor** elements are unclear or missing. • Report makes mostly clear **connections** among topics and ideas presented. • Report includes some discussion of topics addressed. • The report is well organized, neat and well presented. • The writing is **clear**. • The report contains the five elements required for acceptance, with a insightful discussion.	• Report contains some of the five elements required for acceptance, however some **major** elements are missing. • The report is somewhat organized. • The report is missing an in depth discussion or analysis of their topic.	• Report is missing **significant** information and/or multiple sections of the report and does not contain all elements required for acceptance in detail.

GLOBE IVSS 9th-16th Grades Rubric (High School and Undergrad)

**** (Exceptional)	*** (Good)	** (Needs Improvement)	* (Insufficient)
• A "4 Star" report goes above and beyond the expectations of this project. It makes you think, "Wow!" • Report makes clear, in depth **connections** among ideas and concepts discussed. • The report is well organized, neat and well presented. • The writing is **clear** and **concise**. • The report contains the five elements required for acceptance, clearly labeled, and includes an in-depth discussion of each. • Report demonstrates the ability to draw insightful conclusions.	• Report contains **all** of the elements and **most** of the criteria listed below however some **minor** elements are unclear or missing. • Report makes clear **connections** among topics and ideas presented. • Report includes some discussion of topics addressed. • The report is well organized, neat and well presented. • The writing is **clear**. • The report contains the five elements required for acceptance, clearly labeled.	• Report contains the five elements required for acceptance, however some **major** elements are missing. • The report is somewhat organized. • The report is missing one or more of the five elements required for acceptance, may or may not be clearly labeled, and could use some more work in certain areas.	• Report submitted, but is missing significant information or does not contain all five elements required for acceptance in detail.

GLOBE IVSS Badges

In order to develop STEM professional skills and be entered in the stipend drawing for the GLOBE Annual Meeting, students need to earn a minimum of *two of the optional/additional virtual badges*. To earn these badges, you can select up to three badges listed below and write about how you earned them in your IVSS report.

In order to receive these virtual badges, you must display the relevant skills associated with each badge and show evidence of these skills in your IVSS report. To demonstrate these skills, you can include a summary of how you earned each badge in your report.

Tip: *All students who submit a report to the IVSS receive a Student Research Badge, so students can earn up to four badges total.*

Be a **Collaborator**

All team members are listed including students from the same school or schools from around the world, along with clearly defined roles, how these roles support one another, and descriptions of each student's contribution. The descriptions clearly indicate the advantages of the collaboration. If the students collaborated with students from another school, describe how working with other schools improved the research.

Be a **Data Scientist**

The report includes in-depth analysis of students' own data as well as other data sources. Students discuss limitations of these data, make inferences about past, present, or future events, or use data to answer questions or solve problems in the represented system. Consider data from other schools or data available from other databases.

Be an **Engineer**

The report uses student-generated sources of evidence to describe an engineering problem, looks at solutions through engineering, or optimizes a design to address a real-world problem, and describes the potential impact of the engineering principles on the environment.

Make an Impact

The report clearly describes how a local issue led to the research questions or makes connections between local and global impacts. The students need to clearly describe or show how the research contributed to a positive impact on their community through making recommendations or taking action based on findings.

Be a **STEM Professional**

The report clearly describes collaboration with a STEM professional that enhanced the research methods, contributed to improved precision, and supported more sophisticated analyses and interpretations of results.

Be a **STEM Storyteller**

The report describes or shows how the students shared the story of their research in a creative way. This could be via a dramatic interpretation, a blog, Instagram post, artistic rendering, or any other way to creatively share what the students learned.

Appendix

Appendix 1: Guide to Developing Good Research Question

This worksheet provides a list of characteristics of good research questions. When you consider a research question for your investigation evaluate with the list indicated in the table below. A good question does not need to have all these characteristics but you should think carefully before committing to answer a question than has only a few of them.

Research Question Characteristics Worksheet	**Points (0 or 1)**
The answer is not immediately obvious	
There could be more than one answer – the answer is not just YES or NO	
Encourages new or different view of phenomena	
Narrow in focus so that the necessary research can be done	
Clear enough for other people to understand	
Tests an accepted explanation	
Goes beyond existing explanations	
Possible to answer in the time available to you	
Possible to answer with measurement equipment and techniques available to you	
Any data require from others is available or can be obtained through collaboration	
Will sustain your interest for the time required to complete the research	
Test you assumptions about the phenomenon	
Total Scores	

Source: GLOBE Program

Appendix 2: GLOBE 2023 - IVSS Student Report Templates

a) Lower Primary

Front Page

Title
Student Name(s)
Teacher Name
School Name
Country
Date

Other Pages

Summary**:**
- ❖ Give a summary

Research Questions:
- ❖ Indicate the Research Question

Research Methods:
- ❖ Discuss the Methods used in Research

Results: *(Including GLOBE Data!)*
- ❖ Share the research findings

Conclusion:
- ❖ Highlight the conclusions

(Optional) Badge Descriptions/Justifications:
- ❖ Briefly describe how you applied any of the SIX badges

b) Middle Primary

Front Page

Title
Student Name(s)
Teacher Name
School Name
Country
Date

Other Pages

Summary**:**
- ❖ Give a summary

Research Questions:
- ❖ Indicate the Research Question

Introduction*
- ❖ Briefly introduce the Research problem

Research Methods:
- ❖ Discuss the Methods used in Research

Results: *(Including GLOBE Data!)*
- ❖ Share the research findings

Discussion*
- ❖ Discuss the Research Outcomes

Conclusion:
- ❖ Highlight the conclusions

Bibliography/Citations*
- ❖ List the references used in the research

(Optional) Badge Descriptions/Justifications:
- ❖ Briefly describe how you applied any of the SIX badges

c) Upper Primary

Front Page

Title
Student Name(s)
Teacher Name
School Name
Country
Date

Other Pages

Summary**:**
- ❖ Give a summary

Research Questions:
- ❖ Indicate the Research Question

Introduction*
- ❖ Briefly introduce the Research problem

Research Methods:
- ❖ Discuss the Methods used in Research

Results: *(Including GLOBE Data!)*
- ❖ Share the research findings

Discussion*
- ❖ Discuss the Research Outcomes

Conclusion:
- ❖ Highlight the conclusions

References/Bibliography*
- ❖ List the references used in the research

(Optional) Badge Descriptions/Justifications:
- ❖ Briefly describe how you applied any of the SIX badges

d) High School & Under Grad

Front Page

Title
Student Name(s)
Teacher Name
School Name
Country
Date

Other Pages

Abstract:
- ❖ Give a detailed summary of the research

Research Question & Hypothesis:
- ❖ Indicate the Research Question

Introduction a& Review of Literature*
- ❖ introduce and review literature on the Research problem

Research Methods & Materials (incl GLOBE Data):
- ❖ Discuss the Methods, Material and Data (GLOBE) used in Research

Results:
- ❖ Share the research findings

Discussion*
- ❖ Discuss the Research Outcomes

Conclusion:
- ❖ Highlight the conclusions

References/Bibliography*
- ❖ List the references used in the research

(Optional) Badge Descriptions/Justifications:
- ❖ Briefly describe how you applied any of the SIX badgesBriefly describe how you applied any of the SIX badges

Appendix 3: Agriculture Bundle: Sample Case Study

For more details on this Bundle, visit: https://www.globe.gov/web/earth-systems/community/agriculture-bundle

Soil Quality and Climate Affect Sweetness of Mangosteen in Nakhon Si Thammarat Province, Southern Thailand

Students: Kodchamon Bunchutam, Monkolrat Junnul and Nutcha Chuayklay

Mentor: Panini Woranetiwut

GLOBE School: Pa Phayom Phitthayakhom School, 320 M. 9 Ban Phrao Subdistrict, Pa Phayom District, Phatthalung 93210 Thailand

1. Introduction, research questions and hypotheses

Southern Thailand is well-known for its high quality and best-tasting Mangosteen. In fact, there is a large number of mangosteen cultivation in Cha-uat District, Nakhon Si Thammarat Province, Southern Thailand. The taste of the mangosteen cultivated and grown in the said districts were found different. In line with this, the researchers would like to investigate and examine if soil quality and climate in this two locations have significant effects on the sweetness of mangosteen.

Research Questions

1. Does the quality of soil affect the sweetness of mangosteen?
2. Does climate affect the sweetness of mangosteen?
3. How does the size affect the sweetness of mangosteen?

Research Hypotheses

1. Soil Quality affects the sweetness of mangosteen.
2. Weather affects the sweetness of mangosteen.
3. Larger mangosteen fruit is sweeter than small one.

2. Materials and Methods

Study area

a) Ban Tha Samet Village No. 5, Tha Samet Sub-district, Cha-uat District, Nakhon Si Thammarat 80180, Thailand, (Latitude 75544 W, Longitude 99.59, Elevation 17 M)

b) Ban Lan Na Village No. 3, Koh Khan Sub-district, Cha-uat District, Nakhon Si Thammarat 80180, Thailand, (Latitude 7.54 '21 N, Longitude 99.57 / 06E, Elevation 22 M)

Materials

The materials used in this research are listed below:

To analyze the soil and weather parameters using GLOBE protocols

- Soil quality
- Hygrometer
- Thermometer
- Tape measure
- Digital Scales
- Carrier bag (capacity 1 kg)
- Rubber band
- Digging shovel / garden shovel / hoe
- Hammer
- Permanent marker
- Aluminum cup
- Clay incubator

To determine and measure the sweetness

- Sweetness meter
- Basin, bowl, and foam plate
- Dropper
- Beaker
- Cloth filter
- Fruit blender

Methods

1. Soil sampling
   Mangosteen trees were selected randomly. Canopy was measured in 8 directions and each direction soil samples were collected at 30 cm depth for soil parameter measurement. Soil temperature and moisture were measured in-situ
2. Relative humidity and Air temperature
   Relative humidity and air temperature were measured using hygrometer and thermometer respectively
3. Sweetness measurement
   Ten fruits per tree were collected and juice was extracted and sweetness was measured using sweetness instrument

3. Results

The table 1 shows that average soil temperature is higher and soil moisture is lower in Ban Tha Samet. However, the pH value is lower in Ban Lan Na compared to Ban Tha Samet. The mangosteen in Ban Tha Samet has a higher sweetness value.

Area	Soil Temperature (oC)	Soil Moistrue (%)	pH	Quantity			Sweetness (Brix)
				N	P	K	
Ban Tha Samet	28.2	20.5	6.5 Weak acid	Lower	Lower	Lower	23.8
Ban Lan Na	27.2	21.9	5.5 Medium acid	Lower	Lower	Medium	23.2

Table 1. Soil parameters and Sweetness in Ban Tha Samet and Ban Lan Na

The table 2 shows that Ban Tha Samet has an average air temperature of 30.6 degrees with a relative humidity of 73.3% with a sweetness value of 23.8. While Ban Lan Na has an average air temperature of 30.7 degrees and relative humidity of 77.9% with sweetness value of 23.2

Area	Air Temperature (oC)	Relative Humidity	Sweetness (Brix)
Ban Tha Samet	30.6	73.3	23.8
Ban Lan Na	30.7	77.9	23.2

Table 2. Weather parameters and Sweetness in Ban Tha Samet and Ban Lan Na

Table 3 shows that mangosteen with higher circumference was found to be sweeter than the smaller one.

Area	Circumference (cm.)	Sweetness (Brix)
Ban Tha Samet	4.6	23.8
Ban Lan Na	4.5	23.2

Table 3. Mangosteen circumference and sweetness

4. Discussion

Based on the research, the sweetness of mangosteen was much different in Ban Tha Samet and Ban La Na. Clearly, the soil quality and climate can affect the sweetness of mangosteen. The higher the soil temperature, the lower the soil moisture, and the higher the air temperature, the lower the relative humidity, this combination of abiotic parameter produced best-tasting or sweetest mangosteen. Furthermore, the researchers were able to compare the size of mangosteen to determine the sweetness. We found out that the mangosteen in Ban Tha Samet was bigger than Ban Lan Na. Thus, the fruit harvested in Ban Tha Samet were sweeter than Ban Lan Na area. Therefore, there is a relationship between studied soil and weather parameters and the quality of the fruit.

5. Conclusion

1. It is concluded that the soil quality had an effect on the sweetness of the fruit. Thus, the mangosteen from Ban Tha Samet has the sweetest taste.
2. Evidently, the mangosteen cultivated and grown with lower relative humidity and higher air temperature was found the sweetest.
3. As expected, the mangosteen with large size has the sweeter taste than the smaller one.

Additional Example:

Water Quality Bundle

- Research title: Study of environmental factors affecting biodiversity of peat swamp plants in the SouthernInternational Botanical Garden (Thung Khai), Yan Ta Khao District, Trang Province.

Link:

- https://www.globe.gov/documents/10157/0/10754848/780f6cd1-a993-4e8f-059a-817eb8f725ae