



Time:

Two 50-minute periods

If students do not have an adequate understanding of the water cycle, an additional class period will have to be spent reviewing the water cycle before beginning this lesson.

Summary:

In this lesson, students will be introduced to factors that affect rainfall patterns in East Africa, including the Inter-tropical Convergence Zone (ITCZ), orographic rainfall, and coastal rainfall. They will then use their understanding of the water cycle to examine how changes in rainfall patterns affect water availability in two different ecosystems in (savanna and coastal) and make predictions about the effect these changes could have on vegetation and land use.

Materials:

- Computer with internet access
- Projector
- PowerPoint presentation: Water Availability in East Africa

Student handouts and answer sheets:

- Water cycle in English (reference)
- Inland water cycle
- Coastal water cycle
- Discussion questions and answers
- Blank water cycle diagram (optional)
- Water cycle terms in Swahili (optional)

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Changing Rainfall and Water Availability

Objectives

Students will be able to:

- use their understanding of the water cycle to describe how water is lost and replenished in two different ecosystems.
- compare changes rainfall patterns and water availability in two different ecosystems.
- predict possible effects of changes in rainfall in two different ecosystems.

Background

In East Africa, rainfall patterns are changing. In most areas, rainfall is decreasing as temperatures rise, resulting in increased evaporation and transpiration, creating a more arid climate over time and affecting what crops will grow, what livestock can be supported, and what livelihoods will be sustainable in a given ecosystem. Rainfall has become less predictable, and the timing and duration of the rainy seasons is much more variable, making it difficult for farmers to produce the crops they are accustomed to producing. Droughts have become more frequent. When rains fail, water sources for people and livestock dry up, causing people to spend more time walking to distant water sources, increasing the incidence of diseases caused by contaminated water, and making it necessary for herders to take their livestock farther in search of water. In coastal areas, average rainfall remains the same, but has become less predictable and has increased in intensity, causing flooding and erosion. Flooding also spreads diseases and may ruin crops.

Vocabulary

Water cycle
Condensation
Evaporation
Precipitation
Water storage
Surface runoff

Infiltration
Evapotranspiration
Runoff
Ground water
Atmosphere



Introduction to Climate Change in East Africa

Procedure

If students need to review the water cycle before beginning this lesson, take one class period for review. These websites may be useful for helping to teach the water cycle:

1. This website provides thorough, detailed information with diagrams, explaining all of the different processes of the water cycle. <http://ga.water.usgs.gov/edu/watercycle.html>
2. This website provides a simplified interactive diagram of the water cycle that students can click on to read and listen to an explanation of the main processes in the water cycle. <http://scratch.mit.edu/projects/kkope1/99832>
3. This website provides clear diagrams of the processes of the water cycle that can be used as visuals as the teacher describes the processes of the water cycle. <http://earthguide.ucsd.edu/earthguide/diagrams/watercycle/>

1. Activate students' prior knowledge and prime them for the lesson by asking students:

- Why do you think it is important to understand the water cycle?
- What do you think the water cycle has to do with climate change?
- How do you think you could use your understanding of the water cycle to explain what will happen when rainfall patterns change?

2. Show students the PowerPoint presentation on Changing Water Availability in East Africa.

3. Review the content from the PowerPoint presentation. This can be done as a class discussion during or after the PowerPoint presentation, or students can be asked to write their answers on a piece of notebook paper.

- What is the Inter-tropical Convergence Zone (ITCZ) and how does it affect rainfall in East Africa?
- What is orographic rainfall and how does it affect rainfall in mountainous regions?
- How does the ocean affect rainfall in locations on the coast?
- What differences did you see in the change in average rainfall in Arusha (highland savanna) and Zanzibar (coast)?

4. Hand out the two water cycle diagrams to students. Depending on your students' grasp of the water cycle, you may wish to provide a handout of the water cycle as a reference, or you may choose to leave up the PowerPoint slide of the water cycle. Students can work on this individually, in pairs, or in small groups. Have students label the processes of the water cycle in the two diagrams. The diagrams use all of the terms from the water cycle in the example except for groundwater discharge and storage. Many of the terms apply to both water cycles, but there are some that occur in only one of the water cycles (coastal or inland).

5. Once students have successfully completed both water cycles, pass out the discussion questions for them to answer. They will be asked to compare the water cycle in inland and coastal Tanzania, to identify where water is lost from water cycle in inland and coastal Tanzania, and to predict the possible effect of changes in rainfall patterns and water availability on vegetation, land use, and people's livelihoods.

Optional Extension 1: The water cycle in Swahili. Swahili is an African language spoken by many people throughout East Africa and is used as a common African language between people of different language groups. It is also the national language of Tanzania.

Pass out blank water cycle diagrams and the list of water cycle processes in English and Swahili. Have

Introduction to Climate Change in East Africa

students label the water cycle in Swahili. If you wish to have them try to pronounce the words, the vowels are pronounced a=ah, e=eh, i=ee, o=oh, and u=oo. Dh is pronounced “th” as in “there” and the letter r is rolled. In all words, the next-to-last syllable is stressed.

Optional Extension 2: Orographic rainfall

A lesson on orographic lift from the PBS Series, Living Edens, Denali by Dwight Sieggreen is available at: <http://www.pbs.org/edens/denali/orograph.htm>

6. Conclusion: In the next lesson, you will take what you have learned about changes in temperature and rainfall and look at how that affects vegetation in East Africa.

Assessment

- Were students able to list that changes in rainfall patterns include changes in average rainfall, the timing of the rainy seasons, the duration of the rainy seasons, and the intensity of rainfall?
- Did students interpret the rainfall graphs to observe that changes in average rainfall vary in the two different ecosystems?
- Were students able to label and compare the processes of the water cycle in two diagrams showing the water cycle in inland and coastal Tanzania?
- Were students able to identify where water is lost from water cycle in inland and coastal Tanzania?
- Were students able to make predictions about the possible effect of changes in rainfall patterns and water availability on vegetation, land use, and people’s livelihoods?

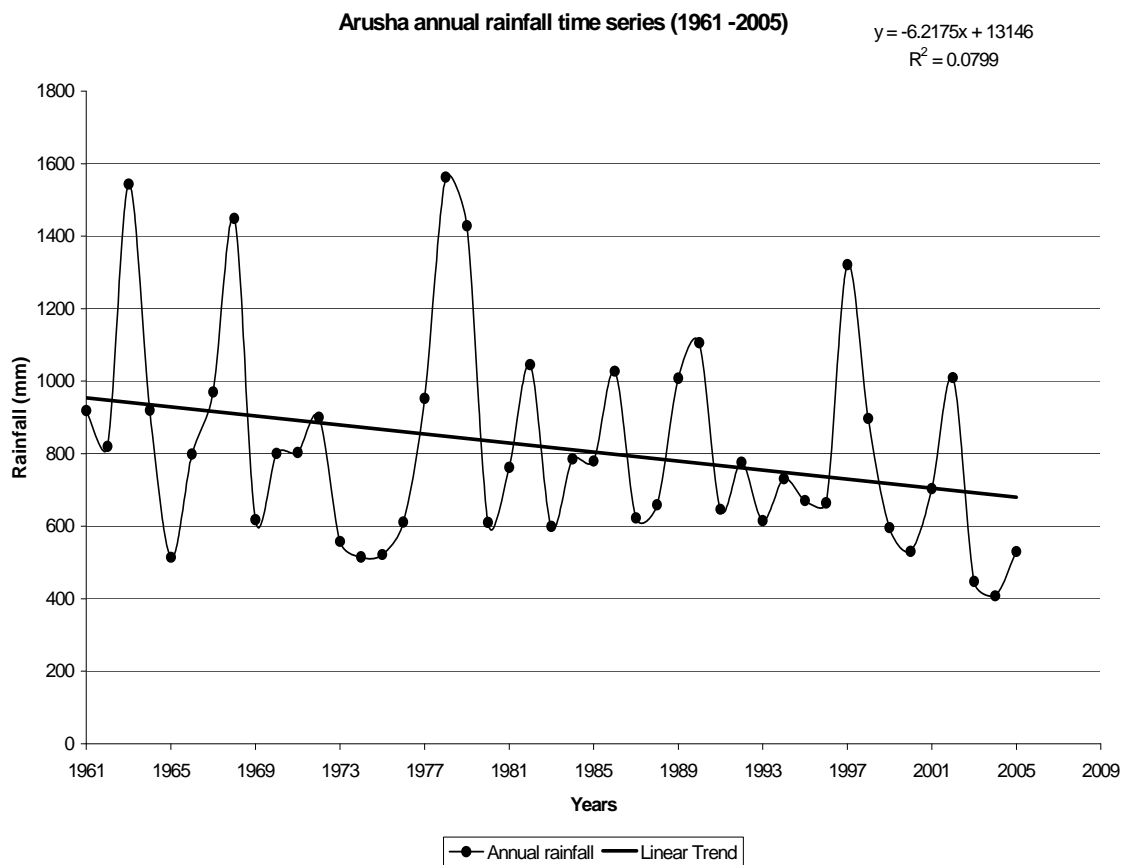
Web Resources

1. This is a detailed description of the processes in the water cycle. http://www.windows.ucar.edu/tour/link=/earth/Water/water_cycle.html
2. This is a web resource that discusses use of water in East Africa, specifically the Mara River in Kenya and the Serengeti ecosystem. This was the beginning of a Biodiversity Action Plan. <http://www.unesco.org/water/ihp/ecohydrology/demos/mara.shtml>
3. This web resource addresses climate change in Tanzania. According to this source, the ice caps of Mount Kilimanjaro are expected to disappear by the year 2020. <http://uk.oneworld.net/guides/tanzania/development#Climate%20Change>



Arusha Annual Rainfall

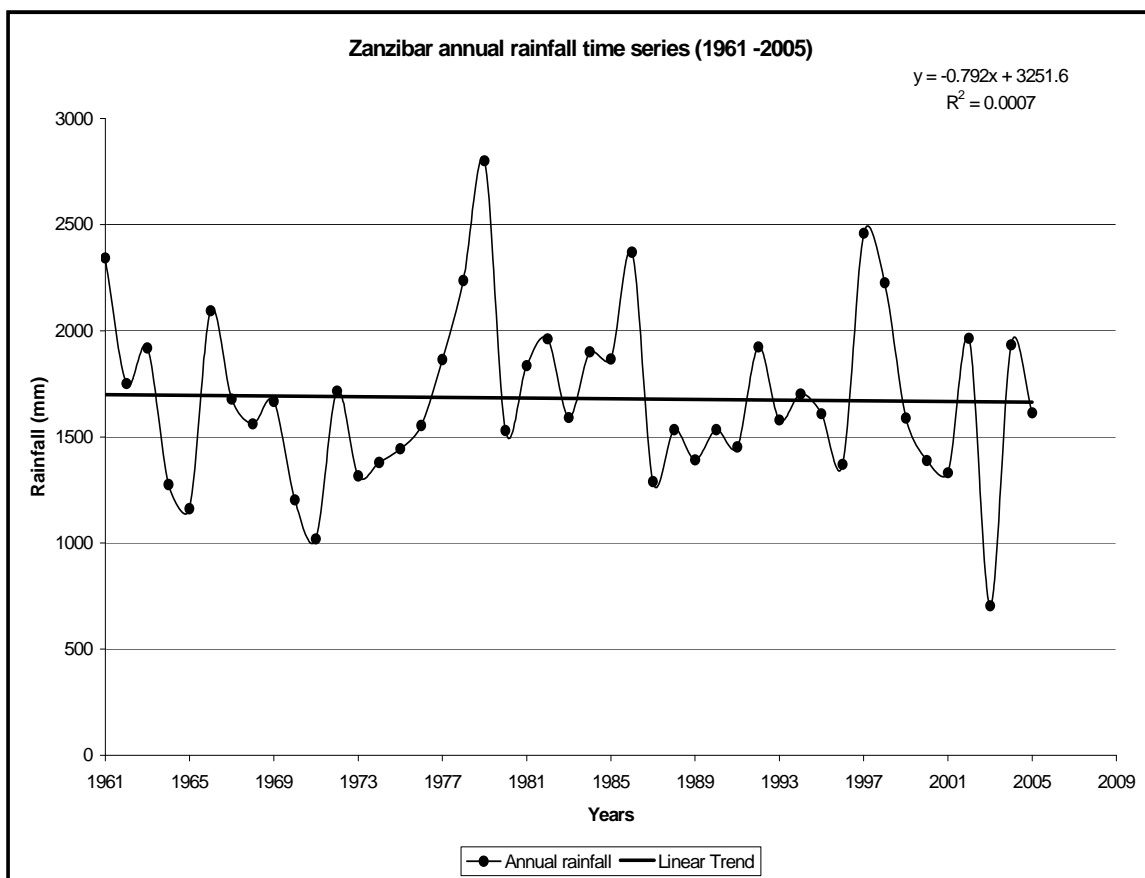
Arusha 1961-2005



Source: Tanzania Meteorological Agency

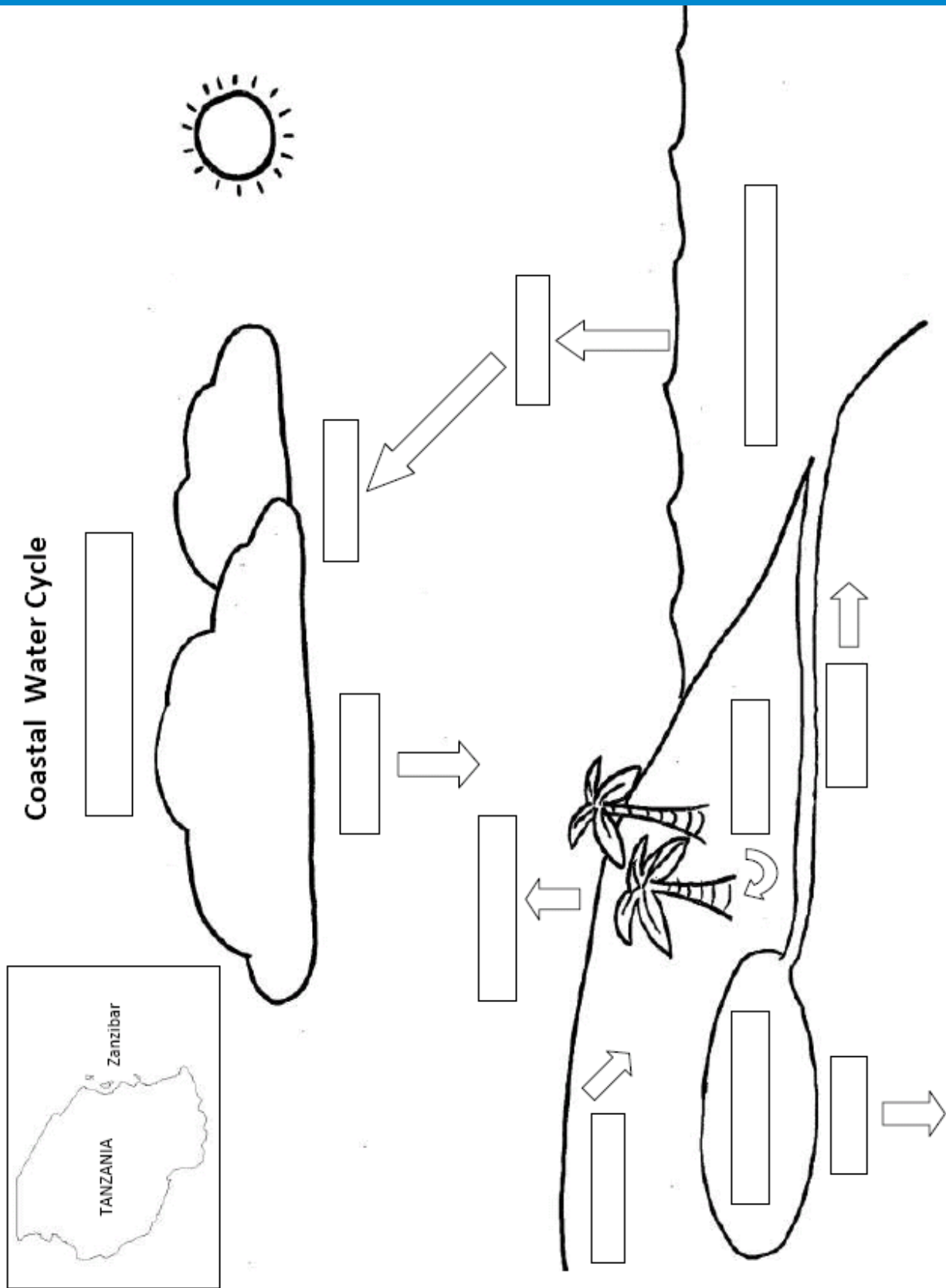
Zanzibar Annual Rainfall

Zanzibar 1961-2005

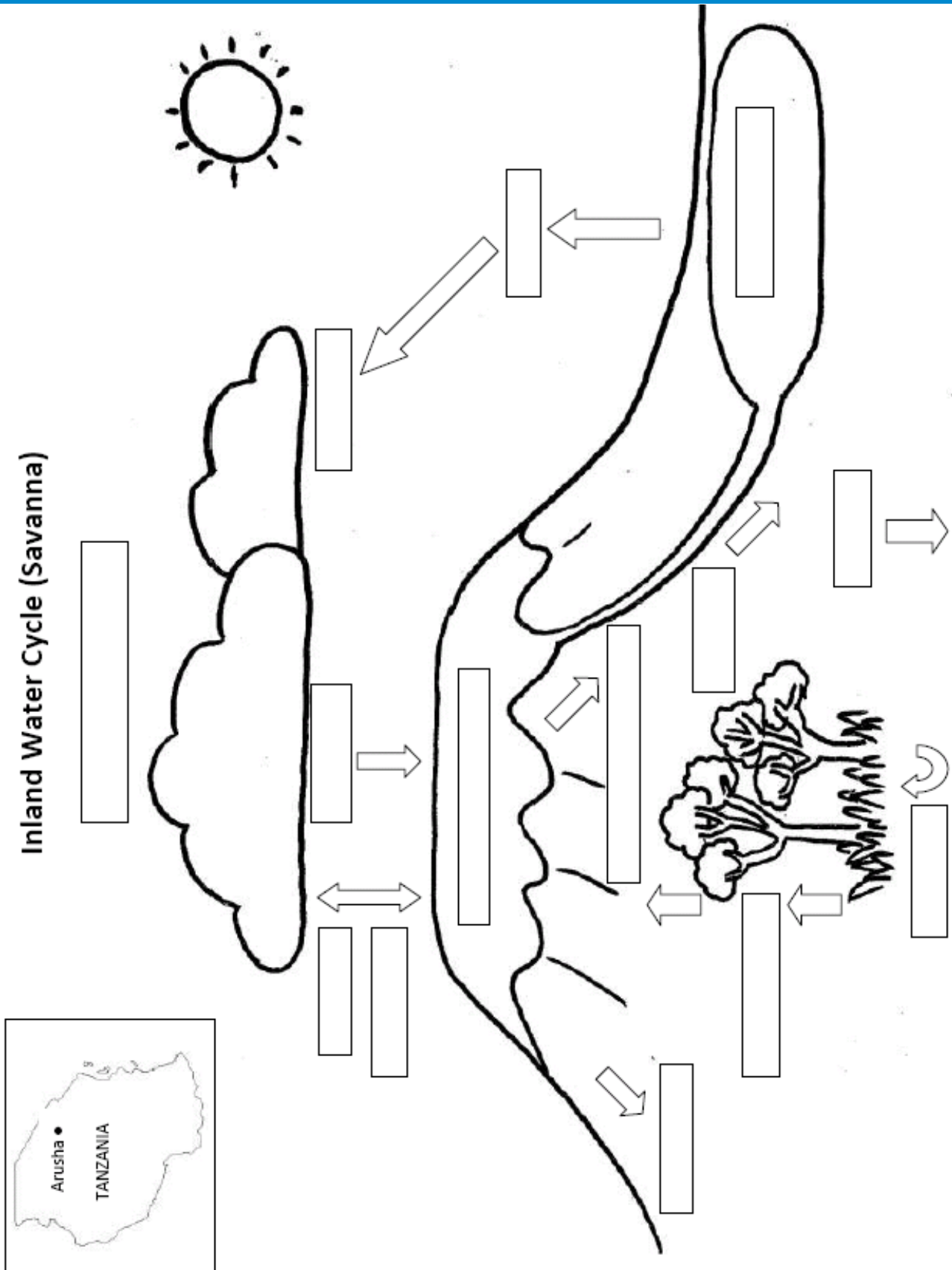


Source: Tanzania Meteorological Agency

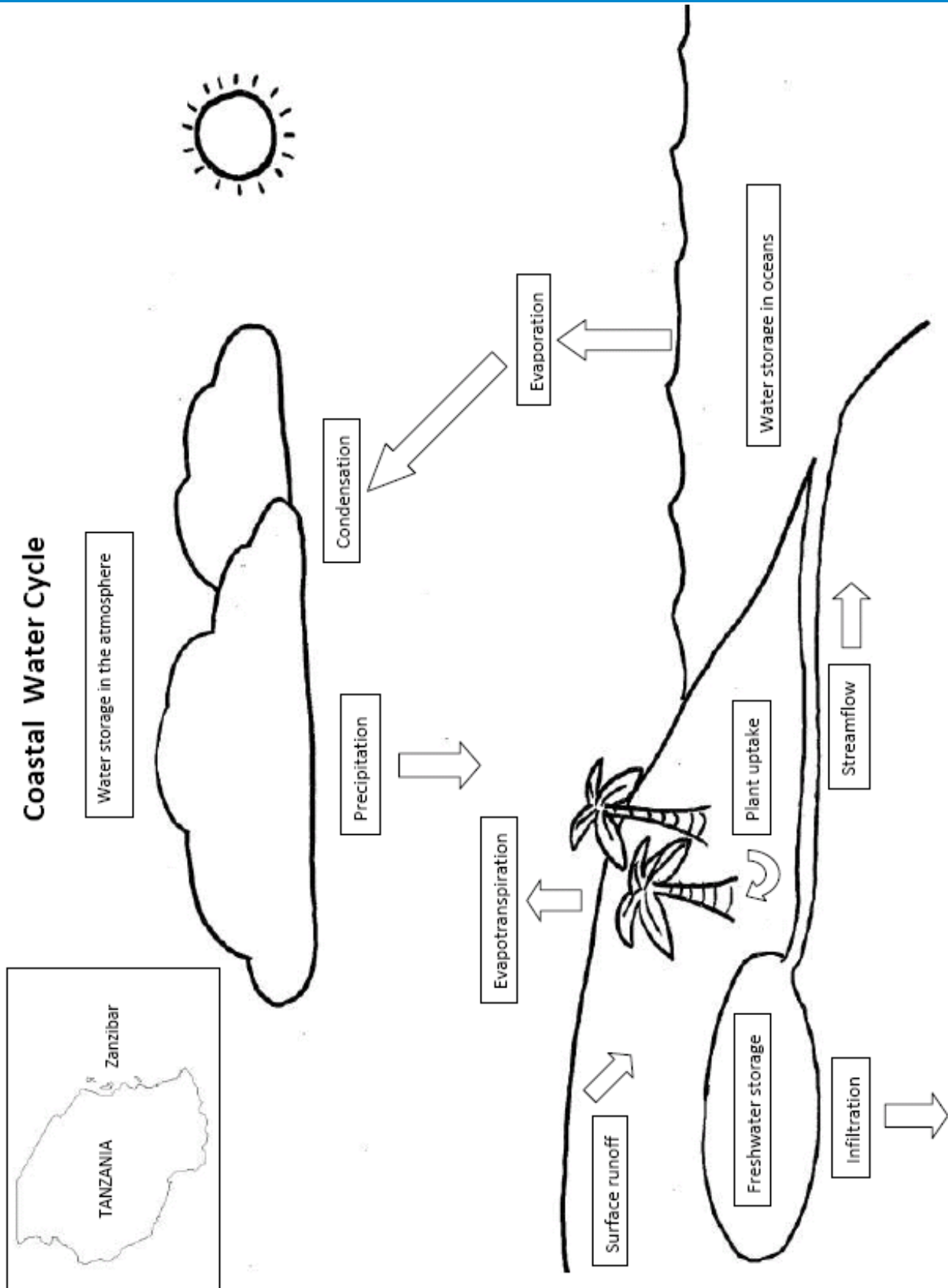
Costal Tanzanian Water Cycle



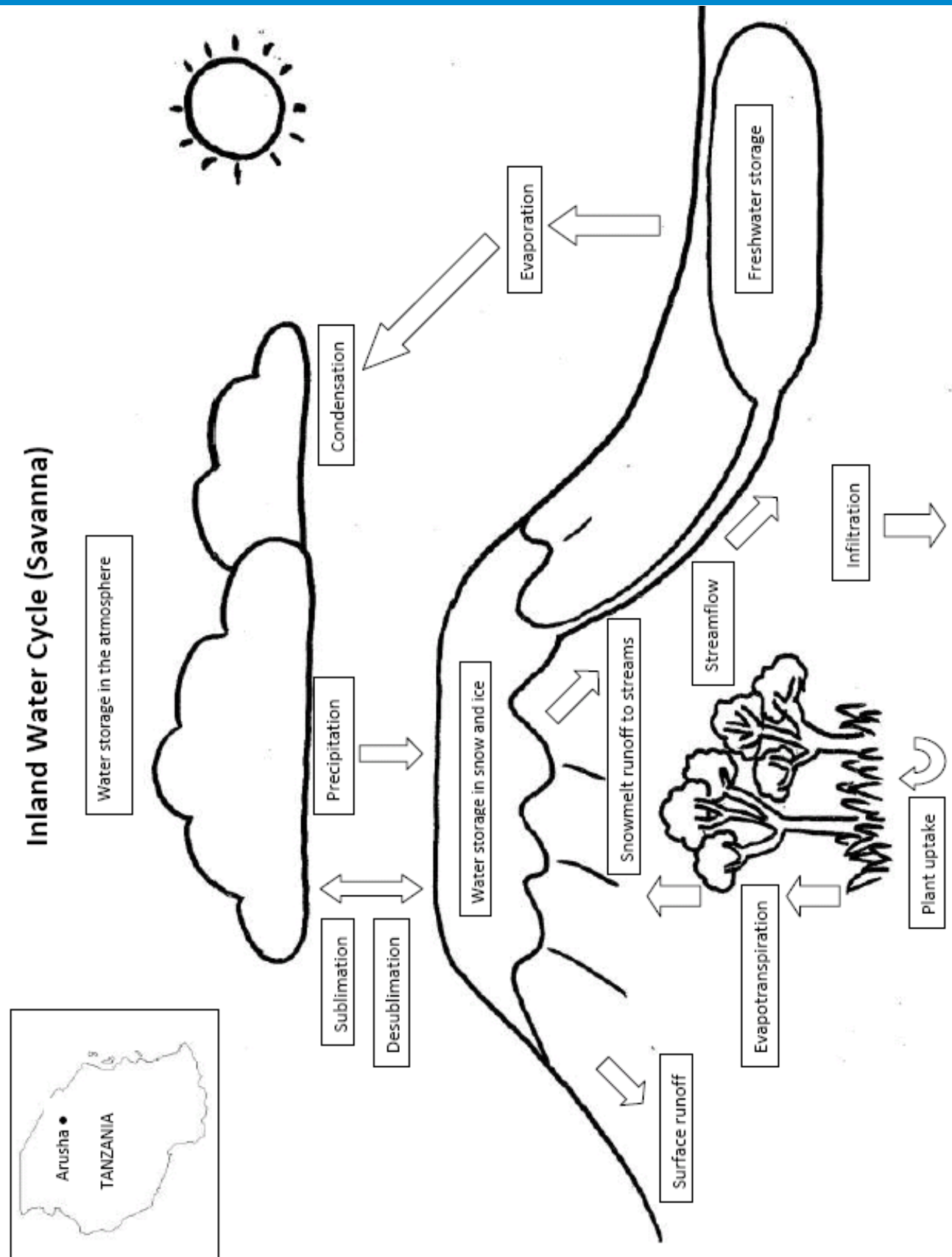
Inland Tanzanian Water Cycle



Costal Tanzanian Water Cycle Answer Sheet



Inland Tanzanian Water Cycle Answer Sheet



Changing Water Availability in East Africa

Discussion Questions

How are the inland and coastal water cycles different?

Where is water lost from the water cycle in inland Tanzania? How is it replenished?

Where is water lost from the water cycle in coastal Tanzania? How is it replenished?

Why is average yearly rainfall decreasing in inland Tanzania and remaining constant in coastal Tanzania?

What changes are there in the rainfall patterns in coastal Tanzania?

How do the changes in rainfall relate to the changes in temperature seen in Lesson 2?

Changing Water Availability in East Africa

Is that what you would have expected? Why or why not?

How do you think the changes in rainfall will affect coastal Tanzania?

Vegetation:

Land Use:

People's Livelihoods:

Other Effects:

How do you think the changes in rainfall will affect inland Tanzania?

Vegetation:

Land Use:

People's Livelihoods:

Other Effects:



Changing Water Availability in East Africa Answer Sheet

How are the inland and coastal water cycles different?

The inland water cycle includes snowmelt run-off, water storage in ice and snow, snowmelt runoff to streams, and sublimation and desublimation.

The coastal water cycle includes water storage in oceans.

Where is water lost from the water cycle in inland Tanzania? How is it replenished?

Water is lost through infiltration, evaporation, evapotranspiration, and surface runoff.

It is replenished by precipitation, desublimation, and snowmelt runoff replenishing streams.

Where is water lost from the water cycle in coastal Tanzania? How is it replenished?

Water is lost through infiltration, evaporation, evapotranspiration, and surface runoff.

It is replenished by precipitation.

Why is average yearly rainfall decreasing in inland Tanzania and remaining constant in coastal Tanzania?

Rainfall in inland Tanzania depends on the ITCZ and orographic rainfall, and has been decreasing.

In coastal Tanzania, rainfall depends on the ITCZ and coastal rainfall. Because water storage in the ocean has not been greatly affected by climate change, evaporation and precipitation on the coast is more constant.

What changes are there in the rainfall patterns in coastal Tanzania?

The average amount only decreasing slightly, but the distribution and severity of rainfall is changing. There are more violent storms and rainfall is less predictable.

How do the changes in rainfall relate to the changes in temperature seen in Lesson 2?

In Arusha (inland Tanzania), temperatures are increasing less rapidly, but rainfall is decreasing more rapidly than in Zanzibar (coastal Tanzania).

Is that what you would have expected? Why or why not?

I would have expected higher temperatures to have more of an effect on rainfall, but it looks like that is balanced out by the amount of water in ocean storage.

How do you think the changes in rainfall will affect coastal Tanzania?

Vegetation:

Not all crops and vegetation will adapt to changes in severity of rain

Land Use:

Rains may be too unpredictable for certain crops; farmers may need to change what crops they grow

People's Livelihoods:

Farming may be too risky—people may need to look for other sources of income

Other Effects:

Flooding may cause health risks.

How do you think the changes in rainfall will affect inland Tanzania?

Vegetation:

The composition of species may change; there may be desertification in some areas.

Land Use:

Farmers may have to change the crops they grow to crops that require less rainfall. Some places may not be suitable for crops, and could shift to grazing or other uses. In some places there may not be enough water for livestock.

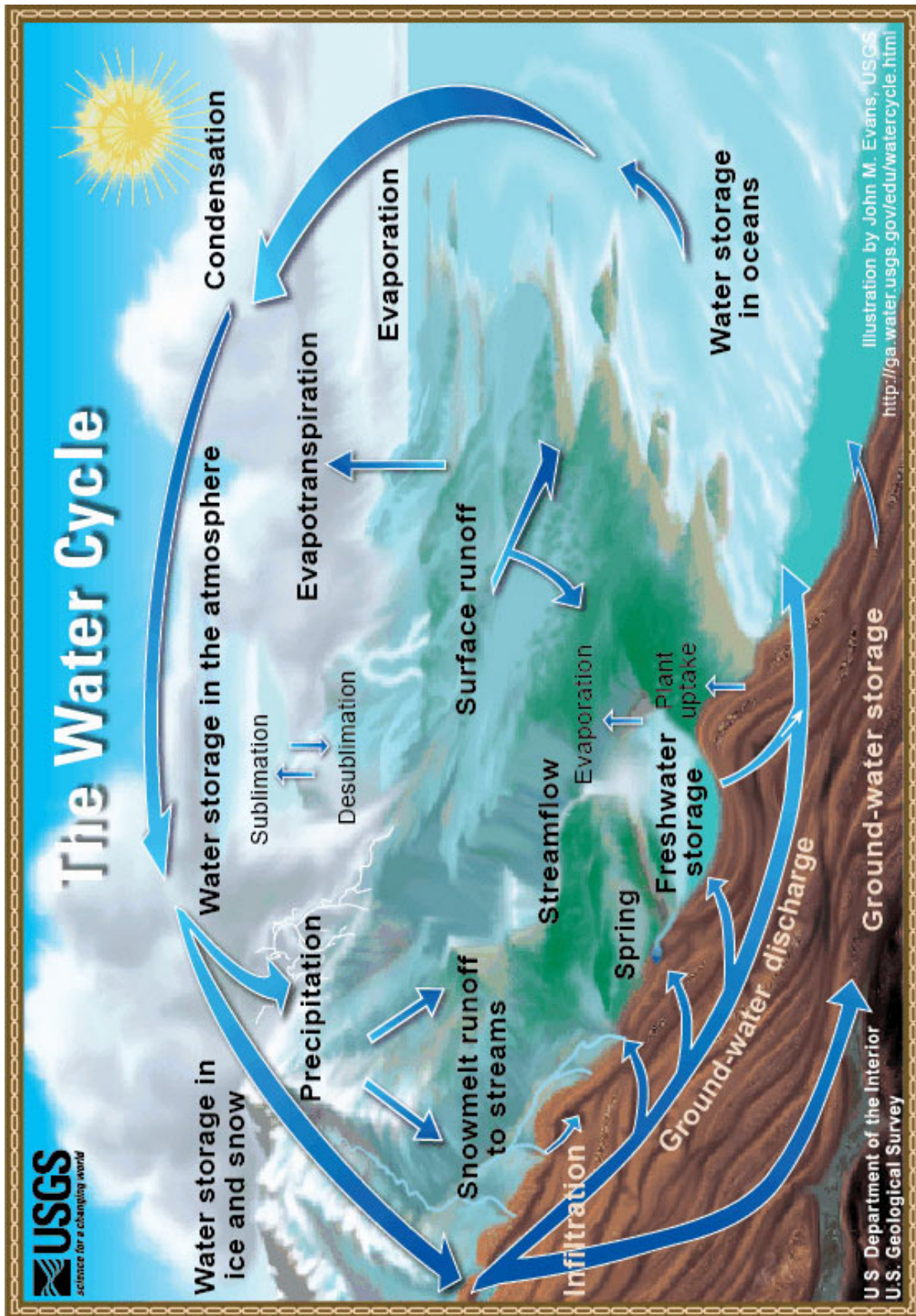
People's Livelihoods:

Farmers and herders may not be able to live off of the same crops or livestock as before and may have to look for other sources of income.

Other Effects:

Lower annual rainfall and less predictable rainfall may result in insufficient water for people to use, requiring people to migrate to areas where there is enough water.

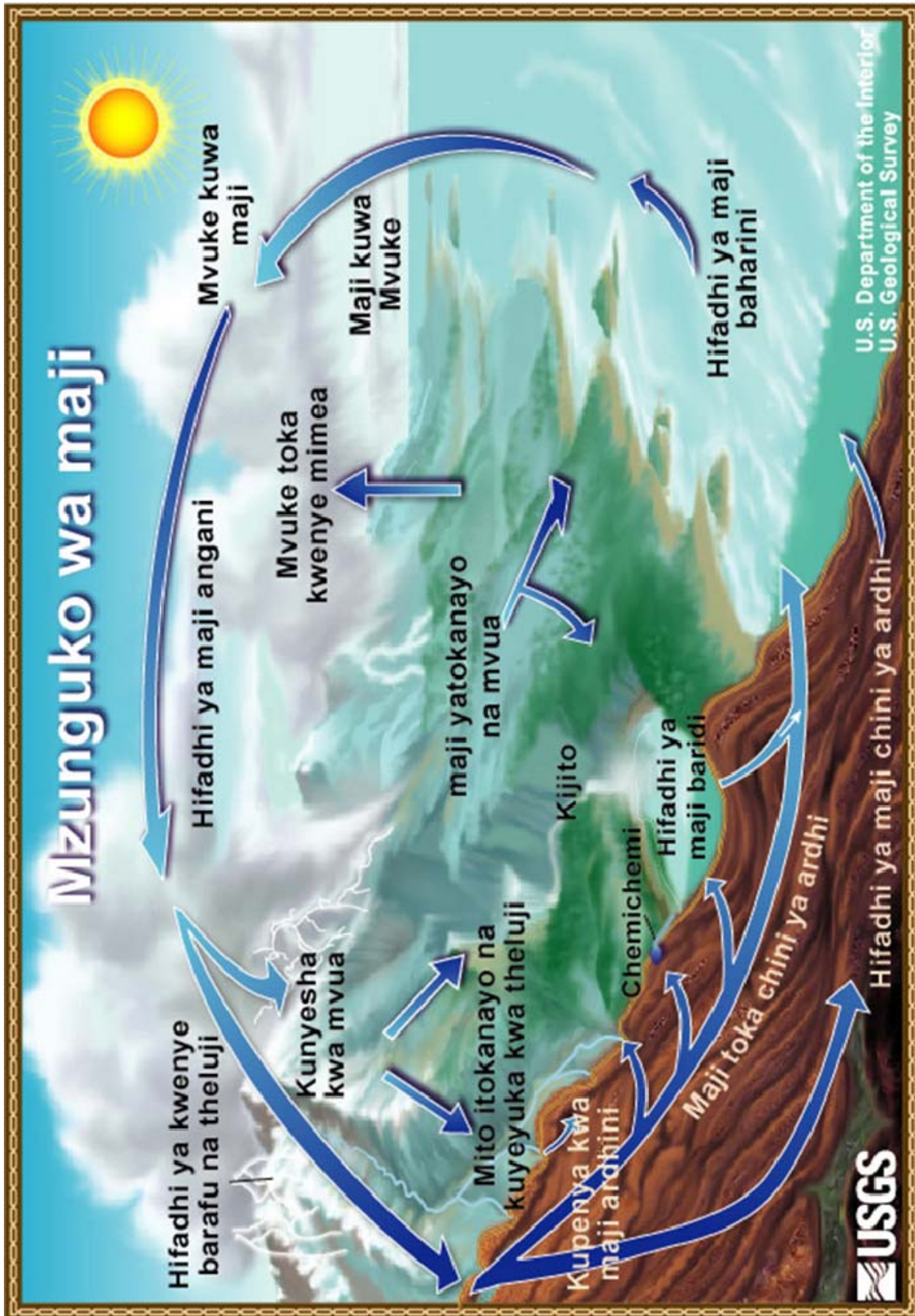
Water Cycle Diagram



Water Cycle Diagram Blank



Water Cycle Diagram Swahili



Water Cycle Terms for Diagrams

Some terms will be on both water cycles; some will only be on one water cycle

1. Condensation
2. Evaporation
3. Precipitation
4. Water storage in oceans
5. Water storage in snow and ice
6. Surface runoff
7. Streamflow
8. Plant uptake
9. Infiltration
10. Evapotranspiration
11. Freshwater storage
12. Snowmelt runoff
13. Sublimation
14. Desublimation
15. Water storage in the atmosphere

Water Cycle Terms in English and Swahili

English

Condensation

Evaporation

Precipitation

Water storage in oceans

Surface runoff

Infiltration

Evapotranspiration

Freshwater storage

Snowmelt runoff

Ground-water storage

Water storage in atmosphere

Swahili

Mvuke kuwa maji

Maji kuwa Mvuke

Kunyesha kwa mvua

Hifadhi ya maji baharini

Maji yatokanaho na mvua

Kupenya kwa maji ardhini

Mvuke toka kwenye mimea

Mifadhi ya maji baridi

Mito itokanyo na kuyeyuka kwa theluji

Hifadhi ya maji chini ya ardhi

Hifadhi ya maji angani

