

Thematic Focus: Climate change and Ecosystem management

Africa without glaciers

Why is this important?

Glaciers are a critical component of the earth's system and the current accelerated melting and retreat of glaciers have severe impacts on the environment and human well-being, including vegetation patterns, economic livelihoods, natural disasters, sea level fluctuations and the water and energy supply (UNEP 2008). Glaciers are one source of the planet's freshwater; they store and release it seasonally, replenishing the rivers and groundwaters that provide people and ecosystems with life sustaining water. Declining glacier melt will affect agriculture, domestic supplies, hydroelectricity and industry in the lowlands and cities far from the mountains (UNEP 2007). Glaciers' decline also often has an impact in the tourism sector, not to mention the general aesthetic/visual value they provide.

Surprisingly, there are a number of glaciers in Africa. They are all located in East Africa near the equator, and since 1900, have lost over 80 per cent of their surface area (Russell and others 2009) (Figure 1). They sit atop the volcanic mountains of Mount Kenya in Kenya and Mount Kilimanjaro in Tanzania, and on the Ruwenzori range in Uganda and the Democratic Republic of Congo (DRC). At the end of the 1990s, these glaciers had a total area of about 10.7 km² (Young and Hastenrath 1991). These mountains' flanks are covered with a great range of vegetation types according to the vast vertical differences in altitude and rainfall. For example, the eight ecological zones on the slopes of Mount



Figure 1: Location of Africa's present-day glaciers, marked with solid red triangles. Redrawn from Young and Hastenrath 1991.

Kenya range from a cultivated zone below 1 800 m to the Afro-alpine zone (areas above 3 500 to 3 800 m) found above most vegetation (UNEP 2009).

Mount Kilimanjaro is 5 895 m high and is located in northern Tanzania 300 km south of the equator. It is the highest mountain in Africa and the world's highest free-standing mountain. It consists of three volcanoes: Kibo, Mawenzi, and Shira. With its ice-cap gleaming under the tropical sun atop its iconic bulk that emerges from the flat plain, it is one of the world's most easily recognized mountains. The 16 named glaciers and 3 ice fields are arranged around the Kibo caldera, while the mountain is relatively undissected and has a 95-km-long by 65-km-wide base (Young and Hastenrath 1991, Frömming 2009).



Some 1.5 million people live around Mount Kilimanjaro, of which nearly three quarters depend on its rich natural resources for their livelihoods, including farming the fertile volcanic soils (Misana and others 2012). Many are employed in the mountain's busy tourism industry that sees more than 35 000 climbers a year, plus 5 000 day visitors (Mitchell and others 2009) and is one of Tanzania's most important economic sectors (Frömming 2009).

Mount Kenya straddles the equator, 193 km northeast of Nairobi and about 480 km from the Kenyan coast (UNESCO n.d.). Its snow-capped peak rises dramatically above the savannah and its silhouette is an iconic symbol of Kenya recognized around the world (UNEP 2009).

At 5 199 m, the mountain is Africa's second-highest. It is the remnant of a large volcano and its diameter from north-to-south is 100 km, which is just slightly larger than its west-to-east axis. Its ice cap is composed of 10 glaciers that occupy the valleys of this very dissected mountain (UNEP 2007).

The mountain attracts thousands of climbers every year and in 2009, some 25 000 people visited Mount Kenya National Park (Government of Kenya 2010). In addition to its beauty and contribution to the country's tourism industry, Mt. Kenya is valuable for timber, farmland, and tourism and its forested slopes are a critical water catchment, acting as "water towers" for much of the country (UNEP 2009).

The **Ruwenzori** massif at 5 109 m is popularly called the "Mountains of the Moon". It is a 50-km-wide block of mountains that rises between two faults in the earth's crust. It straddles the Uganda-DRC border and has a total area of 3 000 km² (Russell and others 2009). The range is heavily dissected into valleys and individual mountains that run about 100 km northwestwards from the Equator. The range's central portion contains 25 peaks over 4,500 m, the highest of which is the Margherita peak on Mount Stanley, which exceeds 5 000 m (Young and Hastenrath 1991). The Ruwenzori glaciers occur on only three of the range's peaks: Mounts Stanley, Speke and Baker (Klein and Kincaid 2007). In the early 1990s, the total glaciated area was about 5 km² (Young and Hastenrath 1991). Their forested slopes are important water sources for the lower plains.

What are the findings?

UNEP's Global Outlook for Ice and Snow (UNEP 2007) reports that "with few exceptions, all the alpine glaciers of the world are losing mass and it is predicted that this trend will continue as global warming progresses". Monitoring of mass ice budgets and surface topography has taken place on Mount Kenya for decades, especially on Lewis Glacier, while less is known about trends in ice thickness on Kilimanjaro (Hastenrath 2010) and even less about the Ruwenzori glaciers (Vidal 2012). There is scientific evidence that during the Pleistocene Epoch (some 2.5 to 11 million years ago), the east African mountain glaciers covered several hundred square kilometres (Young and Hastenrath 1991). Africa's glaciers

began to recede in the 1880s and between 1906 and 2006, they lost about 82 per cent of their area and the larger glaciers became fragmented (UNEP 2007, Hastenrath 2010).

Mount Kilimanjaro

Since at least the 1880s, the ice on Mount Kilimanjaro has been retreating both in thickness and in area, with the latter's decline most dramatic (Campbell 2008). Compared to 1800 when the ice covered about 20 km², by 2003, the area had shrunk to about 2.51 km² (Cullen and others 2006) (Figures 3 and 4). An estimated 82 per cent of the ice cap that crowned the mountain when it was first thoroughly surveyed in 1912 is now gone, and the remaining ice is thinning as well—by as much as a metre per year in one area. According to some projections, if recession continues at the present rate, the majority of the remaining glaciers on Kilimanjaro could vanish in the next decade (UNEP 2005).

The ice cover on Kilimanjaro's Kibo glacier has been mapped intermittently since 1912 (Figure 2). Since then, research by Thompson and others (2009) shows that 85 per cent has disappeared and 26 per cent of the ice that remained in 2000 was gone by 2009. Between 2000 and 2009, the Furtwängler Glacier thinned by about half at the research site, and ice volume on two ice fields thinned or shrank by nearly the same volume between 2000 and 2007 (Thompson and others 2009).

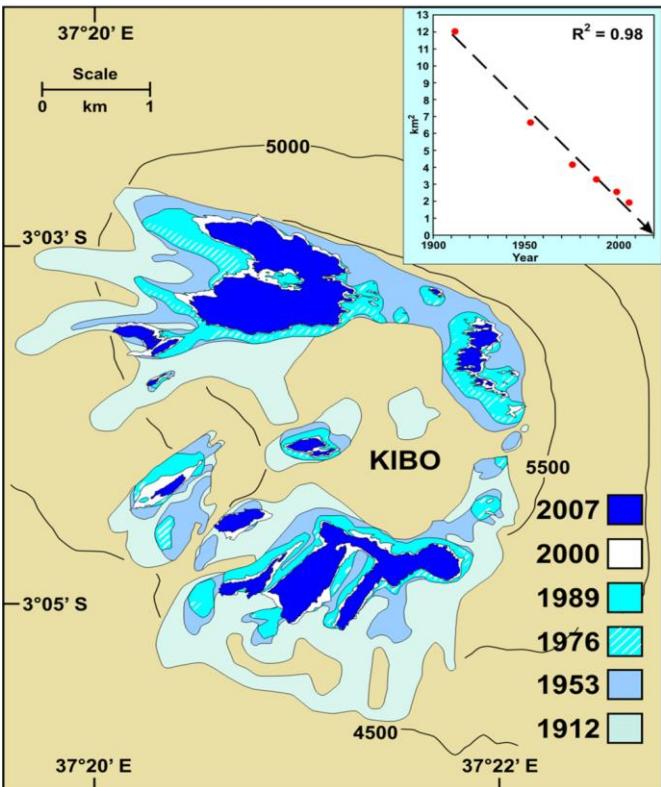


Figure 2: Outlines of the Kibo (Kilimanjaro) ice fields 1912, 1953, 1976, 1989, 2000 and 2007. Source: Thompson and others 2009.

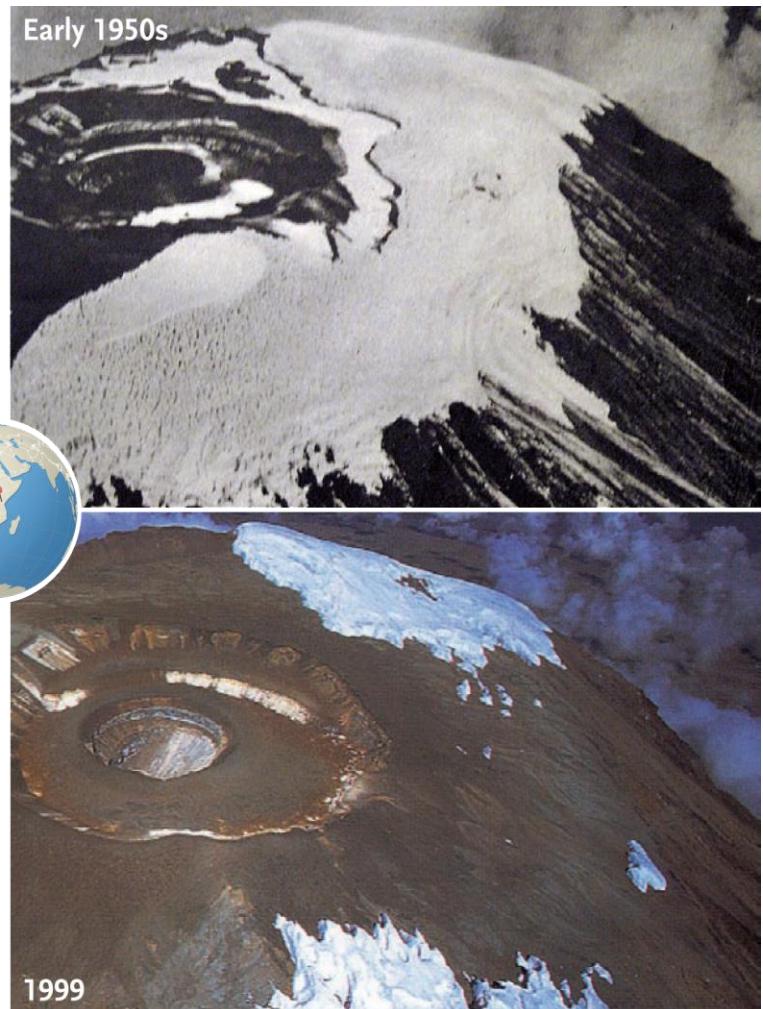


Figure 3: Oblique photos showing the loss of ice cover between the early 1950s and 1999. Source: UNEP 2007.

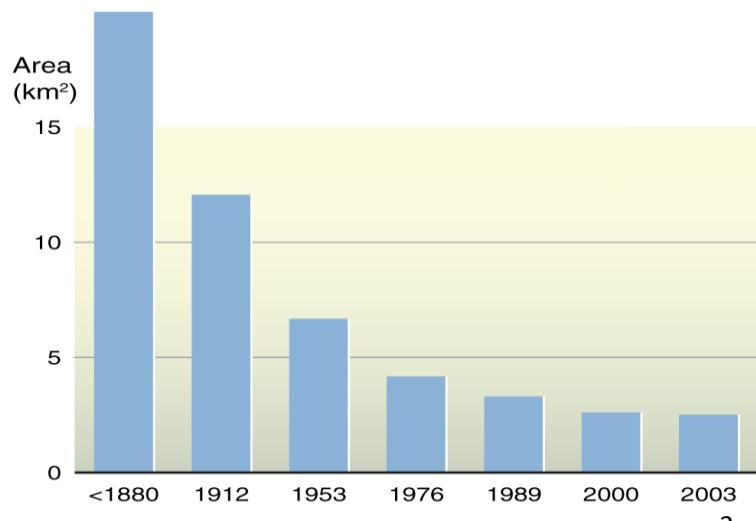


Figure 4: Trend in the size of Mount Kilimanjaro's ice cover. Source: UNEP 2007.

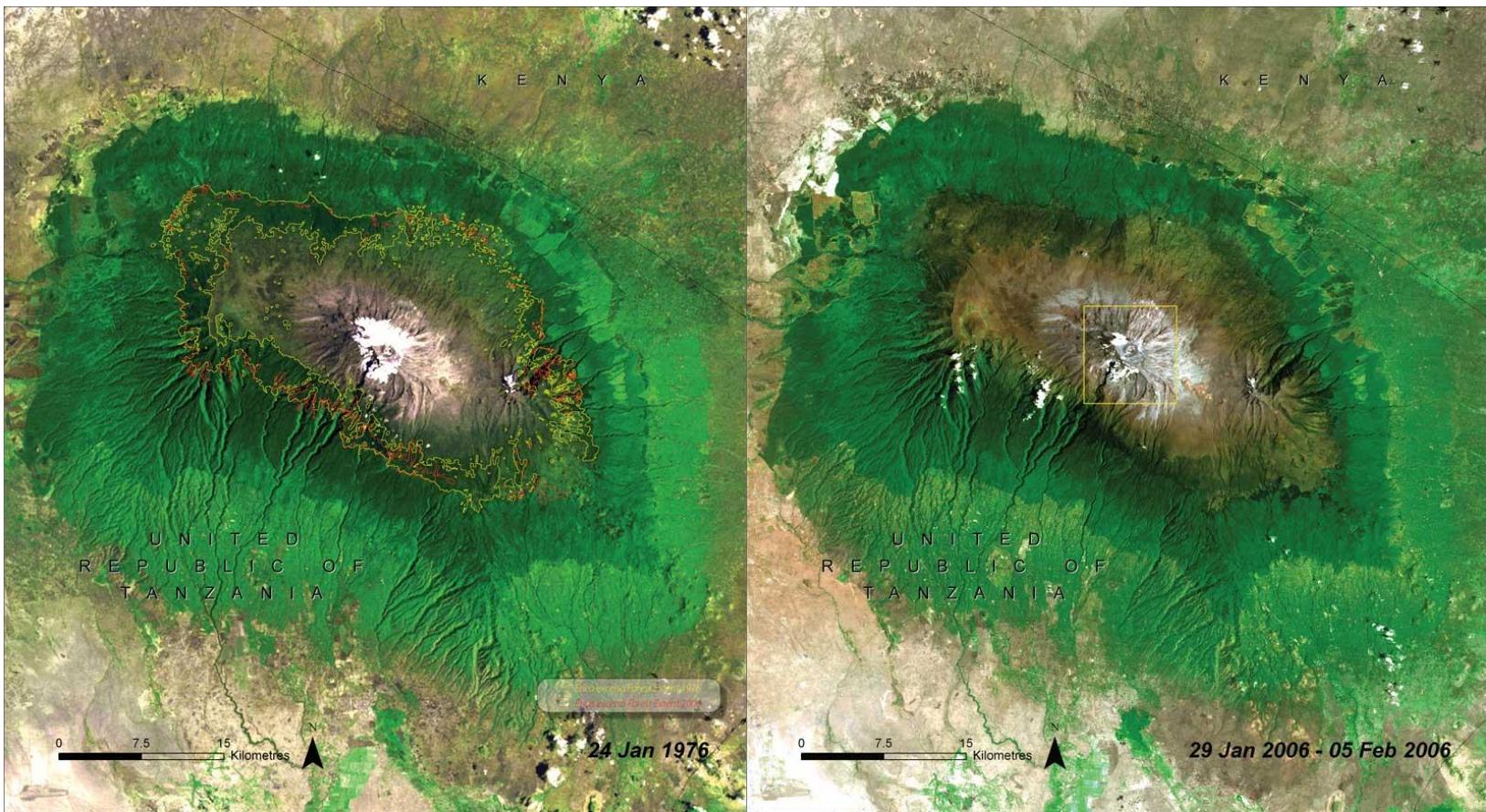


Figure 5: Satellite images from 1976 and 2006 showing the decline of Kilimanjaro's glaciers (UNEP n.d.).

Mount Kenya

Only 10 of the 18 glaciers that covered Mount Kenya's summit a century ago remain, leaving less than one third of the previous ice cover. The ice on Mount Kenya has also become thinner. Emerging evidence suggests the decline has accelerated since the 1970s (UNEP 2009) (Figures 6, 7 and 8).



Mt. Kenya

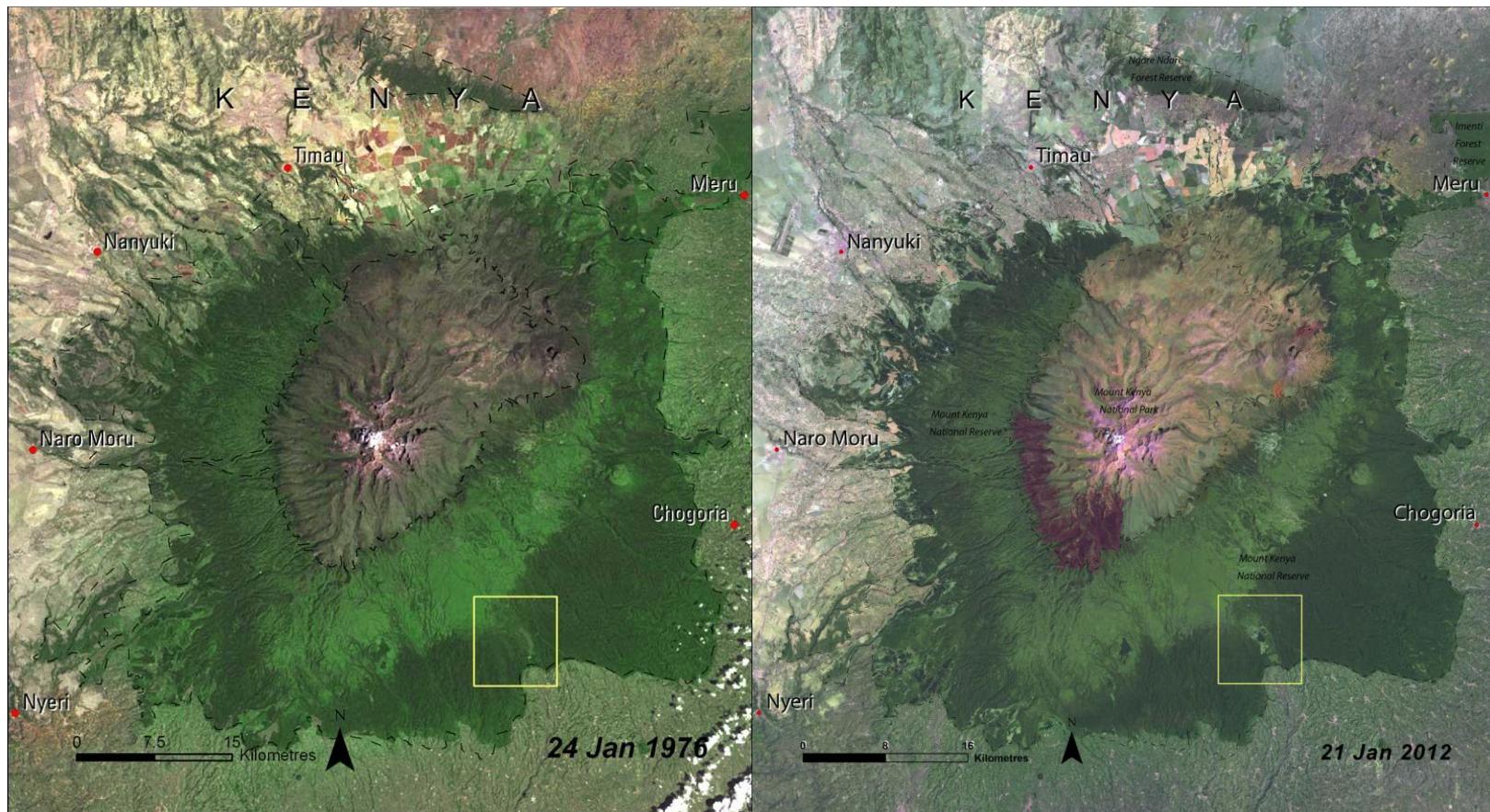


Figure 6: Satellite images of Mount Kenya's glaciers, 1976 and 2012.

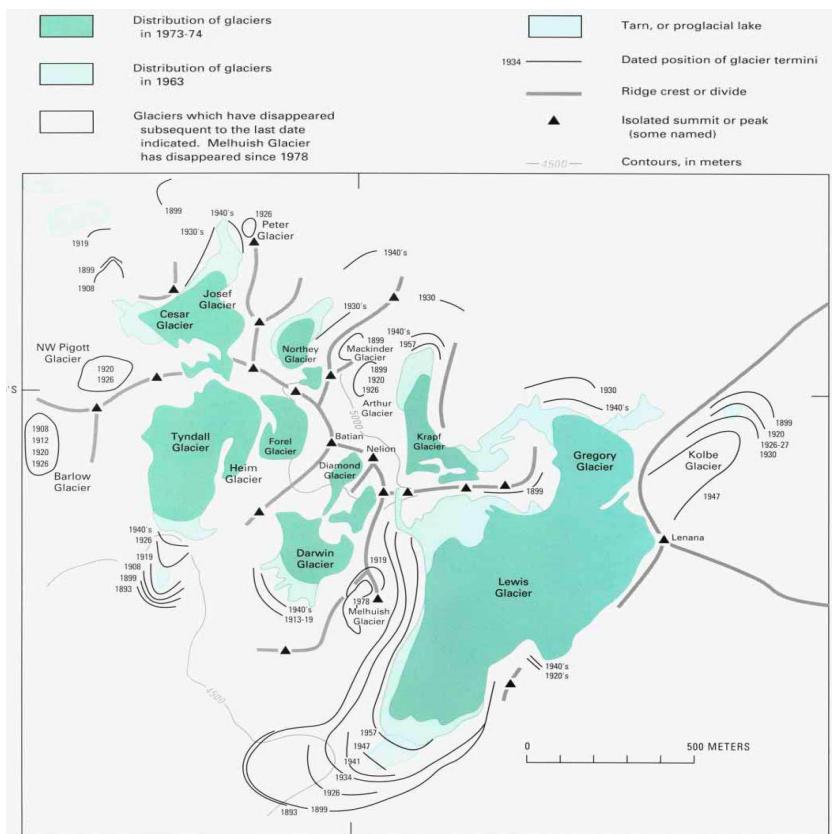


Figure 7: Mount Kenya's shrinking glaciers. Source: (Young and Hastenrath 1991).

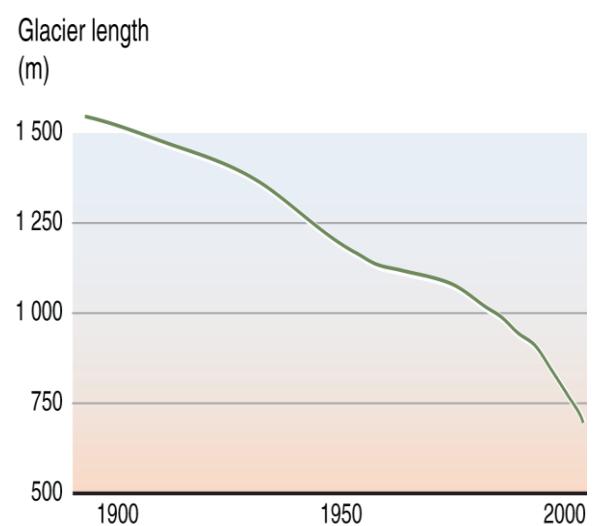


Figure 8: Ice loss on Lewis Glacier, 1900s to 2000s.
Source: (UNEP 2007).

By 2010, Lewis Glacier, the largest on Mt. Kenya had decreased by 90% in its volume (area) since 1934. The highest rates of ice volume loss occurred around the turn of the century (Prinz and others 2011).

The Ruwenzori range

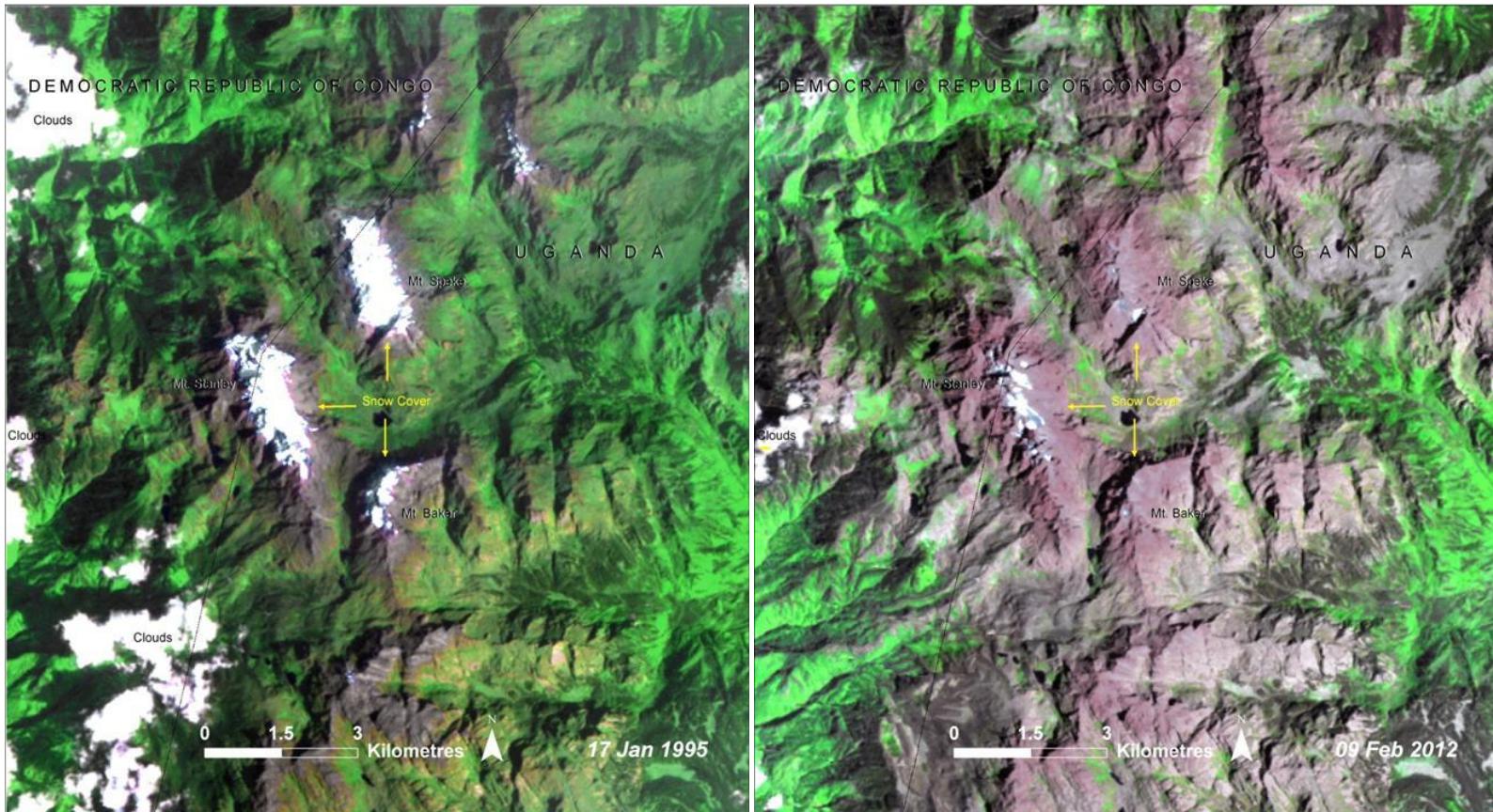


Figure 9: Satellite images of the Ruwenzori, 1995 (UNEP n.d.) and 2012

Perpetual clouds over the Ruwenzori range make it difficult to monitor trends in ice cover through aerial or satellite photography (Vidal 2012). In addition, few researchers have visited the glaciers for field studies (Klein and Kincaid 2007). On one visit in 1974, it was estimated that since 1958, the Speke Glacier had retreated by 30 to 40 m and shrunk laterally by 10 to 20 m (Young and Hastenrath 1991).

Klein and Kincaid (2007) used a combination of images of the Ruwenzori glaciers to determine the area of ice between 1987 and 2006 and found it had decreased by about 50 per cent (from 2.55 km^2 to 1.31 km^2), although uncertainties remain. Satellite images taken in 1995 and in 2012 (Figure 9) show a decline in the extent of the glaciers on these mountain peaks. A century ago the glaciers of the Ruwenzori Mountains covered nearly 6.5 km^2 . If they continue to recede, as they have since 1906, some experts project that they would be gone in coming decades (UNEP n.d., Barry 2006).

Why are the glaciers retreating?

The dramatic shrinking of Kilimanjaro's glaciers has attracted global attention (Thompson and others 2009). In the popular mind, it has come to represent the impacts of climate change. Variations in many conditions can influence glacial melt, however, including precipitation, temperature, cloud cover, direct evaporation from the glacier surface and the mountain's relief (Young and Hastenrath 1991). The glacial loss on East Africa's mountains beginning in the 1880s is thought to have been due to declining precipitation and less cloudiness leading to higher solar radiation. Then in the 20th century, the relative role of higher temperatures occurring



Mt. Kilimanjaro

Abir Anwar/flickr

over the past decades began to be a matter of debate (Young and Hastenrath 1991) (UNEP 2007). For example, Kaser and others (2010) affirm that the primary driver of changes to Mount Kilimanjaro's Kibo glacier over the past 120 years is atmospheric moisture rather than rising local air temperature (Kaser and others 2010). On the other hand, Thompson and others (2009) confirm that warmer conditions near the surface as well as higher temperatures in lower latitudes play important roles in the disappearing ice while noting that the lack of temperature records on Kilimanjaro's peak and the recent and short time span of satellite observations create some uncertainty.

Studies of the Lewis Glacier on Mount Kenya found that higher temperatures during the 1900s were a greater cause of its shrinking than sun exposure (Campbell 2008). Hastenrath (2010) contends that some warming during the 20th century and associated rises in atmospheric humidity, along with a possible contribution of continued solar radiation forcing are the causes of Mount Kenya's recent ice losses.

The glacial recession on the Ruwenzori Mountains is most likely because of higher air temperatures and less snow accumulation during the 20th century (UNEP n.d.), in contrast to the lack of rainfall thought to play an important role on Mount Kilimanjaro (Vidal 2012). It is also possible that decreasing cloud cover over the same time period has contributed to vaporization of these glaciers (UNEP n.d.).

What are the implications?

In the current scenarios of climate change, the ongoing trend of worldwide and rapid, if not accelerating, glacier shrinkage on the century time scale may lead to the deglaciation of large parts of many mountain ranges in the coming decades (UNEP 2008). Regardless of the relative contributions the different causes make to the shrinking glaciers, if present climatic conditions continue, the African glaciers will disappear within several decades, in concert with the retreat of most tropical glaciers throughout the world (Thompson and others 2009).

In mountainous regions where glacial melt contributes to river flows, climate change will significantly affect associated aquatic ecosystems and the human activities dependent on them. At first, meltwater inputs will increase river runoff, but then there will be a sharp decline (UNEP 2007). In Africa, however, the shrinking glaciers will have little impact on water resources because glaciers provide modest, if any, water to lower elevation streams, as most ice is lost through sublimation; water from the small amount of melting evaporates very quickly (UNEP 2009).

The major effects of the shrinking of these iconic glaciers will be the loss of ice that is part of the attraction to tourists, awed by the beauty of the white-topped mountains in their flat arid landscapes, the novelty of snow near the equator and the last opportunity to see the glaciers before they are gone (Campbell 2008). Africa contributes very little to global greenhouse gas emissions considered a key driver of climate change, but it is highly vulnerable to the impacts. Glacier loss is likely to mean the loss of tourism revenues that are so vitally important to the economies of Kenya and Tanzania especially. Policies will need to address how to adapt to these impacts, at the same time as they promote economic development without increasing fossil fuel dependency and using inefficient technologies.

Acknowledgement

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