Rev. Sci. Tech. Off. Int. Epiz., 2021, **40** (2), ... - ...

Climate services' role in safeguarding pastoral disaster communities

M. Sivakumar

27 Chemin des Corbillettes, 1216 Cointrin, Geneva, Switzerland

*Corresponding author: mannavas@gmail.com

Summary

Climate change owing to increasing greenhouse pgas (GHG) emissions is one of the most pressing issues facing society on a global scale. The growth of GHG emissions between 2000 and 2010 was higher than in the previous three decades, and each of the past four decades has been successively warmer than any preceding decades since 1850. Continued GHG emissions will cause further warming and changes in the climate system. Climate change affects livestock production in multiple ways, both directly and indirectly. Many of the impacts on the livestock sector result from increasing frequency and magnitude of weather and climate extremes such as droughts, flash floods, untimely rains, frost, hail and severe storms. This article describes some of the most vulnerable disaster communities in Asia, Africa, Australia, Europe and South America. It then describes the importance of meteorological information provided by the National Meteorological and Hydrological Services to help Veterinary Services support sustainable management of livestock in vulnerable pastoral communities.

Keywords

Disaster communities – Climate change – Climate services – Meteorological information.

Introduction

Article 1 of the United Nations Framework Convention on Climate Change defines climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods' (1). Over the last three decades, climate change has emerged as one of the most crucial issues for humankind, with serious implications for sustainable development.

Around 30% of the Earth's land surface is currently dedicated to livestock production through pastures (approximately 25%) and feed crops (approximately 5%) (2). The livestock sector

accounts for 40% of the global agricultural gross domestic product and 1.3 billion people depend upon livestock husbandry for their livelihood (3). In particular, livestock is a key asset for resource-poor farmers in pastoral and agropastoral systems. As the human population expands, global demand for food of animal origin is steadily growing and the livestock sector will continue to expand accordingly.

Climate can affect ruminant husbandry both directly and indirectly (4). Direct effects of, for example, air temperature, humidity and wind speed influence animal performance indicators such as growth, meat production, wool production and reproduction. Indirectly, weather conditions or climate change may significantly affect feed resources, which in turn influence livestock productivity, the carrying capacity of rangelands, the buffering ability of ecosystems and their sustainability, and the distribution of diseases and parasites.

Observed and future climate change

Observations of the climate system indicate that human activities are contributing to a warming of the Earth's atmosphere. Between 1850 and 2000, the human world's energy use increased by a factor of approximately 15 (5). Over this period, the mixture of fossil fuels used changed dramatically. Atmospheric concentrations of carbon dioxide, methane, nitrous oxide and other greenhouse gases have been increasing steadily since 1750 due to human activity (6). Warming from past anthropogenic emissions will persist for centuries and will continue to cause long-term changes in the climate system and have many associated impacts.

The global average surface temperature warmed by 0.85°C between 1880 and 2012 (6). Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C (6). The change in global average temperature from 1850 to 2018 is depicted in Figure 1 (7). Global warming is likely to reach 1.5°C between 2030 and 2052 if the temperature continues to increase at the current rate.

Most of the problems caused by weather and climate for people and livestock are the result of extremes, or catastrophes. A rise in the frequency and intensity of extreme weather and climate events has been observed since about 1950 (6). Annual losses from weather disasters such as hurricanes, hailstorms and wildfires frequently run into the hundreds of billions of dollars. Since 1980, weather-related natural disasters have caused losses of some US$ 4,200 billion and killed nearly a million people (9).

Disaster communities

According to the United Nations High Commission for Refugees, climate change is the defining crisis of modern times and disaster displacement is one of its most devastating consequences. Many people are living in climate 'hotspots,' where they typically lack the resources to adapt to an increasingly hostile environment. The domino effect of disaster upon disaster triggered by climate change leaves already impoverished communities no time to recover. These communities can be described as disaster communities.

Climate change affects livestock production in multiple ways, both directly and indirectly. The most important impacts are experienced in animal productivity, yields of forages and feed crops, animal health and biodiversity. In tropical climates, heat stress negatively impacts animal growth, milk production and reproduction (10). Under weather conditions of arid and semi-arid regions, heat stress is most common in the summer season. This paper focuses on pastoral communities as these are some of the most vulnerable to climate change and especially to catastrophes, given their reliance on extensive grazing, location in remote areas with consequent lack of access to resources and, in many cases, relative poverty.

Pastoralists comprise several hundred million livestock keepers distributed all over the world whose unique livelihoods face challenges linked to their environment and to the mobility that characterises them. Some examples of disaster communities in Asia, Africa, Australia, Europe and South America are discussed below.

Asia

Mongolia, which is situated in the very centre of the Asian mainland and covers 1.53 million square kilometres (km^2), has an extreme continental climate (11), with arid and semi-arid regions occupying about 40% of the total surface. The Mongolian economy relies heavily on livestock production. Cattle breeding pasture covers 90% of the territory. Pasture production is variable from year to year, and in some years it is quite low because of prolonged drought and warm weather conditions during the growing season.

More than half of Kazakhstan (approximately 100 million hectares) is desert and traditionally used for cattle grazing. The rate of pasture desertification in Kazakhstan could increase this century, according to climate change research (12). Owing to the doubling of CO_2 concentrations in the atmosphere, air temperatures could increase more significantly over the next 60 to 70 years, by as much as 3°C to 4°C in the desert regions of Kazakhstan and up to 5°C to 7°C in

some cases. Consequently, crucial changes may take place in the agroclimatic growing conditions of pasture vegetation and in the condition of pastureland in Kazakhstan (13).

In Uzbekistan, each season is associated with a distinct phase of life for Karakul sheep, and weather conditions may have varying effects on their physiology (14). At the beginning of pregnancy, from late October through to December, sheep experience weather conditions that are favourable enough for grazing. During late pregnancy, the weather conditions become much less favourable, leading in some cases to hyperthermia in cold weather. Interruptions in grazing are the result of both individual and compound meteorological conditions (15).

India is the largest milk producer in the world, having produced 163.7 million tonnes in 2016–17, and eighth in terms of meat production (4). The average milk productivity per animal is comparatively very low owing to a variety of biophysical and socio-economic factors. Climate change studies predict that rising mean surface temperature is likely to hasten livestock vulnerability to heat stress and diseases directly and availability of feed and fodder indirectly.

Most grazing areas in Thailand are tropical natural pastures. Pasture production is relatively low in terms of quality and quantity and it fluctuates as a function of seasonal and meteorological conditions (16). The rangelands in Thailand are used for local beef cattle, improved breeds of beef cattle, dairy cattle and buffaloes. The carrying capacity is approximately three animals per hectare in the rainy season and one animal per hectare in the four-month dry season.

Africa

Africa is one of the most vulnerable continents to climate variability and change owing to its high exposure to climate shocks and stresses (e.g. droughts) and relatively low adaptive capacities (17). The difficulties faced by ten different pastoral communities in Chad (Mbororo), Uganda (Bahima, Nyakwe and Tepeth), Ethiopia (Afar), Kenya (Laikipia Maasai and Samburu), Tanzania (Maasai) and Burkina Faso (Peulh and Bella) are described in a consultancy report titled 'Weather and Climate Services for Effective Climate Adaptation of Indigenous Pastoralists in Africa', submitted for UNESCO's Climate Frontlines project (M.V.K. Sivakumar, unpublished report, 2017)..

Pastoral groups in North Africa herd their animals in arid and semi-arid lands and face numerous urgent problems, including climate change, population growth, insecurity and migration. In West and Central Africa, pastoralists are a large and economically important population group with a strong pastoral identity. The Touareg, the Fulani and other pastoralists in West and Central Africa face many challenges. Western Sahara has a surface of 266,000 km^2 and in the 1960s

70% of its inhabitants were nomads. Nomadic grazers move along the territory and adapt and change in accordance with weather conditions and the consequent presence or lack of pastures.

In most of the agropastoral areas of Ethiopia, the prevailing livestock include cattle, sheep, goats, camels, horses, mules and donkeys (16). The inhabitants practice a grazing system that involves exploiting any region with sufficient water and pasture until they must move to find new access to water and pasture following the dry season. Most of the rangelands are overstocked, though exact figures are difficult to ascertain.

In Kenya, there are nomadic pastoralists in the northern rangelands and agropastoralists and ranchers in the southern rangelands (16). The general condition of these rangelands is fair to poor. The harsh climate, and especially unreliable rainfall, renders these areas suitable only for pasture production, hence the keeping of livestock.

Australia

In Australia, most regions are characterised by low rainfall and a spatially variable climate that is mostly arid and semi-arid, although there are some areas of seasonally high rainfall in the tropics. The main ecosystem types are native grasslands, shrub lands, woodlands and tropical savanna woodlands (16). Sheep and cattle overwhelmingly dominate Australian grazing. A total of 408 million hectares are involved in carrying 23 million cattle and 115 million sheep, close to carrying capacity.

Europe

There is a wide variation in herbage production potential within the temperate zone owing to climatic variation. It has been estimated that the potential dry matter production of temperate-type grassland, with moderate levels of nitrogen use (about 250 kilogrammes per hectare per year) and with monthly harvests, varies from less than 10 tonnes per hectare per year to approximately 15 tonnes per hectare per year between the northern and southern regions of Europe (18).

South America

In the Amazon, pasture is the predominant new land use in the deforested regions, representing 85% of all agricultural lands (10). Deforested land area in the Brazilian Amazon totalled 58.7 million hectares in 2000 (19).

Importance of meteorological information for sustainable management of livestock

Understanding the scope and use of meteorological information can help Veterinary Services in translating knowledge to mitigate climate change and climate catastrophes. The main climatic elements affecting the exploitation of pastures and the livestock industry are temperature, rainfall and humidity, and their main effects are on the composition and quantity of the pasture vegetation (16). Meteorological forecasts (daily, decadal and seasonal) can allow indigenous pastoral communities to better protect their cattle and to increase livestock productivity.

Weather forecasting explores the applications of weather and climate information to sustain or improve on-farm animal performance in terms of factors such as growth, reproduction, and milk and wool production (15). Management intervention is needed not only to improve the genetic potential of the animals, but also to ameliorate the constraints on production set by the climate, the physical environment and various health hazards.

Agrometeorological information is assembled and processed at regional hydrometeorological centres (HMCs) and transferred to regional agricultural divisions, and hence to further users. The basic data collected by field surveys and meteorological stations include air temperature, precipitation, the condition of pasture vegetation (phase of development, height, productivity) and warnings for dangerous hydrometeorological conditions.

Indigenous pastoralists hold a wealth of traditional knowledge on weather and climate, and improved interactions between them and the meteorological community could help integrate the traditional knowledge with modern weather and climate forecasts, as described in the author's 2017 consultancy report for UNESCO. Such integrated forecasts and their applications in the field could help the indigenous pastoralists to better manage their herds and increase pastoral production.

The relationship between the National Meteorological and Hydrological Services (NMHSs), which are the providers of climate services, and pastoralists, who are users of climate information, must be well organised and sustainable. Veterinary Services can play a key role both in identifying necessary information and in making it available to farmers. Climate prediction services are developed through ongoing engagement between providers and users, as shown in Figure 2 (20). The user engagement stage refers to the understanding of user needs, decision-making cycles, dependencies and other related factors. This stage in the process is essential to establish user trust in climate information and thus to enhance uptake and usefulness of the climate information.

For a successful climate service, the component of delivery of products must involve both a mechanism for delivery of information (for example via web portal, e-mail, phone call, mobile app or television) and opportunities for interaction, assistance with interpretation, troubleshooting or a collaborative decision-making process.

Feedback, monitoring and evaluation are essential for capturing the user experience and hence improving the service and its utility. This should be a continuous process that allows both providers and users to evaluate the benefits of the service.

For estimates of the conditions of growth and development and the productivity of grass and natural pasture vegetation, physical–statistical models are used, including methods to forecast their productivity with a one- to two-month outlook (16). The success of these quantitative estimations and forecasts has been considerable. The resulting information is published in ten-day agrometeorological bulletins and appropriate reviews by the Hydrometeorological Centre of Russia and regional HMCs and delivered to regional consumers.

In Thailand, the Department of Livestock Development receives weekly agrometeorological information from the Meteorological Department and circulates this to 33 animal nutrition research centres (16). The information is used as guidance to implement activities related to pasture production and to measure and prevent damage resulting from unfavourable conditions.

Measures taken as a result include actions to:

- preserve sufficient roughage for the dry period;
- distribute the preserved feed as a function of agrometeorological conditions and the expected feed status;
- produce pasture seed in the areas that have favourable agrometeorological conditions.

The most important drought mitigation activities (21) that should be accomplished for livestock are the following:

- move to places not affected by drought
- use modern technology to regulate herd size
- provide feed
- create local fodder supply
- supply additional water to animals eating dry food
- do not overgraze

- distribute livestock at adequate rate to poor grassland
- provide population drought warnings and assessments.

Conclusions

The livestock sector, especially the subsector that depends on extensive grazing in marginal land, is a highly weather-dependent and climate-sensitive sector. Many regions in the world are vulnerable to climate change in view of their large populations, the large number of people facing food insecurity and projected impacts of climate change on the agriculture and livestock sector. There is a need for better assessment of risks associated with variable and uncertain environmental conditions. NMHSs have much to contribute in addressing this priority, and timely availability of weather and climate information and early warnings could facilitate both strategic and tactical decisions in increasing and sustaining livestock production. Veterinary Services can be key partners in translating and disseminating this information.

Le rôle des services climatiques dans la sauvegarde des communautés pastorales sinistrées

M. Sivakumar

Résumé

Le changement climatique dû à l'augmentation des émissions de gaz à effet de serre constitue l'un des problèmes les plus pressants auxquels la société est confrontée à l'échelle mondiale. L'augmentation des émissions de gaz à effet de serre a été plus élevée entre 2000 et 2010 qu'au cours des trois décennies précédentes, et chacune des quatre décennies écoulées a été successivement plus chaude que toutes les décennies précédentes depuis 1850. La persistance continue des émissions de gaz à effet de serre se traduira par une intensification du réchauffement climatique et par d'autres modifications du système climatique. Les changements climatiques ont des effets multiples sur la production animale et interviennent de plusieurs manières, à la fois directement et indirectement. Une grande partie de l'impact subi par le secteur de l'élevage est dû à la fréquence et à la magnitude croissantes des phénomènes climatiques et météorologiques extrêmes tels que sécheresses, crues soudaines, précipitations intempestives, gel, grêle et tempêtes violentes. L'auteur décrit certaines communautés sinistrées parmi les plus vulnérables en Asie, en Afrique, en Australie, en Europe et en Amérique du Sud. Il souligne ensuite l'importance des informations météorologiques fournies par les Services météorologiques et hydrologiques nationaux, grâce auxquelles les Services vétérinaires peuvent

mieux soutenir les communautés pastorales vulnérables dans leurs efforts pour une gestion durable des cheptels.

Mots-clés

Changement climatique – Communauté sinistrée – Information météorologique – Services climatiques.

Función de los servicios climáticos en la protección de comunidades pastorales afectadas por desastres

M. Sivakumar

Resumen

El cambio climático causado por la creciente emisión de gases de efecto invernadero es uno de los problemas más acuciantes que afronta la sociedad a escala mundial. El aumento de las emisiones de gases de efecto invernadero entre 2000 y 2010 fue mayor que en los tres decenios anteriores. Asimismo, cada uno de los cuatro pasados decenios fue sucesivamente más cálido que cualquiera de los anteriores desde 1850. Las incesantes emisiones de gases de efecto invernadero traerán consigo un mayor calentamiento y más transformaciones del sistema climático. El cambio climático afecta a la producción ganadera por numerosas vías, tanto directas como indirectas. Muchos de sus efectos sobre el sector ganadero son fruto de la frecuencia y magnitud crecientes de fenómenos climáticos y meteorológicos extremos, como sequías, inundaciones súbitas, lluvias intempestivas, heladas, granizadas y fuertes tormentas. Tras referirse a algunas de las más vulnerables comunidades afectadas por desastres de Asia, África, Australia, Europa y Sudamérica, el autor explica la importancia de la información meteorológica que facilitan los Servicios Meteorológicos e Hidrológicos nacionales para ayudar a los Servicios Veterinarios a respaldar una gestión sostenible del ganado en comunidades vulnerables que viven del pastoreo.

Palabras clave

Cambio climático – Comunidades afectadas por desastres – Información meteorológica – Servicios climáticos.

References

1. UN General Assembly (1994). – United Nations Framework Convention on Climate Change: resolution/adopted by the General Assembly. 20 January 1994, A/RES/48/189. Available at: www.refworld.org/docid/3b00f2770.html (accessed on 6 July 2021).

2. Monfreda C., Ramankutty N. & Foley J.A. (2008). – Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000. *Global Biogeochem. Cycles*, **22** (1), Article No. GB1022. doi:10.1029/2007GB002947.

3. Food and Agriculture Organization of the United Nations (FAO) (2009). – State of food and agriculture – livestock in the balance. FAO, Rome, Italy, 180 pp. Available at: www.fao.org/3/i0680e/i0680e.pdf (accessed on 1 July 2021).

4. Singh S.V. (2018). – National use of weather forecast for livestock management in agrometeorological services. Animal Physiology Division, ICAR – National Dairy Research Institute, Karnal, India, 77 pp. Available at: www.researchgate.net/profile/Sohan-Vir-Singh/publication/328139048_National_Use_of_Weather_Forecast_for_Livestock_Management_in_Agrometeorological_Services/links/5bbb3347a6fdcc9552d945c1/National-Use-of-Weather-Forecast-for-Livestock-Management-in-Agrometeorological-Services.pdf (accessed on 1 July 2021).

5. Smil V. (2017). – Energy and civilization: a history. MIT Press, Cambridge, United States of America, 568 pp.

6. Intergovernmental Panel on Climate Change (IPCC) (2013). – Climate change 2013: the physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the IPCC (T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P.M. Midgley, eds). Cambridge University Press, Cambridge, United Kingdom, 1535 pp. Available at: www.ipcc.ch/report/ar5/wg1/ (accessed on 1 July 2021).

7. Intergovernmental Panel on Climate Change (IPCC) (2018). –Summary for Policymakers. *In* Special report: global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (V. Masson-Delmotte, P. Zhai […] & T. Waterfield, eds). World Meteorological Organization,

Geneva, Switzerland, 32 pp. Available at: www.ipcc.ch/sr15/chapter/spm/ (accessed on 1 July 2021).

8. Berkeley Earth (2019). – Global temperature report for 2018. Berkeley Earth, Berkeley, United States of America. Available at: berkeleyearth.org/2018-temperatures-new/ (accessed on 1 July 2021).

9. Munich Re (2019). – Extreme weather risks. Munich Re, Munich, Germany. Available at: www.munichre.com/en/risks/extreme-weather.html (accessed on 1 July 2021).

10. Steinfeld H., Gerber P., Wassenaar T., Castel V., Rosales M. & De Haan C. (2006). – Livestock's long shadow: environmental issue and options. Food and Agriculture Organization of the United Nations, Rome, Italy, 26 pp. Available at: www.fao.org/3/a0701e/a0701e00.pdf (accessed on 1 July 2021).

11. Dagvadorj D. (1997). – Weather and climate related to pasture and livestock production in arid and semi-arid regions. CAgM Report 79, WMO/Technical Document No. 989, 32 pp. World Meteorological Organization, Geneva, Switzerland. Available at: library.wmo.int/index.php?lvl=notice_display&id=10914#.Xx_rKZ4zY2y (accessed on 1 July 2021).

12. Pilifosova O.V., Eserkepova I.B. & Dolgih S.A. (1997). – Regional climate change scenarios under global warming in Kazakhstan. *Clim. Change*, **36**, 23–40. doi:10.1023/A:1005368404482.

13. Lebed L., Belenkova Z. & Turbacheva T. (1997). – About influence of changes of a climate on pastures of Kazakhstan. *Hydrometeorol. Ecology*, **3**, 79–90.

14. Babushkin O.L. & Lebed L.V. (2002). – Validation of information requirements on livestock and pasture production in arid and semi-arid regions. CAgM Report No. 86, WMO/TD No. 1134. World Meteorological Organization, Geneva, Switzerland, 84 pp. Available at: library.wmo.int/index.php?lvl=notice_display&id=10921#.Xx_xGp4zY2w (accessed on 1 July 2021).

15. Babushkin O.L. (1981). – Vliianie pogodnykh uslovii na provedenie zimnego vypasa karakuI'skikh ovets v Uzbekistane [The influence of weather conditions on winter pasturing of Karakul sheep in Uzbekistan]. Trudy SANll Goskomgidrometa [Transactions of the Central Asian Research Institute of the State Committee on Hydrology and Meteorology], **83**, 73–77.

16. Lebed L.V., Gandega Y. & Rijks D. (2004). – Impact of agrometeorological information on rangeland and pasture ecology and management. CAgM Report 96, WMO/TD No. 1229. World Meteorological Organization, Geneva, Switzerland, 28 pp. Available at: /library.wmo.int/index.php?lvl=notice_display&id=10931#.Xx_wj54zY2w (accessed on 1 July 2021).

17. Intergovernmental Panel on Climate Change (IPCC) (2014). – Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the IPCC. (Core Writing Team, R.K. Pachauri & L.A. Meyers, eds). IPCC, Geneva, Switzerland, 169 pp. Available at: www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf (accessed on 1 July 2021).

18. Bouman B.A.M., Schapendonk A.H.C.M., Stol W. & Van Kraalingen D.W.G. (1996). – Description of growth model LINGRA as implemented in CGMS. Quantitative Approaches in Systems Analysis No. 7. Wageningen University DLO Research Institute for Agrobiology and Soil Fertility & C.T. de Wit Graduate School in Production Ecology, Wageningen, Netherlands, 93 pp. Available at: edepot.wur.nl/336784 (accessed on 1 July 2021).

19. Kaimowitz D., Mertens B., Wunder S. & Pacheco P. (2004). – Hamburger connection fuels Amazon destruction: cattle ranching and deforestation in Brazil's Amazon. Center for International Forestry Research, Bogor, Indonesia, 10 pp. Available at: www.cifor.org/publications/pdf_files/media/amazon.pdf (accessed on 1 July 2021).

20. World Meteorological Organization (WMO) (2016). – Use of climate predictions to manage risks. WMO-No. 1174. WMO and World Health Organization, Geneva, Switzerland, 46 pp. Available at: library.wmo.int/doc_num.php?explnum_id=3310 (accessed on 1 July 2021).

21. Sivakumar M.V.K., Gommes R. & Baier W. (2000). – Agrometeorology and sustainable agriculture. *Agr. Forest Meteorol*., **103**(1), 11–26. doi:10.1016/S0168-1923(00)00115-5.

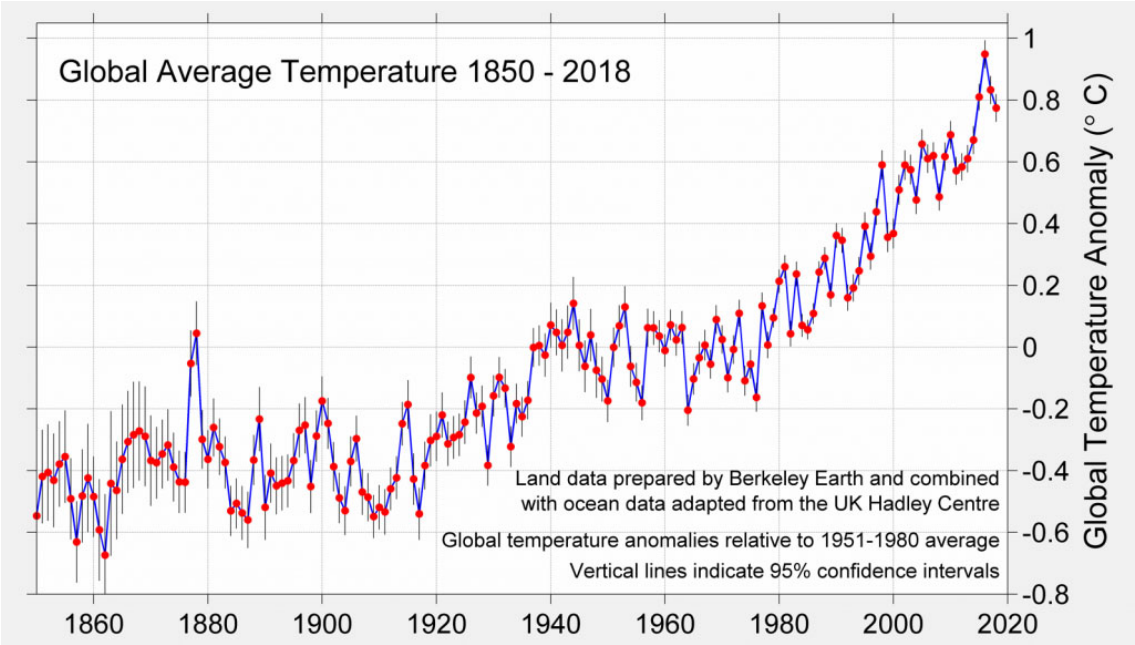

Fig. 1

Change in global average temperature 1850–2018 (7)

Fig. 2

Process of developing climate services (adapted with permission from 20)