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Department:
Agriculture and Rural Development
North West Provincial Government
Republic of South Africa

GLOBAL CLIMATE CHANGE AND AGRICULTURE

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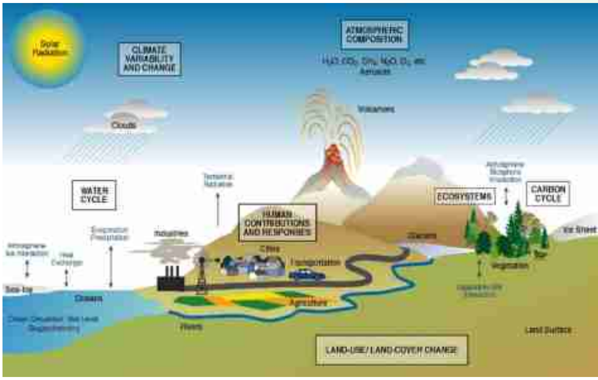
GLOBAL CLIMATE CHANGE AND AGRICULTURE

1. Introduction



The Earth's climate has changed throughout history. From glacial periods (or "ice ages) where ice covered significant portions of the Earth to interglacial periods where ice retreated to the poles or melted entirely - climate has continuously changed.

Scientists have been able to piece together a picture of the Earth's climate dating back to millions of years ago by analysing a number of surrogate, or "proxy", measure of climate such as ice cores, boreholes, tree rings, glacier length, pollen remains, and ocean sediments, and by studying changes in the earth's orbit around the sun.

The ever increasing rise of greenhouse gas emissions is raising the earth's temperature. The consequences include melting glaciers, more erratic precipitation levels, more and more extreme weather events and shifting seasons.

The accelerating pace of climate change combined with global population associated with dwindling household income growth, threatens food security everywhere. As a result climate change has emerged as the most prominent of the current global environmental issues and there is a need to evaluate its impact on agriculture. In this regard, appropriate intervention strategies by extension services are urgently needed than never before.

2. WHAT IS GLOBAL WARMING AND CLIMATE CHANGE?

Global Warming and Climate Change refers to increase in average global temperatures. Natural events and human activities are believed to be contributing to an increase in average global temperatures. This is caused by increases in "greenhouse" gasses such as Carbon dioxide (CO2).

3. DEFINITION OF GREEN HOUSE GASES

Greenhouse gases (GHG) are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and ozone (O3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO2, N2O and CH4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Parties, the sector is called Land Use, Land-use Change and Forestry (LULUCF) whereas for non-Annex I Parties, it is called Land-use Change and Forestry (LUCF). These two definitions are close but not equivalent. Land use, land use change and forest may have an impact on the surface albedo, evapotranspiration, sources and sinks of greenhouse gases, or other properties of the climate system and may thus have a radioactive forcing and/or other impacts on climate, locally or globally.

Data on greenhouse gas emissions are usually estimated according to international methodologies on the basis of national statistics on energy, industrial and agricultural production, waste management and land use, etc.

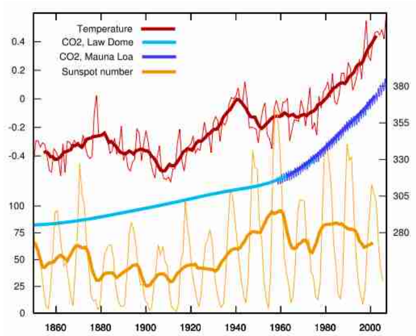
The best known and most widely used methodology is the 1996 Guidelines of the Intergovernmental Panel for Climate Change (IPCC) (see http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm) which is the basis for reporting to the UNFCCC. The latest revision and update of this guideline is 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

4. GASES THAT CONTRIBUTE TO THE GREENHOUSE EFFECT

1. Water vapour

The most abundant greenhouse gas, but importantly, act as a feedback to the climate. Water vapour increase as the Earth's atmosphere warms, but so does the possibility of cloud, and precipitation, making these some of the most important feedback mechanism to the greenhouse effect.

2. Carbon dioxide (CO2)



A minor but very important component of the atmosphere, carbon dioxide is released through process such as respiration and volcanic eruptions and through human activities such as deforestation, land use changes and burning fossil fuels. Humans have increased atmospheric CO2 concentration by a third since the Industrial Revolution began. This is the most important long-lived "forcing" of climate change.

3. Methane

A hydrocarbon gas produced both through natural sources and human activities, including the decomposition of wastes in landfills, agriculture, and especially rice cultivation, as well as ruminant digestion, and manure management associated with domestic livestock. On a molecule-for-molecule basis, methane is a far more active greenhouse gas than carbon dioxide, but also bone which is much less abundant in the atmosphere.

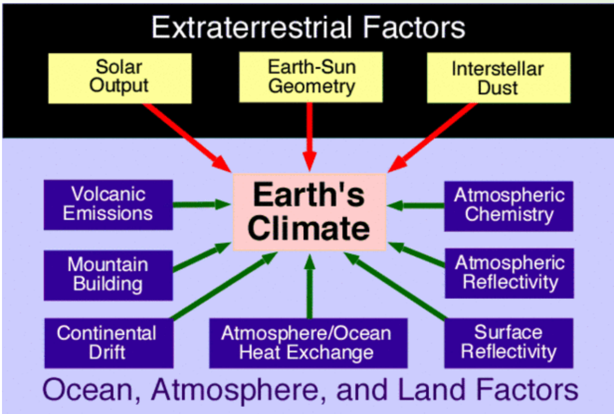
4. Nitrous oxide

A powerful greenhouse gas produced by soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.

5. Chlorofluorocarbons (CFCs)

Synthetic compounds of entirely industrial origin used in number of applications but now largely regulated in production and release to the atmosphere by international agreement

5. CAUSES OF GLOBAL CLIMATE CHANGE



The causes of Global Climate Change can be divided into two:

5.1 EXTRATERRESTRIAL FACTORS

These are the factors influenced by extraterrestrial systems.

5.1.1 Earth-Sun Geometry

Changes in the Earth's Orbit The Milankovitch Theory suggests that normal cyclical variations in three of the Earth's orbital characteristics are probably responsible for some past climatic change. The basic Idea behind this theory assumes that over time these three cyclic events vary the amount of solar radiation that is received on the Earth's surface. The Earth's cyclical variations function in cycles of 100, 000 (eccentricity), 41, 000 (tilt) and 19, 000 to 23, 000 (procession) years.

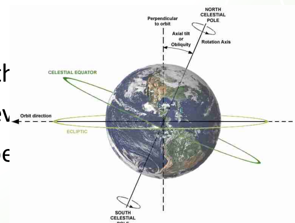
5.1.1.1 The three Cyclical Variations

5.1.1.1.1 Procession

The cyclical variation result from the fact that the Earth rotates on its polar, it wobble like a spinning top changing the orbital timing of the equinoxes and solstices (Figure 2). The effect is known as the procession of the equinox. The procession of the equinox has cycle of approximately 26, 000 years. The Earth is closer to the sun in January (perihelion) and farther away in July (aphelion) at present time.

5.1.1.1.2 Tilt (Obliquity)

The cyclical variation is related to the change in the tilt (obliquity) of th over 41, 000 year period. During the 41, 000 year cycle the tilt can dev 22.5° to 24.5. When the tilt is small there is less climatic variation be winter season in the middle and high altitudes.



5.1.1.1.3 Eccentricity

This controls the shape of the Earth's orbit around the sun. The orbit gradually changes from being elliptical to being nearly circular and then back to elliptical in period of about 100, 000 years. The greater eccentricity of the orbit (i.e. the more elliptical it is), the greater the variation in solar energy received at the top of the atmosphere between the Earth's closest (perihelion) and farthest (aphelion) approach to the sun. The difference in the Earth's distance from the sun between perihelion and aphelion (which is only about 3% is responsible for approximately 7% variation in the amount of solar energy received at the top of the atmosphere. When the distance is at its maximum (9%), are difference in solar energy received is about 20%.

5.1.2. VARIATION IN SOLAR OUTPUT

Until recently, many scientists thought that the sun's output of radiation only varied by a fraction of period over many years. However, measurements made by satellites equipped with radiometers in the 1980s and 1990s suggested that the sun's energy output may be more variable than once was thought. The measurement made during the early 1980s showed 0.1% in the total amount of solar energy reaching the earth over just an 18 month time period. If this trend were to extend over several decades, it could influence global climate.

5.1.3 INTERSTELLAR DUST

Dust is a major factor influencing the earth's climate, as it affects the atmosphere's transparency to incoming solar radiation and outgoing heat. Clouds are the most important element in reflecting solar radiation back into space, and clouds and precipitation depends on the amount of aerosols (small particles) in the atmosphere, including dust thrown up by volcanic eruptions and meteoric dust from space. Some dust particles reduce insolation by direct scattering of sunlight, but cometary particles could cause warming by injecting water into the atmosphere.

5.2.1.1 Aerosol emissions

The volcanic aerosols tend to block sunlight and contribute to short term cooling. Aerosols do not produce long term change because they leave the atmosphere not long after they are emitted.

5.2.1.2 Carbon dioxide

Volcanoes emit carbon dioxide (CO2), a greenhouse gas, which has a warming effect. For about two-third of the last 400 million years, geologic evidence suggests, CO2 levels and temperatures were considerably higher than present. One theory is that volcanic eruptions from rapid sea floor spreading elevated CO2 concentrations, enhancing the greenhouse effect and raising temperatures.

5.2.2 CHANGES IN GREENHOUSE GAS CONCENTRATIONS

The heating or cooling of the earth's surface can cause changes in greenhouse gas concentrations e.g. when global temperatures become warmer, carbon dioxide is released from the ocean. When changes in the Earth's orbit trigger a warm or interglacial, increasing concentration of carbon dioxide may amplify the warming by enhancing the greenhouse effect.

5.2.3 Changes in ocean currents

The heating or the cooling of the Earth's surface can cause changes in ocean currents. Because ocean currents play a significant role in distributing heat around the Earth, changes in these currents can bring about significant changes in climate from region to region.

6. GLOBAL IMPACT OF GLOBAL WARMING AND CLIMATE CHANGE

6.1 Rapid changes in global temperature

Increased greenhouse gases and the greenhouse effect is feared to contribute to an overall warming of the Earth's climate leading to a global warming- even though some region may experience cooling, or wetter weather, while the temperature of the planet on average would rise. According to Global IPCC, temperatures are expected to increase between 1.1 and 1.8° C, whereas in a 'business as usual' scenario global temperatures are expected to increase between 4-6,4°C.

6.2 Extreme Weather Patterns

The warming of the climate will lead to more extreme weather patterns Such as:

- More hurricane and droughts
- Longer spells of dry or intense rain
- Severe colder weather in the areas of the world
- Retreating glaciers could lead to water scarcity

6.3 Super-storms

Global warming may spawn more super-storms. The civi unrest may also increase because of weather-related events. Four billion people are vulnerable now and 500 million are now at extreme risk. Weather-related disasters bring hunger diseases, poverty and lost livelihoods. They pose a threat to social and political stability.

6.4 Ecosystem Impacts

With global warming on the increase and species habitats on decrease, the chances for various ecosystems to adapt naturally are diminishing. It has been pointed out that the rates of extinction of animal and plant species, and the temperature changes around the world since the industrial revolution, have been significantly different to normal expectations.

6.5 Rising Sea Levels

Water expands when heated, and sea levels are expected to rise due toclimate change. Rising sea levels will also result as the polar caps begin to melt. According to Global IPCC, sea levels are expected to rise of up to 0.38m (conservative estimate).

6.6 Increases in Pests and Diseases

An increase in pests and diseases is also feared. According to the report (2009) released by the former UN secretary general's think-tank, the Global Humanitarian Forum, climate change is already responsible for 300,000 deaths a year and is affecting 300 million people.

6.7 Failing Agricultural Output; Increase in World Hunger

Drought and desertification are the starting to spread and intensify in some parts of the world already. If some of this get worse, it is likely that the poorest regions and people are likely to suffer the most, as they would have the least resources at hand to deal with the effects.

Climate change is expected to have the most severe impacts on water supplies. Shortages in future are likely to threaten food production, reduce sanitation, hinders economic development and damage ecosystems.

The populations most at risk it says are in sub-Saharan Africa, the Middle East, south Asia and the small island states of the Pacific.

6.8 Economic Impacts

The same report released by former UN secretary general, the economic losses due to climate change today amount to more than $125bn a year- more than all the present world aid. By 2030, the report says, climate change could cost $600bn a year. If emissions are not brought under control, within 25years, the report states- 310 million more will suffer adverse health consequences related to temperature increases, 20 million more people will fall into poverty, and 75 million extra people will be displaced by climate change.

7. THE IMPACT OF GLOBAL CLIMATE CHANGE ON SOUTH AFRICAN AGRICULTURE

7.1 Temperature Increases

For the Savanna and Grassland areas of South Africa, Tadross and Archer (2009) show for selected stations in Gauteng, Limpopo and Mpumalanga provinces consistent increases in temperatures as well as increases in potential evapotranspiration (PET) and a zero to negative potential moisture index (PM) (with the exception of stations further east). According to Global IPCC, temperatures are expected to increase between 1.1 and 1.8° C, whereas in a 'business as usual' scenario global temperatures are expected to increase between 4-6,4°C.

7.2 Tree-grass ratio

Davis's research raises interesting questions regarding possible significant alterations in the tree-grass ratio – one indicates possible conversion, given very particular assumptions, of the Skukuza and Satara savanna systems to open grassland-savanna.

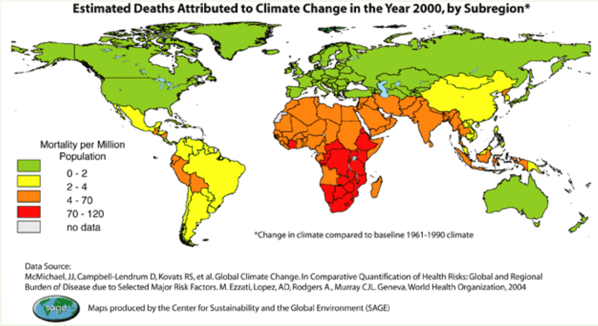
7.3 Desertification

Climate change may critically impact on existing process of desertification if higher frequency of dry spells or lower rainfall season such as that projected for western parts of Southern Africa occur.

In an area under pressure from overgrazing, for example, or over or inappropriate use of water, thus resulting in desertification process, climate change can act as an additional pressure or stressor that can amplify such a phenomenon.

Climate change can further exacerbate desertification process through changes in temperature, precipitation, solar isolation and winds.

7.4 Health



According to Tadross and Archer (2009) observation, climate change on wind, for example, that, changes in wind dynamics may have implications for coal mining operations in the arid and semiarid regions of dynamic has implications for mining personnel and local communities, e.g. more frequent use of dust filters, and dust inhalational problems in environmental health, but it also complicates the process of addressing desertification through reversing or restoring local ecology after possible negative ecological impacts of mines, particularly if changes in wind dynamics are coupled with a higher probability of desiccation.

7.5 Anthropogenic biomass burning

Anthropogenic biomass burning, a key process in land degradation and desertification under particular circumstances, may have critical implication for atmospheric emissions. For example, Mead et al. (2008), measured methyl halide emissions from domestic biomass burning sources on African continent. The authors observed a clear increase in such emissions, suggesting that such an increase could significantly compromise a significant component of the overall global methyl halide budget. Methyl halide comprises a significant source of atmospheric inorganic halogen compounds, which in turn affect many stratospheric and tropospheric chemical processes for example decreasing stratospheric ozone.

7.6 Anthropogenic disturbances of the land surface

Anthropogenic disturbances of the land surface may result in wind erosion, increasing, for example, atmospheric dust loads.

7.7 Irrigated agriculture in drylands

Irrigated agriculture in drylands may critically impact on surface conditions. In the semiarid northern Sandveld in South Africa, for example, an area of high ecological significance at the transition between two internationally recognised biomes, the land surface has been substantively transformed largely by clearing for cultivation by the presence of intensive commercial agriculture.

The provincial nature conservation agency for the area, Cape Nature, indicates that more than half the natural habitat in the area has already been transformed, with clear implication for natural habitat retention, water security and site vulnerability to climate change (Archer et al.2009).

7.8 Changes in land use/cover

Changes in land use/cover change and associated degradation and desertification can play a key role in climate feedbacks and microclimate modification. Over southern Africa, going from a natural vegetation state to a land surface affected by anthropogenic disturbance such as clearing resulted in high-pressure circulation anomalies that can result in drier condition at particular times of the year.

7.9 Biodiversity Loss

Desertification is associated with biodiversity loss and contributes to global climate change through the loss of carbon sequestration capacity and an increase in land-surface albedo.

Biological diversity is involved in most services provided by dry-land ecosystems and is adversely affected by desertification. Most important, vegetation and its diversity of physical structure are instrumental in soil conservation and in the regulation of rainfall infiltration, surface runoff, and local climate.

Different plant species produce physically and chemically different litter components and, together with a diverse community of micro- and macro-decomposers, contribute to soil formation and nutrient cycling.

The diversity of vegetation supports both livestock and wildlife. All plants support primary production that ultimately provides food, fibre, and fuel-wood and that sequesters carbon, thus regulating global climate. Excessive exploitation of vegetation leads to losses in primary production and hence also reduced carbon sequestration. It is the disruption of the interlinked services jointly provided by dry-land plant biodiversity that is a key a key trigger for desertification and its various manifestations, including the loss of habitats for biodiversity.

7.10 Elevated Atmospheric CO2

Plants exposed to elevated atmospheric CO2 at any one time, faster-growing species and their will out-perform the slower-growing species and their CO2-response will be greater, growth and development is not synchronised among species. These differences can ultimately lead to changes in population dynamics (Reekie and Bazzaz, 1991, Morse and Bazzaz 1994) and community composition (Potvin and Vassuer 1997, Navas 1998).

8. BROADER MEASURES TO BE TAKEN BY NATIONS

1. Reduction of Greenhouse Gas Emissions

2. Burning of Fossil Fuels

The reliance on fossil energy can be reduced by using environmentally friendly alternative technologies.

3. Transportation

There should be reductions of cars on roads, through legislation, and use of public transport.

4. Deforestation

The cutting down of trees should be minimized by individuals/communities or nations. The greening of the environment should be encouraged.

5. Energy Conservation

The alternative environmentally friendly technologies such as the use of fluorescent bulbs, solar water heating/geyser blanket should be encouraged. Switch off lights where necessary.

6. National/Intergovernmental Policies

7. Waste Reduction

Reduce/Re-use/Recycle/Repair/Rehabilitate

8. Land-Use

The conversion of natural prairie to farm-land should be minimized or discouraged.

9. HOW SHOULD SOUTH AFRICA RESPOND WITHIN AGRICULTURE

1. There is a need for a need for South Africa to respond in the following manner:

· There is a need for integrated ecological-social approach.There is a need for integrated research, focusing, for example, on the strategies that simultaneously support livelihoods and ecological management (Raynolds et al. 2007)

· Increased recognition of slowly evolving condition.Sectoral responses in the area of biodiversity tend to focus on ecosystem health and ecosystem services, thus a climate change response in the conservation sector, could again, additionally focus on restoring ecosystem services lost under climate change. Sectoral response in the area of water could also focus on improved water use efficiency and better coordination between water users, given projected future water shortages. Such a strategy would simultaneously address the issue of anthropogenic transformation of the land surface in the dry-land areas.

· Recognition of non-linear process.

· Increased recognition of cross-scale interaction.A review of the sectoral policy response should indicate that most are not restricted to the sector in which they have been suggested. A purely sectoral approach, whether targeting climate change, desertification, or amply addressing both phenomena, would be flawed and limited in its ability to address cross-sectoral and cross-scale processes (Reynolds et al. 2007) for example, the protection and restoration of ecosystem services. As a result, a multi-sectoral approach development to strategy development is critical is critical.

- Increased value being placed on local environmental knowledge.Again, whether in the area of climate change, desertification or, preferably, considering strategies that address more than one of such challenges, it is essential to root understanding and design of response within what stakeholders in dry-land areas are currently doing, for example (Archer et al 2008), further emphasising the DDP's (Dry-land Development Paradigm) focus on local environmental knowledge (Reynold et al 2007). From the communal farmer to the mining consortium in a dry-land area, dry-land stakeholders frequently have substantive experience in responding to the challenges of climate risk (whether short term or long term climate variability and/or desertification. A successful response strategy will build on and where necessary add value to what is already planned or underway.

2. Adaptation to climate changes

The Farmers strategies for adapting to climate changes should include the following:

- Water and soil management and agro-forestry techniques
- Improved variety.
- Good application of cropping techniques- better application of technology and following advice provided by the extension service.
- Funding mechanism should be available for vulnerable farmers to adapt to climate change.
- Composting, mulching and placing animals in the field.
- Reforestation, done individually or communally.
- Diversification of crops and activities.
- Protecting the environment and activities.
- Awareness campaigns.

affected. The Extension and other service providers become familiar with the issue and with the range of possible responses, the sooner we will be able to ingrate climate change into our programming, as one of the many factors that farmers should take into account when making management decisions.

The major actions to be undertaken are (1) promoting ways of adapting to climate change, (2) developing new ways of adapting, and (3) creating a unit research into climate, development and societies.

(1) Promoting ways of adapting to climate change

The adoption of adaptation measures encounters financial constraints (poverty of the producers, lack of credit, material constraints (lack of equipment and working material, lack of input for the application of adaptation measures, etc.) and lack of knowledge (no mastery of the adaptation techniques, lack of information about adaptation techniques, etc.).

2) Developing new ways of adapting

The State must favour the participative development of technologies adapted to the agro-ecological and socio-economic conditions. In addition, it must reinforce the link between research and development for a better transfer of adaptation measures to farmers.

(3) Creating a unit for research into climate, development and societies

The climatic changes are now concerns and for this reason national research practically does not have available results to face them. Therefore research programmes should be developed on the phenomenon and activities carried out in the framework of a specialized unit in order to provide as much information as possible.

CONCLUSION

The scientific evidence leaves little room for doubt that our climate is changing, and that agriculture will be affected. The Extension and other service providers become familiar with the issue and with the range of possible responses, the sooner we will be able to ingrate climate change into our programming, as one of the many factors that farmers should take into account when making management decisions.

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References

- *Michael Pidwimy- Atmospheric science and Environmental monitoring*
- *U.S. EPA- Climate Change- Science*
- *Global Issues- Social, Political, Economic, and Environmental Issues That Affect Us All- Climate Change and Global Warming*
- *Propulsion Laboratory- Institute of Technology- Global Climate Change*
- *Naomi Oreskas, 2004 Beyond the Ivory Tower: The Scientific Consensus on Climate*
- *Wikipedia- Effects of Global Warming*
- *David Pratt- Earth's Meteoric Veil*
- *African Journal of Range & Forage Science 2008, 26(3) 127-131.*
- *African Journal of Range & Forage Science, Volume 19(2), 2002.*
- *African Journal of Range & Forage Science, Volume 14 No. 3 of Dec. 1997.*
- *Millenium Ecosystem Assessment, 2005. Ecosystem and Human Well-being: Desertification Synthesis. World Resources institute, Washington, DC.*
- *International Food Policy Research Institute – Food Policy Report- Climate Change – Impact on Agriculture and Costs of Adaptation.*
- *Climate Change and Agriculture: Challenges and Opportunities for outreach- University of Vermont Extension, Centre for Sustainable Agriculture.*
- *Scientific American – 1994.*
- *Agricultural Disaster Risk Management – 25-26 May 2010, MAP WORKSHOP by Seneo Madika – Agriculture, Forestry & Fisheries.*

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