United Nations Environment Programme

Advanced ECOSOC

TOPICS: Effects of Ocean Acidification on Coastal Communities, Urban Sprawl in Sub-Saharan Africa

CHAIRS: Marina Wasden, Dashiell Clark

LAIMUN XXVIII

December 3-4

Letter from the Secretaries-General

Dear Delegates,

On behalf of our entire staff, it is our pleasure to welcome you to Session XXVIII of the Los Angeles Invitational Model United Nations (LAIMUN) conference. LAIMUN XXVIII will take place on Saturday, December 3 and Sunday, December 4 of 2022 at the Mira Costa High School (MCHS) campus.

Our staff, composed of over 100 MCHS students, has been working tirelessly to make your debate experience the best it can be. You will find your dais members to be knowledgeable about the issues being debated and MUN procedure. We pride ourselves in hosting a conference that is educational and engaging, and we hope you take advantage of that as you prepare and debate.

At LAIMUN, we value thorough research and preparation. We ask that delegates write position papers following these directions. The deadline to submit position papers to be considered for Committee and Research Awards is Friday, November 25 at 11:59 PM PT. The deadline to submit to be considered for Committee Awards is Thursday, December 1 at 11:59 PM PT.

We also encourage all delegates to read the LAIMUN Rules of Procedure for conference-specific information and as a reminder of points and motions that can be made during committee.

Feel free to reach out to our staff with any questions or concerns you may have. Delegates can find their chairs' contact information next to their committee profile and the Secretariat's email addresses on the staff page. Any member of the LAIMUN staff will be happy to assist you.

We look forward to seeing you in December!

Sincerely,

Allyssa Lessinger and Brady Stephens
Secretaries-General, LAIMUN XXVIII
secretarygeneral@mchsmun.org

Introduction to the USG

Hello Delegates! My name is Ava Reyes and I am the Under-Secretary General of ECOSOC. This is my fourth year in the Mira Costa Model UN program and I am beyond thrilled to welcome you to LAIMUN XXVIII!

I'm so excited to see the various diplomatic strategies of debate and topical discussions concerning the very real and pressing issues we encounter on a global scale. Our chairs intend to hold the delegates to high standards of research, diplomacy, speeches, and solutions.

As you may know, we have a strict no pre-written resolutions policy—resolutions may only be worked on at your chair's discretion. Please verify that your work is authentic to ensure all delegates experience a fair and relatively accurate depiction of a United Nations conference.

The Mira Costa Model UN program has provided me with incredible opportunities and lasting memories; I hope that LAIMUN XXVIII will be a memorable experience for you as well! Mira Costa MUN strives to ensure that delegates gain knowledge, confidence, speaking skills, and most importantly, a new understanding of international relations and the current events around us that affect the way we live today. All LAIMUN XXVIII staff have been hard at work to provide the best experience for everyone in attendance and we wish you the best of luck throughout your preparation!

If you have any questions or concerns, please don't hesitate to reach out to ecosoc@mchsmun.org or any other secretariat member. Looking forward to seeing you in December!

Regards,

Allyssa Lessinger and Brady Stephens
Secretaries-General

Ava Reyes
Under-Secretary General

Introduction to the Dias

Hello Delegates,

My name is Marina Wasden, and I am so excited to be your chair for UNEP Advanced. I am currently a senior at Mira Costa, and this is my 4th year in the Model UN program. My favorite MUN memories include traveling to New York and seeing the Metropolitan Museum of Art, as well as hosting LAIMUN last year. This will be my second year chairing LAIMUN, and I am looking forward to an engaging and fulfilling debate. Inside and outside of Model UN, I am very passionate about environmental science. Over the summer, I participated in an internship involving habitat restoration in the Ballona Wetlands and volunteered at my community's botanical garden. I also love to try new restaurants and review their dishes. I am vegetarian, so most of the restaurants that I visit are vegan or vegetarian. My current favorites are El Cocinero in the Valley, as well as Monty's Good Burger in Culver City. When I am not visiting restaurants, I work at a restaurant called Health Nut in Manhattan Beach. We serve really good salads, sandwiches, wraps, and teas. My favorite is the tortilla wrap with avocado and our famous house dressing. I am also very passionate about my Spotify playlists. I enjoy making new playlists based on my moods and moods that I think that I may feel in the future. I spend lots of time adding and removing songs from my various playlists. My favorite artists right now are Taylor Swift, Still Woozy, Gus Dapperton, and Small Forward. Please reach out to us at unep.adv.laimun.xxviii@gmail.com if you have any questions about debate.

Best– Marina Wasden

Hello delegates!

My name is Dashiell Clark, but you can call me anytime. I'm kidding, call me honorable chair. I am currently a junior at Mira Costa and I have been in the MUN program for 3 years. Some things I like are lacrosse, history, fly fishing, dogs, and magnets. If you want to know more about my interests, I have been playing lacrosse since my freshman year, and I am a member of the Mira Costa Lacrosse varsity team. If you are a rivaling school, beware, since I'm on the field (joke). I grew up in Arkansas when I was young, and since then, I have fallen in love with fly fishing. I have been fly fishing for about 9 years now, but I don't go very often when I'm in California. I also have 4 dogs; their names are Sunshine, Trixie, Winston, and Frankie. If you have any dog related questions during committee this should give you an idea of who you might wanna talk to. Lastly, I am a Sopranos enjoyer so come up and talk to me if, and only if, you have watched the show. A question that I am often asked is "why did you choose to chair a UNEP committee?" to which I simply say that I love the environment. Hiking on trails, camping, swimming in the ocean, among other things have made me fall in love with the environment and hate what people have done to it. I feel as if my entire life has been leading up to this moment so as you can tell I am very enthusiastic! Can't wait to be your superb and satisfying chair!

Sincerely,

Dashiell Clark

Committee Description

The United Nations Environmental Programme was established in May 1985 by Governing Council Decision 13/2, serving as an organ of the United Nations Environment Assembly. UNEP has been the largest global authority that sets environmental agenda, while ensuring the proper implementation of the environmental aspect of sustainable development. UNEP's actions can be specifically traced to the Sustainable Development Goals (SDGs) in which an emphasis is placed on environmental policy.

The meetings of UNEP are coordinated and directed by the Committee of Permanent Representatives (CPR). The Committee of Permanent Representatives within the UN Environmental Assembly had strengthening measures recently implemented to ensure the proper management of the UN Environmental Programme. These various measures include contributing to the preparation of the agenda of the UNEA governing body, providing substantial advice to the UNEA on policy matters, preparing decisions for adoption by the UNEA and overseeing the implementation of any resolutions or recommendations. Moreover, UNEP covers subprograms aimed at climate action, nature and science policy, environmental legislation, and chemicals and pollution action.

The UNEP's overall mission intends to provide leadership and establish international partnerships in providing support for the environment through inspiring, enabling and informing nations of ways to improve policy without having to compromise the future of new generations.

Overall, UNEP works with 193 member states as well as businesses and other major groups to create multilateral environmental agreements and research agencies.

Topic A: Effects of Ocean Acidification on Coastal Communities

I. Background

The United Nations Educational, Scientific, and Cultural Organization defines ocean acidification as the process through which "the absorption of carbon dioxide from the atmosphere changes the chemical balance of the seawater, resulting in increased carbonic acid concentrations, causing reduced pH levels, which means increasing acidity of seawater".[1] Ocean acidification likely began in the 1800s, as human activity increased due to the Industrial Revolution. The amount of atmospheric carbon dioxide has increased 40% from pre-industrial levels to current levels, which is ten times faster than any other period in Earth's history. More recently, the increase in carbon dioxide emissions can be attributed to the combustion of fossil fuels such as coal, oil, and gas, as well as deforestation. The combustion of fossil fuels releases carbon that was previously sequestered into the atmosphere, and has resulted in the highest carbon dioxide concentrations of the past 800,000 years. Currently, the volume of carbon dioxide emissions produced has surpassed nature's capacity to remove the carbon dioxide from the atmosphere.[2] This results in about 30 percent of carbon dioxide released being absorbed into the ocean, which decreases the pH. When the carbon dioxide is absorbed by the ocean, the concentration of hydrogen ions increases due to a series of chemical reactions. This increase of

[1]Isensee, Kirsten, and Luis Valdes. “GSDR 2015 Brief Ocean Acidification.” *Sustainabledevelopment.un.org*, 2015, https://sustainabledevelopment.un.org/content/documents/5844Ocean%20acidification.pdf.
[2]Osterloff, Emily. “What Is Ocean Acidification?” *Natural History Museum*, https://www.nhm.ac.uk/discover/what-is-ocean-acidification.html.

hydrogen ions is what causes a reduced pH in the ocean, which causes the ocean to become more acidic.[3] Since about 1850, the pH of the ocean has been reduced by 0.1 units, from 8.2 to 8.1, corresponding with a 26% increase in ocean acidity.[4] The steady fall in pH of Earth's ocean, as well as the increasing rate of acidity, reflects the need for action on this pressing issue.

Ocean acidification can also be exacerbated by issues aside from atmospheric carbon dioxide absorption. When fossil fuels are combusted, water and carbon dioxide are released as byproducts. However, nitrogen oxides and sulfur dioxide are also released. These compounds are acid-forming, and as they fall back to Earth's surface, they land in ocean surface waters, or become acid rain. Ocean acidification can also become amplified due to excess nutrients in streams. Many farmers utilize nitrogen and phosphorus in their fertilizers in order to promote plant growth. Other sources of excess nutrients include sewage, nitrogen oxide air pollution, and wastewater treatment plant pollutants. Erosion and rainfall can wash the nitrogen and phosphorus used by farmers into rivers and the ocean. These nutrients promote the growth of algae, which eventually dies off. When the algae dies off, the decomposing plant matter adds carbon dioxide into the water. This causes acidification without atmospheric carbon dioxide.[5]

Ocean acidification has numerous effects on the marine environment as well as humans. However, the effects of ocean acidification will differ depending on the climate and location of affected regions. Upwelling regions as well as polar seas will likely acidify more quickly

[3]US Department of Commerce. “What Is Ocean Acidification?” *NOAA's National Ocean Service*, 1 Aug. 2012, https://oceanservice.noaa.gov/facts/acidification.html.
[4] “Ocean Acidification and Its Effects.” *Coastadapt*, 27 Apr. 2017, https://coastadapt.com.au/ocean-acidification-and-its-effects.
[5]“Understanding the Science of Ocean and Coastal Acidification.” EPA, Environmental Protection Agency, 3 June 2022, http://www.epa.gov/ocean-acidification/understanding-science-ocean-and-coastal-acidification#ocean.

compared to tropical and temperate regions.[6] As a result, policymakers must consider the urgent action regarding more acidified surface waters.

One effect of ocean acidification is a loss of carbonate in seawater. When excess CO2 results in an increase in the concentration of hydrogen ions, carbonate is reduced. Carbonate is reduced because hydrogen ions experience a great attraction to carbonate. However, when hydrogen ions and carbonate bond, a bicarbonate ion is formed. Marine organisms are unable to extract carbonate from bicarbonate ions, which prevents them from forming new shells.[7] Although some organisms are able to overcome the lack of carbonate, forming a new skeleton now takes a greater amount of energy. This can interfere with the organism's ability to participate in other important activities such as reproduction. If ocean waters become extremely acidic, the abundance of hydrogen ions may begin to break down calcium carbonate molecules, which dissolves the already formed shells of organisms. Shell forming organisms that may be affected due to a lack of carbonate in acidic waters include corals, oysters, clams, and mussels.[8] A lack of carbonate also affects coastal communities greatly. As shelled organisms are unable to replenish their populations, economies surrounding fisheries and tourism will decline greatly. Furthermore, consumers will be effected as food prices rise in order to cope with the loss of shell forming organisms

[6] "Ocean Acidification and Its Effects." Coastadapt, 27 Apr. 2017, https://coastadapt.com.au/ocean-acidification-and-its-effects.
[7]The Ocean Portal Team, and Jennifer Bennett. "Ocean Acidification." Smithsonian Ocean, 20 June 2019, https://ocean.si.edu/ocean-life/invertebrates/ocean-acidification.
[8]"Ocean Acidification." The U.S. Integrated Ocean Observing System (IOOS), 15 July 2020, https://ioos.noaa.gov/project/ocean-acidification/.

Another negative effect of ocean acidification is the disturbance that food webs and coastal ecosystems will endure. As carbonate is reduced in increasingly acidic oceans, the levels of shell forming organisms such as clams, oysters, and sea urchins will decline. However, as the population of these smaller organisms declines, the abundance of the larger animals that feed on shell forming organisms will also decline. By the end of the century, it is estimated that the United States alone will suffer from consumer losses of about $480 million due to the effects of ocean and coastal acidification on shellfish. This causes a ripple effect throughout the food web, which can eventually begin to alter the composition of marine life. The severity of this issue will likely go unnoticed due to the complexity of ocean food webs as well as other environmental issues, which hides the extent to which ocean acidification harms food webs.[9]

Ocean acidification can also severely affect a region's ecosystem services. Ecosystems services are defined as the benefits to humans that healthy ecosystems and the natural ecosystem are able to provide.[10] In regards to the ocean, ecosystem services can include aquaculture and fishery harvests, storm protection along the coast, cultural identity, and tourism.[11] However, ocean acidification severely disturbs all of the ecosystem services. In regards to fishery harvests, a lack of shell forming organisms will contribute to a decline in larger species, therefore reducing the yields of fisheries. Furthermore, a decline in coral reefs caused by a lack of carbonate will

[9] "Effects of Ocean and Coastal Acidification on Ecosystems." *EPA*, Environmental Protection Agency, 7 Mar. 2022, https://www.epa.gov/ocean-acidification/effects-ocean-and-coastal-acidification-ecosystems.
[10]The National Wildlife Federation. "Ecosystem Services." National Wildlife Federation, 2022, https://www.nwf.org/Educational-Resources/Wildlife-Guide/Understanding-Conservation/Ecosystem-Services.
[11]Cooley, Sarah, and Scott Doney. "Ocean Acidification's Potential to Alter Global Marine Ecosystem Services: Oceanography." Ocean Acidification's Potential to Alter Global Marine Ecosystem Services | Oceanography, 2 Oct. 2015, https://tos.org/oceanography/article/ocean-acidifications-potential-to-alter-global-marine-ecosystem-service.

reduce storm protection along the coast, thus contributing to larger amounts of damage following natural disasters. For many, cultural identity is based off of food eaten and activities performed, many of which will become unavailable if ocean acidification is allowed to continue at its current pace.

Overall, the effects of ocean acidification are already being seen across the world, and strong action must be taken in order to reduce further damage toward coral reefs as well as shellfish supplies.

II. United Nations Involvement

The United Nations has established numerous resolutions and meetings designed to reduce the impact of ocean acidification on marine life as well as coastal communities. The 1982 United Nations Convention on the Law of the Sea (UNCLOS) is an agreement that encourages nation to regulate carbon emissions, which would also reduce ocean acidification. Furthermore, the UNCLOS also has provisions that concern the preservation and protection of the marine environment, as well as the conservation of marine resources.[12] However, the UNCLOS could be utilized to foster greater action and change regarding ocean acidification, as there are currently not international agreements designed to combat ocean acidification. Current agreements are commonly sectoral and restricted in regards to addressing ocean acidification and eventually minimizing the issue.

[12] Harrould‐Kolieb, Ellycia R. "The UN Convention on the Law of the Sea: A Governing Framework for Ocean Acidification?" *Review of European, Comparative & International Environmental Law*, vol. 29, no. 2, 2020, pp. 257–270., https://doi.org/10.1111/reel.12321.

In 2013, the United Nations also held an informal Consultative Process on the oceans. This four day long meeting is designed to identify areas where more cooperation and coordination on issues relating to the ocean is needed.[13] The Consultative Process allows nations to discuss the increasing hardships caused by ocean acidification, as well as the technical and scientific aspects of ocean acidification. Scientists and researchers also gave presentations on the process of ocean acidification, as well as activities to combat its impacts. Finally, nations also discussed the lack of global international instruments designed to combat ocean acidification.

The United Nations also aims to combat ocean acidification through Sustainable Development Goal (SDG) fourteen, which emphasizes conserving and sustainably using the ocean and its resources. This SDG acknowledges the extent to which coastlines, food, and drinking water is provided and regulated by the ocean. Furthermore, SDG fourteen recognizes the deterioration that ocean acidification causes in regards to the functioning of ecosystems as well as marine biodiversity.[14] It also encourages the sustainable management of the ocean and its resources through regulations regarding ocean acidification, marine pollution, and ocean acidification.

The United Nations also hosted an Ocean Conference from June 27-July 1, 2022 in Lisbon, Portugal. The conference was co-hosted by the Governments of Kenya and Portugal, and aimd to discuss the issues in society that were exposed due to the Covid-19 pandemic. The

[13]"UN General Assembly Set to Explore Impacts of Ocean Acidification | | UN News." United Nations, United Nations, 17 June 2013, https://news.un.org/en/story/2013/06/442472-un-general-assembly-set-explore-impacts-ocean-acidification.

[14] "Oceans - United Nations Sustainable Development." *United Nations*, United Nations, https://www.un.org/sustainabledevelopment/oceans/.

conference also aimed to discuss the major structural transformation and common solutions that must be utilized in order to protect the oceans. In order to encourage action, the Conference will motivate new, science-based solutions that will allow for more effective global ocean action.[15]

Although the United Nations has hosted many conferences, and encouraged ocean protection through the UNCLOS as well as the SDGs, a lack of international measures regarding ocean acidification is preventing much needed action from occurring.

III. Topics to Consider

A. Carbon Emissions

There are many natural and anthropogenic sources of carbon emissions, however, the anthropogenic sources are the greatest contributor to ocean acidification. Anthropogenic sources of carbon dioxide emissions can include deforestation, fossil fuel combustion, as well as cement production. About 87% of anthropogenic carbon dioxide emissions are caused by the burning of fossil fuels, while deforestation causes about 9%.[16] Although natural emissions contribute more carbon dioxide to the atmosphere, anthropogenic emissions are the greater issue, as they disrupt the natural balance of carbon dioxide in the atmosphere. While the natural carbon dioxide emissions are absorbed by carbon sinks, the anthropogenic emissions are absorbed by the ocean in amounts large enough to disrupt the ocean's chemistry, which causes ocean acidification. If carbon dioxide emissions continue at the same rate, the surface waters of the ocean could lower

[15] "2022 UN Ocean Conference." *United Nations*, United Nations, https://www.un.org/en/conferences/ocean2022.
[16] "Main Sources of Carbon Dioxide Emissions: CO2 Human Emissions." *Main Sources of Carbon Dioxide Emissions | CO2 Human Emissions*, 13 Dec. 2017, https://www.che-project.eu/news/main-sources-carbon-dioxide-emissions.

to a pH of about 7.8, which was last seen in the Miocene era.[17] In order to effectively combat ocean acidification, nations must consider the impact of their own carbon emissions, as well as those of other nations.

B. Coral Reefs

As ocean acidification continues, coral reefs will be placed under great stress. Corals must utilize aragonite (a form of calcium carbonate) in order to build and thicken their skeletons, so the increase in hydrogen ions and decrease in carbonate due to ocean acidification severely impedes their ability to grow. Scientists at the Woods Hole Oceanographic Institution have found that ocean acidification specifically harms the thickening process of the coral skeletons.[18] The corals are still able to grow upwards, but are unable to form enough aragonite crystals to properly thicken their skeletons. This decreases the density of the coral skeletons, which makes them more prone to breakage. A decrease in coral skeleton density can cause great harm, as entire coral reefs are more vulnerable to damage from eroding organisms and waves. Furthermore, reefs are already under a great amount of stress due to warmer ocean temperatures as well as rising sea levels. Paired with ocean acidification, coral reefs will see a severe decline in health and size. Some effects of ocean acidification on coral reefs are already being seen, as the Great Barrier Reef in Australia has suffered from a 14% decrease in coral growth since 1990, which is the greatest loss seen in the last 400 years.[19] The impact of ocean acidification on coral

[17]"Ocean Acidification." National Oceanic and Atmospheric Administration, 1 Apr. 2020, https://www.noaa.gov/education/resource-collections/ocean-coasts/ocean-acidification.
[18] "Scientists Pinpoint How Ocean Acidification Weakens Coral Reefs." *Woods Hole Oceanographic Institution*, 29 Jan. 2018, https://www.whoi.edu/press-room/news-release/scientists-identify-how-ocean-acidification-weakens-coral-skeletons/.
[19] "Effects of Ocean Acidification on Corals." *Oceana USA*, https://usa.oceana.org/effects-ocean-acidification-corals/.

reefs must be fought, as coral reefs provide over 500 million people with food, income, and protection.[20]

C. Tourism

Ocean acidification has the power to severely harm nations that have an economy based on tourism. When oceans acidify, coral reefs are unable to absorb enough carbonate to properly thicken their skeletons. Eventually, this leads to a loss of coral reefs, as they are unable to regenerate quickly enough to combat the erosion that they face. This can have severe consequences for coastal communities, as coral reefs hold an economic value of $36 billion per year, with over 70 million trips annually visiting coral reefs.[21] Without coral reefs, many aspects of coastal communities will begin to suffer economically, as those working in hospitality and tourism will be left without jobs. Ocean acidification can also discourage tourism due to its ability to promote harmful algal blooms. When oceans experience low oxygen and high nutrient levels, along with acidification, algal blooms occur. In some cases, the algae coverage can become thick enough to prevent aquatic plants from receiving sunlight necessary for photosynthesis. These harmful algal blooms also affect humans, as many produce toxins that can kill animals and harm humans. Symptoms caused by harmful algal blooms can include skin and eye irritation, as well as shortness of breath.[22] Overall, ocean acidification has the power to

[20]"Coral Reef Ecosystems." *National Oceanic and Atmospheric Administration*, https://www.noaa.gov/education/resource-collections/marine-life/coral-reef-ecosystems.
[21] "Coral Reef Tourism: Data Highlights Conservation Opportunity for Industry." *Mapping Ocean Wealth*, https://oceanwealth.org/coral-reef-tourism-data-highlights-conservation-opportunity-for-industry/.
[22] Montgomery, Madison. "What You Need to Know about Ocean Acidification and How It Affects You." *One Green Planet*, One Green Planet, 17 Dec. 2014, https://www.onegreenplanet.org/animalsandnature/what-you-need-to-know-about-ocean-acidification-and-how-it-affects-you/.

severely disrupt tourism due to its negative effect on coral reefs, as well as its ability to cause harmful algal blooms.

D. Impact on Fisheries

Fisheries will also suffer as a result of increasing ocean acidification. Organisms such as oysters, plankton, and shellfish will be unable to grow shells due to a loss of access to carbonate in more acidic waters. In some cases, the water may grow acidic enough to dissolve preexisting shells. The loss of smaller organisms such as plankton is particularly worrying, as they are the primary food source for many larger animals like salmon and sea birds. Without the plankton, the populations of these organisms will drop, which will decrease the harvests of fisheries. This can have a drastic impact on food access, as over 1 billion people globally rely on fisheries for their primary source of protein.[23] At times, fish are directly impacted by the effects of ocean acidification. A Stony Brook University study found that cod larvae experience severe organ damage when placed into conditions with high levels of carbon dioxide.[24] Furthermore, other studies have found that acidification can harm the ability of clownfish to smell, as well as their behavior around predators. The results of these studies carry serious implications for other species of fish that will soon be living in highly acidic waters.

IV. Case Study: *The Great Barrier Reef*

Although ocean acidification has not progressed enough to result in the total destruction of coral reefs globally, some regions, such as Australia, have begun to see its effects. The Great

[23] Morello, Lauren. "Ocean Acidification Threatens Global Fisheries." *Scientific American*, Scientific American, 6 Dec. 2010, https://www.scientificamerican.com/article/ocean-acidification-threatens-global-fisheries/.
[24] Hoag, Hannah. "Acidic Oceans Threaten Fish." *Nature News*, Nature Publishing Group, 11 Dec. 2011, https://www.nature.com/articles/nature.2011.9607.

Barrier Reef, located in Australia, is a biodiversity hotspot, as well as one of only seven natural wonders of the world. However, it has already seen a reduction in its strength and viability due to ocean acidification.

When ocean acidification occurs around the Great Barrier Reef, organisms must attempt to adapt to a lower ocean pH, as well as a decrease in aragonite and an increase in sea surface temperature. When carbon dioxide absorbs into the ocean water, carbonic acid and hydrogen ions are formed which acidifies the water. This can reduce the ability of shell forming organisms to use carbonate to form their calcium carbonate shells. Some estimates state that increasing carbon dioxide levels in the Great Barrier Reef will reduce coral growth rates from 9%-56%.[25] When the organisms must spend more time on forming their shells, they lose time that could be spent on reproduction, which leads to a decrease in the amount of corals. The Great Barrier Reef is specifically harmed by reduced levels of aragonite due to the currents present throughout the reef. This causes northern corals to absorb more aragonite than southern corals, thus contributing to unequal levels of biodiversity across the Great Barrier Reef.[26]

A decrease in the amount or health of coral reefs can result in reduced biodiversity, which is disastrous for the ecosystem of the Great Barrier Reef. Many organisms face extreme stress due to the loss of healthy coral reefs as they lose their habitats. Bivalves and gastropods are also victims of ocean acidification in the Great Barrier Reef as their shells dissolve due to the acidic waters. This limits their rates of reproduction and shelter.[27] Ocean acidification can also cause

[25] De'ath, G; Lough, J. M. (2009). "Declining coral calcification on the Great Barrier Reef"
[26] Mongin, M; Baird, M. E. (2016). "The exposure of the Great Barrier Reef to ocean acidification". Nature Communications.
[27] Gattuso, Jean-Pierre 2011. Ocean acidification: Background and history

hypercapnia, which is an excessive amount of carbon dioxide in the bloodstream, usually caused by inadequate respiration.[28]

Certain organisms in the Great Barrier Reef are at higher risk of harm due to ocean acidification. Species that are endemic and rare are in peril due to ocean acidification as they rely on the Great Barrier Reef and its resources greatly. These organisms are also placed at risk due to the possibility of the collapse of coral reefs. Coral reef collapse would severely affect biodiversity, as more vulnerable organisms would no longer have a habitat or shelter. Ocean acidification can also stress out organisms in other ways. When ocean acidification interferes with biological processes like reproduction or photosynthesis, organisms can become more susceptible to disease.[29] This negatively affects biodiversity, as populations can decrease due to disease related deaths.

Ocean acidification in the Great Barrier Reef can also result in higher surface water temperatures. This is disastrous for coral, as higher temperatures can harm the connection between zooxanthellae and coral, which causes bleaching. Coral bleaching is the process by which zooxanthellae leave the coral skeleton due to extreme stress. This results in the lightening of the coral, as only a white skeleton is left behind. Due to the lack of zooxanthellae, the coral skeleton slowly dies and is dissolved by the acidic waters. This damages the structural integrity of the Great Barrier Reef, as many supporting reef structures are dissolved. Furthermore, coral bleaching reduces the biodiversity of the Great Barrier Reef, as organisms that rely on the

[28] "Hypercapnia." *Hypercapnia - an Overview | ScienceDirect Topics*, 2021, https://www.sciencedirect.com/topics/earth-and-planetary-sciences/hypercapnia.
[29] Veron, J. E. N.; Hoegh-Guldberg, O 2009. "The coral reef crisis: The critical importance of <350ppm CO2". Marine Pollution Bulletin.

zooxanthellae and algae of healthy coral must leave the reef to search for food elsewhere. Overall, the Great Barrier Reef is already experiencing the effects of ocean acidification, and they will only intensify if carbon emissions are not reduced.

V. Guiding Questions

1. How would a reduction in carbon emissions affect the progression of ocean acidification?
2. How is biodiversity affected by ocean acidification?
3. How does ocean acidification affect the economy globally?
4. How does ocean acidification affect the economy of coastal cities?
5. How are some regions affected by ocean acidification differently?
6. How will ocean acidification affect coral reefs?
7. Will ocean acidification have an effect on tourism globally?
8. How can ocean acidification be prevented, and how can it be combatted once it has already begun?

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Topic A: Urban Sprawl in Sub-Saharan Africa

I. Background

Urban sprawl is the term used to describe the rapid growth of cities that extend urban areas geographically, and it's often characterized by its inefficient/unsustainable land use. Urban sprawl most often occurs in places experiencing rapid population or economic growth, a prime example being Sub-Saharan Africa. Sub-Saharan African cities could be subject to urban sprawl since they are expected to develop rapidly and the number of people who live in urban centers are set to double by 2050[30]. It is crucial that the states in Sub-Saharan Africa take the proper steps to ensure that development is sustainable for their growing populations— it's critical to curb the consequences of the seemingly inevitable urban sprawl. Urban sprawl's roots in Sub-Saharan Africa are linked to the industrial and economic boom that happened in the 1950s and 60s after the decolonization period. After decolonization, many of the Sub-Saharan African states were flooded with investments from European and American investors[31]. This helped partially industrialize these countries' economies and one of the results of this was a 5% increase in the population of cities from 1950-1980. Enthusiasm from investors quickly dissipated by the late 1970s to 1980 after there was little return on investment. Furthermore, the recession in the United States in 1981 additionally decreased the desire to invest in Sub-Saharan Africa. The

[30] Kanos, David, and Chris Heitzig. "Figures of the Week: Africa's Urbanization Dynamics." *Brookings*, Brookings, 9 Mar. 2022, www.brookings.edu/blog/africa-in-focus/2020/07/16/figures-of-the-week-africas-urbanization-dynamics/.
[31] "Africa's Cities Are About to Boom – and Maybe Explode." *Africa's Cities Are About to Boom – and Maybe Explode | Center for Strategic and International Studies*, www.csis.org/analysis/africas-cities-are-about-boom-and-maybe-explode.

mounting debt finally reached a breaking point and created an economic crisis which further increased Sub-Saharan Africa's reliance on foreign aid and imports[32]. Due to low economic activity, cities in Sub-Saharan Africa grew much more slowly and urban planning wasn't taken into consideration much by these states[33]. Lack of funding towards city planning led to immense urban sprawl, this is most prevalent in the vast slums of sheet metal shacks in cities such as Lagos, Nairobi, Dakar, and many more. After another recession in 2008, investments began pouring in again from China as a part of their One Belt One Road Initiative. The renewal of infrastructure has led to an increase in rural to urban migration in Africa, along with this Africa is also continuing to industrialize and move away from their agrarian economies. More medicine and nutritious food being available has led to a lower infant mortality rate and higher life expectancy, Sub-Saharan Africa is the second stage of the demographic transition model which is characterized by these statistics[34]. Population is expected to keep growing and if not done sustainably there could be horrible environmental and economic repercussions[35].

Uncontrolled urban sprawl is linked to many environmental problems that are detrimental to the environment. Some of these consequences of urban sprawl include; habitat destruction, poor water quality from runoff, increased reliance on fossil fuel powered transportation, and less

[32] Fole, Alemayehu Geda. "The Historical Origin of African Debt Crisis." *Eastern Africa Social Science Research Review*, Organization for Social Science Research in Eastern and Southern Africa, 22 Nov. 2002, muse.jhu.edu/article/10309/pdf.
[33] Wolfrom, Marie. "Sixty Years on, Africa Still Seeks Right Model for Growth." *Phys.org*, Phys.org, 29 Dec. 2019, phys.org/news/2019-12-sixty-years-africa-growth.html.
[34] Drew Grover | October 15, 2014. "Stage 2 of the Demographic Transition Model." *Population Education*, 16 Aug. 2019, populationeducation.org/stage-2-demographic-transition-model/.
[35] Written by Ernesto Zedillo, Director of the Yale Center for the Study of Globalization. "Is Africa's Growth Sustainable?" *World Economic Forum*, www.weforum.org/agenda/2015/08/is-africas-growth-sustainable/.

groundwater recharge[36]. Note that many of the world's most endangered species are in Sub-Saharan Africa and the expansion of human settlements into their habitats will cause populations to continue to decrease. All of those effects aren't only detrimental to the environment but also affect people in these cities, many of the lower income citizens rely on ecosystem services for their everyday life and livelihood. The economic effects from urban sprawl like the environmental effects are unsustainable for people. When cities are spread over a large area of land it increases energy consumption for all people, especially for transportation. A characteristic of many Sub-Saharan African cities is the large economic zones in the center and the slums on the outskirts. Since many of the available jobs are in the business/market areas of these cities it increases the commute for many of the lower income workers. This increases the cost of living and also increases CO2 emissions because lower efficiency fuel such as palm oil is used to power their combustion engine vehicles[37]. Poor city planning doesn't only lead to urban sprawl but also a whole host of other problems when building infrastructure and basic city services. Due to the high number of informal sectors (slums) city planners avoid creating services in these lower income areas. This cuts a large portion of people in these cities away from important services such as; clean water, medical facilities, waste management, paved roads, and etc. In some cities such as Nairobi, Kenya, there are an estimated 2.5 million slum dwellers

[36] Resnik, David B. "Urban Sprawl, Smart Growth, and Deliberative Democracy." *American Journal of Public Health*, American Public Health Association, Oct. 2010, www.ncbi.nlm.nih.gov/pmc/articles/PMC2936977/#:~:text=Urban sprawl can reduce water,pollutants into streams and rivers.&text=Poor water quality is associated,, kidney disease, and cancer.

[37] Chiriacò2, Maria Vincenza, et al. "IOPscience." *Environmental Research Letters*, IOP Publishing, 7 June 2022, iopscience.iop.org/article/10.1088/1748-9326/ac6e77.

which adds up to 60% of the cities total population[38]. The 60% of residents living in slums in Nairobi represents the number across the whole region since around 200million people in the whole region are living in slums which makes up 61.7% of the population of Sub-Saharan Africa [39]. The rapidly growing cities in the region have been unable to control the growth of slums and other impoverished settlements and have neglected them.

Slum growth is set to increase as the population in Sub-Saharan Africa continues to Soar. To curb Slum growth countries such as Zambia are implementing policies that will limit the slums by using preemptive planning and districting, this will make it impossible for slums to grow in these areas. The economic, human health, and environmental impact of urban sprawl simply makes unsustainable cities.

Recently, the outbreak of Covid-19 has led to many municipalities to start working on planning out cities. The dense slums were practically a breeding ground for Covid-19 and prompted city planners to create more residential areas that are more hygienic. Cities such as Addis Ababa in Ethiopia have used tall apartment style buildings that are government subsidized to move people out of slums. These buildings are important for reducing urban sprawl and encourages more cities to build vertically. The current situation leads many to find new and innovative solutions as the time to prepare for the future states to disappear. If not addressed the region is set for a humanitarian crisis that more developed countries would be forced to get

[38] "Some Facts and Stats about Kibera, Kenya." *Kibera UK*, 14 Feb. 2018, www.kibera.org.uk/facts-info/#:~:text=Kibera Facts & Information,the biggest in the world.
[39] Thelwell, Kim. "Sub-Saharan African Slums: The Housing Crisis." *The Borgen Project*, Kim Thelwell Https://Borgenproject.org/Wp-Content/Uploads/The_Borgen_Project_Logo_small.Jpg, 2 Oct. 2020, borgenproject.org/sub-saharan-african-slums/#:~:text=Sub-Saharan Africa is experiencing,the world for urban poverty.

involved in. As more developed states block refugees from coming in it is in their best interest to contain the problem. With outside help and resources urban sprawl in the region could instead be replaced by sustainability.

II. United Nations Involvement

The development of Sub-Saharan Africa has been a point of high interest for the United Nations since its founding. Many of the 17 sustainable development goals target Sub-Saharan Africa since it is the most undeveloped region in the world. In order to rebuild the region sustainably the United Nations have been focusing on stabilizing the region[40]. Currently there are 6 UN peacekeeping missions and as of April one hundred million dollars in relief aid was sent to fight hunger[41]actions like these and many more help pave the steady road to sustainable development. Poverty in Sub-Saharan Africa is one of the issues most directly linked to urban sprawl and unsustainable development, a key feature on the effect of development that poverty causes is the vast seas of slums on the outer limits of large cities. The United Nations agency most directly involved in the development of Sub-Saharan African cities is UN-Habitat. UN-Habitat has been working to combat poverty and reduce slums by investing in slum upgrading and improving local financial systems[42]. Other ways that the United Nations have been able to prevent urban landscapes reaching into ecosystems is by protecting vast areas of land near settlements. Recently there has been debate on reconfiguring these protected areas, the

[40] "Welcome to the United Nations, It's Your World." *United Nations*, United Nations, www.un.org/.
[41] "UN Releases $100 Million to Fight Hunger in 6 African Countries and Yemen | | UN News." *United Nations*, United Nations, news.un.org/en/story/2022/04/111.
[42] "Global Action Needed to Tackle Urban Squalor as Number of Slum-Dwellers Continues Rising Worldwide, Second Committee Told | Meetings Coverage and Press Releases." *United Nations*, United Nations, www.un.org/press/en/2010/gaef3294.doc.htm#:~:text=He noted that during the,community savings for slum upgrading.

growing population has put concern in the eyes of the IUCN since they fear that habitat fragmentation could become more of a threat to wildlife[43].

Other international organizations have also begun looking into the problem of urban sprawl and are creating plans to make Sub-Saharan Africa sustainable economically and environmentally. One of these organizations is the African Union which has worked on developing Africa's cities through their commission of the Department of Rural Economy and Agriculture (DREA). The African Union's DREA plans to develop Africa's cities more sustainably by building vertically, protecting larger areas of land, developing disaster reduction programs, making cities climate change proof, advancing water accessibility and sanitation, and lastly forming and implementing the Integrated African Strategy on Meteorology. This set of strategies is meant to help Africa develop into the mid 21st century as population continues to increase and help reduce the damage done by climate change[44]. African Smart City Innovative Foundation (ASCIF) is one of the NGOs that is targeting urban sprawl and focusing on creating sustainable cities[45]. ASCIF labels itself as an "implementing organization", what they do is help municipalities draft cities sustainable by bringing in experts who will help create and implement their plans. Currently ASCIF is working with the African Union to help member states with their Covid-19 outbreaks, they are also working with the African Union on rural electrification which is a part of their main mission of "nation building". Coming out of the Covid-19 pandemic many states are looking to build back and prepare for the future. The biggest challenges to Sub-Saharan

[43] *PAPACO*, papaco.org/.
[44] "Sustainable Environment." *Sustainable Environment | African Union*, 19 Sept. 2020, au.int/en/directorates/sustainable-environment.
[45] "About." *ASCIF*, www.ascif.org/about.html.

African States is creating cities suitable for populations that will double by 2050 and climate change, with international assistance this can be done and done sustainably.

III. Topics to Consider

A. Using Zoning and City Planning to Promote Sustainability

One of the roots of urban sprawl is lack of planning combined with fast growth which is why it's also one of the solutions. There are many ways zoning and city planning can be used to reduce urban sprawl. One of them is to zone areas before they are developed so that things such as low density residential areas aren't built on large expanses of land extending the cities geographical borders. This has worked well in Sub-Saharan Africa in the past since plotting ahead of time meant that slums couldn't develop on that land. Another way to use zoning to promote sustainability is by utilizing new urbanism[46]. New urbanism is a model of city where mixed use zoning is used to create compact walkable cities. This would in turn not only reduce urban sprawl but greatly reduce the carbon footprint of the people living in cities utilizing this city planning method. It also incentivises and promotes being healthy since people would be able to walk everywhere and there would be no need to own a personal vehicle. This also would be effective in developing states because many people cannot afford private vehicles so it would also make cities more affordable for residents. Educating communities on sustainable practices is very important because it helps communities become more sustainable. This makes it easier for the communities to work with governments when changes to implement more and new sustainable practices would be made

[46] Bsummers. "What Is New Urbanism?" *CNU*, 10 May 2022, www.cnu.org/resources/what-new-urbanism.

B. Transforming Slums/Informal Districts to be Environmentally Friendly

In many Sub-Saharan African cities, cities begin to sprawl out when slums continue to expand and grow. One way municipalities in Sub-Saharan Africa and in other parts of the world have been able to reduce slums is by upgrading them[47]. By upgrading slums people aren't displaced like they would be if they were just simply cleared out. Many organizations use the community itself to upgrade housing in slums, such as in Tijuana Mexico where the community set up a shared fund and slowly began upgrading the slums. Local governments have also done this in the past by creating more institutions and infrastructure in these areas, such as hospitals, new roads, and even subsidized housing. Another way to prevent the growth of slums and prevent sprawl is by developing rural areas so there is less migration to cities[48]. By bringing jobs to rural areas countries have been able to revitalize the rural landscape, an example of this is Namibia which funds large infrastructure projects and has created a tourism industry in rural areas so that there are an abundance of jobs.

C. Rehabilitating Ecosystems Disrupted by Urban Landscapes

Urban sprawl causes great amounts of habitat loss and ecosystem destruction by its nature. Some of the consequences include habitat fragmentation, decreased water quality, deforestation, reduced air quality, and many others. Habitat fragmentation splits and divides ecosystems which is detrimental to species of animals. One solution to this problem is to create wildlife corridors above or under large roads so that animals can cross. In cities such as Melbourne in Australia they have already created some of these wildlife bridges so that species

[47] "Slums and Slum Upgrading." *Cities Alliance*, www.citiesalliance.org/themes/slums-and-slum-upgrading.
[48] *World Bank*, projects.worldbank.org/en/projects-operations/project-detail/P090712.

are able to cross safely[49]. Many impoverished people in Sub-Saharan African cities don't have access to running water so rely on natural sources of it. Urban sprawl negatively impacts water quality due to many factors but one of the most important is runoff. Runoff from streets leak into water sources that people need, such as rivers. The pollutants reduce the water quality and could lead to water borne diseases such as cholera. Many people who live in the outskirts of the city work in the downtown city centers which means that they have large commutes, this leads some to use private vehicles. These vehicles with combustion engines have great greenhouse emissions and ground level ozone which is hazardous to people lungs. By creating more compact cities there wouldn't be a need for personal transportation which would greatly reduce the carbon footprint of the citizens in the city.

IV. Case Study: *Urban Sprawl in Shenzhen*

At the turn of the 21st century China started to experience a massive economic period of growth. From 2000 to 2010 China's GDP has grown by almost 10% each year, increasing by 100 million people. These factors and an increase in rural to urban migration create the perfect situation for urban sprawl. In 2001, Shenzhen, China, began to experience a massive increase in people moving into the city. Between 2001 and 2005, the population grew from 7.25 million to 8.28 million people, this is an annual growth rate of 3.38%. This led to an increase in land use at the same time and the city's area expanded from 470.68km² in 2001 to 703.47km² in 2005. Population density has even decreased in this time and has gone from 154 persons per hectare to 118 persons per hectare, this is a 23.4% decrease in population density.

[49] Hall, Len, and Rodney Abson. "Calder Freeway Wildlife Crossings." *TRID*, 30 Nov. 2005, trid.trb.org/view/795626.

Unlike less developed countries this urban sprawl is caused by suburbanization and real estate development. The main cause of this is cited as an effect of an industrialized economy, but suburbanization is different in China than in other western countries. In western countries such as the United States richer people move into the suburbs to escape the city but in China many of the rich people prefer to live in the downtown areas of cities. Another effect of this dynamic is that the highdensity inner city has more developed infrastructure than the suburbs which are more neglected. In Shenzhen this can be seen by the lack of main roads such as highways from the suburbs to the downtown areas of Shenzhen. Although it's hard to compare urban sprawl in China to urban sprawl in Sub-Saharan Africa they both have detrimental environmental and economic effects.

Urban sprawl in Shenzhen has created a whole host of problems that weren't taken into consideration as the city began developing. As the city expanded a whole plethora of environmental complications came into sight. Many cities near Shenzhen in the Guangdong Sheng province have been expanding similarly to Shenzhen and are facing urban sprawl. A result of this is a 20% decrease in forest cover since 2000, this released approximately 830 metric tons of CO^2 emissions. The province of Guangdong Sheng represents one of the top 4 provinces responsible for the most deforestation since 2001. Greenhouse gas emissions have also sharply increased due to the increased commute distance, many who live in the suburbs work in the city and use public transportation or use inefficient fuels such as palm oil to power private vehicles. Air Pollution has continued to increase also with air being hazardous to breathe on most days[50],

[50] "Shenzhen Air Quality Index (AQI) and China Air Pollution." *IQAir*, www.iqair.com/us/china/guangdong.

this is primarily due to the ozone (O^3) from combustion engines[51]. Another environmental impact is habitat fragmentation, habitat fragmentation is when a habitat is divided into small pieces by human development. Many of the roads and highways extending out of the growing city have fragmented habitats and are resulting in a large dyoff of species in the Guangdong Sheng area. All of these consequences that happened from the urban sprawl in Shenzhen and the greater Guangdong Sheng area are seen in most places facing urban sprawl.

Shenzhen, although facing immense urban sprawl, has begun enacting policies to control the extent to which the sprawl is occuring. One of these policies that have been used to control urban sprawl is by using zoning, zoning and limiting areas where the construction of housing can take place it would incentivize building more dense domiciles. Other zoning policies that would help curb the sprawl would be zoning and protecting key areas that provide ecosystem services. Shenzhen and other parts of China have partially implemented the second solution to reducing urban sprawl which is utilizing smart growth. This form of city planning is characterized by compact living spaces with the use of mixed zoning. Its purpose is to lower environmental effects caused by urban sprawl and promote sustainability. In China and around the globe it has worked very well which is why Shenzhen is looking to implement smart growth on a larger scale.

V. Guiding Questions

[51] Bian, Yahui, et al. "Evolution of Anthropogenic Air Pollutant Emissions in Guangdong Province, China, from 2006 to 2015." *Atmospheric Chemistry and Physics*, Copernicus GmbH, 20 Sept. 2019, acp.copernicus.org/articles/19/117

1. Does your country have policies on reducing urban sprawl or sustainable city planning practices?
2. What are the demographics of your country's development and economy?
3. How has your country promoted sustainable city development in the past?
4. Will your country's cities be affected by climate change and how great of a problem will it be?
5. Has your country helped promote sustainability in other countries/regions?
6. Would your county benefit from utilizing more sustainable urban development practices?

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