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Research

Creating a climate changed future with the sea level rise interactive-fiction game "Lagos2199"

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ABSTRACT. Story-based futures serve an important role in climate change scenario development. Stories are particularly useful in exploring sea level rise possibilities, since we know many coastal areas are specifically vulnerable to accelerating rises in sea level. This discrete change in coastline is different from most other climate change impacts, and offers a clear basis for scientifically informed, future scenarios. We demonstrated this with a creative world-building effort set in Lagos, Nigeria in the year 2199. Further, we employed story-based scenario development, and created a learning-oriented serious game that allows users to experience a future Lagos in an open-ended, text-based adventure style. This collaborative process blended scientific research, story-telling, and artistic co-creation to iteratively construct the game "Lagos2199". A pilot-use case of Lagos2199 is documented herein, with preliminary survey results from the student users. We present two core insights. First, we demonstrate how scientific projections regarding sea level rise can be leveraged as an entry point for world-building and scenario development of the future. Second, we show that such a scenario can be transformed into an immersive, story-based serious game to creatively communicate possible futures. Providing the next generation of citizens with fluency in both climate change impacts and how society will interact with such impacts is critical for providing adaptive capacity over the coming decades and centuries of accelerating global change.

Key Words: *climate change; education; fiction; future; Lagos; Nigeria; sea level rise; serious game*

INTRODUCTION

Climate change impacts to the Earth system will be far-reaching and consequential to every aspect of human society (Wuebbles et al. 2017, Steffen et al. 2018). Recognition of these impacts, however, has not led to a commensurate effort to educate future generations to understand and prepare for a new world (e.g., Gillenwater 2011, Monroe et al. 2019). Part of this challenge is due to the fact that climate change is becoming an all-encompassing reality with heterogeneous impacts globally (Vincent and Hamilton 2020). Temperature changes may increase dramatically or modestly, depending on the location of the planet and the season being considered (Dai 2012, Mueller et al. 2016). Precipitation and drought are also notoriously difficult to frame effectively, given that some parts of the world are likely to get wetter (Giorgi et al. 2011, Allan et al. 2020), while drought will get worse elsewhere (Fu et al. 2013, Findell et al. 2019).

Global increases in mean sea level will, contrary to other impacts of climate change, unfold more consistently around most of the planet (Kopp et al. 2019, Levermann et al. 2020). While the range of sea level rise scenarios is indeed quite wide (Church et al. 2013), the geophysical location of these impacts is concentrated along the relatively narrow area of land that will or will not be inundated (Hsiang et al. 2017, Hauer et al. 2019). Moreover, given that global humanity is concentrated in larger numbers on coastlines compared to inland areas, sea level rise is highly consequential for global economies, cultures, and political stability in the future (Rigaud et al. 2018, Bell et al. 2021).

Sea level rise visualizations are increasingly being used as both a vehicle for narrative experience and engaging participants' interest in climate change. Stephens et al. (2014) identified the emergence of personal narrative construction in relation to the use of computer platforms that depict sea level rise. Building on this, Stephens and Richards (2020) found that conveying risk and uncertainty in purely quantitative terms may not be the most effective strategy, but that discovery via sea level rise projections enable better appreciation for conveying the nuances of sea level rise risks. Games have been widely used as a method of providing educational resources for learning about and practically working through climate change impacts and adaptation (Flood et al. 2018). Serious games, so-called since they are explicitly for purposes other than entertainment, have been used for increasing capacity among policy-makers as well as for stakeholder engagement (Wu and Lee 2015). A recent systematic review of serious games used in climate change adaptation provides a great deal of insight into the potential for games to advance stakeholder learning, engagement, and action (Flood et al. 2018). Serious games can effectively contain complex scientific information and enable simulated decision-making with this information (County of Marin 2016). This uptake can be a critical hurdle to achieving broader engagement on complex cross-disciplinary topics like climate change, which games evidently can address (Mendler de Suarez et al. 2012). There are also challenges to using serious games, including the length of the gameplay, the method of data collection (if any) about the user experience, and the balance between quantitative and qualitative game elements.

Many of these serious games are sophisticated, with many layers of interaction among players, and often have considerable facilitation components. Sterman et al. (2015) provide an example of a facilitated, climate negotiation game that includes participation and learning about the complexity of climate policy and responses. Rumore et al. (2016) underline the value of role-play simulations for advancing engagement in climate change action, and these findings are echoed in other work (Lee et al. 2013, Meya and Eisenack 2018). While both facilitation and group collaboration can contribute to important forms of

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collective learning, individual narrative games provide a parallel value of individual experience and agency. Reckien and Eisenack (2013) discuss the dominance of role-playing games in the field of climate change, though acknowledge the increasing role of online games. They highlight a need for games that focus on climate adaptation as much as mitigation. An example of such an online game is FloodSim (Rebolledo-Mendez et al. 2009), which is an interactive, online policy game that allows a user to explore flooding in the UK.

While some serious games are focused on teamwork and decision-making, narrative-rich, story-based games can also provide important contributions to climate change education (McComas and Shanahan 1999, Spoel et al. 2008). Storytelling-based scenarios have emerged as a key feature of futures thinking globally, ranging from industry to government to education (Rasmussen 2008, Sakakibara 2008, Milkoreit 2017). Specifically, science fiction prototyping has emerged as an effective vehicle for creating engaging and immersive visions of a future that is radically different from the present day (Johnson 2011, Burnam-Fink 2015, Merrie et al. 2018). Likewise, approaches such as the "Seeds of a Good Anthropocene" and the "Nature Futures Framework" employ creative scenario approaches that intentionally focus on trajectories toward a more sustainable future (Pereira et al. 2020a, 2020b).

Nuanced, complex, and sometimes contradictory pathways are critical to properly envisioning a future—particularly in parts of the world that are often depicted as a single story and in a negative light (Adejunmobi 2016). Science fiction has contested ideas of a globalized, Western design of the future (Csicsery-Ronay 2012). Particularly, African science and speculative fiction has emerged as a dominant locus of decolonial and endogenous ideas about African futures, thereby fostering robust debate and discourse (Hugo 2017, Thompson, 2017, Serpell 2019). In parallel with the contemporary recognition of the historical and topical depth of African science fiction is the present-day reality that many parts of West Africa are demographically the fastest growing and are among the most economically dynamic in the world (e.g., Rosling 2019). In particular, Lagos, Nigeria has emerged as a focal point for global ambition, economic development, and local narratives that contest Western perceptions of development (Hecker 2010, Shiru et al. 2020). For these reasons, situating narratives about future worlds, especially worlds that characterize local agency, is of paramount importance for adequately reflecting reality in climate change education (Pereira et al. 2018).

In this work, we leverage cutting-edge research on the long-term inundation caused by sea level rise in the Lagos region of Nigeria. Then, we use science fiction prototyping and other futures methods to generate an engaging, scientifically rooted story of the future of Lagos, informed by the latest projections of climate change (Brown et al. 2011, Fashae and Onafeso 2011, Croitoru et al. 2020, Shiru et al. 2020). We then transform the story into a text-based game, blending storytelling, visual art, and music to create an immersive experience about a future Lagos set in the year 2199, called "Lagos2199". The first-use case of this game is described using a survey of students that had actively learned about sea level rise and climate change prior to playing the game.

We present two core insights. First, we demonstrate that scientific projections regarding sea level rise can be leveraged as an entry point for world-building and scenario development of the future. Second, we show that such a scenario can be transformed into a serious game to creatively communicate possible futures. We also discuss how the educational value and impact of Lagos2199 (as well as other games) could be studied, based on pilot survey data. The layout of this paper is as follows. We first describe the quantitative process of sea level rise projection to 2199, followed by a description of the methods for developing the scenario world. Then, we share the iterative process of developing the story, incorporating the game platform, designing character art, rendering conceptual environments, and identifying musical accompaniment. We next report on a pilot survey of the game's first users. We discuss Lagos2199 in the context of climate change games, futures research, and art–science collaboration.

CREATING THE GEOGRAPHY OF A FUTURE LAGOS

Theoretical estimate of sea level rise in Lagos, Nigeria

First, we identify an inundation scenario that is consistent with an intermediate projection of sea level rise for 2200 (Sweet et al. 2017). While global mean sea level will not be precisely true anywhere because of relative differences in, for example, topography and bathymetry, it is a suitable proxy for a conservative estimate of sea level rise in low-lying areas such as Lagos, Nigeria (Kopp et al. 2014). Thus, using an intermediate scenario, we find that sea levels will likely rise by 2.8 m globally.

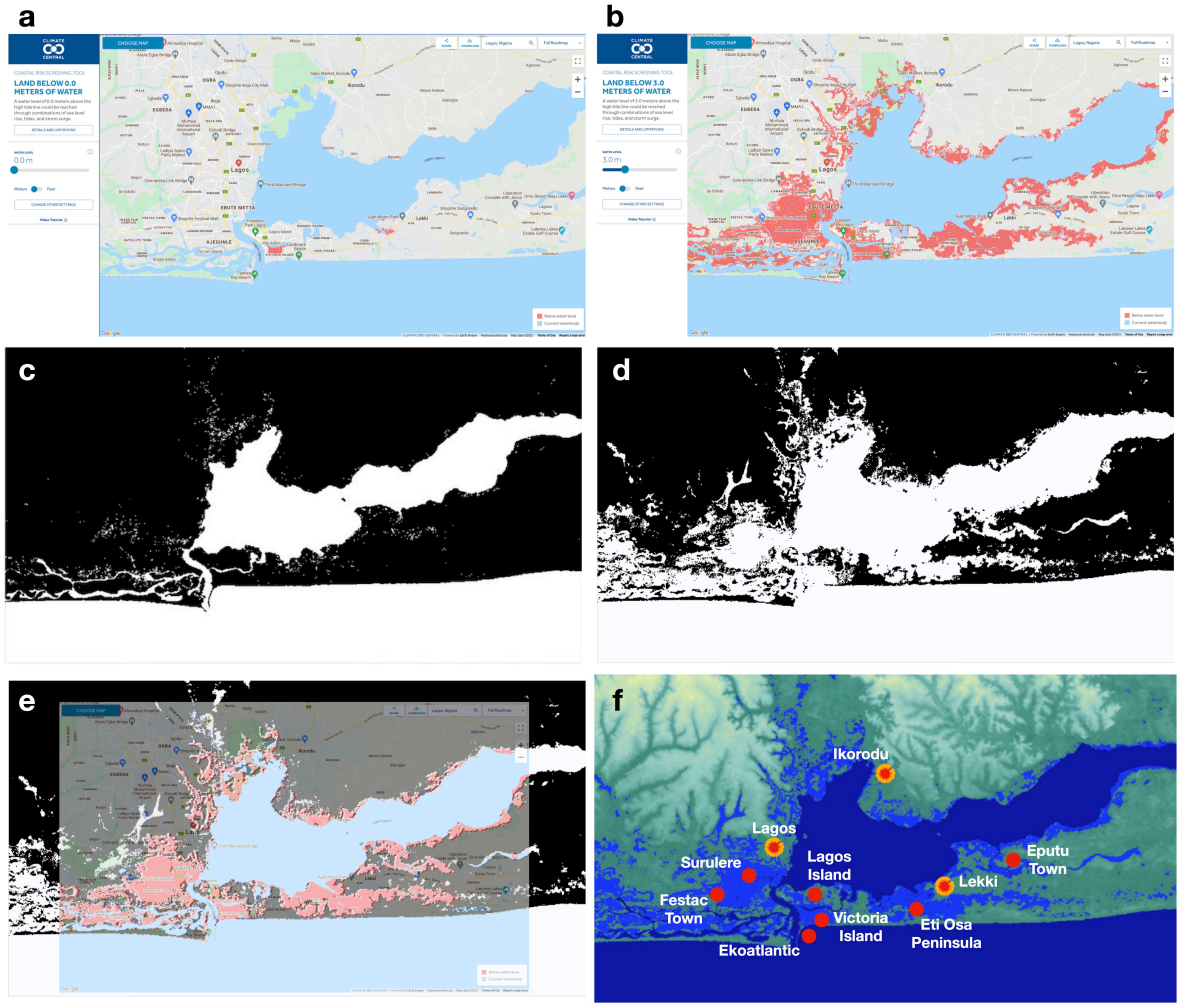
Locally, sea level rise will be experienced through high tide and annual flooding events. In Lagos, the average high tide is slightly less than 0.5 m above mean sea level (Melet et al. 2016). So, under an intermediate sea level rise scenario of 2.8 m, plus a regular high tide of ~0.5 m, the typically inundated area for Lagos in 2200 will be above 3.0 m. For the purposes of this analysis and simplicity in subsequent steps, we rounded the amount of change to 3.0 m by 2200.

We note that such a scenario of sea level rise corresponds to a relatively successful strategy of mitigating carbon emissions in the 21st century but not the most aggressive climate change mitigation path forward. The lowest projection of sea level rise associated with 2199 is 0.39 m, and the highest is 9.7 m (Sweet et al. 2017). While 0.39 m would change the coastline much more modestly, 9.7 m would be catastrophic and would likely be reached only with enormous meltwater pulse events, similar to the deglaciation during the transition from the last glacial maximum to the present-day interglacial (Deschamps et al. 2012, Brendryen et al. 2020).

Sea level rise visualization

We used Climate Central's coastal risk screening tool (https://www.climatecentral.org/) to map inundation in the Lagos, Nigeria region (Kulp and Strauss 2019). These maps are a combination of (a) high-resolution satellite imagery (NASA JPL 2013), (b) existing sea level rise analysis (Tebaldi et al. 2012, Kopp et al. 2014), and (c) proprietary sea level rise projections made available for educational and research use (Strauss et al. 2012). We used the Climate Central inundation map to reveal both the current coastline of Lagos (Fig. 1a) and a projection of sea level rise in Lagos based on the theoretical rise of 3 m (Fig. 1b).

Fig. 1. Mapping process of Lagos region: (a) current coastline from Climate Central inundation map, (b) potential coastline from Climate Central inundation map associated with 3 m of sea level rise, (c) current coastline without digital elevation model (DEM) modification (black corresponds to land; white corresponds to water), (d) potential coastline with DEM modification representing 3 m of sea level rise, (e) overlay of potential coastlines from Climate Central and DEM modification, and (f) finalized map showing 2021 inundated areas (dark blue) and 2199 inundated areas (lighter blue).



While the Climate Central map for 3 m of sea level rise demonstrated profound inundation of the Lagos region, we were not able to effectively export the web-based map for use in the Lagos2199 game. Thus, we complemented the Climate Central spatial estimate of inundated areas with a simple analysis based on a digital elevation model (DEM). We used digital elevation data that are based on the Shuttle Radar Topography Mission with information at the 90-m resolution (NASA JPL 2013). In this DEM, the data indicated the height above (or below) sea level. This information is depicted in software with colors corresponding to different elevations. Fig. 1c shows the current coastline of the Lagos region.

Our sea level rise map for the Lagos region was produced by changing the symbology in QuantumGIS (i.e., QGIS, a freely available geographic information system software) to indicate that water started at the 3-m elevation level in the DEM rather than at zero (Fig. 1d). While this is a straightforward and somewhat simplified approach, the map that was generated is nonetheless very useful for showing which present-day cities and areas of the Lagos region may be underwater in an intermediate projection of sea level rise (Sweet et al. 2017). Likewise, it is possible to see the profound change simply by adjusting this color scheme in the DEM, and to provide a new sense of which areas on dry land are inhabitable and which areas will be more or less permanently

underwater. This simple, straightforward approach allows us to use spatially georeferenced data layers that are readily available (e.g., locations of cities, roads).

Cross-check between Climate Central and GIS-based estimates
By comparing an overlay of the Climate Central estimate of sea level rise and the simple DEM-based estimate, we found high correspondence (Fig. 1e). While there was some disagreement, particularly in low-lying portions of western mainland Lagos city, the pattern and extent of inundation was highly consistent. Thus, we have high confidence in the base map of the Lagos region, as well as the future map associated with 3 m of sea level rise (Fig. 1f).

Map of Lagos present day versus 2199
The map presented in Fig. 1 illustrates how profoundly Lagos will be transformed with 3 m of sea level rise. Using QGIS, we were able to depict this change with the dark blue colors corresponding to presently inundated area, light blue corresponding to newly inundated area by 2199, and green corresponding to areas above the hypothetical 2199 high tide.

Between the present day and 2199, the Lagos Lagoon is transformed into Lagos Bay. In the present day, the entry to Lagos Lagoon is a clear waterway between the southwest area of the Lagos Port and areas on the eastern side, such as Eko Atlantic, Victoria Island, and Lagos Island. In the future, the channeled waterway forming an entry into Lagos Lagoon becomes a fractured coastline of semi-inundated areas. The areas of Victoria Island and Lagos Island (center of the south-facing coastline) now appear to be open water, though would likely be marshy, highly vegetated areas. Likewise, after 180 years of sea level rise, this region may be unnavigable due to changed and collapsed infrastructure in the region. Further into the lagoon, the western part of Lagos that contains Surulere, Festac, and other regions (left side of the map) are inundated almost entirely, forming a small bay. The other area in the region that is more transformed than most of the other areas is the Eti-Osa peninsula in the southeast (center to the right side of the map). Administrative areas such as Lekki, Eputu, and others have been massively inundated by 2199.

While it is possible to use existing spatially georeferenced data layers in a GIS analysis, we used the present locations of cities and major social focal points as suggestive rather than indicative of future locations. In other words, we allowed for the fact that in the next 180 years, the current structure of habitation and population will adjust to changing sea levels, while at the same time, recognizing that cities are remarkably persistent, despite enormous disasters and changes (McGranahan et al. 2007).

SCENARIO DEVELOPMENT

World-building
The setting, or world, for the Lagos2199 story was developed using a systematic, structured futuring approach, which was adapted for the specific purpose of generating a story from sea level rise-induced changes. The story creation process was iterative and generative, meaning that the relatively linear path shown in Fig. 2 is described with retrospective clarity. First, as previously mentioned, we used the modified DEM and existing spatial data on points of interest, cities, and other landmarks to learn what the new geography of 2199 could be. Using the map of the Lagos Bay in 2199, we focused on the transition of three major regions from the present to the future: Lagos becomes Eko City, Ikorodu becomes Ikorodu City, and Lekki becomes New Lekki City (red dots with yellow outlines, from Fig. 1f to Fig. 2a).

Second, we imagined how these three cities might appear in 2199, and we brainstormed how the ideas might be connected to one another in the future (Fig. 2b). Using the Futures Wheels approach (Glenn 2009), we looked for both logical and contradictory connections (Pereira et al. 2018) among the three main cities in Lagos Bay. This included identifying first-order details related to these future cities, such as the consequences of 200+ years of adaptation to climate change impacts and how physical infrastructure has (or has not) been successful in that adaptation. Moving outward, we described the interacting social, political, economic, and cultural reality of 2199 in each city. For example, what distinguishes Eko City in the future? It is the largest and oldest part of the region, and this informs the cultural and social role that it plays. This means that part of its adaptation has been to focus on the connectivity of its historic architecture and arts. Comparatively, the progressive inundation of the Eti-Osa peninsula over 200 years has continually remade New Lekki such that it has emerged as a dynamic and changing metropolis.

The Three Horizons framework was then used to explore "patterns of innovation and change through a systems lens" (Curry 2015, Sharpe et al. 2016). The three horizons were the present world, a transition period, and the future world (i.e., the target time period of the story) (Fig. 2c). We used the Three Horizons framework to situate the three cities in 2199 (at the fully realized, third horizon) and to design a future history characterized by systemic changes that propel the entire region. Working backward, we identified how the world has transformed from the present day to the hypothetical future world. We then focused on three specific intersections in this future world, where the first, second, and third lines intersect. The three intersections were as follows: (a) in the mid-late 21st century, Nigeria develops cutting-edge biotechnological tools to mitigate carbon emissions, (b) a glacial meltwater pulse event leads to catastrophic sea level rise at the end of the 21st century, and (c) in the early 22nd century, the three cities that comprise Lagos Bay become independent from the Nigerian national government.

Navigating new social-ecological geographies
Based on the structured futuring procedures, we revised the map of Lagos2199 and identified the core idea of the story. In this case, the story centered on a water taxi operator who ferries people around Lagos Bay, to reveal how things have changed in the future owing to climate change and more. With an emergent sense of the future of Lagos, the nascent story, and a sense of how the history has unfolded, we focused on key waypoints throughout Lagos Bay. We made sure each waypoint served a specific narrative goal and illustrated a particular climate change or sea level rise feature (Table 1).

We briefly describe how three of these waypoints provide a glimpse of a changed set of social-ecological systems and geographies in Lagos Bay. First, Eputu Town has been transformed from a suburban community in the middle of the Eti-Osa peninsula into a sprawling, now-coastal city of climate refugees. The socially progressive management of the community

Fig. 2. World-building methods, building first from the initial map of Lagos2199, with the Futures Wheels and interactions, followed by the Three Horizons framework. These summary figures are meant to visually convey the approach.

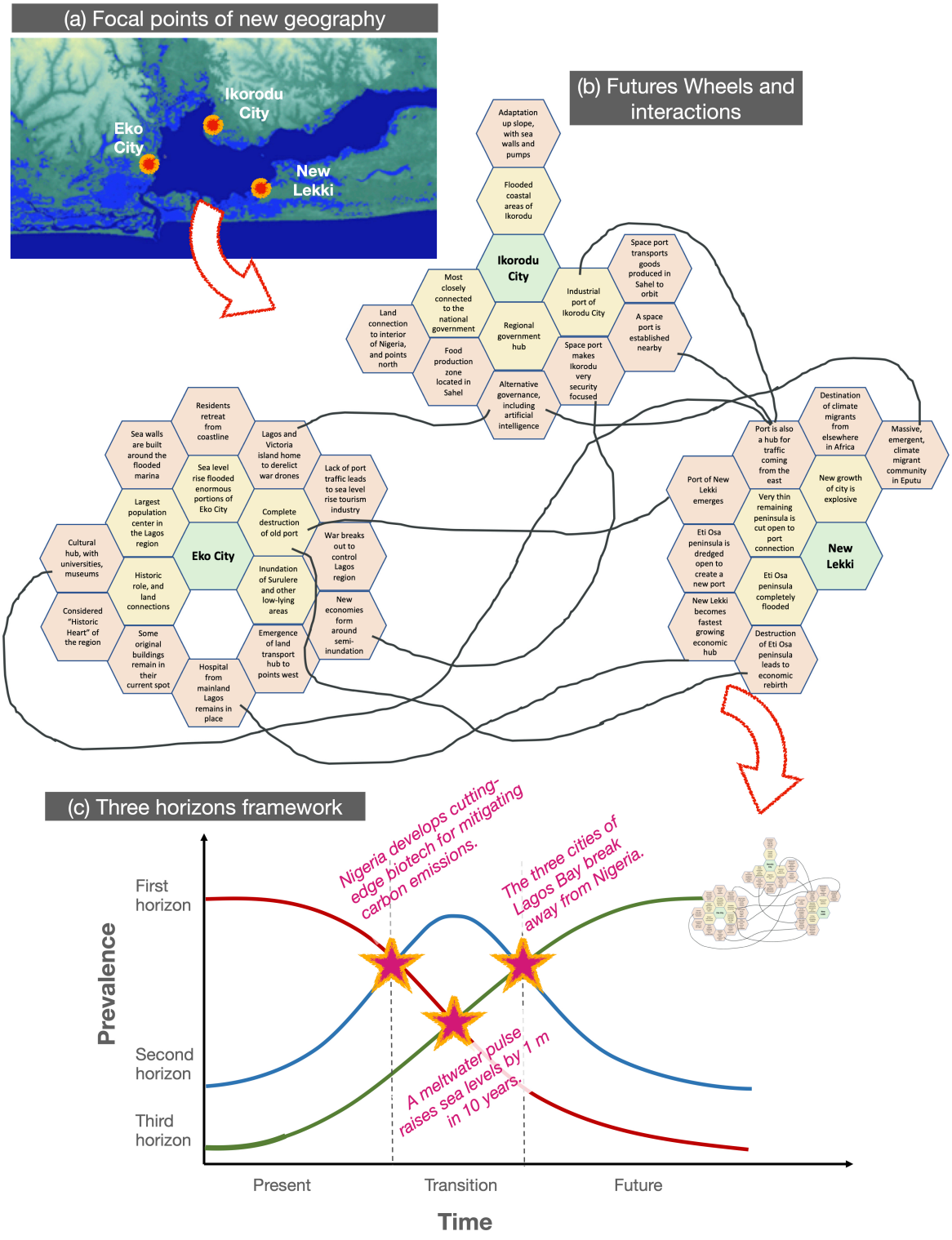


Table 1. Summary of Lagos Bay waypoints, the relevance to the narrative structure, and the specific sea level rise-related (or climate change-related) feature that is highlighted.

Lagos Bay waypoint	Narrative goal	Sea level rise feature
Eko City	Historical heart of region	Persistence in the face of sea level rise
Ikorodu City	Bureaucratic and administrative hub	Technological adaptation for complex circumstances
Space Port	Space-faring civilization	Technological advances despite climate change
Eputu Town	Persistent, adaptive slum	Social dimensions of climate refugees and migrants
New Lekki	African megalopolis	Rebuilding following sea level rise disasters
New Lekki Port	Transit connection to Africa	Adaptation to sea level rise and infrastructure collapse
Ekoatlantic Ruins	Hubris of the past	Legacy of failure to consider long-term risks of sea level rise
Atlantic Point Base	Military resurgence	Emergence of military governance during and after sea level rise
Snake Islands	Port infrastructure collapse	Permanence and difficulty of dealing with old infrastructure
New Festac	Inundated community	Adaptive community and restorative economics
Old Lagos	Legacy of regional warfare	Historic legacy of sea level rise and climate change conflict
Bat's Mouth	Biotechnology hub	Local scientific advances to mitigate climate change
N'etiti (Bat Forest)	Religion merging with action	Realignment of culture to make sense of existential crisis of climate change and sea level rise

has made it a magnet for people throughout West and Central Africa who are seeking a new start. Second, the Ekoatlantic ruins have been transformed from a land reclamation and luxury construction project into a lawless, half-submerged swampy ruin. The proximity to Lagos Island (which is the site of a regional battle, circa 2100), makes the region a restricted zone. Third, Bat's Mouth is a 22nd century illicit marketplace that exists within the genetically modified colossal mangrove forest. The forest itself dates from the late 21st century and represents the Nigerian and Lagosian contribution to climate mitigation via large-scale biological carbon sequestration. The colossal mangroves grow to enormous size by continuously sequestering carbon among the deep, dense root network. Importantly, all the waypoints in Table 1 are intertwined in a complex web of history, ecology, and people moving throughout the bay and the broader world. The game itself could be viewed as a vision of a future urban social-ecological system.

Main and supporting characters

Considering the entire set of waypoints detailed in Table 1, we began developing the story that occurs throughout Lagos Bay. Given that the main character in this scenario is a water taxi operator, we decided that the story should unfold in a way that makes logical sense from the perspective of somebody taking passengers around the bay. As such, the sequence of waypoints featured in Table 1 is in the same order in which they are encountered in Lagos2199. Thus, beginning with Eko City, the story proceeds clockwise around the exterior of Lagos Bay before concluding in the interior of the bay. The development of the story plot was iterative, and early versions of the story involved a more complex navigation of the bay. However, given that the central character in this story is a water taxi operator who is navigating around the bay, we wanted to avoid duplication of locations within the story, and to provide the maximum exploration possible within a single day.

As the geographic and world-building of the scenario became clear, so did the supporting cast of characters that the water taxi operator encountered during the story. These characters helped propel the narrative forward, provided information about the world, and motivated the action and events of the story. Table 2 shows the specific characters that are picked up and dropped off around Lagos Bay, and emphasizes the narrative role they play in the story.

Build story beats and write story

The world-building, the waypoints defined by the geography of Lagos Bay, and the characters the water taxi operator might encounter all provided the scaffold for writing the story. We created the outline of the story by defining the core "story beats" that would help distribute the events of the story, where and how the characters interact with the water taxi operator, and how to provide a satisfying story experience. This helped shape the arc of the game narrative and ensured that the text effectively delivers on the primary goal of the story. The following is a brief overview of seven key story beats, which begin in italics:

1. *Once upon a time,* there was a normal water taxi operator in Lagos Bay.
2. *Every day*, the water taxi operator would perform this uneventful job while trying to avoid dangerous areas, like Old Lagos and the Bat Forest.
3. *Until one day,* the water taxi operator happens to be assigned a very fancy boat, which is out of the ordinary.
4. *Because of this*, the taxi operator can travel much farther around the bay, and has a string of unexpected passengers that know information about the Bat Forest.
5. *Because of that*, the taxi operator becomes tangled up in a mystery involving Old Lagos, biotech, and the dying Bat Forest, with a drone technician and a gene edit dealer.
6. *Until finally*, the taxi operator winds up solving the mystery of why the Bat Forest is dying.
7. *Ever since then*, the taxi operator has a deeper involvement in what happens in Lagos Bay and a greater awareness of their role in things.

This list of story beats then provided the framework around which the story was woven. To be very clear, while the description that is conveyed in this article suggests the entire process was directed and linear, the writing process was an iterative loop of drafting,

Table 2. Overview of characters that the water taxi operator transports around Lagos Bay.

Character	Pickup	Drop-off	Narrative Goal
Business person	Eko City	Space Port	Explain there is a problem in Lagos Bay related to dying Bat Forest
Student	Space Port	Eputu Town	Explain purpose of Bat Forest with regard to climate change mitigation
Soy vat scientist	Eputu Town	New Lekki	Provide glimpse of possible scientific reason for dying Bat Forest
Coast Guard officer	New Lekki	Atlantic Point Base	Explore the danger of scofflaws in the bay, as well as the tension between the three cities and the Nigerian government
Tourist	New Lekki Port	Snake Islands	Comic relief. Also, providing an outsider's perspective for some of the sea level rise damage to the bay
Drone technician	Atlantic Point Base	New Festac	Explain the Lagos War, and the ways technology has accreted around the bay
Gene Edit dealer	New Festac	N'etiti (Bat Forest)	Dramatic tension for the Third Act of the story, where the mystery of the sick Bat Forest and other things get resolved

testing in the Twine game software (see *Game design*), experimenting with music and art, and returning back to revising the story itself.

The full text of the story is available in Appendix 1. We emphasize, however, that certain aspects of the story leverage the fact that the users themselves must interact with the story by making choices, all while seeing the visuals and hearing the game music. Thus, the text is most effectively experienced in the game context.

Make it weird

Finally, the story was examined for how well it managed the tension of remaining realistic while also being strange. Following Dator's second law of futures research, "any useful statement about the future should at first appear to be ridiculous", we aimed to imagine a world that has elements that are wholly different from the present (Dator 1993, 2019). At the same time, certain features of the present may be too permanent or unchangeable to convincingly transform (O'Neill 1981). Thus, we aimed to balance the story to push the limits of what is believable or possible while not going so far as to have the reader disengage. It is worth noting that this is not a process of science fact prototyping but science fiction prototyping. In this case, with a world that is 180 years in the future, it was critical to make certain aspects of the technological and socio-political world very strange. Thus, some elements took on a fantastical component, including the following:

- The Ikorodu government is managed by an Artificial General Intelligence,
- West African governments are different from present-day geopolitics, including Lagos Bay, which is a city-state autonomous from the Nigerian national government,
- Climate change has led to migration crises from Europe to Africa, and
- Humanity has colonized the inner solar system, including orbiting colonies around Mars.

These aspects are definitely fictional yet also theoretically or scientifically plausible. Given the far time frame in which this story is set, sufficiently capturing the potential for strangeness is critical (Dator 1993, 2019).

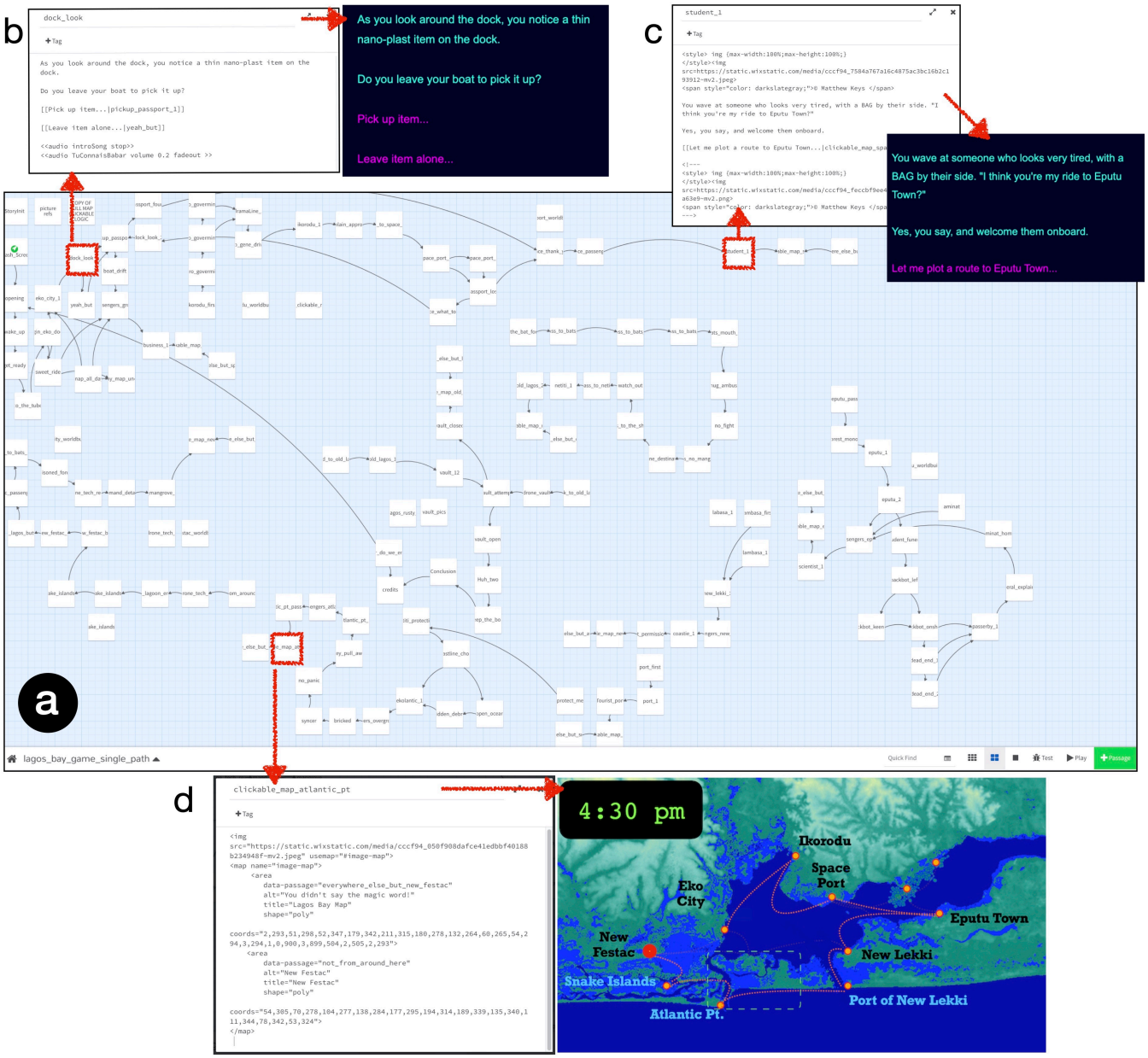
Game design

Following the development of the initial scenario world, we needed a freely available, open access, and user-friendly game platform. We used the Twine software to develop the game. Twine is an open-source, text-based software that has its own internal coding languages (e.g., SugarCube 2.0) and can incorporate common internet coding languages; i.e., HyperText Markup Language (HTML), Cascading Style Sheets (CSS), and Javascript. The platform is highly customizable and permits flexible pathways for a click-based story, and is reminiscent of early, text-based adventure games from the late 20th century. The Twine platform incorporates a graphical user interface, presented as a flowchart of discrete "Passages" (i.e., story components) and connections that link the story together (Fig. 3a).

The game development was, necessarily, highly iterative. Originally, the game was planned to be a multi-branching story, such that the water taxi operator could go in nearly any direction within Lagos Bay. However, this was halted, given that such a game would not permit a common user experience or a structured exploration of the game world. A key goal of the game development was to foster a common user experience in terms of both the storytelling and the exploration of climate change impacts on the region. Thus, a single-path story was developed, with minor branching elements.

Example "Passages" from the final Twine game are shown in Fig. 3. This is absolutely not meant to be a comprehensive explanation of all the code in Lagos2199. However, we highlight how Twine blends its own coding language (in this case, Sugarcube 2.0) with HTML and Javascript. First, the game often provided the user with multiple options to explore, as depicted in Fig. 3b, where the user is deciding whether or not to pick up an item. Another element visible in Fig. 3b is the command to play or stop music within that panel. Second, there are specific commands to display imagery, including the character artwork (Fig. 3c). This used additional HTML code and referenced a web-based data server (see *Web-based gameplay*). Third, the user in Lagos2199 navigates the region via a clickable map (Fig. 3c). This required using a process of mapping an image's pixels, and then identifying which part of an image would connect a user to a different passage. The game design process required a great deal of trial and error to ensure that the many different elements of the game, including music, imagery, and game logic, were all correctly rendered during user gameplay. Furthermore, this was a quintessential example of

Fig. 3. Twine game interface, with (a) the main screen showing the overall flowchart of the Twine game, (b) an example passage with two options a user can click with the corresponding game screen, (c) an example passage where the user meets a character with the corresponding game screen, and (d) an example of the clickable map interface within the game with the corresponding game screen.



"learning-by-doing", in the sense that the authors have never developed anything like this before; thus, existing web-based Twine user forums were critical for creating the game.

Lagos2199 Art and Music

Given the goal of creating an immersive game experience, significant effort went into the development and creation of unique artwork for Lagos2199. Characters were drawn digitally, which provided visual anchors for each of the personalities that the water taxi operator encounters (Fig. 4). For additional information on the character design process, see Appendix 2.

Using photographic material that is in the public domain or under permissive Creative Commons licenses, we also created artwork to accompany the story. Thirty-eight pieces of concept and environment art were developed for the final game. This art is available in Appendices 3 and 4, which include corresponding photographic references, the source artist's name, and the relevant license governing the use of each source. Four examples of the types of environment and concept art used in the game are shown in Fig. 5.

Fig. 4. Clockwise from top left: Student returning home to Eputu Town; Tourist visiting the Snake Islands; Soy vat scientist en route to New Lekki; and Drone technician.

Fig. 5. Example of the story art that visually depicted the changed landscape of Lagos 2199. Clockwise from top left: a color-shifted image of the city of Bat's Mouth, flooded forests in N'etiti, decaying Old Lagos, and flooded port facilities near the former Lagos port complex.

The story was complemented by music from the open access Free Music Archive, which is a database of freely available, creative commons copyrighted music. Songs were selected to accompany the different locations around Lagos Bay to match the situation in the story, dramatic tension, and tone. All songs were used in a manner consistent with the individual Creative Commons licenses associated with each song. The full list of songs, artists, and individual licenses is available in Appendix 5.

Web-based gameplay

Given that the game would be played on the web, it was necessary to have the game assets (e.g., artwork, music) also available on the web. Thus, a web server was set up using a free website, and all game assets were loaded onto this website. In this way, the Twine game could reference the assets on the dedicated web server from anywhere in the world and without having to download anything to a local machine. In the case of Lagos2199, the Wix web platform was used to host the data for the duration of the project.

The final game is freely available at https://climate_futures.itch.io/lagos2199, and we encourage you to explore the game for yourself. Gameplay requires about 30–60 minutes, depending on how long one takes to navigate the various pathways. The game itself is released under a Creative Commons License Attribution 4.0 International (CC BY 4.0). This license permits users to share and adapt Lagos2199, providing they provide attribution to the creators.

PILOT-USE CASE OF LAGOS2199

Preparation and approval for documenting first-use case

This game was piloted in an advanced undergraduate (i.e., 3rd and 4th year students) course on sea level rise at Colorado State University. The course is not required for any degree or major, and the students in the course originate from departments across the university campus, which necessitates a broad and interdisciplinary approach to education. The students are primarily from the United States, but demographic information beyond that is not disclosed. The primary learning objectives for the course are (1) assess the physical basis for sea level rise, (2) interpret and use sea level rise projections to articulate potential policy responses, (3) discuss ethical implications of sea level rise from cross-disciplinary perspectives, (4) assess how future sea level rise projections will impact different geographic and economic regions, and (5) explore sea level rise from the perspective of the humanities, such as art, poetry, fiction, and film.

The educational goal of Lagos2199 was specifically to foster imagination and visualization of the future of Lagos, Nigeria under conditions of climate change and sea level rise. Thus, a survey was administered to understand whether the game effectively delivered on this goal. In order to conform to ethical norms in research, the survey questions and methodology were submitted to and approved by the authors' Institutional Review Board. All relevant ethical guidelines were observed, and the user responses were (and remain) anonymous. In total, 15 participants were invited to provide feedback on the initial game; 12 of those respondents provided feedback and user data. None of the user

responses contain identifiable information, nor are they publicly available, except as presented in this article.

Volunteer participants were individually instructed to play Lagos2199, and at the end of their version of the game, there was a link to take a survey. The link took each participant to a Google Forms-based survey. The survey questions included a Likert scale ranking of agreement with four different statements, as well as open-ended questions to gather additional thoughts and reactions. For the Likert scale questions, participants were encouraged to rate their level of agreement with the statements on a scale from 1 to 7, with 1 corresponding to "strongly disagree", 4 corresponding to "neutral", and 7 corresponding to "strongly agree". The survey is available in Appendix 6.

Survey results

The number of survey respondents was not large enough to draw generalizable conclusions. We report the results as indicative of user experience, and as a basis for future exploration of both broader pedagogical methods and potentially game redevelopment. The results of the survey indicated that the Lagos2199 game was broadly effective at improving students' ability to visualize and consider sea level rise in Lagos, Nigeria. First, most students disagreed with the statement that prior to playing Lagos2199, they could easily imagine future life in Lagos (Fig. 6a). After playing the game, most students agreed that they could (now) easily imagine future life in Lagos (Fig. 6b). Second, most students agreed that the story in Lagos2199 effectively conveyed climate change in Lagos (Fig. 6c). However, one-quarter of respondents were neutral regarding this question. Third, most students either agreed or strongly agreed that the story was effective at conveying sea level rise in Lagos (Fig. 6d).

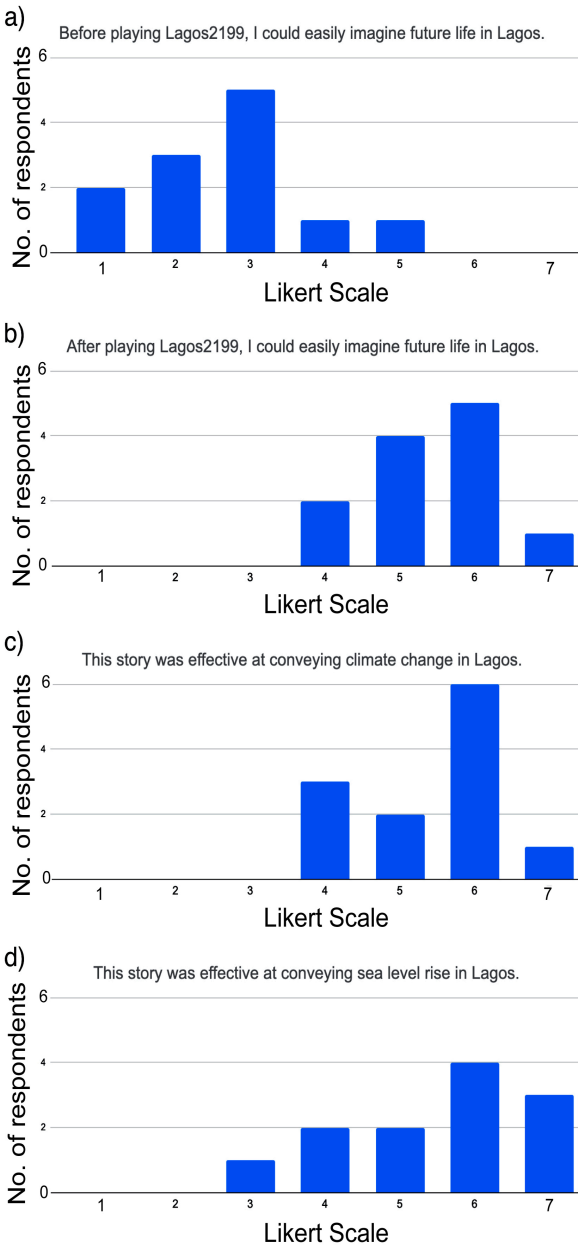
The survey yielded some negative results as well, notably that one student somewhat disagreed and two students were neutral regarding whether Lagos2199 was effective at conveying sea level rise impacts in Lagos (Fig. 6d). This represents one-quarter of the participants, and while most thought the game was effective (9 of 12 respondents), it is worth noting that there could be improvements to the communication of the sea level rise elements in the game.

In addition to the Likert scale questions, the survey respondents had an opportunity to provide open-ended comments regarding their experience of the game. When asked whether the game was "effective at conveying climate change in Lagos", one respondent commented that "I think that for people with a basic knowledge and understanding of climate change will be able to understand it, but it might be harder for someone who doesn't have that understanding." This is important feedback because it illustrates that prior exposure to climate change education may be necessary to be prepared to imagine such a radically different future.

We emphasize two major caveats. First, the number of survey respondents was quite limited ($N = 12$); thus, broad interpretation is not justified. Our preliminary, indicative findings suggest possible future directions for both how to glean more insight from the user experiences and how to distinguish what aspect of the educational process led to particular learning outcomes. Second, the structure of the questions revealed what the student perceived as a change, but whether this reflects an actual change in their learning is debatable. A more rigorous set of questions, both in terms of number of questions and formatting, would be required to effectively triangulate actual changes in student learning. Likewise, future work could aim to distinguish between the learning effectiveness afforded by the class, the game, and a combination of the two.

Given that climate change education is being delivered among many universities, an opportunity exists to recruit collaborating climate change educators and share the entire curricular module on "Sea Level Rise in Lagos." A much broader comparative effort

Fig. 6. Summary survey results from the first-use case of the Lagos2199 game. The scale ranges from 1 to 7: 1 = "strongly disagree", 2 = "disagree", 3 = "somewhat disagree", 4 = "neutral", 5 = "somewhat agree", 6 = "agree", and 7 = "strongly agree".



could then be made to understand what aspects of this particular learning game are effective at improving student understanding regarding sea level rise dynamics, climate change adaptation, socioeconomic transformations, and imaginative inspiration (none of which the current version of the survey aims to accomplish). By understanding whether and how Lagos2199 is (and is not) contributing to understanding about the aforementioned topics, it is possible that subsequent climate games could be much more finely targeted at specific aspects of student learning.

DISCUSSION

Sea level rise is highly visualizable

The fact that sea level rise will permanently change the coastline is self-evident. However, the fact that very specific places around the world will be changed in relatively well-understood geophysical ways provides an opportunity to glimpse the future remarkably clearly. In this case, we explored the changed coastline of Lagos, Nigeria. While climate change is often discussed in terms of short-term policy time horizons (5–10 years) to medium-term strategic time horizons (20–30 years), we aimed to describe a future that is far removed from the present, which permits much more substantial cultural, technological, and Earth system changes. We selected 2199 because it corresponds to a time horizon where even modest rates of sea level rise will have led to substantial inundation globally and the transformation of many coastlines from anything they resemble today. Moreover, climate change will be a societal challenge for centuries to come. Sea level rise is a climate impact that provides an entry point for depicting specific geographic changes in the far future (> 100 years) with relatively high confidence. In this way, 2199 permits a visit to a transformed future world under relatively staid projections of climate change.

Regardless of the scenario that is used, the first-order impact of any sea level rise scenario is inundation of land and change in the coastline. We have demonstrated that one can use multiple existing sea level rise simulations and couple them with a direct analysis based on a digital elevation model of any location on Earth. Compared to most climate impacts, this is an unprecedented ability to peer into the future. Other story-based scenarios of sea level rise have directly employed this feature of sea level rise to develop a future coastline. In the novel "New York 2140", Kim Stanley Robinson used the approach of identifying a new floodline (albeit improbable) in Manhattan (Billings 2017). Robinson said "If Manhattan is inundated by 50 feet—an amount unlikely but not impossible—you can look at topographic maps from the U.S. Geological Survey and see what would be underwater and what would still be dry" (Billings 2017).

Our work directly builds on this evidence that sea level rise mapping can be productively blended with immersive, narrative experiences to engage users on the topic of climate change. Moreover, the method we developed is ultimately rooted in public data on sea level rise, and could be replicated for any coastline on the planet for which sea level rise projections are available (which is nearly the entire global coastline). Thus, there continues to exist considerable future opportunities for employing a method of detailed scenario analysis based on scientific projections of sea level rise. Likewise, as a method for teaching and education, such scenarios allow students to explore specific locations, which subsequently permits a more direct understanding of sea level rise consequences to society and ecosystems.

Critical reflection

The authors of this work reflect that these imaginative methods are inherently subjective. Specifically, the development of the story and the practice of creating a map-based game reflect the subjective interpretation of quantitative and qualitative data. As such, this work reflects dimensions of positionality (i.e., Western, non-Nigerian) and social privilege (i.e., scientists from a research university). The subjective imagination of future geography, albeit based on the objective projections of sea level rise and current geographic information, impose constraints on the game itself and the experience of the players. Participatory methods are, by definition, more inclusive and could lead to a greater diversity of viewpoints and perspectives. Future versions of the game would be improved by fostering local participation in story or game redesign. Nonetheless, while this narrative was written by two people, the ideas and inspiration were drawn broadly from both scholarly research on climate change and contemporary Nigerian writing (Abani 2018, Onuzo 2018, Okungbowa 2019).

Futures methods for sea level rise education

A central goal of this work is to show how a story-based fictional game could potentially improve the capacity of undergraduates to imagine a future radically unlike the present. This goal is related to other work that has employed story-based futures methods for educational purposes (Wu and Lee 2015, Abraham and Jayemanne 2017). Subsequent research could improve and deepen the user experience of Lagos2199 in multiple ways. First, the game itself could be made more complex with additional branching storylines that delve into deeper treatments of aspects of the game. For example, each waypoint could include additional options for exploring how that location has changed due to sea level rise, and the coincident social-ecological change. Second, the students could be empowered to develop their own immersive scenarios following the same sea level rise-based methods we have detailed.

Also, though Lagos2199 was designed for a specific class that is learning about sea level rise, to think more broadly about the future, the game could be incorporated into other types of coursework focused on climate change impacts, as well as courses focused on creative futures methods and climate fiction. There is also the potential for application outside academia. The game could serve as a platform for a community group trying to envision sea level rise and climate change, and does not need to be restricted to Lagos, Nigeria or even Africa. Stephens and Richards (2020) provide an approach to constructing a nuanced experience of sea level rise that manages to bridge global projections with local stories. Their method is based on the lived experience of the storytellers in the project. The Lagos2199 game mirrors this with the character encounters from the perspective of the water taxi operator.

It cannot be overstated how important it is to leverage multiple forms of media for engaging the world beyond academia to think more deeply about climate change. Education, especially with regard to climate change, must be perceived as more than a flow of information. Cultivating experiential, interactive opportunities that permit entangled emotional and intellectual engagement will be increasingly critical, especially as the anticipated future diverges ever more strongly from the past.

Feedback between artistic process and scenario design

The interplay between artistic creation and story development was neither linear nor isolated but rather multi-directional and iterative. The initial story design provided input to the character design, and vice versa. As an example, the Nigerian Coast Guard Officer began as a character that would simply allow the water taxi to explore the coastline of Lagos Bay. Then, as the broader scenario began to take shape and the importance of the character took on different aspects, the design and artwork changed to clarify the more sinister role the character served.

This iterative aspect is an important characteristic of scenario methods, particularly when trying to tether them to social aspects of the future (Raven and Elahi 2015). The importance of design is also a critical feature for understanding how individual and group norms can be tacitly embedded in perspectives of the future (Evans and Sommerville 2007). Moving forward, there exists a significant opportunity to more deeply engage artistic co-design in the development of sea level rise-based scenarios, and advance this effort more directly into design thinking curricula (Evans 2010).

CONCLUSIONS

Sea level rise will transform the coastlines of planet Earth in ways that are hard to imagine, within the lifetimes of children born today. We document a method that takes a projected change in sea level rise, explicitly models such changes on the coastline, and develops a novel scenario-based future through the creation of an immersive, educational game about climate change impacts. The resulting game, Lagos2199, is then explored in a preliminary survey of a pilot-use case.

While Lagos2199 provides a unique vision of a sea level rise future in Nigeria, we expect our methodological contribution to have broad implications for the field of story-based scenarios of sea level rise and climate change. First, sea level rise projections are publicly and freely available, and based on the methodology we describe herein, a baseline map can be developed for scenario analysis anywhere in the world and with basic GIS skills. Second, such a map is a fruitful starting point for story-based scenario design, particularly in the future beyond 2100, when sea level rise impacts are likely to be highly consequential. Such stories can be integrated into games, using free software and multimedia, to foster an immersive learning experience. Third, and finally, such story-based games can provide an important complement to existing climate change education programs, particularly those tasked with equipping students with a futures curriculum. Indeed, providing the next generation of citizens with fluency in both climate change impacts and how society will interact with such impacts is necessary right now for effectively responding to accelerating global change.

AVAILABILITY OF LAGOS2199

The final game is freely available and downloadable from https://climate_futures.itch.io/lagos2199. The game is released under a Creative Commons Attribution 4.0 International License (CC BY 4.0). This license permits users to share Lagos2199, providing they provide attribution and do not use the game for commercial purposes. The individual artwork and music have individual licenses from the original creators, and are found in the appendices.

SUPPLEMENTARY INFORMATION

A considerable amount of information is available in the appendices for this paper, including the full text of the story, the 38 pieces of artwork in the game, a table of source material for the conceptual artwork with corresponding licenses, a table of music sources with corresponding licenses, and the original survey questionnaire.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/13393

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Data Availability:

All data that were used in this work are publicly available for educational and research use. The sea level rise projections from Climate Central are available at https://sealevel.climatecentral.org/maps/. The digital elevation model topography data are available at https://portal.opentopography.org/datasetMetadata?otCollectionID=OT.042013.4326.1. The open access QuantumGIS Geographic Information System software was downloaded from https://qgis.org/en/site/forusers/download.html . The sources for the photographs and music are available in the respective Supplemental tables. The GNU Image Manipulation Program (GIMP) is available at https://www.gimp.org/. The Twine software can be downloaded from https://twinery.org/.

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Supplementary Information for the article:
Creating a climate changed future with the sea level rise interactive-fiction game ‘Lagos2199’

Full Passage text for ‘Lagos2199’ game

Author note:
The text below tells a coherent story. However, this text was designed to be read in the game setting, with the corresponding pacing, imagery and music. Nonetheless, the text is shown here since it will permit an easier reading and understanding of the full story in the absence of playing the game itself. The Bold text represents the choices that are clicked to travel to the next story passage.

Opening:
In this game, you can make choices.

Some choices will determine the outcome of the game, while others will not.

You cannot return to previous choices.

The menu on the left hand side of the screen allows you to save your progress in the game, or restart the game. You can also adjust the volume.

1.
Wake up
"BEEP BEEP BEEP"

You wake up, slapping the table next to you to turn off your morning alarm.

"BEEP BEEP BEEP"

You sit up, groggy, unable to figure out why your alarm is still going, then you realize that it's not your alarm, but your Feed.

You click into your Feed, and see that you have the boat today.
Strange, you didn't think it was your turn till next week.
Either way, if its your slot, your slice depends on every shift you can get.

2.
Get ready

More importantly, you look down at the faces projected above your table and smile.
Any work beyond your normal shift goes to you - and you hope for their sake that today is busy.

You make your lunch as you listen to the morning newscast.

“In local news, stocks in AbujaTech are up, despite multiple gene hacking scandals. AbujaTech denies all allegations. The African Union has approved the deployment of growing season rain triggers throughout the Sahel. Local authorities in Kano have praised the news, and have suggested yields could be record-breaking. In sport, The Shooting Stars prevailed over Bridge F.C. 4 - nil. With the home advantage in New Ibadan, the Shooting…”

You suck your teeth. The Shooting Stars! Again! Walé will never let you hear the end of this.

“Now over to Ife with the weather.” You start paying attention, “Thank you Samad. It will be hot today, with temperatures reaching 35 C in Eko City and Ikorodu and 30 in New Lekki. No rain today, though the Govermind has suggested that if it gets too hot, it may deploy micro-seeders for a late afternoon shower to cool the bay off. We will keep you updated if and when we learn more.”

“Thank you Ife. Now, over to Chima for the latest on the African Union closing of the border to the ongoing European migrant crisis…”

You grab some water and head out the door, clicking off the lights in your cube and the news in your Feed.

3.
Head toward the Marina
As you take a tube to the dock, you stare out at the city around you. Holoboards flash along the walls of tube…

“Euro-Churn Tours presents ‘THE DUTCH COLLAPSE’. Adventure Awaits!” A giant wave splashes toward you, but you're already onto the next ad.

A giant eye blinks open “HOW MUCH DO YOU TRUST THE GOVERMIND?” It winks out, with a spinning logo of the Nigerian national government.

“If the Govermind can't stop Bat's Mouth, who will? Support a Federal Lagos!" another spinning logo of the Nigerian national government...

You reflect that the Bat Forest has not felt safe since the city of Bat's Mouth set up shop. One visit to that city was enough for you... you can't help agreeing with that Ad. Why hasn't the Govermind done anything?

"Get around the bay in style? HALtech gets you where you need to go." You chuckle and sigh, as you close your eyes from the visual onslaught.

There's a chime, and then “NEXT STOP. MARINA SOUTH"

4.
Prepare to disembark
The sun shines on the marina of Eko City. You look out at the docks and see people disembarking from drone ferries heading into the growing heat of Eko's massive sprawl.

You tap your Feed and your display shows you which boat you're operating today. There must be a glitch. You tap the Feed again. Nope...

5.
Look at the boat
Usually your HALtech boat is standard. This, though... is not.

It's at least an Oba 350, maybe a 400. Turbo boost, custom tap panel, and is that? You walk to the stern, and sure enough on the back is a custom hoverdrive.

Bemused, you shake your head, access HALtech in the Feed, and the boat purrs to life. You check the diagnostics, and the boot sequence looks good.

6.
Glance at the map of Lagos Bay
The city is a thrumming hive of activity. It has many names - New Lagos, Eko City, and Ekopolis - and yet defies easy classification. It sprawls back to the west into Surulere, meeting New Festac behind that, and onward all the way to the Unified Niger Republic. 50 million people by the last estimate.

Here it is easy to see the legacy of sea level rise. Unlike New Lekki to the south, and Ikorodu to the north, Eko City still retains pieces of its past, stretching back many hundreds of years. And despite the chaos of The Churn, the scattered sea walls and flood protection throughout the city have been transformed into elevated parks, also providing much needed escape from the sweltering heat of the city.

You can already see the heat shimmering above the rooftops - it will be hot today.

Look around marina
As you look around the dock, you notice a thin nano-plast item on the dock.

Do you leave your boat to pick it up?

7.

Pick up item[1]
You pick-up the item, its an Ares Orbital passport.

8.
Hop back on your boat
You realize your boat is drifting a bit, so you tuck it in your pocket, and quickly forget you have it.

9.
Reconnect to dock
There is a person approaching your boat wearing an agbada.

10.
Ask the person where they are headed
"Nǐn hǎo. The Space Port?

You smile and nod.

Let me plot a route to the Space Port

Ikorodu first
Ah ah. Before you can deliver the business person to the Space Port, you have to update your boat's permissions. The only way to do that is to approach Ikorodu Bay, so the Govermind can update the AI module accordingly.

The passenger says, "Will that delay the journey to the Space Port."

Not really, you say.

The passenger says "OK. But, I'm not from here, what is the Ikorodu Govermind?"

11.
Tell the passenger about the Ikorodu Govermind
Well, Ikorodu is an AI protectorate, with everything that comes with it. The passenger laughs and says "I have no idea what any of that means."

You say that back near the turn of the century, Ikorodu worked with some scientists from Abuja to put an AI in charge of city management. Or rather an Artificial consciousness - you're still not totally clear what the difference is.

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[1]Or:
Leave item alone: As you turn away from the item, you see a Mars logo, and now you're curious. (back to "*Pick up item*").

"Really!?" Exclaims the passenger.

Yes, you say. Apparently, it was a first of its kind test in the world. The scientists did not know what would happen, and other countries threatened war over the perception that the region might be destroyed by a rogue computer program. That's part of what led to the Lagos War...

12.
Passenger wants to know more about the Ikorodu Govermind
But, reality you say, is much more mundane.

It turns out that the Iko Govermind is a pretty boring leader. It cut ties to the Abuja scientists in 2121, and has been independently managing Ikorodu, and much of the bay in general, ever since.

It provides economic, political, and social continuity. Honestly - its helped create a transparent democracy, with a leader that is not susceptible to bribery.

13.
Passenger wants to know more about the Ikorodu Govermind [2]
"Isn't there any risk that the Govermind will go superintelligent?" says the passenger.

You answer, "Sort of. The worry of what will happen if the Govermind goes super intelligent is a constant discussion point, but since it hasn't happened anywhere else that machine governance has been tried (and there are many experiments throughout humanity's domain) that people have stopped being concerned.

The running joke is that they wish the Govermind was more intelligent - but people always think that of their leaders, don't they?"

You laugh to yourself and turn to your control panel to the intiate the update to your AI.

14.
Talk to business man
You ask the business man why he was in Eko City.

He answers, "I'm here discussing future investments in gene drive technology — are you familiar?"

Yes [3]

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[2] Or:
Passenger is checking out of the conversation, skip to #14
[3] Or:
No, tell about it: Also goes to #15

15.
Gene drive
"Fair enough," says the business man, "Well, gene driving is now almost two centuries old, so its relatively ancient technology. It is still the directed evolution of a specific organism, but its probably better to say designer evolution..."

You stare... maybe a little blankly.

"Anyway — " says the business man, "I am a trade representative for the Martian guilds. The American team made an impressive presentation today, and I daresay that the Lagosian team was caught flat-footed when the American's pointed out the inability to even keep the Bat Forest healthy...."

You nod, and consider this. The Feed has chattered recently about the health of the Bat Forest and the risks to N'etiti...

16.
Approach the Ikorodu marina
Approaching the Ikorodu marina from the south shows a very different landscape from Eko. The buildings present a much more utilitarian view, with a clear emphasis on functionality and sufficiency, rather than the hodgepodge architecture of Eko City.

"Why do you look nervous?" asks the passenger.

Do you look nervous?

A little… [4]

17.
Explain approval
"Nervous? Well... I always have some trepidation with the Govermind. Not really nervous — just healthy respect for the Govermind"

The panel on your boat chirps.

Ah, here we are, You say, "Let's go."

18.
Head to space port
You tell the passenger that its only a short trip to the Port from here, and gesture up at the uncanny quiet of a transport gliding overhead.

---

[4] Or:
No: Also goes to #17

19.
Steer toward the Space Port
The Lagos Space Port is an odd reflection of the region as a whole. The legacy of past sea ports are visible meters below the surface of the bay. Some of this infrastructure even peeks out of the bay — with pylons and rusty beams covered in vegetation, and populated by crocodiles and the water birds that nest there.

20.
Explain more about the port
As the central hub for the African continent, the Space Port a key point for transporting goods into orbit, especially the weekly transport of dehydrated food from the vast Sahel food production zones. The Space Port, like Ikorodu, employs a machine intelligence to manage all logistics among grounded, transferring and orbiting craft. This is sort of the only way to do it, since the ships all are driven by AI anyway.

21.
Passport is lost
The passenger exclaims, "Ah! I've lost my passport!"

Show them the passport you found on the dock.

22.
Thank you
"Thank you - you have saved me a much delayed trip back home."

Tell them they are welcome.

23.
Drop off
You approach the dock, to drop off your passenger.

"Thank you for the journey. It was much more enjoyable and informative than I expected."

You wave goodbye to the passenger.

24.
Look to the dock to see who is waiting
You wave at someone who looks very tired, with a BAG by their side. "I think you're my ride to Eputu Town?"

Yes, you say, and welcome them onboard.

Let me plot a route to Eputu Town

25.
To Eputu Town
You say, it will take a little bit to get there from here.
"We'll pass by the Bat Forest, if you're interested." you mention to the passenger.

"Ah, right... I don't know how I forgot about the Forest." says the passenger.

26.
Are you from around here?
"Yes, I grew up in Eputu" says the passenger.

The boat's AI is navigating the water easily, so you gaze up at the towering mangroves as you cruise by.

"Did you know" says the passenger, "That these were planted to help stop -"

"Climate change." You finish their sentence. You both smile.

"It was such a massive achievement! Literally, and figuratively..." The passenger stops as you are both caught in the shade of some of the 100 meter tall giant mangroves in the middle of the Bat's Forest. "What's wrong with that patch there?" The passenger points to a yellowing part of a mangrove, set back in the canopy.

"Ah - well, for the last few years or so, the Forest has been changing. Some patches have almost entirely died back - and the scientists don't know why. The Feed says that the Bay hasn't really changed, so its unclear what has happened, or what is happening..."

The passenger looks worried, and asks, "Is it salinity changes? Maybe something with thermal tolerances?" You laugh and say you have no idea, sadly.

You tell the passenger that you used to visit N'etiti quite a lot, making offerings at the shrine. But you haven't been for some time. And Bat's Mouth seems to be creeping outward toward N'etiti making it less desirable to risk a visit...

You look back and realize the passenger is spacing out looking at the water. Easy to do...

27.
Approach Eputu Town
As you near Eputu, it is clear why many consider this the most vibrant part of the Bay. By land and sea (and even sometimes a cobbled together airship) people with nowhere else to go, have come to Eputu Town. The watery, semi-flooded shanty town has been in the same place for centuries. As the water has crept higher, and then jumped in bursts, Eputu just goes up, too.

The passenger, rubbing their eyes, looks up at you and says, "Did you know what governments would do in the past?"

28.
What did they do?
The passenger says, "Way back, before the Churn, apparently the government was so obsessed with economic growth and impressing foreigners, that the military would raze settlements with no warning."

You say that you had not heard this.

"Its true." they say, "But now, Eputu Town is protected by the three Cities, and provided with essential services - well mostly."

The passenger inhales deeply and takes in the smell of the nearby Eputu Coffee Roaster - best in the region. They turn to you and thank you for the trip.

29.
Ask them where they are headed in Eputu.
"I'm here for a funeral" says the passenger. "I'm a student up at Luna University - studying nano-organic engineering. But... my great-grandmother died - would have been 170 years old this Tuesday. She was a wonderful woman, so, the whole family is coming back here." She looks out at Eputu. "It is nice to be back though."

You nod, and give them your condolences.

"Thanks" they say.

The student disembarks and quickly disappears into the throng of people at the Eputu docks.

30.
Look back to your boat
The students BAG was left behind in the boat. You quickly look back at the crowd, craning your neck to see if the student is still visible.

31.
Wait for student to return for BAG [5]
The BAG begins making a keening sound as it clearly has a proximity sensor in it for security.

You sigh heavily, and guide the BAG onto the dock so you can find the owner.

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[5] Or:
Take BAG onshore and look for student: Skip to #32

32.
Head onshore
You take the BAG up to a dockside kiosk, and see whether you can learn where the student disappeared to...

33.
Ask Kiosk if it knows of a funeral happening locally [6]
"HELLO!" Shouts the kiosk. You wince and look around. "YOU HAVE ASKED ABOUT FUNERALS. A FUNERAL IS ONE OF MANY CUSTOMS FOR HONORING THE DEATH OF A PERSON. WOULD YOU LIKE TO KNOW MORE?"

34.
Try to re-ask the kiosk about a funeral that is happening today [7]
"OF COURSE. FUNERALS TODAY. ON THIS DAY IN 2093, FAMOUS BRITISH-BORN YORUBA PSYCHIATRIST AND AUTHOR TADE THOMPSON DIED AT THE AGE OF 124 YEARS."

You sigh.

35.
"THOMPSON WAS KNOWN FOR PIONEERING WORK IN THE GENRE OF NIGERIAN SCIENCE FANTASY AND AFRICANFUTURISM."

You groan, with resignation and bring the BAG further into the crowd.

36.
Ask a passer-by whether they know of a possible funeral
You manage to stop a young fruit seller before they disappear into the tunnels and walkways of Eputu.

"You wouldn't happen to know of a funeral happening today - for someone who was about 170 years old?" As you say this, you realize how hopeless this is.

"Ah ah! Of course I do. Are you joking? Everyone knows of Mama Aminat's passing."

You light up, gesturing at the BAG...

37.
Explain your situation

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[6] Or:
Ask a passer-by whether they know of a possible funeral: Skip to #36

[7] Or:
Ask a passer-by whether they know of a possible funeral: Skip to #36

As you explain the situation of the student visiting their great-grandmother. A dawn of recognition passes over the face of the fruit seller, "Come with me" they say.

You hurriedly get the BAG walking beside you and move to keep up with the fruit seller.

"Mama Aminat helped make Eputu Town what it is today. During the last 100 years, so many people have poured into the Bay, and Eputu Town is one of the only places that they could go. Mama Aminat helped negotiate with Old Lagos, before the Churn, and ever since, with Eko City, New Lekki, and even with Ikorodu City. Don't you see? Everyone knows who Mama Aminat is."

You are run walking on the uneven boards to keep up while the gangle-legged BAG staggers to keep up.

38.
Walk across a walkway over water
The fruit seller sweeps aside a curtain and you see the student standing right there looking distraught, then surprised. "Thank you!" they exclaim. "I was so caught up in thinking about the funeral that I completely forgot about my BAG." The BAG shuffles past you, backing next to the student. You swear you hear a purr.

You smile and say they are welcome. "This is really important. I just had my funeral dress tailored at the space port for Grandmother Aminat's funeral, so thank you." You nod looking at what you now realize is a garment bag.

"The period of mourning is almost over and the celebration will begin tomorrow. Please feel welcome to join us as my personal guest."

You thank the student, smile, and wave goodbye.

39.
Return to your boat
As you step through your boat's deterrence field, you start up the boat's engine. And look around for people waiting near the floating market.

40.
Person talking loudly to their Feed about soy vats
"Hi!" says the person waving you over, "Can you take me to New Lekki?"

Yes, you say.

41.
Let me plot a route to New Lekki
As you make your way out of Eputu Town, you ask whether the scientists at the conference are talking about what is making the Bat Forest sick...

"Not really — but I did just read an article about old gene driven species being susceptible to nano-mesh bombarding..."

You stare completely blankly at the scientist.

"Sorry - my interpretation was that old gene-driven species, especially high carbon sequestering species like the Bat Forest, are very good at what they do. But, since they're very good at sucking up carbon, this ability can be hacked. That means that something disguised as a CO2 molecule or something, can slip in and start messing with the genes of the plant itself."

You look shocked.

"Well — I dunno — I'm just a soy vat scientist after all!" They smile.

42.
Motor around Lambasa Island toward New Lekki
Among the hubbub of Lagos Bay, New Lekki stands apart as a true city of the future. Emblematic of Africa's inevitable ascendance to global power in the 23rd century, New Lekki is evidence of this coming transition. The skyscrapers in New Lekki give meaning to that word in an unexpected way. Built on biological, rather than geophysical, foundations, the buildings of New Lekki are evidence of the profound progress of synthetic construction. The organic nano mesh that interweaves the mangrove base to the top of the steel and glass towers can stretch more than a kilometer tall.

43.
Approach the dock
As you approach the dock, with the buildings reaching far out of sight above you, the scientist collects their things.

"Thank you for that swift trip. I was worried I would be stuck in Eputu much too late, and miss the conference social - truth be told, its my favorite part of the whole thing." They smile at you.

You wait for them to disembark - and then stretch. It already feels like you've been around the whole bay, and its not even noon yet. You notice that someone with a stiff gait is approaching your boat.

44.
Person in Nigerian Coast Guard uniform
The coast guard officer strode briskly toward the boat, with rank and insignia holos flickering in the sun. "I'm headed to Atlantic point. I need you to get me there."

You apologize and say you can't, because you don't have the permissions to enter that part of the bay.

45.
Ask if the coastie would like to go somewhere else?
The officer sighs. "That's fine. I've got permissions. I just need to get there."

You open your permissions menu on your boat's panel, and the coastie holds their hand near the panel till it chirps.

All of a sudden, you look at your map and see that you have access to parts of the bay that you've never been to.

"What are you waiting for?" says the coastie "Lets get out of here..."

46.
Let me plot a route to Atlantic Point
"Did you see the Chinese have taken the Americans to the International Criminal Court?" asks the coast guard officer.

You answer that you did not know this.

"Yes, apparently the Americans were caught messing with Chinese supertuna or something..."

You nod, but is a little strange — why would anyone want to mess with China? You shake your head, and pay attention to boat traffic as you near the port.

The Port of New Lekki is a deepwater port dedicated to regional and global trade, including being the primary port of entry for most of Nigeria and points inland, as well as the O'Neill Vactrain that connects Lagos Bay south to Cape Town, east to Nairobi, and north to Marrakesh and Cairo. And, while the old hyperloop terminal is still technically functioning, it only services regional transport.

47.
Arriving into the Port
The New Lekki Port was literally sliced open, from the flooded Eti-osa peninsula in 2090, and over time has been dredged, deepened, and widened to become the primary point of entry into Lagos Bay. With the continuing failure to address the Drone Sentry problem in Old Lagos, this is the only method of entry that is considered safe (let alone, insurable).

48.
Notice somebody waving frantically at you
Waving frantically — no, excitedly — from the dock, is someone in a custom, yet ill-fitting Agbada, and a multi-holo projection. Must be a holologger.

You ask the Nigerian coast guard officer if they mind the extra passenger, and they wave their hand distractedly as their eyes glaze, reading the news.

You let HALtech know you're accepting another fare, and approach the dock. The person says, "Salam! Can you take me to the Snake islands? I am visiting a friend". You raise your eyebrows, but welcome them aboard.

You tell the tourist you'll be taking this Nigerian coast guard officer to Atlantic Point first, and they nod clearly just excited to be in the Bay.

49.
Add Snake Islands to your route
You sweep past the coastline, now outside the harbor, and look back.

From here, you can see how the Port is also equipped with force deterrence. Apparently, the New Lekki Port Authority works together with the Ikorodu Govermind to assess threats, both digital and physical.

You mutter something about being in the open water, and ask N'etiti for protection...

The tourist says "What was that?"

50.
Explain the mantra
You look at the Tourist, and explain that the mantra is just a saying. You're not that superstitious. N'etiti is the shrine in the Bat Forest. It is said to offer protection in the Bay, especially to people who live and work on the water.

The Tourist nods appreciatively, and you smile back a little sheepishly.

You mention that you have not been to the shrine in N'etiti in quite some time, that its probably worth a return visit...

5**1.**
Continue west to Atlantic Point
You reach a point where you must choose a route. You can skirt the flooded waterfront of the Eti Osa peninsula, traveling through the swamp of Ekolantic. Its collapsed towers, buildings, and overgrown canals can be risky with hackers or pirates. Or at least so you've heard.

Or, you can risk taking the open ocean route along the coastline, but you're not sure if your boat can handle it. You assume the AI wouldn't take you where you can't manage, but then again, you've never had the permissions changed like this....

52.

Open ocean [8]
You begin heading out along the coastline and you see that the water is calm today. You zoom along the shoreline, and you have a fantastic view of the coastal mangroves, as well as the flooded interior of the mangroves

You look down at your panel to check the sonar for debris on the bottom, and you hear the Tourist let out a shriek.

53.
You look up just in time
Your boat's AI veers to the right around a fresh shipwreck! Now you find you are in a path snaking through the mangroves. The tourist stops shrieking behind you.

You shiver at the close call, and look ahead as your boat more or less makes it's way back to the route it would have taken before.

54.
Emerge into Ekolantic
As you enter the overgrown canals of Ekolantic you turn to your passengers. You tell them that we will go a bit slower through here to avoid attention, and to also watch out for debris.

The tourist is wide-eyed, and nodding at you. The coast guard officer looks bored, and says something to themselves about how the Govermind really should do something to clean this up. You smirk to yourself, since this is all administered by the National government, and the Govermind has no jurisdiction in this part of the bay.

As you slide quietly over the canal, the mangoves form a tunnel around you. Then, turning a corner, the tunnel opens up, and you're in the open sun, and you see the Ekolantic towers listing to the side, collapsing in the center, and smaller buildings covered in greenery. You glance back and see the Tourist is gesturing at several of the holo screens. Apparently this adventure might make it onto this guy's channel...

The canal provides two directions and your boat AI says both get you to Atlantic Point, at the same time.

55.
Towers overgrown [9]
This canal takes you closer to one of the old towers. A century ago this was a luxury complex, and you can see the hints of that beneath the mud and decay. You see a mudflat, with covered in broken, half-submerged boats. A restaurant peaks out from behind a retaining wall. Set back

[8] Or:
Ekolantic: Skip to #54
[9] Both ‘Left’ and ‘Right’ take you to the same destination.

from the canal, you think you see a swimming pool, overgrown with ferns, and even a few crocodiles on deck, basking in the sun.

At the same time your boat stops humming, and you feel the bow drifting. You tap your panel, and groan — surprised.

56.
What happened?
You look over your shoulder to your passengers, and tell them not to be alarmed but that you've been bricked. The tourist says okay, looking unalarmed.

The coastie, though, is now alert, and looking around. They flip down an apparently recessed AR display and turn, in a slow, systematic circle, taking in all the buildings and some of the driverless boats moored around. They pause, chuckle, and turn back a half inch.

5**7.**
What is it?
"Over there, on the shoreline." they say. "A couple hacks. One with a shoulder mounted Syncer by the look of it."

You turn and see two people on the shore. One with with a large piece of cobbled electronics over their shoulder, and the other with an all-too-familiar weapon trained on your crew.

58.
Definitely panic [10]
"Don't panic." said the coastie. "They clearly did not see that I was with you, otherwise, they would not have just done this very stupid thing."

"Tell them that you're a free vessel taking passengers to Atlantic Point." says the coastie.

As you drift over toward them, you shout this over the closing water. They bark with laughter.

"Yea right. Only coasties go there, and you're not..."

The coast guard officer stands up, before they can finish the sentence.

59.
Reach to stop them [11]

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[10] Or:
Don’t panic: Takes you to the same destination, #58.

[11] Or:
Sit back: Takes you to the same destination, #59.

The officer moves too quickly for you — or anyone — to stop them. You're shocked since you took this person for a lethargic, uncommitted bureaucrat.

As they move forward, the tele-scoping boathook in their hand whips out to snag the gun away and fling it in a high arc overhead into the water. The person loses their balance and splashes into the water, cursing.

Almost before the other one can register what has happened, the butt of the boat hook thumps the person in the gut, and whips up to their chin flinging them onto their back, while the hooks whips back around, snags the strap of the shoulder mounter syncer and tele-scopes back in. The coastie retrieves the syncer, and looks at you with a grin. "I like souveniers" they say. With a few taps, the boat's AI is back online.

As the first one slumps back onto the edge of the canal, and the other one is coughing after having the wind knocked out, the coastie says "I don't want to see you again."

They nod, cursing, from the shore as your boat glides away, the coastie chuckling, and the tourist — frantic and wide-eyed — gesticulating into their holo screens for an unseen audience.

60.
Head toward Atlantic Point
As your heart thumps, you finally exit Ekolantic, and start gliding toward Atlantic Point.

This was the ancient entry to Lagos lagoon. The Churn changed all of that and it is now a military outpost for the Nigerian Coast Guard.

Unlike most of the rest of the Bay, Atlantic Point, as well as Ekolantic and Old Lagos, are all the territory of the National government. The Three cities, let alone the Govermind, have no jurisdiction, and most of the area is completely restricted.

The outpost has two primary purposes: First, help rescue ships that are sent to sea by the Drone Sentries on Old Lagos. Second, deter ships trying to enter Lagos Bay illegally. If the reputation is accurate, they pursue this second task with gusto.

61.
Approach the dock
As you near the outpost dock, the officer mutters a, "Thanks." And then they're gone. You laugh to yourself out of shock, since that was hands-down the most exciting trip you've taken through the Bay.

You are about to push away for the Snake Islands, when your Feed chimes and you see you have another passenger.

That's odd since you shouldn't even be here without that coastie's permissions.

62.
Look to the dock
A Drone Tech stands waiting, eyes focused more clearly than almost anyone you've seen. No Feed?

They look down at you. "New Festac?" they ask.

63.
Sure, let's plot a route
You nod, and they hop on board. Clearly very comfortable on boats.

"What were you doing back there?" Asks the tourist, surprised, and taking in the drone tech's analog kit.

"Well," says the drone tech, "Mostly just getting diagnostics. It's almost impossible to remotely monitor the drone sentries, so we have to go tap in directly." The tech gestures at the anolog equipment. "The sentries can't mess with this gear since it doesn't connect to the net. But the ghosts have been surprisingly active the last week or so and we don't quite know why. Anyway, I shouldn't say anything else about it."

The tech looks guiltily back toward the docks, but no one is looking your way. The Tourist, wide-eyed, blurts out "What's a Drone Sentry?"

64.
What's a Drone Sentry?
The bemused drone tech looks at the tourist, tilting their head to the side. "Not from around here?" The tourist shakes their head no...

"The Sentries on Old Lagos are relics of the Lagos War... During the Churn, they were set there to fight a cold war of deterrence between the Nigerian Government, some foreign navies, and what we now call The Three Cities. As the coastline disappeared, tensions snapped. But then things got settled and they were just left there ever since."

"Now they're acting up — in ways we've not seen before. Their signals are being detected as far as the Space Port, but don't seem to be bricking any ships lately. So we're stumped" the tech says. "I'm trying to triangulate the path of the outgoing signal, so that we can at least figure out who or what the sentries are communicating with."

The Tourist is wide-eyed.

The drone tech wiggles their fingers and says "Sometimes we call them... the Ghosts of Old Lagos."

The Tourist grins nervously, and you assure them you're not going near Old Lagos today. Then, you remind the passengers that getting through the channel will be a little dicey, given all the debris. "Slow and steady" smiles the tech.

Slow and steady you say to yourself...

65.
Continue slowly toward the Snake Islands
As you navigate the flooded warehouses, port facilities, and apartment blocks, Atlantic Point feels miles away. The interiors of the buildings seem to watch you — but truth be told that here, at least, you've never had a problem.

"What is all this" gestures the Tourist expansively at the overgrown, half-sunken forest of shipping containers.

"This is the Port of Old Lagos" you say. Given the Tourist's surprise, you realize that the Churn would have been different everywhere — but the devastation here might be worse than some...

66.
Approach Snake Islands drop-off
The Snake islands have become a quasi-biodiversity preserve, with extraordinary bird life, flourishing ecosystems, and a sizeable crocodile population that has become endemic. And of course, lots of snakes. Historically, this was the heart of the Port of Lagos... but the sentries put a stop to that.

The Cities have created a more or less protected area. Some boat traffic is allowed, particularly tourist traffic, but broadly speaking it is seen as an ecological experiment in restorative conservation.

67.
Continue onward
As you approach the destination, it's amazing how run down it looks. The Tourist is surprised too, saying that they thought a Snake Island research station would be much nicer. Then, as the projection flickers, you both realize it's just holo camoflage. "Pretty good job of it ..." mutters the impressed Drone Tech.

Then, the door in the building opens and a person waves them over. The Tourist, smiling and waving, stands to jump over the water to the dock. You pat their shoulder telling them the crocodiles are very real.

As you pull to a stop, they step onto the station dock. You wave and call out your thank you, and make your way slowly back out of the thicket of metal, concrete, and swamp — toward New Festac.

68.

Head toward New Festac

As you exit the swamp behind you, the open water of New Festac Bay is deceptive. The Port of Old Lagos were massive - with buildings scattered around sticking up out of the water, and if you look down you can see the roofs of low-lying almost directly beneath the surface. You lucked-out getting a hoverdrive today.

69.

Head up to New Festac

This part of the bay has seen some of the most significant loss of land, particularly the densely populated areas of the former Lagos City. During the Churn, Festac Town was in constant flux. As sea level rise has slowed down, New Festac has emerged as a counterpoint to the metropolises of Eko City, Ikorodu, and New Lekki. Exemplifying circular economics, New Festacarians have sought to find a balance with the surrounding environment, developing novel gene stocks for tea and coffee, and being a hub for Churn Tourists.

70.

Say goodbye to Drone Tech

"Do you ever go to Old Lagos?" Asks the drone tech.

Not if you can help it, you say.

"Well, this is something that might help if you get into trouble offshore, since the sentries are becoming a little unpredictable." The Tech pulls an item from a bag, and hands you the small device.

"What is this?" You pause. "Does this turn them off?!" You exclaim.

Laughing, "No." Says the tech, "I wouldn't give you that if that's what it did. No, its called a Thumper. It cloaks you as effectively as we can right now. As you're taking people around the bay, I don't want you getting blasted by some random ghost."

The Tech shows you how it works, simple. One large button on the top.

71.

Look for new passengers

As the Drone Tech jumps off, you tap into your Feed and finish your HALtech shift. You stretch, thankful for a busy day - but one that has come to an end.

Then your Feed chimes. You have another passenger!
You're sure you had just turned things off, but here you are, the HAL logo rotating in the corner of your vision. Not taking a passenger looks bad on your ratings, so...

Someone approaches, "Take me across the bay?"

You begin to ask where, but they start climbing aboard.

72.
Uh...
"Bat's Mouth." they say.

You begin to protest but you feel hear a chime realize they've already paid. "A down payment." You check. You say that they've made a mistake you start -

"No. I recognize what I'm asking and you'll receive the same on arrival." This is more than everyone else's payments combined.

You start to explain the risk of the dark city, that Bats Mouth is not just the entry to the Bat Forest, and then you see it. The portable editor under the arm, the phosphorescent tattoo at their waist, and the furtive looks to the security kiosk.
You hold up your hands and start to protest...

"Please. Yes, Obviously I'm a gene editor, but I'm trying to get some results to my superior. I'm not doing what you think I'm doing."

You cross your arms and say you'll need a little more to go on.

73.
Explain this again
"I've been digging into what's going on with Bat's Mouth." says the gene editor.

Huh. You mention the possible gene hacking you heard about to the editor.

"Yes! Exactly. Wait - how do you know that?" they suddenly grow suspicious.

You relate the story from the Scientist earlier.

"Well — yes. That scientist was close. I'm not certain, but the ghosts of Old Lagos might have something to do with this. I don't want to say anything till I get back to Bat's Mouth."

74.
Hmmm...
The Drone Tech appears back on the dock, "I just got a message. Any chance you can drop me off at Old Lagos? You can use the Thumper to safely land on the shore."

You say no. Firstly, no one is permitted to approach Old Lagos. Its restricted by the Nigerian government, Second-

The Gene editor chimes in, "I think you'll find you still have permissions from that nationalist you ferried earlier today."

You start to ask them how in the world they know, and then you look up at the Drone tech, who smiles and shrugs. You look from the gene editor to the drone tech. "Hey..." they say to one another. Maybe you should have guessed that these two would know each other.

The gene editor catches up the drone tech on your plan, and you realize that the gene editor must have been the one that messaged the drone tech...

75.
Demand more details
The Drone Tech says "Let me explain... No, there is too much. Let me sum up. The unexplainable disease in the Bat Forest and the unexplainable activity of the drone sentries on Old Lagos might be related." The tech looks to the Gene Editor for confirmation, and they nod.

"I understand your reluctance — " says the Drone Tech, tyring to smooth things over. "This sounds a little zany. But to pull off this heist..."

"It is not a heist" says the Gene Editor.

"So - to pull this off, it sounds like I might need to be on Old Lagos, if there's a connection to the sentries, right?" The Gene Editor nods.

"OK." says the Drone Tech. "If you can drop me off at Old Lagos, then you can get this one " motioning to the Gene Editor "over to the Bat Forest."

"N'etiti, specifically" says the Gene Editor.

"What?" you ask. "Why N'etiti?"

76.
Why N'etiti?
"That..." says the Gene Editor "Is something I cannot tell you right now. But I will once we get there."

You give a long look between the Drone Tech, and the Gene Editor... and you can't help your curiosity. "OK." you say. "Lets get you to Old Lagos."

"The Bat Forest Heist..." whispers the Drone Tech.

"Can you please stop saying that..." mutters the Gene Editor.

"Hey, if it looks like a duck, quacks like a duck, its a heist" says the Drone Tech.

"That doesn't even make sense," says the Gene Editor, rubbing their face.

The Drone Tech sits back, and just starts whistling, periodically saying 'Heist!'

Smiling to yourself, you tap in a course for Old Lagos.

77.
Head to Old Lagos
The gene editor and drone tech are speaking quietly in the back of the boat, while you stare out at the water, making sure the boat navigates the way it should. Your thoughts wander to where you are headed, and run down what you know about the drone sentries.

The semi-permanent drone sentries might be left overs from the Churn war, but they were too durable, and programmed in systems that were too well-encrypted. The result has been an impasse of responsibility, and the National government has continued to let them sit for now.

The area denial that the National government has established prohibits any civilian traffic here, but, with your permissions, well.... Either way, the thumper in your pocket gives you a little boost of confidence that you won't get bricked tonight.

78.
Contine to Old Lagos
You see the shape of a sentry, half buried with green creeping all across it.

79.
Approach the shore
As you make a landing at Old Lagos, the Drone Tech splashes out, and approaches what looks like a vault or door into the side of one of the Drone Sentries.

"I discovered this door last year, and haven't been able to get through — its too old." says the tech. "But, the signal is coming from this sentry."

You approach the vault. "Give it a try," says the tech. "It can't hurt..."

Should you try to open the vault door?

80.
Attempt to open the vault [12]
The vault stays shut

81.

[12] It is only possible to open the vault, after visiting the Shrine in N'etiti. An attempt at this point in the game will fail. If "No" is selected, skipt to #81

Vault is closed
The vault remains closed.

"No surprise there." says the drone tech. "Good luck and keep in communication." The Tech tosses a wrist communicator to you.

You grab it and look at them questioningly. The tech says "Its two-way only."

82.
Continue on toward the Bats Mouth
The Gene Editor says "When we get to Bat's Mouth, just relax. I'll take care of everything."

You nod, skeptical.

You pass boat made to look like an old Chinese junk. You can see the hover motor at the water's surface though, so you know its just a replica for foreigners.

83.
Continue the passage to Bat's Mouth
You turn to the gene editor "So we are just going to pass directly through the gate of Bat's Mouth? No problems? Just like that?"

The editor smiles widely, and says "Trust me."

You roll your eyes and open your mouth to speak.

84.
The gene editor interrupts you
"Look. I know this sounds a bit wild. But how much do you actually know about Bat's Mouth? How much about the Forest itself?" asks the gene editor.

You say that you know its the most dangerous part of the bay.

"Purportedly" says the gene editor. "Do you know anyone personally that has come to harm there?"

You say not really, but that its well-known.

"Hmm." says the gene editor. "And the shrine?" They raise their eyebrows.

You say that before Bat's Mouth became so dangerous in the last decade, that you used to visit the shrine. Quite a lot actually as a child. Its in the heart of the forest, and is a place you can pay respects to the forest for saving humanity. Its been here a long time, since the start of the Churn.

85.
Journey toward entry to Bats Mouth
The gene editor nods.

"You are helping me, and I trust you — " they look directly into your eyes. "So I will let you in on part of the story that you do not know." The gene editor continues "Bat's Mouth is not what it seems. And it is not an accident that it is located so close to N'etiti. Several decades ago the gene curators of the shrine decided that something must be done to increase the protection of the forest - our spies abroad had finally detected what we had feared for some time. Anger at the ascendance of Lagos Bay into something more than a backwater. We - "

You stand-up wide-eyed...

The gene editor looks flustered, then takes a breath. "Yes. We." they say. "I am a representative of the shrine. At another time, you might call me a gene priest. But yes, We decided something must be done. So, Bat's Mouth."

You remind the priest that you know Bat's Mouth is not a fake city. You remind them you've been there, that you've been threatened there.

"Yes, probably by one of my colleagues" says the priest. "But you are not dead, correct?"

You are shocked, and shake your head, indicating you were scared, but no, you did not die.

The setting sun disappears.

86.
Enter Bat's Mouth
The night city, Bats Mouth, towers overhead, in a seamless web of mangrove and neon. It is — well, you thought it was — the most dangerous part of the bay. You look around - and you know that while this priest next to you seems confident that this is a ruse, you realize that this place is still dangerous — and that the reputation it has is not all wrong. It just might not be the murderous hole that you thought it was.

The priest is watching you.

You can't help staring — offerings for illicit gene deals, stem mods, and black market grafts. Then you stare up into the canopy, seeing the neon illumination in the gloom. Then a shout brings you back, as fight breaks out nearby and someone falls into the water. You point at the victim, gesturing as if to say "What about that?"

"Like I said, they aren't dead." You pass by the storefronts covering the roots and trunks of the mangroves, as the Bat Forest residents scowl down at you.

87.
Take Gene Editor to their stop
In the middle of the canal, there are two thugs standing in a canoe, barring your way.

"Si n'ụzọ pụọ." threatens the priest.

The two thugs give an almost imperceptible bow, while paddling quickly away. You briefly glimpse the same tattoo as you saw on the priest.

You can't believe it, and you float right past them.

88.
Wait
Wait — You ask if you just say that the next time you're here, as you look back at the Bat's Mouth — which you simply cannot believe you just floated easily through...

"No." the priest laughs "You would not get the pronunciation correct, and they would know." says the priest, then they continue as though you hadn't said anything. "The shrine as you know it, is called N'etiti or ‘Ni aarin’. Even we do not know when the shrine started exactly, but it became quite clear something must be done when people began arriving in large numbers."

You duck as the mangroves nearly close around you but then open into a cathedral of open space with other trees towering far overhead.

89.
What are these?
You look around you and ask the Gene priest what kinds of trees these are.

"Now you see why we built Bats Mouth" says the Gene priest. "Despite the best intentions of the visitors to the shrine at N'etiti, they brought gifts of soil and seeds — and many problems. Competition for nutrients, foreign pests, and things still more nefarious. The exotic fruit trees alone have attracted close to a million fruit bats." The gene editor waves absently above you.

"So, while the gene priests of the forest continue to carefully monitoring carbon sequestration by the mangroves, the city of Bat's Mouth helps keep the visitors to manageable number."

You shake your head — everything you thought you understood is turned on its head about this place.

90.
Where are you going?
You ask if you are now headed to the shrine?

"Yes. Well, not exactly. We must enter secretly - since I do not know who is involved. I did not expect to be doing this with the help of a drone tech and a ferry operator, but here we are."

You whisper to yourself that it really is a heist.

The priest rolls their eyes and looks upward at the towering trunks above you.

91.
Pass toward the shrine
You get a buzz on the communicator, realize its the Drone Tech, "Are you getting close? The signal from behind the vault door is almost perfectly aligned with the signal in the wrist transponder."

You see that you are actually behind the shrine, as you knew it. The priest motions for you to head directly toward a root decscending into the water, and as you approach you see a crocodile swimming toward you...

92.
Uhhh
Ahhh!

93.
Steer away from the crocodile! [13]
Before you can do anything, the crocodile passes through you — and you realize it was just a projection.

You see that the holo projection masked an entryway into further canals into the heart of the shrine. These, however, form concrete alcoves and what appears to be flooded control stations?

The gene editor says something into their Feed, and...

94.
Look at the alcoves
At once, the water disappears, and you see that this area is actually dry, well mostly. The water is a projection also, and the gene editor hops over the flood wall and races along the alcoves until they duck into one.

You hop down into the dry canals, and look over the priest's shoulder.

"Here." The priest says, pointing to a small patch of lichen on the wall.

"This little organism should not be here. In fact this does not grow anywhere in this part of the world. A nice gene hack by some standards, but clumsy to an expert." Taking one of the

[13]This option, and ‘Crouch down in the boat!’ both take you to the next passage, #93.

instruments from their shoulder, the priest gently opens the lichen, revealing organocircuits beneath. "Hold this" they say handing you the instrument, and a part of the organocircuit.

As you take the instrument, they deftly use another tool that appears to scan the lichen. "There, now. It was a clever job of gene hacking - but its been stopped. It will take time to repair the damage, especially without the original Rhizophora stock. But at least the bombardment has been halted."

95.
Return to Old Lagos
This," they hold up a vial containing a single hair. "Needs to make it back to Old Lagos. It is the key to finishing this."

You let out burst of air, and start to object —

"Come on! Its the Bat Forest Heist!" grins the priest, goading you to object.

You need to know what this is.

The priest says, "It is a key that is more than 100 years old..." They raise their eyebrows. "I will stay here," says the priest, "and make sure this is properly reprogrammed, I may be seeing you around — now that you know some of these secrets..." The priest gives you a long glance, and then goes back to their work.

How did you get mixed up in this?

96.
Back to Old Lagos
You exit N'etiti, and then out of the Bat Forest, into the setting sun. With your batteries at full, recharged apparently in N'eiti, you glide swiftly back across the bay.

Looking down in the boat, you remember to hit the thumper - despite everything, the ghosts of Old Lagos could still brick you.

In a matter of less than an hour, you are pulling up to Old Lagos... again.

97.
Approach the Drone Tech on the shore
"Team Bat Forest Heist!" calls the Drone Tech as you hop ashore.

You explain what transpired in N'etiti. The tech looks surprised about the gene hack discovered at the Shrine, but not that the gene editor is a priest. You stare, open mouthed.

"Well — I've worked a lot of contracts in this Bay..." says the Drone Tech. "Now, lets see that message in a bottle."

You hand the vial to the tech, who carefully opens a panel on the vault door that has been painstakingly cleaned. The Tech drops the hair onto the panel.

"Why don't you try the vault again...?" says the tech.

98.
Try to open the vault door
The vault opens.

99.
Vault opens
The vault opens up before you, as the Drone Tech carefully retrieves the hair and replaces it in the vial. You immediately get a buzz on your wrist.

"Did it work" pants the priest.

Yes, you say. Then you quickly ask whether the priest is safe.

"Of course. There were just a few more surprises waiting for us. Its fine now." they say. "Are they intact?"

You stare into the vault, open mouthed. Row, upon row, upon row, of protected sealed storage containers on the walls. The Drone Tech whistles their surprise, and grabs the communicator "Yes, everything is intact."

You look at one of the labels "Rhizophora colosseus" - then you smudge some dirt away "Colossal Mangrove".

The Drone Tech claps you on the back. "We've got it!" They turn the knob on an ancient looking drawer, and against the odds, it opens with a hiss. The Tech carefully extracts a box, puts it in their front pouch, and says "Lets get this back to N'etiti."

You ask if you're just going to leave all this here.

The Drone Tech says. "We're going to seal this back up, like we were never here. The fewer people that know this is here, the safer these seeds are."

100.
Huh.
You take a step back and stretch. What a day. As you go to leave, you hear a chirp in your Feed, and see a message from HALtech.

Text starts appearing in the corner of your eye...

"Thank you for your assistance to N'etiti, and for restoring balance to the Bat Forest. Though we may seem all powerful, we are not."

What is this?

"Only last week did we discover where the original gene stock for the Bat Forest was kept and that the seal was gene locked to the original scientists who created the vault. Only this morning were we able to identify a suitable courier for all that unfolded today - You. But now we know where the ancient seed vault is, and more importantly, we can fight back against the combined efforts of the nationalist and foreign factions that seek to hobble our home. Again, thank you."

Who is this? Is it the priest?

"No, we are not the priest."

Wha-

"We're the Govermind."

101.
Uh.
You are speechless.

"An appropriate response." the Govermind says. They go on, "Oh yes. You may wonder about your good fortune in securing this boat today. That, too, was not an accident. And, as a small gesture of gratitude, please accept this as your own personal craft. HALtech strives to keep its employees satisfied."

You blink in shock, and the text is gone. Did that just happen?

102.
Exit the vault
As you exit the vault in a daze, the drone tech is doing a little dance. "Should we go celebrate?" they look more closely, "Are you okay? You look like you just had a conversation with a Ghost."

You shake your head, and smile. You say you are fine.

The Drone Tech asks again, "So, lets get this back to the priest. And then go celebrate...." They continue their dance.

You realize that, yea, the excitement of today will not ebb soon.

You sigh, look over at the Drone Tech, and say "OK, where to?"

103.
End the game.

Supplementary Information for the article:
Creating a climate changed future with the sea level rise interactive-fiction game ‘Lagos2199’

Methodological supplement ‘Lagos2199’ game

Character design methods

Initial concepts for each character were developed, and iterated until the final art was complete. Importantly, as the character art was developed, this process modified the narrative itself. This feedback between art and scenario development was very important for the final game experience, and emphasized the need for responsiveness and narrative agility in story-based narrative design. The user does not have a visual character in the story. This was intentional to allow any user to project themselves into the role of the water taxi operator.

To start the design process for the non-player characters that would populate the game, a synopsis of each character was drafted including details about who they were, what part in the story they played and a short list of descriptive details of appearance to provide a jumping off point for creating designs. There was no specific gender or age assigned to any character, but that eventually came out organically through the creative process. Reference material was significantly used to capture modern day clothing, which would then be given futuristic aspects for the setting. This included taking the Nigerian Agbada and giving it a more fitted look for the businessperson character, and a more loose and stylized look for the tourist character. Modern day Nigerian military uniforms were used as reference for the Coast Guard character, allowing for the creation of a uniform for a currently non-existent branch of law enforcement in Lagos prior to the sea level rise event of the game.

The characters were initially hand-drawn, the drawings then shared with the game design team for review before further work would be done to digitally ink and color the drawings. This was an important step to allow opinions of the group to be voiced about the design of the characters and any aspects that did not fit in the narrative. For example, one character was visiting the Lagos Bay area from the Lunar University on the Moon, and the initial design included the torso of a partially disassembled space suit (Fig S1a). However, upon discussion, a space suit would not fit the heightened temperatures that global warming would be exhibiting in the year 2199, particularly in tropical Lagos. This led to the character having a more skin-tight suit with a vest; the vest having patches identifying Nigeria, the Lunar University and the activist stance of the character (Fig S1b). This enriched the character’s background more than identifying the character coming from space by wearing a spacesuit.

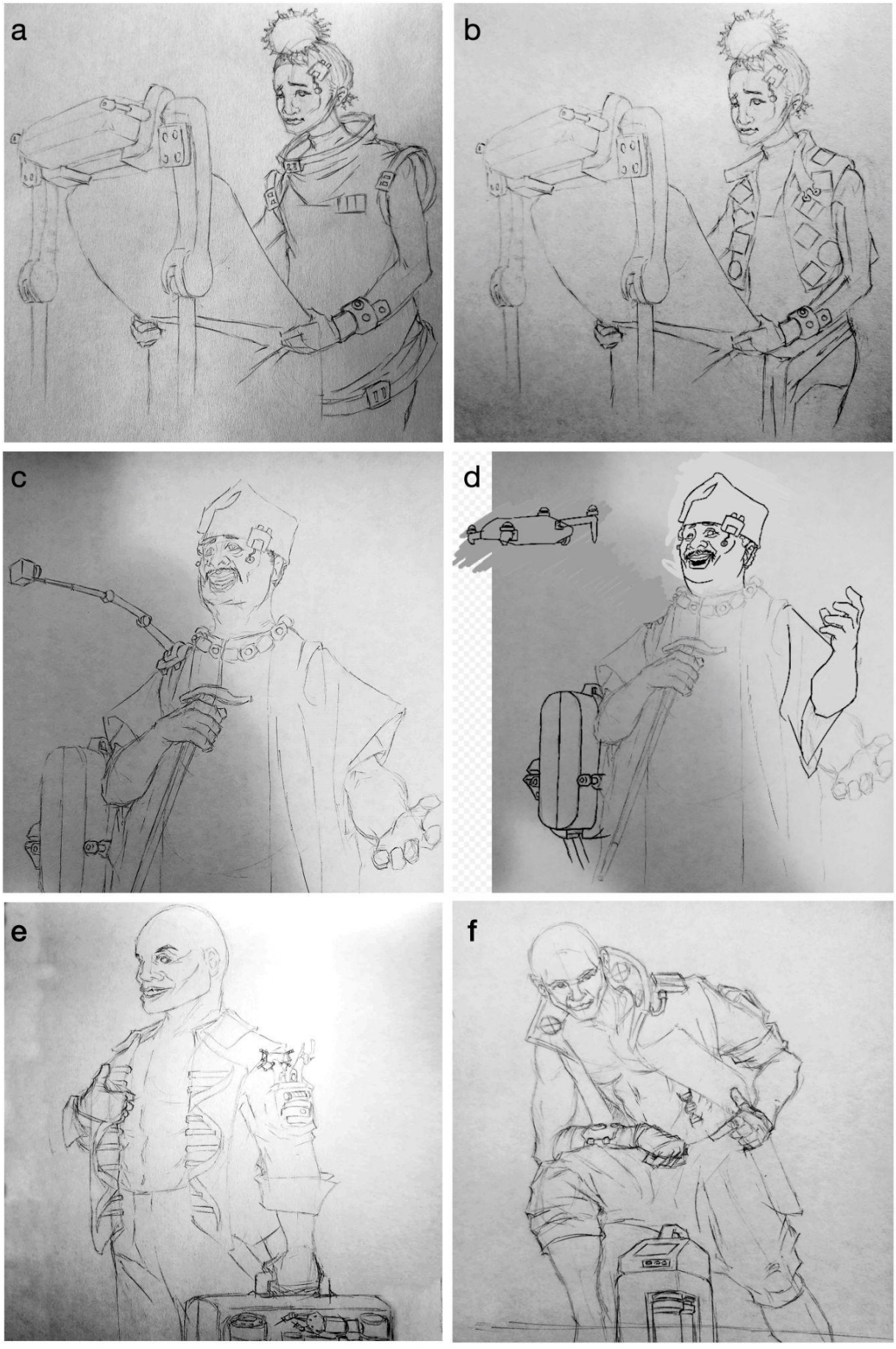

a
b
c
d
e
f

Figure S1. Example of character development process for a,b) the Student from the Lunar University, c,d) the Tourist, and e,f) the Gene Edit dealer.

Additionally, small modifications were made to make characters more expressive. Through the character design process, using the digital inking mechanism to make modifications was helpful in that the original hand-drawn design did not have to be modified, all adjustments could be made digitally. For example, the tourist character is actively vlogging and orating, and to make the character more futuristic and more expressive, the camera on selfie stick and lowered arm were digitally edited out and replaced with a vlogging drone and raised arm (Fig S1c,d).

Other times the initial concept did not really hit the mark, such as the gene edit dealer. Initial concept was too overt in design, had anachronistic tools, and did not suitably convey potential menace (Fig S1e). In this case, a new concept was drawn up, allowing the character to covertly reveal their status as a Gene Edit dealer, the tools of the trade looking more streamlined and futuristic (Fig S1e,f).

Once the design was agreed upon, the digital inking and coloring occurred. This included the use of a pressure-sensitive pen tablet such that the line work in the digital inking would look drawn rather than have a static width. In the digital drawing application, it allowed for different layers to be added to the artwork, allowing the inking to occupy layers separate and above the coloring layers. The artwork could then be broken up into foreshortened pieces, each piece worked on separately, allowing quick rework to be done on one piece without affecting other pieces. The layers having transparent backgrounds allowed for making semi-transparent elements such as the holographic screens present in many of the character designs.
Coloring for clothing and peripherals was done in a comic book fashion, with simple shadows to make the images more pronounced. In contrast, multiple references were used to capture the diversity of skin tones of the characters, and the skin was inked using a more blended approach giving it a softer feel. Digital color palettes were made to keep colors consistent between the different layers of the digital art. Four final character renders are shown in the main manuscript in Figure 4.

Environment and concept art

Using photographic material that is in the public domain or under permissive Creative Commons licenses, we created immersive artwork to accompany the stories. Given that the future depicted in the story is radically different from the existing world, these photos were manipulated using the freely available GNU Image Manipulation Program (GIMP). The manipulation of the photos

ranged from simple application of preset image-manipulation filters within the GIMP program, to multi-image composites. For example, the environment for Old Lagos (a waypoint in the game), includes photographic sources that were digitally manipulated in GIMP (Fig S2).

Figure S2. Example of the components of a multi-image composite including a coastal lighthouse, destroyed and decaying buildings, and tangled vegetation. While these source images are blended throughout the composite, elements from the originals on the left are indicated in the composite on the right.

Supplementary Information for the article:

Creating a climate changed future with the sea level rise interactive-fiction game 'Lagos2199'

Table of source information for Environment, Concept, and Character art for 'Lagos2199' game

Concept art number	Title of concept art	Photographic subject	Photographic source	Photographic license	Photographic URL
1	Eko City docks	Causeway Bay Typhoon Shelter, Hong Kong	Bernard Spragg	Public domain	https://flickr.com/photos/88123769@N02/16013769556
2	Eko City skyline	New York skyline	Pierre Blaché	Public Domain	https://www.flickr.com/photos/pierre9x6/49180240557/
3	Business man background	Adelaide jetty	Bernard Spragg	Public domain	https://www.flickr.com/photos/volvob12b/19857206540
		Hong Kong Kennedy tower	Bernard Spragg	Public domain	https://www.flickr.com/photos/volvob12b/14860195136
		Hong Kong harbor	Bernard Spragg	Public domain	https://commons.wikimedia.org/wiki/File:Victoria_Harbour,_Hong_Kong._(9062593818).jpg
		Hong Kong buses	Bernard Spragg	Public domain	https://flickr.com/photos/88123769@N02/21282059684
4	Ikorodu City	Singapore skyline	Srijn Dijkstra	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/photo-of-singapore-cityscape-during-golden-hour-2499786/
5	Space Port close-up	Low Angle Photography of Rocket	Pixabay	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/low-angle-photography-of-rocket-65704/
6	Space port launch	Soyuz launch	NASA's Marshall Space Flight Center	Creative Commons Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0)	https://www.flickr.com/photos/nasamarshall/34197041775
7	Space port dock	White dome interior	gdtography	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/long-exposure-photography-white-dome-building-interior-911758/
8	Exterior Bat forest	Mangrove patch	B Balaji	Public Domain	https://www.flickr.com/photos/bbalaji/2387221908
		Mangrove patch	B Balaji	Public Domain	https://www.flickr.com/photos/bbalaji/2387221908
		Mangroves, Costa Rica	Personal photo	Personal photo	
		Galapagos islands	Anne and David	Public Domain	https://www.flickr.com/photos/annedavid2012/47102851422/in/album-72157707084914424/
9	Eputu Town	Boats on sandy surface	Mateausz Marek	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/view-of-skyscrapers-against-cloudy-sky-312214/
		Can Tho homes	Personal photo	Personal photo	*No URL*
10	Eputu Town boardwalk	Can Tho boardwalk	Personal photo	Personal photo	*No URL*
11	Soy vat scientist background	Batac street, Philippines	Bernard Spragg	Public Domain	https://www.flickr.com/photos/volvob12b/16830189588
12	New Lekki views	Bank of China, Hong Kong	Bernard Spragg	Public domain	https://flickr.com/photos/88123769@N02/15631655393
13	New Lekki looking up	Frankfurt am Main, Germany	Philipp Birmes	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/low-angle-photo-of-four-high-rise-curtain-wall-buildings-under-white-clouds-and-blue-sky-830891/
14	Coast guard background	Hong Kong	Bernard Spragg	Public domain	https://www.flickr.com/photos/volvob12b/29430956511
15	Port of New Lekki cargo	Indonesia port	Tom Fisk	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/aerial-photography-of-container-van-lot-3063470/
16	Port of New Lekki	Port of Melbourne	Bernard Spragg	Public domain	https://www.flickr.com/photos/volvob12b/24103687861
17	Tourist background	Princess Cruises Star Princess	Port of San Diego	Creative Commons Attribution 2.0 Generic (CC BY 2.0)	https://www.flickr.com/photos/8123170@N06/8057439759
18	Sunken ship	Ship on its side Greece	George Desipris	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/white-and-black-sunken-ship-2056194/
19	Ekoatlantic ruins	Abandoned hotel resort, Hawaii	Jeff	Creative Commons Attribution 2.0 Generic (CC BY 2.0)	https://www.flickr.com/photos/peptic_ulcer/7184132722
20	Ekoatlantic hackers	Advance contingent of ANISOM troops	AMISOM Public Information	Public domain	https://flickr.com/photos/61765479@N08/7213739614
21	Atlantic Point	Honor Bound Guard Tower	National Guard	U.S. Government Works	https://www.flickr.com/photos/thenationalguard/5343896666
22	Drone Tech background	US Navy landing craft unit	US Dept. of Defense	Public Domain	https://www.flickr.com/photos/39955793@N07/45008828844
23	Port of Lagos	Jakarta, Indonesia	Tom Fisk	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/pile-of-metal-trash-utilizing-in-junkyard-6196281/
		Beirut, Lebanon	Jo Kassis	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/city-water-storm-industry-6462775/
24	Snake Islands crocodile face	Close up of a reptile	Pixabay	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/green-eyed-reptile-39068/
25	Snake Island research station	Photo of Abandoned Building With Graffiti	Alex Montes	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/photo-of-abandoned-building-with-graffiti-1805268/
		Abandoned house in forest during autumn day	Aleksey Kuprikov	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/abandoned-house-in-forest-during-autumn-day-3551232/

		Calm river flowing among autumn trees in park	Ryutaro Tsukata	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/calm-river-flowing-among-autumn-trees-in-park-6249494/
26	New Festac dock	Old House on pier	Maria Orlova	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/old-house-on-pier-in-ocean-at-sunset-4969993/
27	Gene Editor background	No swimming dock	Matthew Barra	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/boat-beside-dock-near-gray-post-813073/
28	Old Lagos	Trees and moss	Dominika Roseclay	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/trees-covered-with-green-moss-near-river-6399516/
		Reykjavik lighthouse	Luc Coekaerts	Public Domain	https://www.flickr.com/photos/luc_coekaerts/28070247878/
		Abandoned building, Japan	JordyMeow	Pixabay license (free use, no attribution req'd)	https://pixabay.com/photos/japan-island-nagasaki-kyushu-725795/
		Destroyed concrete building	Zenjoe	Pixabay license (free use, no attribution req'd)	https://pixabay.com/photos/house-trash-ruin-concrete-3466731/
29	Drone Sentry	USS Mount Whitney	Commander US Naval Forces	Public domain	https://www.flickr.com/photos/94966166@N02/26820929978
		Trees and moss	Dominika Roseclay	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/trees-covered-with-green-moss-near-river-6399516/
		USS Donald Cook	Commander US Naval Forces	Public domain	https://www.flickr.com/photos/cne-cna-c6f/50596312016/in/album-72157640431436334/
		Reykjavik radar	Luc Coekaerts	Public domain	https://www.flickr.com/photos/luc_coekaerts/28070249228/in/photolist-2iExQoG-MFRQiV-a1SYXq-nc5NiX-45VkHE-JLtn9h-Ag6rGL-bWKUz1-8bVq3X-45R6eB-gkL1iM-k3Qy43-piDzRe-29gzcK4-k3NNS4-gkKvbF-gkKjM3-gkL1WF-gkKjys-gkKujF-MRpLP-gkL2ep-5X25qN-6FoHZY-gkL1Ce-gkKHmd-daWTE9-gkL2dn-edqAcg-gkKufc-gkL1ZB-6prmcJ-gkL1Gn-gkL2iT-gkKkdU-gkKuW2-7eL8N2-gkL1Mx-gkKkw9-gkKkrj-gkL1xe-gkL1j8-gkKHuQ-gkKv84-gkL19D-gkKv2x-gkKv4M-gkKudZ-9deZSG-o8pi6c
		Reykjavik lighthouse	Luc Coekaerts	Public domain	https://www.flickr.com/photos/luc_coekaerts/28070247878/
		Cleveland Trust Building under construction 1907	Tim Evanson	Public domain	https://www.flickr.com/photos/timevanson/48672912952/in/photolist-2k5VRJL-P3FMBB-nTG5ry-2iqrt4P-eYhAmr-eYhLPx-eYhAtV-NVB4j2-hbECJG-GJWJeN-AQgrwU-KVHfep-6HeVBS-3ejQkR-FNd5gi-2ha4phm-3epeJ3-s8zs34-kzb5kP-3ejQxc-5e89Cr-3ep3LL-NKC19-3ejCqM-a1W1yE-P35UqN-2kn9bda-JHPo6T-eSaeWM-T1qt4j-dQCydQ-JyKDKN-JEKDq7-HMy2TS-HMxNDK-dQvSDt-eWcfXL-egFTCR-JyKvNq-JHPm5P-etZU3e-eu1iTg-ie8SiR-3ejBkk-JyKAHL-HMy1CW-sYozy7-HMxZAA-ie8gzV-egCb3T
30	Old Lagos vault closed	Bank vault closed	Pablo vanden bosch	Pixabay license (free use, no attribution req'd)	https://pixabay.com/photos/vault-copper-bank-2069293/
31	Sunset bay with boat	Hong Kong boat			
32	Bat's Mouth neon towers	Low angle high rise in Hong Kong	Irina Iriser	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/low-angle-photo-of-highrise-building-1083807/
33	Bats's Mouth thugs	Woman and Man in Black Leather Jackets	cottonbro	Pexels license (free to use for any purpose)	https://www.pexels.com/photo/man-in-black-leather-jacket-standing-beside-woman-in-black-leather-jacket-4904538/
34	Interior Bat Forest	Mangrove patch	B Balaji	Public Domain	https://www.flickr.com/photos/bbalaji/2387221908
		Mangroves, Costa Rica	Personal photo	Personal photo	*No URL*
		Mangrove sunset	Personal photo	Personal photo	*No URL*
		Forest scene	Adobe	Royalty free	No link available
35	N'etiti shrine exterior	Old Growth Temple	James Wheeler	Creative Commons Attribution-NonCommercial-ShareAlike 2.0 Generic (CC BY-NC-SA 2.0)	https://www.flickr.com/photos/james_wheeler/6068292168/in/photostream/
36	Crocodile jumping	Crocodile jumping	Lisa Ann Yount	Public domain	https://www.flickr.com/photos/136594255@N06/25365338812/in/photolist-EDrZvN-4juWZ-3YjAE-pMKUAP-pMMykC-p8kxA5-pMKZT2-pMJCWf-q5g4Ys-pMKSue-p8ogyD-cvMGnd-bn1xuP-RZVLv8-7J5mRy-6AsPCR-6AsPER-31WVH-ou7qVp-oySM3Y-ox5t4H-oRBa4u-oLGuoG-oLh9gr-p8PVoz-67QP9K-oNttpu-oLG1p7-p3vHEv-p9nNyd-pafAxh-3YjAy-oPycqt-oLhPY2-oV7Hr3-oKkAH4-p7iRy3-4VGXqA-oT8XNn-oLFfdy-p2LtDm-oPkCKo-oRAFHj-ozGBjJ-oTVxRW-pcfHSG-p9G5Pi-oMF9F5-oSsim4-oYK14S
37	Shrine interior	Alcoves	Daniel Nebreda	Pixabay license (free use, no attribution req'd)	https://pixabay.com/photos/perspective-monument-architecture-4309467/
		Mangrove patch	B Balaji	Public Domain	https://www.flickr.com/photos/bbalaji/2387221908
38	Old Lagos vault open	Bank fault open	ahobbit	Pixabay license (free use, no attribution req'd)	https://pixabay.com/photos/vault-business-bank-vault-bank-1144249/

Supplementary Information for the article:
Creating a climate changed future with the sea level rise interactive-fiction game ‘Lagos2199’

Environment, Concept, and Character art for ‘Lagos2199’ game

Author note:
The art below accompanies the ‘Lagos2199’ text-based game. The numbering of each piece of art corresponds to the Supplementary Table entitled ‘Supplementary Information: Reference table for Environment and Concept art for ‘Lagos2199’ game. So, Image #1, corresponds to the same numbered image in the Table.

#1: Eko City docks

#2: Eko City skyline

#3: Business man background

#4: Ikorodu City

#5: Space Port close-up

#6: Space Port launch

#7: Student background

#8: Exterior of Bat Forest

#9: Eputu Town

#10: Eputu Town boardwalk

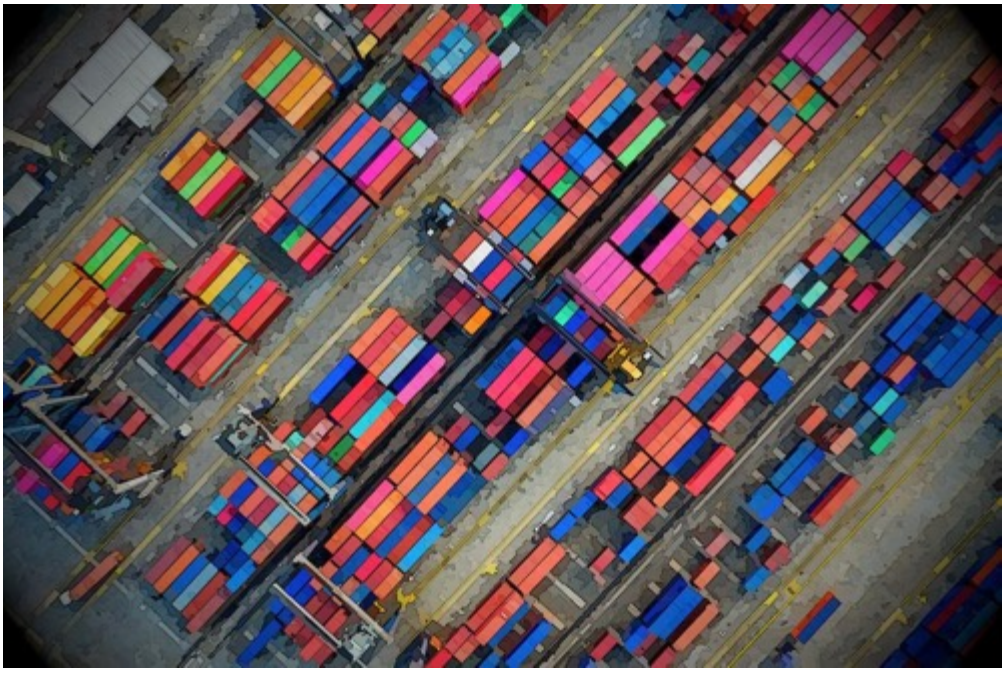
#11: Soy vat scientist background

#12: New Lekki views

#13: New Lekki looking up

#14: Coast guard background

#15: Port of New Lekki cargo



#16: Port of New Lekki

#17: Tourist background

#18: Sunken ship

#19: Ekoatlantic ruins

#20: Ekoatlantic hackers

#21: Atlantic Point

#22: Drone Tech background

#23: Port of Lagos

#24: Snake Islands crocodile

#25: Snake Islands research station

#26: New Festac dock

#27: Gene Editor background

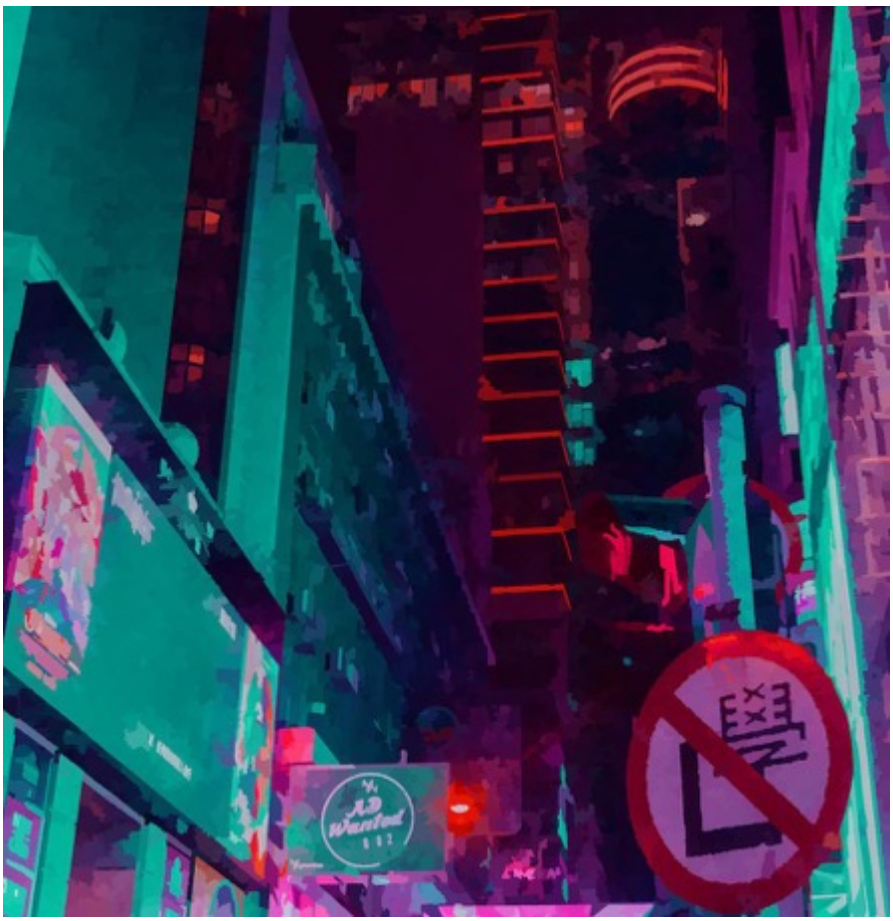
#28: Old Lagos

#29: Drone Sentry

#30: Old Lagos vault closed

#31: Sunset bay boat

#32: Bat’s Mouth neon towers



#33: Bat’s Mouth thugs

#34: Interior Bat Forest

#35: N’etiti shrine exterior

#36: Crocodile jumping

#37: Shrine interior flooded

#38: Shrine interior dry

#39: Old Lagos vault open

Supplementary Information for the article:			
Creating a climate changed future with the sea level rise interactive-fiction game ‘Lagos2199’			

Table of source information for musical score for ‘Lagos2199’ game

Title of song	**Artist**	**License**	**Link**
Tu connais Baba	Mocke	CC BY-NC-SA 4.0	https://freemusicarchive.org/music/Mocke/Commune_Oreille_explore_La_Souterraine/Mocke_-_SUPER_TERROIRS_et_RUINES_NOUVELLES_-_05_Tu_connais_Babar_-
Wind	Crowander	CC BY-NC 4.0	https://freemusicarchive.org/music/crowander/cinematic-indie-filmtv-music/wind
Parapentes Circl	Lobo Loco	CC BY-NC-ND 4.0	https://freemusicarchive.org/music/Lobo_Loco/beings-of-lights/parapentes-circle-id-1496
Kali Yuga	ZAIRE	CC BY-NC-ND 4.0	https://freemusicarchive.org/music/ZAIRE/1_1947/06_-_Kali_Yuga_1516
Espia Tuerto	ZAIRE	CC BY-NC-ND 4.0	https://freemusicarchive.org/music/ZAIRE/1_1947/05_-_Espia_tuerto_1957
Walnut Roots	Jurica Jelić	CC BY-NC-SA 3.0	https://freemusicarchive.org/music/Jurica_Jelic/Fragments_1861/Jurica_Jelic_-_Fragments_07_Walnut_roots
Polacha	Jurica Jelić	CC BY-NC-SA 3.0	https://freemusicarchive.org/music/Jurica_Jelic/Fragments_1861/Jurica_Jelic_-_Fragments_02_Polacha
Leonard Nimoy	ZAIRE	CC BY-NC-ND 4.0	https://freemusicarchive.org/music/ZAIRE/1_1947/07_-_Leonard_Nimoy_1059
Butterfly in the St	Chtin Mara	CC BY-NC-SA 3.0	https://freemusicarchive.org/music/Chtin_Mara/Madhouse_Blues/08_chtin_mara_-_butterfly_in_the_stomach
C▲LCHØNΛ RI	Humanfobia	CC BY-NC-ND 4.0	https://freemusicarchive.org/music/Humanfobia/calchona-ritual/clchon-rikztl
Viento midi	ZAIRE	CC BY-NC-ND 4.0	https://freemusicarchive.org/music/ZAIRE/1_1947/04_-_Viento_midi_1302
Awen	The Mind Orches	CC BY-SA 4.0	https://freemusicarchive.org/music/The_Mind_Orchestra/The_Mind_Orchestra_-_Singles/awen
Chaos in the Mat	Filmy Ghost (Sáb	CC BY-NC-ND 4.0	https://freemusicarchive.org/music/Filmy_Ghost/glitch-on-the-matrix/chaos-in-the-matrix-feat-mist-spectra
Coming Storm	Ketsa	CC BY-NC-ND 4.0	https://freemusicarchive.org/music/Ketsa/abundance/coming-storm
Isla de Java	ZAIRE	Public domain	https://freemusicarchive.org/music/ZAIRE/zaire/ISLA_DE_JAVA

Supplementary Information for the article:
Creating a climate changed future with the sea level rise interactive-fiction game ‘Lagos2199’

Survey questions (copied directly from Google Forms)

Lagos 2199 survey

Time to complete is less than 5 minutes.

Instructions: There are two Parts to this survey. Part 1 asks you to rate your level of agreement with a statement, and Part 2 includes more open-ended questions.

* Required

PART 1: Please check the box below each question that most closely corresponds to your answer.

BEFORE playing Lagos2199, I could easily imagine future life in Lagos. *

	1	2	3	4	5	6	7	
Strongly Disagree	○	○	○	○	○	○	○	Strongly Agree

Please elaborate (or type none). *

Your answer

AFTER playing Lagos2199, I could easily imagine future life in Lagos. *

	1	2	3	4	5	6	7	
Strongly Disagree	○	○	○	○	○	○	○	Strongly Agree

Please elaborate (or type none). *

Your answer

This story was effective at conveying sea level rise impacts in Lagos. *

	1	2	3	4	5	6	7	
Strongly Disagree	○	○	○	○	○	○	○	Strongly Agree

Can you specify any details here? (or type none) *

Your answer

PART 2: Please answer these three questions.

1. Who was the most interesting character to you? Why? *

Your answer

2. What aspect of sea level rise that was depicted in the story do you remember most clearly? *

Your answer

3. What aspect of the story was unclear or confusing to you? *

Your answer

Submit