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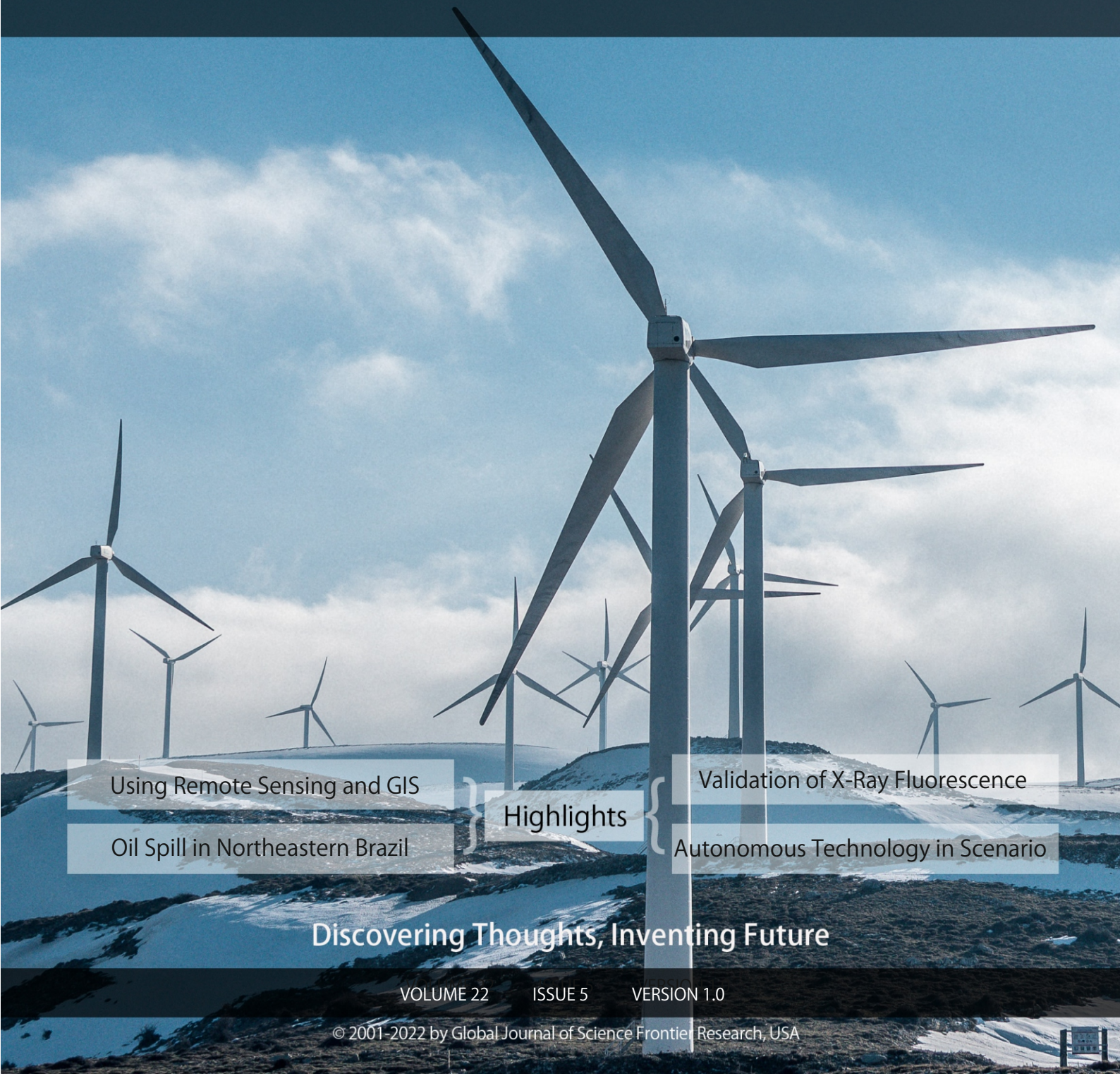

Using Remote Sensing and GIS

Oil Spill in Northeastern Brazil

Highlights

Validation of X-Ray Fluorescence

Autonomous Technology in Scenario

Discovering Thoughts, Inventing Future

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An Inquiry into "Convention"as a Problem and what we Might do About it?

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Abstract- Adequately responding to our national and global deteriorating environmental and fragmenting social situation is a matter of increasing urgency. An obstacle to achieving a concerted response is the way that we have normalized "convention" or as some author's claim "thoughtless convention." I take on this obstacle (i.e., convention, thoughtlessness) as subject of this paper. Our current problems are typically framed, embodied, and emplaced from within convention using a "metaphysics of control and mastery or dominance" over the biophysical and social world. This approach can block what should count as our appropriate relationship (human dignity, "sustainability," coexistence) with the world, including non-human life. Accepting convention (status quo), which is very widely accepted absolves us from thinking too deeply or looking at ourselves and our problems. This translates into the present social and political organization of our culture, problem solving heuristics, and academic curriculums.

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An Inquiry into "Convention"as a Problem and what we Might do About it?

Susan G. Clark

Abstract- Adequately responding to our national and global deteriorating environmental and fragmenting social situation is a matter of increasing urgency. An obstacle to achieving a concerted response is the way that we have normalized "convention" or as some author's claim "thoughtless convention." I take on this obstacle (i.e., convention, thoughtlessness) as subject of this paper. Our current problems are typically framed, embodied, and emplaced from within convention using a "metaphysics of control and mastery or dominance" over the biophysical and social world. This approach can block what should count as our appropriate relationship (human dignity, "sustainability," coexistence) with the world, including non-human life. Accepting convention (status quo), which is very widely accepted absolves us from thinking too deeply or looking at ourselves and our problems. This translates into the present social and political organization of our culture, problem solving heuristics, and academic curriculums. Why is convention so powerful? Perhaps it is because of our evolutionary/psychological dynamics and because there are so many problems – personal to global – that we do not understand or know how to address. Fortunately, some people move beyond convention integrating conventional and functional understandings to address our problems. An integrative standpoint looks for connections, relationships, and systems properties across social processes and decision making. My recommendations to overcome limits of convention and thoughtlessness help people, leaders, and institutions to learn integrative concepts and operations for effectively orienting to problems, functionally in realistic and pragmatic ways. Finally, recommendations focus on education in the academy to skill students for integrative problem solving. Our future, global solidarity, and any global movements will turn on what learning and transformations we can bring about to address our problems.

Keywords: convention, thoughtlessness, education, environment, social situation, integrated problem solving, leadership, social change, institutions, mass movements.

I. Introduction

There is no doubt that humankind is going through the most critical period in its history.[1] Since 1970, our problematic situation has become clear with irrefutable data supporting a growing and interconnected suite of diverse issues (e.g., climate change, disruption of ocean currents, massive extinctions, social and political unrest, rising expectations of violence, and a host of conflicting individual anxieties, demands, and movements).[2] For example, the Alliance of World Scientists with 25,781 scientists has been a leader in characterizing our situation. They have a Scientists' Warning Publication Series with eleven new scientists' warning articles published or in press, in addition to the nine previously published articles (scientistswarning@oregonstate.edu). There are many other assessments confirming these results.[3] Taken together, documents and sources characterize our problem(s).[4] Yet, our responses seem slow and cumbersome. Perhaps we do not have a full or deep picture to know how best to respond.

It appears our social and environmental problems are outpacing our good efforts to address them. This paper first introduces "the problem" of convention. Simply stated, convention limits our understanding of ourselves as humans and how we should order our relationship with other humans, nonhumans, and the biophysical world. Further, it hinders effective responses – problem-solving. As such, it obstructs how we organize the academy and educate about knowledge and skills for tackling challenges. Second, this paper makes recommendations, focusing on people, leaders, institutions. It offers integrated problem-solving concepts and operations to help us overcome conventions limitations. And, third, this paper discusses prospects for global solidarity, mass movements, and a different approach to higher education. This paper contributes to the broader rivers of thinking and problem solving that have built up over the centuries.

II. Methods

This paper rests on the works of integrative policy scientists and allied scholars. It is based on my experience on diverse applied environmental and social cases, and teaching over five decades at colleges, universities, in workshops, and field trips. The integrated method used here is grounded in a jurisprudential method.[5] This jurisprudential orientation is labeled the "policy sciences"– configurative approach. Brunner summarizes and appraises this approach.[6] The term "integrated" in this paper is equivalent to the configurative or policy sciences. Terms in the educational literature and the "interdisciplinary and transdisciplinary" community are labels somewhat equivalent to the integrated approach, at least in intent. I use the term "integrated," and use these three terms interchangeably. The integrative method is grounded in pragmatism, functionality, and contemporary systematic

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legal, social, and political thought.[7] This distinctive approach is focused on "human dignity" for all in healthy environments.

III. "Convention," its "Normalization" as a Problem

What might explain our "shortfall" in addressing diverse social and environmental problems? Hannah Arendt's label for the problem or arguably a big part of it is our overreliance on "convention," or "thoughtless convention."[8] The term, "thoughtless convention," means that we humans tend to just go along daily with the mainstream, averaged off thinking, status quo in our respective fields, communities, and cultures. It suggests that we do not question basic assumptions and we tend to stay within frames of accepted citizenship, professional, and cultural thinking and practices.[9] Arendt's books and writing include *On Origins of Totalarnism* (1951), *The Human Condition* (1958), and the *Life of the Mind* (1977). Also, she wrote *Arendt and the Eichmann Trial* (1961-1963) and *Men in Dark Times* (1968). Can we move beyond this problem to the extent it exists?

Michael Bonnett's collective works, especially his 2013, Normalizing catastrophe: sustainability and scientism. *Environmental Education Research,* 19(2), 187-197 is insightful in this regard. Heoffers reasons for the normalization of our views and work (i.e., convention). Bonnett notes that "normalization" constitutes our conventional (both thoughtful convention and thoughtlessness) views.[10] Convention tells us what to understand – ourselves, society, and the environment or nature – and what to make of our everyday experiences. It tells us who and what counts or matters in an appropriate relationship to nature, other people, and the world. It tells us what is ethical and practical. It tells us what are the problems we should recognize and attend to.

Both Arendt and Bonnett provide clarion calls to recognize and address sides of the same problem: thoughtlessness and thoughtful convention, hereafter convention. Convention vitiates against effective engagement with the natural environment, ourselves and our cultural world, and our problems. It does so by subverting our sensitivity and attentiveness to our own existential, social, and value directed character (on to our everyday conventional selves).

This limits our understanding of our own perspectives, values, and actions. Functional interconnections are often overlooked by those who uncritically and unreflectively use convention. Convention frames thought and reality in a way that collapses any questioning of it back in to convention, and as such questions appear absurd to conventional citizens and colleagues.[11] This normalized convention (thoughtless or not) leads to at least some of our problems. Bonnett develops this view more deeply than space allows here.

When Arendt's accounting is combined with Bonnett's argument, we have an explanation for shortfalls in addressing our problems. Taken together, combined with other observations, this explanation says our underperformance is due to "normalized thoughtless convention." This is not to denigrate vast efforts by millions of people and national and international leaders and governments undertaking actual cases or activists' movements to address problems. Many gains have been made. Breaking the bonds of normalized convention is a meta-challenge for us to advance to more sustainable futures, most likely.

Underlying considerations of this thesis including: (1) our limited self-awareness and self-understanding that is too often blocked by our own ego defensive psychology, existential coping, and our conventional culture, (2) our finding in hard for those reason and others to deal with the discomfort we experience when we think about the magnitude of the problems we have created for ourselves and the scale and scope of what is needed to address them, and (3) our beliefs, expectations, and the lives – and cultures – that we have come to live within. I bring this literature together to interrogate a multi-dimensional of convention.[12]

Convention instills a very deep pervasive framing of who we are as a species, as individuals, and as collective cultures that set us in a particular version of reality or system of meaning making.[13] Our genetics, evolution, and social-conditioning through acculturalization, socialization, and institutions, such as family, state, and educational and media systems all come together to shape our views of reality. Views of reality – conventional or otherwise serve as a metaphysics (i.e., an ontology, epistemology, axiology, ordination, and pragmatist approach).[14] As such, views of reality function to normalize both thought and thoughtlessness, which can come to dominate our sense of self, our agency, and our individual and collective efforts to address our social and environmental problems. If we narrowly stay within the bounds of convention (as normalized), we likely miss much of the richness of the world, a deeper awareness of self and other life, and limit our understanding and options to respond to our growing interconnected problems. What are we to do?

IV. Problems: Writ Large

Problems are really a reflection of how we view the significance of possible harmful futures. Or put another way, what is the foreseeable consequences of ongoing trends and conditions in society and environment, if we do nothing. For example, what happens to humans and civilizations, if we do too little to

address climate change? What happens if we change North Atlantic oceans currents? What happens because of all the extinctions? I clump interrelated substantive and process challenges we face into three sets below, about people, social concerns, and environmental matters.

a) People

First are problems with how we construct our sense of self and meaning that prefigures or limits our understanding of the world and problems. We typically do so conventionally. We know that there is great variability among people's attentiveness, observations, and judgments across individuals and cultures. We know that people vary fundamentally in existential psychodynamics, personality and value commitments, and education and experience.

Different forms of convention exist everywhere, as a kind of localized "uniformity" of perspective and it shapes how we see problems. This uniformity can lead to fragmented, divergent, and limited perspectives. Further, it can lead to divisive rancor and violent conflict as people act on how they see the world differently.[15] Importantly, it leads to dysfunction in problem recognition and solving. Yet, "noise" exists in our lives and it affects our judgments, sometimes bringing convention into question.[16] Whether individuals possess "democratic character" or not makes a difference in how they understand the noise, and their interactions and collective outcomes.[17]

b) Social Concerns

Second are problems about our goals. Much has been written on the overriding goal of humankind, ranging from secular (physical) to religious (metaphysical) texts. The goal is really about the meaning of life, human dignity, and human rights, at least in western nations.[18] The choice before us is between systems of public and civic order that promote a commonwealth of human dignity in liberal democracies or garrison police states as totalitarian regimes. Our goal is about really how we understand our relationship to each other, nature, and all non-human life. Currently, there is disagreement on goals across humankind, (e.g., contrast ISIS - K in Afghanistan vs. social democracy in Sweden). I collapse these immensely complex matters into a short review below.

Global goals are there in critical international documents of the "judicial revolution" of human dignity and rights, now underway since 1945 (post WW II).[19] These include the Declaration of Human Rights 1948, the revised Geneva conventions of 1946, and the international convention of asylum of 1951.Goals address whether morality and values (e.g., respect, well-being, rectitude) are universal.[20] Individual, social, and political dynamics are typically based on deeply felt images of self, identity, authenticity, status, role, and power.

Third are problems about the social and political organization and institutions within and among societies. Fundamentally, social matters are about the basic educational and moral commitments that individuals, groups, and societies aspire to. This includes matters of population size, growth, and consumption. Questions arise, such as: What is the relationship among human rights, democracy, and constitutionalism? Ignatia (2001) suggests that human rights standards will be compromised in the future by gulfs between universalistic declarations and national interests in our crises ridden world. The human "capacity to come closer to realizing aims is widely questioned, especially prospects outside of our now highly organized communities of human rights activists," notes Gutman (1994., pp. vii-viii). Today the "human dignity" revolution is far from complete.

c) Environmental Matters

Environmental problems are an outward manifestation of standpoint considerations and social and political problems. Today, humankind is divided into many parochial ideologies and cultures each with its own goals and modes of living. These are organized often as nation states to smaller, more localized kinship and tribal groups at varying spatial scales and degrees of control. Each shows a different life script for individuals and it's collectives. Some have a long history, transmitted intergenerationally through oral history and traditional knowledge systems. Others have a long history of formal constitutions, bodies of law, and public and advanced institutions, especially governance and educational ones. Critical here is the problem of social and political fragmentation. Also, there are questions about the use of science, and even the validity of science itself in some social circles.[21] The ongoing Covid 19 case and the anti-science and anti-vax contingent well illustrates problems.

Take these few environmental problems. First is about climate change and consequences to the human enterprise. Unless we rapidly address this problem, some observers think that collapse of civilization is the most likely outcome. The Earth's poles are warming at two to three times the rate of the rest of the world, Second is about the extinction crisis. It also poses existential threats to civilization. Biodiversity is declining worldwide, wreaking havoc on ecosystems. Third is about changes in the Atlantic ocean that may be heading for collapse due to climate change. The consequences of a collapse of eh current would be far-reaching. Currently there is a weakening of the Atlantic Meridional Overturning Circulation, which transports warm, salty water from the tropics to northern Europe and then sends colder water back south along the ocean floor.[22]

Finally, there is the problem of the overall, human environmental footprint on Planet Earth. The

World Wildlife Fund says, we are not on a sustainable path for our planet's future.[23] Another way to look at this is to say that it would take 1.6 Earths to produce all the renewable resources we use today. And worse, the growing human population is expected to use the equivalent of two Earths of renewable resources per year by 2050. NASA's data supports the conclusion that humanity would need five Earths to produce the resources needed if everyone lived as Americans.

We are demanding nature's services – using resources and creating CO2 emissions – at a rate 44 percent faster than what nature can regenerate and reabsorb," a NASA document said. One article asks as, *World's Population Booms, Will Its Resources Be Enough for Us*? New projections of escalating human population growth increases the tension between humanity's expanding needs and what the planet can provide. The Scientists-warning@lists.oregonstate.edu effort tracks these and many other vital trends and conditions. Clearly, we need to up-grade our problem-solving knowledge and skill, urgently, and follow-on actions.[24] And then there is war, which all people hope can be avoided.[25] In sum, history shows devastating disagreement among nations and cultures.[26] Conflicts stem from lack of agreement on the overriding goal of humankind, over the needed social, political, and economic organization, and our relationship to each other, nature, and all non-human life.

V. Humans, Problem Solving, Education

Problems derive from our thinking, social organization, and individual and collective actions – from personal existential matters to large scale policy processes. The evolution and psychology of humans, as well as our social and political organization, prefigure how we go about problem solving and educating the young, especially in colleges and universities, to recognize and attend to challenges. Briefly, I review these three dimensions, each showing the latent power of convention that encourages or forces people into a certain, often limited mode of thinking and behaving.

a) Humans - Us

The biggest problem we face stems from (mis) understandings about our basic nature, biology, cultural history, and our relationship to nature and all non-human life. This is a neurological, philosophic, social, and political matter.[27] We are no longer a secret to ourselves. In the last 50 years, a huge volume of hard evidence from paleontology, anthropology, psychology, and sociology has given us data into our basic nature and how that plays out in our respective societies, cultures, and individual and group behavior.[28] This data describes and explains why people behave the way they do. The ape that became human over the last 100 thousand years has retained its biology today while it invented and continues to evolve symbolic culture – systems of collective meaning.[29] We did so, one word at a time, over tens of thousands of years, but especially in the last 10 thousand years.[30] Our present science of humans is our knowledge about ourselves.[31]

As I see it, the lack of widespread shared, basic knowledge about our own evolutionary, psychological, and cultural standpoint creates a highly fragmented and conflictual social situation – locally, nationally, internationally. There are huge differences in perspective/identities, political systems, and actions everywhere. Diverse views abound over what is "humankind?" And, what are our goals, ideal living arrangements, and responsibility relationships? Also, these differing views vary about our responsibility to nature and all nonhuman life. History shows dramatically different, often hardened perspectives on all these issues, divergent systems of meaning, and social organization that cause conflict (e.g., WW1 and WW2, Cold War, and proxies). This situation will likely persist.

We are a species with an individual termination date (death) struggling to come to grips with our highly complex symbolic, technological cultural, and its proper relation to nature. Reconciling all this is the basic problem we face.[32] This reconciling matter is proving difficult due to the hold of convention across societies, cultures, and time. The single best alternative is that we need to educate ourselves about these matters, especially about our evolution, existential psychodynamics, and actually use our best knowledge and skills for "human dignity" for all.

Today, the dominant conventional view of ourselves is anthropocentric and egocentric. This fosters instrumentalizing nature, other life forms, and other humans. These conditioning factors combine to make it easy for people to conventionally seek short term self-interest, ego enhancement, and support existing social order.

b) Problem Solving

The next problem is that there is no clear agreement on what the problems are that we face or useful methods of problem solving – rational problem orientation.[33] Today the dominant, conventional view of knowledge and problem solving is positivistic. It's benefits and limitations are widely known. There are counter epistemologies in competition with positivism (e.g., pre- and post-positivistic, traditional and local knowledge, critical theory). Positivism reinforces anthropocentrism, materialism, and instrumentalization of nature and other humans. Yet, it has obvious material and other advantages.

Problems are really a reflection of how we make meaning and how we think and talk about our concerns. They reflect how we think and talk about our concerns, often implicitly and conventionally. Defining problems as discrepancies between goals and actual or anticipated states of affairs attests to the fact that problems are

socially constructed.[34] Perhaps the single most important task before us is to use and apply a problem oriented (integrative, functional) approach (as noted below). All scholars and practitioners can do is help society produce realistic problem definition(s).Problem dentitions function as a "package of ideas that includes, at least implicitly, an account of the causes and consequence of undesirable circumstances and a theory about how to improve them."[35] Without a clear problem definition, there is NO basis for even talking about solutions (options), much less for appraising choices or implementing them. There are many obstacles to realistic and actionable problem definitions, including our presently normalized conventional thoughtlessness.

c) Education

The goal of our colleges and universities is or should be to cultivate graduates who are willing and able to be self-governing in their personal and social lives and contribute to problem resolution – personal and societal. The academy is the chief training ground for future citizens, professionals, and leaders. Ideally, the academy is concerned about advancing education in the common interest and in ameliorating social and environmental problems through empirical enquiry and analytic judgement.[36] Yet, today the dominant, conventional view of education is scientism and economism – neoliberal capitalism, often. Some education emphasizes critical theory, postmodern deconstruction, and selected ideological versions of history. This mix of epistemologies and perspectives makes the academic project dynamic and complicated.

Education is conducted through a mix of courses, books, discussions, and experiences that inspire and unite, ideally. It should, more broadly teach us about our intellectual and social heritage, and our larger context over evolutionary time. It should teach us about our culture and foreign cultures and our human struggles across the ages. Sometimes it falls short.[37] With Richard Wallace and myself, we noted that goal muddle and dominance of conventional approaches in the academy "puts into sharp relief the inadequacy of some academic programs to address major social and environmental challenges."

Last is the fragility of integrated problem solving, now in its infancy. This approach is in a weak position currently, status-wise, as are integrated scholars and educators themselves. There is a lack of a shared, grounding identity across members of the academy in many different departments, programs, and institutions, which is problematic. In response, some college and universities are going to the "big tent" model of education, wherein more and more disciplines, epistemologies, and perspectives and ideologies are added into the curriculum. Is this thoughtless convention at work?

d) A Problem Overview

The UN Sustainable Development goals dominate the global discussion currently. Regardless how goals are stated, the ideal approach is to bring about constructive change in all the channels that we can influence, and quickly. Take the evidence of climate change or biodiversity extinctions, for example? How about our social and political problems? What are we collectively doing and is it successful?

We collectively know the barriers to constructive change across diverse arenas. The world is full of conventional thought and inaction, normalized because of our own fears, unsustainable self-stories, and dysfunctional institutions that block promising ways of organizing our lives and living together with dignity for many. Among obstacles to a transition to a better situation are status quo cognitive, social, and political pressures. Convention has too often foreclosed our considering integrated approaches to challenges. To the degree this is so, it is difficult for us to provide a healthy future for the next generations (and all nonhuman life on the planet). At base, the key question is what is our relationship to nature? In other words, what are we supposed to get out of nature, and do we relate to her and transact with her, in order to get what we need? Perhaps we need to ask, what is our major social duty to renewal of depleted nature? Do we have an obligation to pass a healthy nature onto future generations?

VI. Recommendations

Numerous authors have offered recommendations that variously target individuals/ groups, national and international leaders, mass social movements, and the academy. Others favor focusing on climate change, population growth, or substantive subjects (e.g., extinctions. oceans, subnational to local issues). Still others prefer upgrading processes (e.g., problem solving, leadership, education). History is full of seemingly impossible change actually happening (e.g., ending of the cold war). Future success depends on how people see problems (and themselves), define them, and act on them. What are some options?

a) People, Leaders, Institutions

Change is in the air, for better or worse. We must come to address problems commensurate with the content and size of the problems. What might we do, if the underlying problem we face is convention? What changes are needed on the part of people, leaders, and institutions to move us toward more integrative thinking, understanding, and action? If successful, change would alter our perspective towards ourselves and nature, and our relationships with other humans and nonhumans – to be relatively more sustainable.

i. *People*

Targets for upgrading should include individual people (their standpoints, knowledge, skills) and our collective social outlooks. The question here is how can we best attend to future thinking and work "outside and ahead of convention," while continuing conventions advantages? How can we get down to specifics and actions that make a real difference for the better?

Considering recommendations, Bonnett argues that we are operating now with an impoverishment of experiences and perception with nature and ourselves. We are trapped inside a conventional concern for "mastery over nature "that insulates us from the world and knowing ourselves deeply. Convention with its doctrine and formula objectifies, materializes, and commodifies nature. Bonnett thinks this buries us in a particular form of untruth. It limits our understanding of engagement with problems –self, social, and environmental. He argues that this makes us insensitive and even dismissive of experiences of normative aspects of the natural world and our own living. In an earlier paper, Bonnett asks what a new kind of awareness looks like, as part of our moral sensitivity to nature and non-human life.[38] In the end, his recommendation is a call for a "re-awakening" in and of ourselves about our environment.[39] Changing people's perspectives is an important change target. The academy could lead such an effort.

ii. *Leaders and Institutions*

Change targets should include national and international leaders too. For example, Falk argues that our way forward is to engage globalism and whole human communities, at appropriate scale, including leaders. He says that we need to affirm that our shared collective striving for recognition and a dignified material, social, and political life is in the realm of the possible. We must reimagine a sense of our place in the universe. He argues that this can create a sense of solidarity, a kind of patriotism for human and nonhuman kind wherein all of us are contributing to an enterprise much larger than our individual lives. This is transcendence in action. Such a perspective would not blur differences among people, however, it might set up a system to view ourselves working in complementarity. Transformation is dependent on the kind of leaders we get.

This, Falk says is a helpful place to start our needed transformation. Yet, as Falk notes, our current leadership and institutions(and views of ourselves), which are largely conventional will remain impervious to change toward a more cooperative, peaceful, just, and ecologically sound world. It seems currently that we are paralyzed by normalized convention (thoughtlessness). The most urgent need is for an integrated problem-oriented leadership and citizenry. There is a trend toward integrated undertakings by many people that is underway now, worldwide. Many changes are at the individual or small group level. The challenge before us is formalizing transformative education and application of integrated problem-solving in the academy? Do we have time?

Another recommendation by Witter is that global mass movements present an opportunity for gains.[40] Global networks of activists can have influence well beyond national borders. He summarizes historic movements, such as antislavery, the labor movement, socialist movement, the peace movement, environment movement, nuclear disarmament, movement against corporate globalization, and the women's rights movement. True, all these movements have faced furious backlash and opposition. Nevertheless, the rise of global movements seems to have come from recognition of the interconnection of all peoples around our common cause (e.g., human dignity in healthy environments). He argues that global movements need to be organized, focused, and (self-) empowered, as they seek transformative change.

There is much needed work ahead. Perhaps most important is to make change in the world around oneself. This is the situation in which we can be most influential and constructive. There is no guarantee we will be successful in overcoming the powerful normalized convention that now dominates most everywhere. Nevertheless, there are promising avenues for constructive change that reinforces hope for the transformation needed.

b) Integrated Problem Solving

Perhaps the most promising way to bring about constructive change is teach and use integrative problem solving. As a key target or opportunity, this is likely the most direct, transformative way to upgrade our actions. Here are five considerations that make up integrated problem-solving. This approach is being taught successfully in the academy now and inapplied work.[41] These five considerations taken together function to help us overcome limitations of only operating within convention.

i. *Five Key Perspectives*

There are five important perspectives to take on any program or policy to understand it and ameliorate problems. By "perspective," I mean a distinctive way to look at the program or policy in question. Each perspective is important if you want to avoid being misled by ignorance, convention, or by a promoter – a propagandist, lobbyist, or partisan promoter or salesperson, for example. These five and their foundation comes out of social and political thought and are abstracted into the policy sciences – the configurative framework. The framework consists of a logically complete set of mapping categories that can help us understand and address policy problems. This framework is a practical means of organizing our

thinking, our knowledge, and our problem-solving efforts, and therefore it allows us to define a problem usefully in context. Doing so opens up options.

This *integrated problem-oriented approach* permits users to:

- *Find* the important pieces of information on a program or policy, in a maze of reports that is typically incomplete and distorted;
- *Identify* what pieces are important but missing in those reports and actions;
- *Organize* the pieces into a coherent picture of the problem and response under inquiry;
- *Evaluate* that picture from rational, political, and moral standpoints; and
- *Construct* a more educated perspective of the program or policy or a new program or policy of your own.

The five perspectives follow. First is *standpoint clarification*, which is about you own perspective, assumptions, and viewing angle (see notes Clark 2002, pp. 111-126). Ideally, standpoint is about self-awareness in psychological, existential, professional, and social sense. It is about you being both a participant and an "anthropological" observer.

Second is the *problem orientation*, which directs your attention to the rationality of the program or policy – and asks, whether it is reasonable enough? The problem orientation is a strategy for constructing a more rational policy (see notes for Clark 2002, pp. 85-110). The basic concepts involved in it are:

- *Goals* are preferred outcomes—something what you want to achieve.
- *Trends* are past and recent events relevant to goals.
- *Conditions* are factors that shape those trends causes, motives, policies, etc.
- *Projections* are probable future developments under various circumstances.
- *Alternatives* are courses of action—what you can do to realize goals.

In these terms, the logic of sound policy making is to choose the alternative that you expect (on the basis of trends, conditions, and projections) is the best means of realizing your goals.

Third is the *social process* (a mapping tool), which directs your attention to the people involved in any issue, their perspectives, and the context (see notes Clark 2002, pp. 32-55). It rests on the principle of contextuality (see notes Clark 2002, pp. 29-30). This principle recognizes that all things are interconnected and that the meaning of anything depends on its context. It is comprised of seven elements: participants, their perspectives – (identities, expectations, and demands), the situation, values involved, strategies in use, outcomes, and longer-term effects.

Fourth is the *decision process*, which directs your attention to the politics arising from conflicts among policies (see notes Clark 2002, pp. 56-84).The decision process is a means of reconciling conflicts and achieving consensus on policy and programs through politics. Politics are inevitable because people develop and promote different policies reflecting their special interests. This brings us to the fifth task that directs us to look at "basic premises."

ii. *Basic Premises*

Fifth is about *basic premises*, or relationships among beliefs, worldviews, myths, paradigms, which directs your attention as a problem solver to the morality of policies. That is, whether they are morally justified within the community, given the cultural myth (myth is used in anthropological terms) (see notes Clark, 2002, pp. 21-23). Premises in cultures are accepted largely as a matter of faith (not reason) through socialization and acculturalization of young children and adolescences.

The political myth serves to justify and explain the possession and use of power – whether or not its assumptions or premises are true.[42] Myth is used here in the anthropological sense, the basic beliefs of individuals, communities, and cultures. In convention usage, myth means false belief. In our use, myth is what people see themselves to be ("who am I"), how they fit in, and an explanation of what and why their community does what it does. Myth has three components as we use it.

- *Doctrine* is the part of the myth that sets forth the basic aims and expectations of the community. Authoritative statements of doctrine are often found in preambles to constitutions and other formal declarations.
- *Formula* is the part of the myth that prescribes the basic rules for progress according to the basic aims and expectations of the community. This is the basic law or constitution, which may or may not be written.
- *Miranda* are the symbols to emulate and admire in the political myth. They include the heroes, flags, and anthems that are displayed on ceremonial occasions.

Premises are continuously reaffirmed and redefined through use in the social and political discourse. Conflicts over policies, programs, and politics (the uses and abuses of power) can become so acute that they threaten to disrupt or destroy a political system. The various meanings are located in the minds of people, who occasionally and with various degrees of skill express what they mean through manipulation of signs and symbols.

These five concepts and operations comprise integrated problem solving. They open up a functional view on convention (see notes for Clark 2002, pp. 123-125). They are practically invaluable in application.

Learning this problem-oriented approach, the framework, and its skillful use requires a great deal of practice and experience. However, it is possible to understand the basic concepts and operations, including how they have been used by other people in one course or workshop.[43] The integrated problem-oriented approach can be useful to students, professionals, and leaders alike. This brings us to education and the academy.

c) *Education and the Academy*

Currently, there are problems in conventional education in colleges and universities. This is due to their struggle to organize and teach knowledge across disciplines and educate students to become problem solvers and leaders. Despite an interest in the academy in meeting these goals, many remained mired in goal muddle, an offering of a disciplinary hodgepodge, and a curricular smorgasbord. Criticisms of conventional education and programs include claims that they tend to emphasize narrow, technical proficiency. Typically, it is disciplinary based. These sources reify convention. This in in contrast to education for more integrative, policy-oriented problem-solving knowledge and skills for real world applications that compliment content courses.

As to goals for the academy, among them should be: (1) education should aim to develop the skill of critical, independent thought, (2) it should induce attentiveness, sensitiveness of perception, receptiveness to new ideas, imaginative sympathy with the experiences of others, (3) it should strive to cultivate an intelligent, thoughtful loyalty to the ideas of the democratic society, and (4) it should really empower those inner resources and attributes of character that enable the individual, when necessary to stand alone.[44] Targets of educational efforts should attend to these goals and supporting curriculums. Successful academic programs could produce both disciplinary and interdisciplinary (integrated) knowledge, as well as developing students with the wisdom and skills to address complex problems and complex social, and environmental matters.[45]

i. *Goal Clarity*

We recommend explicitly adopting the overriding goal of "human dignity," including the requirement for mutual respect and other values essential for people to live full lives in healthy, sustainable environments." "Human dignity, which is both a value position and a moral aim, is a summative symbol that represents a desired state associated with certain basic human values (such as respect, health, well-being, freedom, rectitude, ad education. Environmental conditions and human dignity are tightly linked. Human dignity cannot be achieved without conservation of nature, protection of environmental quality, and thriving of all non-human life.

Colleagues and I have recommended three principles for improvement education: goal clarity, integrated problem orientation (interdisciplinarity), and skill-based pedagogy. They are: (1) an understanding of how the policy-making system works and how human value interactions constitute the core of professional work, (2) mastery of skills in critical thinking and development of an integrated (interdisciplinary) "procedural rationality" for analyzing problems and evaluating potential solutions, and (3) development of influence and responsibility within policy and programmatic systems.[46] Seminars, case studies, and field trips are among the tools that can develop these skills in students and others. All these should be teaching us to be free and that human dignity is worth striving for. Finally, the educational community has great potential to improve the utility and relevance of education.

ii. *Skill-Based Education and Effective Programs*

Graduates will carry out diverse tasks in their work lives, whether academic or applied, hopefully for the public good. Problem-solvers activities overlap and interact with the work of public policymakers and leaders. Graduates figure into and influence social and decision process, including conducting research (basic and applied), writing and publishing technical and popular articles, monographs, and books, lecturing to professional and public audiences, commenting on matters of civic and public interest, teaching short courses, leading field trips, in-service training short courses, and formal academic courses, participating in professional and civic organizations, preparing, reading, commenting on, and reinterpreting agency and other documents and decision, advising organizations and leaders, or serving on boards and formal advisory organizations, consulting and negotiating with allies and adversaries, bringing out fact (or concealing) facts or policies that decision makers need, and serving as ordinary or expert witnesses.

What knowledge and skills do graduates need to participate responsibility in these roles? Three specific bodies of knowledge would contribute to educating students to be policy-oriented. They are: (1) understanding human interactions, (2) developing professional skills, and (3) influencing policy.[47] In sum, for many college and university programs these require changes from existing education. Many authors have laid out what they see is needed for establishing college and university programs that educate for these three in the service of "human dignity" in healthy environments. These requires effective delivery of knowledge and skills via curriculums.

Understanding problems, and problem-solving concepts, operations, and skills must grow case-by-case over time. Among recommendations, Brunner's *Raising standards: a prototyping strategy for*

undergraduate education is important. And, Bammer recommends uniting, organizing, responding, and fighting for such programs. She sees that institutionalizing "transdisciplinarity" requires its practitioners to co-construct a big picture vision.[48] Unfortunately, she notes that many people who have pioneered such an approach have often fought draining battles for even the smallest gains. She recognizes the barriers cited earlier in this paper to both her and my recommendations. And for the record, my colleagues and I, and many others, have been struggling against this conventional syndrome, which has foreclosed promising opportunities for imagination, learning, and experimenting with our own individual development and the "integrity" problem convention causes.[49]

The integrated approach I recommendation invites us to "reimagine a future by exploring what might be possible. This requires an initial willingness of the imagination to let go of the trappings of the present [convention] without engaging in wishful thinking, "says Falk. He sees that our shortfall or failure to date to bring about the needed transition is due to convention.

VII. Discussion

This paper examines our current conventional (thoughtful or thoughtless) approach to problems, problem solving, and education in different ways as a major problem in the world today. Currently, we all are faced with huge social and environmental problems that portend catastrophe unless we address them effectively. "More than ever, we must face the question; can the peoples of Earth, doomed to share a ravaged planet, learn to live together in way that encourages our species flourishing in the emergent future," says Falk (2021). What do we need to do?

a) *Global Solidarity*

Will a new kind of global "solidarity" help us?[50] Some authors see that a global "movement" is needed. I argue that the academy could front integrated problem solving as a means to explore this option. There is much to do to get us to a shared global identity to tackle climate change, species extinctions, and widespread ecosystem degradation, much less ramped human indignity. Global solidarity is well outside conventional, parochial identities, at many locations currently. There is much activism, science, and movement currently appealing to individuals identities, loyalties, institutions now, some helpful, some not.

What is a new global "solidarity?" Lasswell's (1972) treatise on the *Future systems of identity in the world community* is helpful here.[51] For goal solidarity to come to reality, we need to understand "identity" and foster a new shared human identity of solidarity. Public and civic order and social movements depend on many factors, identity being a major one. Our future will continue to be affected by the predispositions of people whose identity and loyalties are expressed in the kinds of institutions they support. People who share identity, share a self-image, a cognitive map of themselves and others.

At present, these features are organized at the tribe to national levels supporting unifying identifications and security, including nationalism and war fighting capabilities. These are factors affecting our future and our present system of world public order. Despite the UN, European Union, and many other constructive efforts, people's perspectives and identities are dominated by a structure that produces division and sustains the institutions of nationalism and war fighting. Just look at the present global picture of vying national states, level of resources going into military, and security alliances.

b) *Mass Social Movements*

Will mass social movements help and are they likely to happen? The task before us it to mobilize and organize mass action in favor of decisions and institutions that can bring about change and transformation needed to avert disaster. What the future holds will be influenced by the attitudes and actions of the young. Clearly many young in the world today are disturbed by events. This can lead to alienation as problems become clearer and our ability to address them seem to recede.

Can mass social action be organized across class, education levels, and many other features of our current divisions? In some localities, youth are poise for collective action on varying scales needed. Yet some are busy cancelling people they feel are opposed to them and engaged in other diversionary actions. Are the preconditions present or can they be constructed to mobilize the outpouring of the emotionality, intellect, and energy needed found in youth today for constructive social action?

We need to find ways to render contingencies more vivid. In doing so, we must address injustices, as they currently fuel conflict, fragmentation, and division. Can we accelerate a convergence of life styles and identities without obliterating nature, other life, our individuality, and the resources on which we depend? This bring out questions of population size and growth and consumption patterns. How do we overcome status quo interest coalitions and build new coalitions to address our urgent shared problems? Will today's young catalyze and lead a transformation to the needed new identity, solidarity, and action?

Successfully motivating for mass action in the face of powerful restrictive interests and forces (the status quo) is ongoing. Can we mobilize enough people/identities to make a difference in time? Can we change global and civic order to stave off disaster? Communications can help, as we now live in a world where internet/social networks reach millions in an

instant. Yet, there is much misinformation afloat – fake facts. Can our gifted and educated young, using rationality, modern science, and technology foster a wave of mass social action? Can they overcome parochial interests, misinformation, and conventional arrangements? Many youth think they can. How can the academy help?

c) Higher Education

The conventional view to problem solving and education, according to some authors, has been 'conventionalized" and "normalized" – disciplined (and hybridized). Problems, however, cannot be understood or addressed using convention or one or a mix of disciplines or hybrid disciplines alone. A combined functional and conventional approach (taken together the integrative approach) permits us to better assay a problem (using problem orientation) by interrogating the content and context (social process), and exploring options (via decision process), all the while we are aware of our standpoint (values, knowledge, skills).

Further, the academy could engage with deep knowledge and skill that the academy now generates and transmits. Some authors argue that the academy should be featuring personal experiences of nature as a transcendent other. And, that we should learn to see nature as an inherent, intrinsic value. Further, we should develop a moral sensitivity. This amounts to a kind of attentiveness and ethic.[52]

My case in this paper is to support science, in fact we need more of it in our integrated problem solving, yet we must learn to use science in a fully integrative, contextual, and problem-oriented way. The distinction between conventional and functional perspectives and problem solving that I use comes from anthropology, psychology, and sociology, and professional policy analytic understanding of human interactions. A functional approach can in fact confront convention in problem solving. Presenting the functional value-added approach to otherwise conventional problem solvers can open up much insight and many opportunities for improvement. The academy can be the chief agent in doing so.

VIII. Conclusion

One big problem we face seems to be "convention," thoughtless or not. We are immersed in the all-knowing, averaged-off, common sense of the anonymous "they" – what everybody knows and understands – convention. This paper included contemporary, wide-ranging literature to introduce and illustrate challenges we face across social and political organization situations, and especially in the academic arena. Convention likely has deep existential, psychological origins and thus is are not easily recognized as such or successfully addressed either in our individual or collective lives. We are loath to recognize or engage these because doing so reveals our precarious situation and our anxieties. In fact, we have generated hugely successful defense mechanisms – personal and cultural – to avoid confronting them. Thus, convention dominates our thinking and actions. These blinding mechanisms are little discussed today for reasons of fear, ego maintenance, individual and collective coping in our uncertain and complex world, and because institutionalized rewards favor those that maintain the status quo. These block a deeper understanding of ourselves and the world and what to do about problems.

Addressing the problem of convention might allow us to thrive and live in a free, sustainable way with each other and the material and living environment on which we totally depend. We create problems and at the same time are the solution to them. The basic concepts and operations in the integrated problem orientation, the social and decision process, and basic premises, are tools for critical thinking and can help us address problems. With some effort a person can expect to understand the concepts – including how they have been used. A functional problem solver looks for connections, relationships, and systems prosperities in social and decision processes. Often, this view makes connections that are frequently overlooked by those who uncritically and unreflectively use conventional, ordinary ways of understanding, talking and doing. Functional understanding depends explicitly and systematically on a comprehensive mode, map, or image of the social process to guide attention to the value significance of details. The integrated problem solver sees the same events and process as other people that are limited to convention, but has an added capacity to develop a richer, more complete, and more useful understanding of the meaning of things. The conventional approach assigns ordinary meaning to concrete circumstances, whereas the functional analysis looks for special meaning depending on the contents. Good problem solving integrates what is rational, authorized under law, and justified under basic premises.

Personally, as a member of the academy and interested in critical scholarship grounded in long experience and pragmatism, I hope this article can lead to improved integrative and cooperative problem solving. This paper points to promising integrative concepts and operations, and integrative education in the academy and in the field over multiple fronts. In the end, can we as a species vitalize and act toward our dreams (global goals of realizing a commonwealth of dignity in healthy environments) for humanity taking pragmatic actions?

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Autonomous Technology in Scenario by Rare Geophysical Processes (Underwater Focus)

By Laís Raysa Lopes Ferreira

Abstract- From an ecological perspective, scientific investigation of the “Earth system” reveals its complexity, evidenced by the interaction of geophysical processes – which occur in the “global atmospheric system”; in the “world ocean” – both favoring the “world climate”; in "the interior of the globe"; and, between each of these parts and outer space. Environmental risks (geophysical) exist due to the configuration of extreme circumstances (CAPRA, 1982; MCWILLIAMS, 2006; SKINNER and MURCK, 2011). In the nuclear age, and taking into account the possibility of employing emerging autonomous technology as a weapon of this category, a geopolitical risk exists (KAHN, 2007; NICHOLS *et al*., 2022). Crossing between risks (geophysical and geopolitical) can be imagined (WEICK, 1989; GAUB, 2020; MCLENNAN *et al*., 2021). Analyzing the plausibility of the coincident occurrence of risks (crossed – geophysical and geopolitical) as a critical uncertainty for scenarios – and due to the vulnerability of autonomous systems to the (*sui generis*) flow of fluids by unlikely geophysical processes – the present study ratifies the technology "in the sea” (underwater, in focus) as a possible threat to the “Earth-system”; in the conception of scientific thought for the 21st century.

Keywords: *autonomous technology; underwater vehicle; earth system; deterministic chaos; geophysical processes; scenario; war games.*

GJSFR-H Classification: *DDC Code: 551 LCC Code: QC801*

Strictly as per the compliance and regulations of:

Autonomous Technology in Scenario by Rare Geophysical Processes (Underwater Focus)

Tecnologia Autônoma Em Cenário Por Processos Geofísicos Raros (Foco Subaquático)

Laís Raysa Lopes Ferreira

Abstract- From an ecological perspective, scientific investigation of the "Earth system" reveals its complexity, evidenced by the interaction of geophysical processes – which occur in the "global atmospheric system"; in the "world ocean" – both favoring the "world climate"; in "the interior of the globe"; and, between each of these parts and outer space. Environmental risks (geophysical) exist due to the configuration of extreme circumstances (CAPRA, 1982; MCWILLIAMS, 2006; SKINNER and MURCK, 2011). In the nuclear age, and taking into account the possibility of employing emerging autonomous technology as a weapon of this category, a geopolitical risk exists (KAHN, 2007; NICHOLS *et al.*, 2022). Crossing between risks (geophysical and geopolitical) can be imagined (WEICK, 1989; GAUB, 2020; MCLENNAN *et al.*, 2021). Analyzing the plausibility of the coincident occurrence of risks (crossed – geophysical and geopolitical) as a critical uncertainty for scenarios – and due to the vulnerability of autonomous systems to the (*sui generis*) flow of fluids by unlikely geophysical processes – the present study ratifies the technology "in the sea" (underwater, in focus) as a possible threat to the "Earth-system"; in the conception of scientific thought for the 21st century. Concomitance between events would be very rare however plausibly – also of holistic impact yet immeasurable (hence, uncertain).

Keywords: autonomous technology; underwater vehicle; earth system; deterministic chaos; geophysical processes; scenario; war games.

I. Introduction

From a broad investigative perspective, Skinner and Murck (2011) scientifically present the planet as the "Earth system" – analyzing the Earth holistically (a "closed system"), as a set of parts or subsystems (geosphere, hydrosphere, atmosphere, biosphere, and anthroposphere – each an "open system") and interactive processes – the basis of "earth system science" (SKINNER and MURCK, 2011).

Energy flows (external and internal) drive these processes (natural or anthropic) between the Earth's subsystems (SKINNER and MURCK, 2011). Due to systemic complexity, chaos theory (branch of mathematics) can be employed in its approach (for example, concerning the "global atmospheric system") (SKINNER and MURCK, 2011).

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Most of the surface of the "Earth system" is dominated by the "world ocean" about the extreme importance of the ocean in "controlling atmospheric composition" (SKINNER and MURCK, 2011; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b). Ocean modeling is relevant for many applications such as fisheries management, pollution control – as well as for many naval operations (including the defense needs and the commerce between nations) (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b).

Dual-purpose, autonomous underwater technology (autonomous vehicles or systems; commonly known as drones or robots) challenges conventional maritime models. It is derived from industrial and scientific revolutions and also characterizes a specific aspect of the "military revolution" scenario (set up by elements such as technological change, systems development, operational innovation, and organizational adaptation) (FOSSEN, 1994; KREPINEVICH, 1994; FOSSEN, 2002; GRIFFITHS, 2003; MOURA, 2007; BREIVIK and FOSSEN, 2009; DO and PAN, 2009; INZARTSEV, 2009; FOSSEN, 2011; BAYLIS *et al*., 2018; FANELLI, 2020; YAN *et al*., 2021).

However, if used as a "weapon" the technology "at sea" poses risks (SPARROW and LUCAS, 2016; BAYLIS *et al*., 2018; PIOTROWSKI, 2018; FERREIRA, 2021a; FERREIRA, 2021b; NICHOLS *et al*., 2022; SLOFER, 2022; FERREIRA, 2022).

Once vast military power is concentrated in the hands of "unpredictable countries" in a nuclear age (KAHN, 2007); also, not being easy to obtain information about the perceptions that lead to conflict in international relations; geopolitical risk exists (KAHN, 2007; KAHN *et al*., 1976; GAUB, 2020; MCLENNAN *et al*., 2021).

Environmental risk also exists (MCLENNAN *et al*., 2021) – about processes in the flow of geophysical fluids (planetary – from the inside of the earth; from the oceanic circulation; and the atmosphere – and astrophysical), unpredictable (MCWILLIAMS, 2006; VALLIS, 2016). Due to the interaction of the geosphere with the ocean, fluids can escape from the ocean floor to the overlying water column, which can affect the

activities on the seafloor (autonomous underwater technology, in focus). Also, atmospheric fluids can affect autonomous Technologies – even the underwater ones if they are, for example, on the surface. (FOSSEN, 1994; GRIFFITHS, 2003; MUKHERJEE, 2006; BREIVIK and FOSSEN, 2009; DO and PAN, 2009; INZARTSEV, 2009; FOSSEN, 2011; SKINNER and MURCK, 2011; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; JUDD and HOVLAND, 2007; MCLENNAN *et al*., 2021; FERREIRA, 2021a; FERREIRA, 2021b).

Crossing between risks (geopolitical and geophysical) can be glimpsed (WEICK, 1989; SCHWARTZ, 1996; GAUB, 2020; MCLENNAN *et al*., 2021). Good scenarios are thought and perception devices that make visible a new reformulated perspective – plausible (WEICK, 1989; GODET, 2000; VAN DER HEIJDEN, 2005; WADE and WAGNER, 2012, RAMIREZ and SELIN, 2014; SCHWARTZ, 1996; MINVIELLE and WATHELET, 2020; GAUB, 2020).

There is a "sea of uncertainties" concerning the systemic environmental complexity, particularly from a perspective of responses ("self-regulation") to anthropic interventions of harmful proportions, according to current holistic scientific thought (21st century) (CAPRA, 1982, CAPRA, 1983; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; BERTUGLIA and VAIO, 2005; MUKHERJEE, 2006; JUDD and HOVLAND, 2007; SKINNER and MURCK, 2011; GAUB, 2020; ÖZSOY, 2020; MCLENNAN *et al*., 2021; MCLENNAN *et al*., 2021; MCLENNAN *et al*., 2022; NICHOLS *et al*., 2022; SLOFER, 2022).

However, one sure thing is the surprise: "a rule and not an exception in nature (CAPRA, 1982, CAPRA, 1983; STEWART, 1997; BERTUGLIA and VAIO, 2005; JUDD and HOVLAND, 2007; MUKHERJEE, 2006; SCOTT, 2007; SKINNER and MURCK, 2011; ÖZSOY, 2020).

Regrettably, "the understanding of terrestrial systems has often been influenced by social history, leaving future generations the task of responding to the environmental burdens of all past human activities" (ÖZSOY, 2020) – *post-factum*.

From the perspective of scientific thought for the 21st century, the present study ratifies autonomous technology (underwater, in focus) as a possible threat to the Earth-System (geopolitical risk); particularly for its vulnerability to (*sui generis*) flow of fluids by rare geophysical processes (geophysical risk) – analyzing the plausibility of the coincident occurrence of such perspectives (by crossing risks), as critical uncertainty for scenarios.

Despite being a delicate subject it is of broad interest due to the need for preparation, according to a present-day review of the theme. Considering the harmful consequences of a "thermonuclear war," it is expected to contribute to the salvation, in some way, of a more significant number of people (FERREIRA, 2021b) around the world - from the correct exposure of knowledge (as a flash of revelation), and critical scientific analysis (in a context of various uncertainties); that is fundamental to decision making, by inferences.

Regarding the theme, given the fallibility of the human essence (FERREIRA, 2021a); and, as the decision-making action will always be in "man's hands" (about pressing "the button"); it is very relevant to understand that the hypothesis (WEICK, 1989) of a reaction through unlikely geophysical processes would indeed be extreme; however, responsive (divinely) (FERREIRA, 2021b).

II. The Threat of Autonomous Technology (Underwater) to the (Earth) System

The concept of systems is used in studying complex problems due to their many interacting parts, in which processes are often coupled – as is the case of the Earth system – highly complex and dynamic. The holistic approach to the planet, presented in Skinner and Murck (2011), would be the "key" to its understanding.

The Earth is considered a "closed system": this means that there is no loss or gain of matter – but energy can indeed enter or leave the system – which points to the need to understand the "science of the Earth system" as interdisciplinary interactions between all parts of the set (including how energy move out around the system) (SKINNER and MURCK, 2011).

In a systemic context, the most significant interest is in the necessary balance of all this energy (from external and internal sources); especially regarding the "life zone": life on Earth occupies a narrow zone (no larger than 20 km), where interactions between the geosphere, hydrosphere and, atmosphere create a habitable environment (SKINNER and MURCK, 2011). "If the balance is not maintained, the Earth's life zone must heat up or cool down," for example (SKINNER and MURCK, 2011).

As the earth is a "closed and complex system," some implications are of interest, as Skinner and Murck (2011) highlights: a) the planet's mineral resources are finite (that is, limited); b) residues remain within the limits of the Earth system; c) changes or disturbances in one part of the system, eventually affecting other parts of it (an entire chain of events can happen, even); d) causes and effects of natural disturbances are very difficult to predict (one of the main challenges of earth system science); e) numerous disturbances constantly occur (since the formation of the earth until today), but in different places, and causing impact at different levels (SKINNER and MURCK, 2011).

Despite the complexity of the interactions processes, as the earth's subsystems are well balanced, the system is "characterized" as self-regulated (in its

entirety) – in this case, mainly, about natural interventions. In any case, it takes a long time (especially on a planetary scale) for the Earth system to tend towards self-regulation and a state of equilibrium (SKINNER and MURCK, 2011).

To obtain a broad scientific approach to the Earth system (a real challenge), new tools for observation (at varying scales), measurement and management of large amounts of data would be needed (from multiple locations) – the representative modeling of systemic processes (on a manageable scale) is simplified (SKINNER and MURCK, 2011).

The oceans act as thermal flywheels and climate moderators due to their large extension (covering more than 70% of the earth's surface) and the high heat capacity of water. Also, they are huge reservoirs (sinks) of CO_2 (containing about 60 times the amount of CO_2 in the atmosphere) – gas exchange takes place from the ocean to the atmosphere: "almost all the oxygen found in the earth's atmosphere was created by oxygenated photosynthesis in the ocean, carried out by single-celled phytoplankton – with oxygen levels reaching current levels around 2.2 billion years ago" (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; SKINNER and MURCK, 2011).

Concerning the geosphere, it is the main solid reservoir on earth "which appears to be constant and unchanging, but nothing could be further from the truth" (SKINNER and MURCK, 2011). It is a boundary layer – it is linked to the hydrosphere (about the ocean floor) as well as it reaches the atmosphere at the surface of the earth's crust (SKINNER and MURCK, 2011). The dynamic nature of the geosphere can be dangerous to human interests through geophysical processes (SKINNER and MURCK, 2011).

As quoted in Skinner e Murck (2011), immediate effects of this geophysical process are the earth's movements with the rupture of the surface itself; and the side effects are fires, landslides, soil liquefaction, and *tsunami* ("a seismic wave, initiated by the sudden movement of the sea bottom due to an earthquake, volcanic eruption or underwater landslide, and which have been particularly destructive in the Pacific and Indian oceans") (SKINNER and MURCK, 2011).

Due to the significant impact of their occurrence, much research focuses on earthquake prediction based on an understanding of the tectonic scenario and the history of local seismic activity. Despite advances in researchs, "success with issuing accurate and specific short-term forecasts and early warnings remains elusive" (SKINNER and MURCK, 2011).

"The scientific basis for modern forecasting efforts is the observation of precursor anomalies – any strange or unusual occurrences that could signal an impending seismic event" (SKINNER and MURCK, 2011). It turns out that such anomalies are highly inconsistent. Also, the erratic nature of such precursors, combined with the inherent difficulties in monitoring events that occur underground (at unexpected times and places), limits progress in earthquake prediction, according to the authors.

A curious account in Skinner and Murck (2011) is about a case of strange animal behavior (well-documented) hours before an earthquake in China (Tianjin): "the normally quiet pandas screamed, the swans refused to approach the water, yaks did not eat, and snakes did not enter their burrows" (SKINNER and MURCK, 2011) – the tremor (magnitude 7.4) happened around noon of the same day; and the animals were sensitive to the circumstances of the environment, in some way – by correct perception.

As for natural hazards and global climate change, for example, the uncertainty involved in the scientific understanding of the earth system is challenging for decision-makers and politicians. It is based on the precautionary principle – considering that if the potential consequences of an anticipated event are unacceptably severe, the authorities have a responsibility to take measures to avoid or mitigate those consequences (even if the probability of occurrence is small – and despite the scientific uncertainty) (SKINNER and MURCK, 2011).

The issue of human influence on Earth-system reservoirs, and the systemic reaction to this interference over time, is a problematic issue from a scientific point of view (SKINNER and MURCK, 2011). An anthropic circumstance – totally bizarre – according to Kahn (2007), is about the possibility of thermonuclear war: "the mind recoils from overthinking about it; one prefers to believe that this will never happen" (KAHN, 2007). Many of the military strategic concepts were developed from a "Cold War" era perspective in Kahn (2007), however it can still be verified (as an analysis parameter).

"Herman Kahn earned his reputation as a futurist through his public willingness to consider what most people denied in the early 1960s: that a nuclear war could take place [...]. By raising the possibility publicly, he helped people to really see what they had at stake" (SCHWARTZ, 1996).

People hardly consider the problems of thermonuclear warfare – "most of us simply do not believe in war, or at least in deliberate thermonuclear warfare, and most people also find it difficult to be concretely concerned about nuclear accidents and miscalculations" (KAHN, 2007). Kahn (2007) considers it essential to critically examine the crises resulting from war (hypothetical and potential) in an attempt to anticipate them in time to program corrective measures.

"Defense problems in the modern world are of unprecedented complexity" – they have become disordered, and their solution is unrelated to principles that the military has derived from experience (KAHN, 2007). Due to stockpiles of nuclear bombs in the world,

Kahn (2007) argues that total nuclear disarmament is not possible: “even if all nations one day agree on total nuclear disarmament, it must be assumed that there would be the concealment of some weapons or nuclear components (as protection against the other side)” – and an international arrangement to prohibit war through disarmament would not be effective (KAHN, 2007).

The initial idea of thermonuclear war is wild and destructive for the parties involved, antagonistically however Kahn (2007) cites that some can be conceive it by a convincingly reasonable bias – “depending on the course of military events, it could be an unprecedented catastrophe for the attacker and also for some neutrals, or not” (KAHN, 2007).

Despite the hysteria and social fear about the consequences of a thermonuclear war, according to Kahn (2007), a catastrophe can be “quite catastrophic without being total” – “few would call it a “total catastrophe” if all survivors of a thermonuclear war lost few years of life expectancy” (KAHN, 2007).

Also, according to the author, a catastrophe (even if it is “unprecedented”) would still not be an “unlimited” catastrophe – “the limits of the magnitude of the catastrophe seem to be intimately dependent on what kinds of preparations were made and how the war was conducted” (KAHN, 2007): from this perspective, the author considers it entirely possible to estimate the limits and consequences of thermonuclear war; he even shows some optimism about the *a posteriori* scenario – what exists “is an enormous psychological difficulty in dealing with the concept of thermonuclear war as a disaster that can be experienced and recovered” (KAHN, 2007).

From questions (followed by his immediate answers), Kahn (2007) makes a distinction between the “possible degrees of horror” of the many post-thermonuclear war states, examining their effects – as follows: a) “survivors will envy the dead ? [...] The world may be permanently (that is, for perhaps 10,000 years) more hostile to human life” (KAHN, 2007); b) “Can we restore pre-war living conditions? [...] No!" (KAHN, 2007); c) “how happy or normal lives can survivors and their descendants expect to have?” (KAHN, 2007) – “Objective studies indicate that while the amount of human tragedy would greatly increase in the post-war world, the increase would not prevent normal and happy lives for most survivors and their descendants” (KAHN, 2007). Regarding the last proposition, there was no better citation (about which “objective studies” the author referred to).

The analysis performed by Kahn (2007) for the “complete description” of a thermonuclear war included: a) several programs in phases of deterrence and defense and their possible impacts; b) wartime performance, with different pre-attack and attack conditions; c) problems with acute precipitation; d) survival and restoration; e) maintenance of economic dynamism; f) long-term recovery; g) post-war medical problems; and, h) genetic problems. However the post war environmental issue was not glimpsed in Kahn, mainly from a systemic, holistic, and ecological perspective (2007).

For Capra (1982), the threat of nuclear war is the greatest danger that humanity can face; since atomic weapons increase the probability of “global destruction.” The lethal stock of nuclear weapons, and the endless arms race, in addition to other issues (such as contamination by a wide variety of chemical products), are some of the examples of threats to "ecological systems on which our existence depends" – modern physics understands that the development of such questions occurs in a systemic, interconnected, interdependent, and uncertain way (CAPRA, 1982; CAPRA, 1983).

Capra (1982) cites that at the end of the 20th century scientific investigation from the “exploration of the atomic and subatomic world” (submicroscopic) revealed the “limitation of classical scientific ideas” – the change of perspective led, therefore, to the “radical revision of innumerable basic concepts” – there was a profound change in the view of the world concerning the physical universe: from the mechanistic conception of Descartes and Newton (intimately linked to a rigorous determinism) to a holistic and ecological vision (which understands reality in terms of totalities integrated) (CAPRA, 1982; CAPRA, 1983).

“The natural world, in turn, is composed of infinite varieties and complexities; it is, in fact, a multidimensional world, where there are no straight lines or entirely regular shapes, where things do not occur in sequence, but concomitantly; a world where — as modern physics informs us — even empty space is curved” (CAPRA, 1983).

Bertuglia and Vaio (2005) identify the various stages in the historical evolution of scientific thought, from the confident certainties typical of the mechanistic or reductionist view (whose roots are in Cartesian philosophy) to the progressive recognition of intrinsic difficulties (TABLE 01):

Table 1: Stages of the Historical Evolution of Scientific Thought

Historical Phases of Scientific Thought	Main Researchers	Period
Determinism (classical mechanics)	Newton, Leibniz, Lagrange, Euler, Laplace.	From 1687, the year of publication of Newton's *Principia*, to the first decades of the 19th century.
Statistical Indeterminacy	Clausius, Lord Kelvin and Boltzmann.	In the second half of the 19th century.
Quantum Indeterminacy	Bohr, Heisenberg, Schrödinger, Dirac, etc.	From the first decades of the 20th century.
Deterministic Chaos	Poincaré.	At the end of the 19th century.
	Lorenz, Smale, Yorke, Prigogine, etc.	Last decades of the 20th century.

Source: Adapted from Bertuglia and Vaio (2005).

Regarding the uncertainties and risks due to the technological race, Kahn (2007) analyzes the possibility of using weapons of mass destruction (from history, in terms of their use); and evaluates defense weapons systems "in terms of the worst they can do," envisioning "ingenious and specially designed unconventional means (such as suicide ships or submarines carrying super-large bombs to explode on our shores, causing tidal waves or extreme precipitation)" (KAHN, 2007).

It turns out that, for the present days, the question of the use of technology as a threat is no longer "a glimpse" – Nichols *et al*. (2022) warn about the risk regarding the suitability of emerging disruptive technology as "weapons of mass destruction" (drones or robots), concerned about the future use of these cheap devices and their availability to malevolent actors.

Based on the most recent geopolitical conflicts and informations, Nichols *et al*. (2022) note the trend to employ autonomous air and sea vehicles (or systems) in the military operations of the future as having a massive impact in conflict, particularly, if abjectly used (chemical, biological, nuclear, radiological, electromagnetic, and explosive weapons – CBNRECy) (NICHOLS *et al*. 2022).

It is about a "new technological era" where emerging disruptive technology (robotics by artificial intelligence) will transform the war aspects, adding complexity to the conflict. Mainly, autonomous technology (underwater, in focus) raises concern because of a differential feature – occultation in the "blue planet" (hidden in an environment that is fundamental to the regulation of climatic conditions and to life itself) (LIANG and XIANGSUI, 1999; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; SKINNER and MURCK, 2011; BEYERCHEN, 2007; MOURA, 2012: SPARROW and LUCAS, 2016; BAYLIS *et al*. 2018; PIOTROWSKI, 2018; FERREIRA, 2021a; FERREIRA, 201b; NICHOLS, *et al*. 2022; FERREIRA, 2022).

"Unfortunately, the dark side of human imagination and ingenuity cannot be ignored because, in the wrong hands, it can kill millions at the push of a button." (SLOFER, 2022) – of people... or, of (living) beings, apart from the "non-living" affected (and beyond): a threat to the (Earth) system (CAPRA, 1982; CAPRA, 1983; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; SKINNER and MURCK, 2011; SLOFER, 2022; NICHOLS et al., 2022).

III. Probability of Chaos in Geophysical Fluids (for Models)

"The management and regulation of ecosystems is a complicated matter" (STEWART, 1997) – According to Stewart (1997) in the distant past of the human race, the absence of pattern in the natural world was attributed to the whims of the powerful and incomprehensible deities that ruled it (STEWART, 1997).

To deal with the complex phenomena of the 21st century (questions never before conceived concerning the physical world) the new scientific perspective is that of "non-linear science" (a metascience) through the recognition that in all of nature "the whole is greater than the sum of the parts" (SCOTT, 2007), "unexpected things happen" (SCOTT, 2007), and "minimal causes can explode into powerful effects" (SCOTT, 2007).

Systems composed of numerous elements, among which there are reciprocal, nonlinear interactions, are called complex systems (BERTUGLIA and VAIO, 2005). The phenomenology of complexity is relevant due to the transversality of the aspects that appear in such systems, and that characterize their nature (BERTUGLIA and VAIO, 2005).

Complexity and chaos are present in deterministic systems (deterministic because there is always a law that dictates their evolution) whose behavior is generally unpredictable, as it is extremely difficult (or impossible) to identify the effect of the various parameters of the system (considered individually, or in its entirety) (BERTUGLIA and VAIO, 2005).

Deterministic laws, which "apparently make the world algorithmically comprehensible," according to Bertuglia and Vaio (2005), are reduced from large data sequences (thanks to phenomenological recurrences). But systemic complexity is difficult to be completely described in a deterministic way – certain properties of complex systems are emergent (they are not intrinsically identifiable in any of their parts taken individually) (BERTUGLIA and VAIO, 2005).

The complexity demonstrates that causality is not linear since in the long term, it acts so that the links between causes and effects of systemic phenomena can dissolve (not being identified), as highlighted by Bertuglia and Vaio (2005). In the short time, if causality can be successfully "explained" by the "set of encoding, decoding and implication processes" of "deterministic" laws, then a model could be built (BERTUGLIA and VAIO, 2005).

The "butterfly effect" became the "popular slogan of chaos" (SMITH, 2007). Chaos, in the scientific sense, is a particular aspect of how something changes over time (in fact, change and time are the two fundamental themes that together form the basis of chaos), according to Williams (1997). Thus, chaos presents problems that challenge accepted ways of working in science, breaking down the lines that separate scientific disciplines – severing the principles of Newtonian physics, and eliminating the Laplacian fantasy of deterministic predictability (GLEICK, 1987).

In various configurations, chaotic behavior can be observed, even if the equations that describe the system are not. Even elementary systems, described by simple equations, can have chaotic solutions (to the surprise of many scientists). Furthermore, the same system can behave predictably or chaotically, depending on little changes in a single term of the equations that describe it (SPROTT, 2000).

Understanding that the study of chaotic behavior has received substantial attention in many disciplines, Berliner (1992) reviews mathematical models and definitions associated with chaos, emphasizing the relationship between chaos mathematics and probabilistic notions (pointing aspects of particular interest to statisticians and probabilistic), since chaos is related to complex "random" behavior and forms of unpredictability (BERLINER, 1992).

Chaotic processes are not random – but there is a relationship – as even simple rules can produce extreme complexity (a mixture of simplicity and unpredictability). It is widely understood by the scientific community that being "deterministic" does not mean being "predictable" (SPROTT, 2000).

As there are different ways of quantifying what is meant by complex or unpredictable behavior, a universally accepted mathematical definition of chaos does not seem to exist (some definitions related to chaos involve notions of ergodic theory – positive Liapunov exponents and the existence of continuous ergodic distributions) (BERLINER, 1992).

Regarding the concept of chaos and the concept of probability, Bartlet (1990) also recognizes the relationship of their properties with the concept of chance: "it can be said that events are governed in part by the operation of the "laws of chance" (BARTLET, 1990). For Bertuglia and Vaio (2005), chaos and chance manifest themselves in the same way, both characterized by the disorder – in chaos, determinism is present but hidden (apparent disorder). In chance, there is the absence of determinism (real disorder, in random phenomena) (BERTUGLIA and VAIO, 2005).

"The methods used to distinguish deterministic processes from stochastic processes are based on the fact that a deterministic system always evolves in the same way, starting from certain conditions" (BERTUGLIA and VAIO, 2005). The law of dynamics generates a single state consequent to a given state, according to the author. On the other hand, in a stochastic or random system, consequent to a given state, there are more possible states among which the dynamic system somehow selects (according to a probability distribution) (BERTUGLIA and VAIO, 2005).

In practice, however, it cannot be assumed that a time series consists of data that result only from a deterministic law, having no stochastic components (BERTUGLIA and VAIO, 2005). Any series of experimental data is always "mixed with a stochastic process" that overlaps it, as background noise (called "white noise"), which reduces the quality of the information – this is due to a series of reasons (for example, there are unavoidable practical difficulties in measuring data, or data when measured never constitute a continuous sequence in time, and also any measurement is always affected by approximations of various types and origins) (BERTUGLIA and VAIO, 2005).

And, to be sure of obtaining only the deterministic law for a system, it would have to be "closed" (no interaction with the outside environment). Thus, it would undoubtedly be deterministic since all its dynamics would be endogenous (BERTUGLIA and VAIO, 2005). However, in practice, the number of variables needed to consider the system closed would be so high as to make the calculation time unacceptably long to effectively identify the deterministic law at the origin of the observed dynamics, according to Bertuglia and Vaio (2005). That is, "it would certainly be closed and deterministic in theory, but impossible to treat from a practical point of view" (BERTUGLIA and VAIO, 2005).

Chance plays a central role in human understanding of the nature of things – a probability that is neither "0" nor "1" corresponds to an uncertain event; however, ignorance about it would not be total – since "chaos limits the intellectual control we have over the world" (RUELLE, 1993).

In reality, the "chance versus determinism" dilemma is a false problem – as follows: a) there is no logical incompatibility between chance and determinism (the state of a system at the initial instant, instead of being precisely fixed, can be disposed according to a particular law of chance); b) in practice, the state of a system at the initial instant is never known with perfect precision; and, c) the little chance at the initial moment can provide a lot of chance (or a lot of indeterminacy) at a later moment (RUELLE, 1993).

"The central epistemological impact of chaos research is on issues of long-term prediction, and on the computability of most nonlinear deterministic systems" (LEIBER, 1998).

The advent of deterministic chaos in the natural sciences has counter-argued the question of "perfect predictability" based on mathematical determinism, according to Leiber (1998). Since mathematical determinism is empirically meaningless, the assumption that mathematical determinism must imply long-term numerical computability is simply wrong (any kind of error, deviation, or perturbation is amplified exponentially). Based on systemic modeling for technologies, if there are severe quantitative limitations for long-term computability, there will also be limitations in terms of controllability (LEIBER, 1998).

Problems that present "exponentially increasing algorithmic complexity" (depending on some system parameter) are considered "intractable" by Leiber (1998).

As for physical systems of the marine environment (atmosphere and ocean), systemic complexity is characteristic (nonlinearity) – in meteorology and oceanography, one deals with fluids whose density depends on temperature and pressure (MARSHALL and PLUMB, 2008).

In the context of geophysics, with regard to ocean analysis: Kamenkovich (1977) understands that it is necessary to comprehend the characteristics of the large-scale movements of its waters (due to its fundamental role). Olbers *et al*. (2012) also look at the influence of the oceans on earth's climate, weather, and ecosystems.

Monin and Ozmidov (1985) highlight the primordial importance of turbulence in the formation of hydrological fields in the ocean for the governance of the "world climate" – heat is accumulated in ocean waters due to turbulent mixing in the tropics and is subsequently transferred by sea currents to temperate and arctic zones. Most of the energy in the ocean's motion is contained in turbulent vortices rather than the average circulation – this is a new conception which should replace the universally accepted notion of the ocean as a quasi-stationary system (with a pattern of turns on a constant scale) (MONIN and OZMIDOV, 1985).

According to Monin and Ozmidov (1985) turbulence is a phenomenon observed in a large number of rotational flows (liquids and gases) whose thermodynamic and hydrodynamic variables suffer chaotic fluctuations (velocity vector, temperature, pressure, the concentration of contaminants, density, speed of sound, electrical conductivity, refractive index, etc.) (MONIN and OZMIDOV, 1985).

Since the ocean is a vast reservoir of organic life, the intense turbulent movement in ocean waters is directly related to atmospheric exchanges. Otherwise, "the resources of biogenic material in the upper photosynthetic zone of the ocean and those of oxygen in the abyssal layers would soon be depleted [...] ocean would then change to a lifeless desert" (MONIN and OZMIDOV, 1985).

As described by McWilliams (2006) the atmosphere and oceans exhibit complex patterns of fluid motion on a wide range of space and time scales (climate is a combination of these motions, on a planetary scale – a response to solar radiation inhomogeneously absorbed by the compounds of the air, the water, and the earth). "Spontaneous, energetic variability arises from instabilities in planetary-scale circulations, appearing in many different forms, such as waves, jets, vortices, boundary layers and turbulence" (MCWILLIAMS, 2006).

"Geophysical fluid dynamics" (GFD) is the theoretical science of all types of fluid motion of complex nonlinear dynamics (planetary fluids – fluids from within the earth; lava flows from volcanoes; fluids from ocean circulation; and the atmosphere – and astrophysical fluids, since many of the scientific questions are similar). Mathematical analysis and computational modeling are essential research methodologies for the identification and study of dynamic processes behind of the observed phenomena (MCWILLIAMS, 2006).

Most of GFD is a branch of physics (relevant aspects of dynamics, energy transfer by radiation, and atomic and molecular processes associated with phase changes) – however, GFD does not cover the entirety of ocean-atmosphere physics (it merely provides a mathematical representation and interpretation of the facts about earth's natural fluids). Also there is some chemistry, and even biology, in GFD as they influence the movement and evolution of reactive materials (MCWILLIAMS, 2006).

Due to the complexity of geophysical motions (which is generally a consequence of fluid turbulence), "even tides, arising from spatially smooth and temporally periodic astronomical forces, can be quite complex in their spatial response patterns" (MCWILLIAMS, 2006).

Although the dynamic equations used in GFD are "deterministic" in a mathematical sense (with the property of sensitive dependence - where any little

differences rapidly amplify over time) most geophysical time series are more appropriately called "chaotic" than "deterministic" (MCWILLIAMS, 2006).

Vallis (2016) also discusses the role of GFD in understanding the natural environment in the search for the phenomenological essence; noting that complex systems of interaction present "fluid dynamics emergent phenomena" (which emerge from the collective behavior of the system's constituents – not being a property of its components). According to the author, "at each new level of complexity, new properties arise that do not depend on the details of the underlying laws and qualitatively different behavior occurs" (VALLIS, 2016).

As some of the main goals (and past triumphs) of the GFD are in the explanation of "emergent fluid dynamic phenomena," Vallis (2016) presents two reasons why such phenomena should be understood: a) the scientific understanding of the natural world is "an end in himself," which affords admiration and respect, in proportion to his greatness; b) the understanding of phenomena enables better prevention, and finally, practical social benefits (public policies can be implemented with a focus on atmospheric and oceanic dynamics, for example).

In many geophysical systems of interest, information about systemic behavior can be obtained by quasi-direct numerical simulation of governing equations, for Vallis (2016). In this sense, GFD describes a method and an object of study (VALLIS, 2016).

It turns out that there is little scientific understanding regarding the intricate details of ocean circulation, the limits of its biological productivity, its interaction with the atmosphere, or its tolerance for waste dumped by the growing human population (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b).

The task of faithfully modeling the circulation of the oceans (across the spectrum of their temporal and spatial variability), for example, is highly complex, challenging, and arduous – meticulous attention to detail is required, both dynamically and numerically (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b).

IV. Plausibility of Rare Event by Geophysical Process (for Scenario)

In a world of great uncertainty, scenarios are tools for achieving a long-term vision, and a method for understanding, articulating and moving between the different possible future paths, from "[...] stories that can help us recognize and adapt to changing aspects of our current environment" (SCHWARTZ, 1996).

"The study of scenario-based planning is the study of learning and invention" (VAN DER HEIJDEN, 2005). There is a debate among scenario planners about the preference for plausible or probabilistic methodologies, according to Ramirez And Selin (2014). As the two species have incompatible conceptions (about knowledge and uncertainty), both can be approached by critical and etymological examining (from techniques and tools, schools of thought, criteria of effectiveness, epistemological and ontological differences) (RAMIREZ and SELIN, 2014).

Regarding the etymology of the words "plausibility" and "probability," Ramirez and Selin (2014) address three different historical periods: a) in the first period (until the 16th century), both terms were used confusingly, for its origin (derived from classical Latin) – probability denoted "seeming true" (a perception associated with "likelihood"), and plausibility "seeming reasonable or probable" (a perception about "false appearance"); b) in the second period (17th century), probability started to be seen in a more scientific way, related to observational rigor; c) in the third period (from the 18th century onwards), probability becomes a central aspect of statistics (mathematically defined); and plausibility continued in its original sense of providing "the appearance of credibility and reasonableness" (RAMIREZ and SELIN, 2014).

The probabilistic approach for scenarios is deductive, positivist, and reductive, approximating absolute claims by exclusion and simplification (captured in formulas, statistics, and regressions) through a scientific, predictive vision, that providing the measurement of occurrences based on a degree of objective and rational belief. However, "this approach is based on facts, which are all in the past" (RAMIREZ and SELIN, 2014). On the other hand, "plausibility is considered a characteristic of credible cause and effect relationships" which, and not objectively, proposes "new beliefs" (RAMIREZ and SELIN, 2014).

Probabilistic scenarios would be epistemologically close to a prediction (RAMIREZ and SELIN, 2014). But prediction only makes sense in a domain where probabilities can be evaluated. Another issue regarding forecasts is the fact that, generally, people assimilate a specific routine and settle down, according to Van der Heijden (2005) (in reality, there is always a point in time when structural changes will occur, and behavior will have to change). "Forecasts can work very well for a period, but forecasters need to be aware of variables that will suddenly break the relationship with the past, creating a trend break" (VAN DER HEIJDEN, 2005).

For plausibility, the scenarios would only help, in intrinsically uncertain and unpredictable situations, according to Ramirez and Selin (2014). "The final confrontation concerns the roles of creativity and codified knowledge in alternative futures, making scenario planning something that involves "art" or "science" (RAMIREZ and SELIN, 2014).

Schwartz (1996) highlights that through a scenario the world of facts is connected to the world of perceptions (as in a theater, in which spectators suspend disbelief relative to any point and react to the scenes – as if they were actually following the real world). A good scenario leads people to "voluntary suspension of some disbelief," during the sufficient time to appreciate the impact of "new beliefs," according to the author.

As noted by Ramirez and Selin (2014), if the fundamental objectives of a scenario are to bring up implicit assumptions, test tacit knowledge, question prejudices of the impossible and the possible, and change views and minds – ambiguity and uncertainty would be productive. "If each scenario is as plausible as the next, every scenario is worthy of attention; and the defined scenario is not the only one – it is the comparisons between them that generate value" (RAMIREZ and SELIN, 2014). Van der Heijden (2005) highlights the importance of multiple futures (equally plausible), which serve the purpose of a test bed for policies and plans.

By the plausibility method, scenario planning only assesses plausible futures using qualitative tools; they can be produced inductively or deductively – if it were possible to establish probability about a certain end, there would be no need to build scenarios (RAMIREZ and SELIN, 2014).

"Scenarios emerged after the Second World War as a method of military planning. The US Air Force tried to imagine what its opponents might do and prepare alternative strategies" (SCHWARTZ, 1996). Indeed, conflict is a profoundly existential phenomenon, potentially destructive to lives and livelihoods, hence the numerous attempts by many researchers to make it more predictable (GAUB, 2020).

Concerning the military, although war is a prerogative of the state, creative works imagine how war might evolve in the future and directly influence it (for example, by speculating on possible new problems – testing the limits of new technocentric approaches) (GAUB, 2020).

On the possibility of nuclear conflict, Gaub (2020) points to the reasoning of experts at the "opposite end of the scale," who hold firmly to the theory of deterrence – the idea that the possession of nuclear weapons, in itself, is enough to avoid war. Although it is a plausible conception, it can generate relative comfort (in limiting knowledge, ideas, and action to be taken about an imminent conflict of this nature) (GAUB, 2020).

Focusing on the ways and means by which conflicts will be fought in the future, and "without the ambition to develop generalized theories or predict the beginning of a conflict before it happens" (GAUB, 2020), the author considers it relevant that societies and institutions are prepared for an imminent conflict, so that there are fewer surprises (GAUB, 2020).

Imagination must be applied to this (GAUB, 2020). Using imagination is working with the anticipation of facts, mainly due to possible impacts that, by chance, are possible to occur. The author also notes that there may be degrees of imprecision, especially if future conflicts are contemplated as an extrapolation of current trends, or if they are entirely different from the past (disruptive illusion) (GAUB, 2020).

In 1960, from the perspective of "conflict in a nuclear age" (thermonuclear wars), Kahn (2007) approached this problem for human civilization from the analysis of scenarios. Subsequently, Kahn *et al*. (1976) also used the same methodology to examine "other kinds of real problems" facing humanity (by presenting a partial report on crucial long-term issues of broad interest). About the scenarios developed by Kahn (2007) and Kahn *et al*. (1976), analyzes referring to environmental issues proved to be insipid (KAHN, 2007; KAHN *et al*. 1976).

The perspective for humanity presented in Kahn *et al*. (1976) credited as "the most likely and representative" for a 200-year interstice opposes what the authors cited as "popular and generalized discussions [...] that indicate bleak prospects" (KAHN *et al*. 1976). That is, the scenario described by Kahn *et al*. (1976) is entirely diferent, in the sense of being more positive for humanity, and not "doomsday literature" (KAHN *et al*. 1976).

A paradoxically intriguing observation concerns the credit given to the vision in Kahn *et al*. (1976) "as the most likely and representative" – since the perspective presented is "deliberately non-technical; suggestive and speculative; and may present errors and omissions" (KAHN *et al*. 1976).

That is, about "popular and generalized discussions [...] that indicate bleak prospects" (KAHN *et al*. 1976), Kahn *et al*. (1976), similarly, heuristically, and superficially discuss the future – only from an entirily optimistic approach, based on the belief in public policies, by the impact (directly, indirectly, and in a lasting way) of the thoughts and ideas resulting from their "investigations."

Based on the quote: "what is well known is misunderstood, and what is taken for granted is taken without thinking" (KAHN *et al*. 1976) – by a crude and simplistic interpretation of this – the authors justify their suggestive reasoning, also disregarding the discussion and the opinion of intellectuals and academics.

With some exceptions (for example, the problem of nuclear proliferation), Kahn *et al*. (1976) are in favor of "progress" (as exemplified by science, technology, and industrialization), considering that technological "progress" will help society to deal with facing absolutely "all" future problems (radiation, and chemical or toxic waste, also including) – "it seems quite

likely that within a century or so man will be able to avoid harm, and that calculations of accumulated harm 10 to 100 generations hence are likely to become irrelevant" (KAHN *et al*. 1976) – in a perspective of "progress" at any cost[1]. A contradiction, at least, about science itself and its understanding (KNELLER, 1978).

Through a succession of movements, in the broad historical course of civilization, science (knowledge about nature that aims to fully explain its order, as well as all human activity to expand this knowledge) is a source of information indispensable to technology, according to Kneller (1978). However, being a human enterprise based on theories that accumulate in laws, it is fallible (KNELLER, 1978; FERREIRA, 2021a).

Therefore, every, each statement or set of scientific reports can be revised or replaced in the light of new evidence and ideas, and so, science can criticize itself and transform itself into a rational validation acceptable to other scientists in a community. The evolution of research traditions, with the accumulation of laws, makes science grow and scientific imprecision decrease, "towards true progress". However, if incommensurable theories exist, there is no way to know whether science advances towards the truth (KNELLER, 1978).

Kneller (1978) considers that science is progressive (by using an increasing number of increasingly precise investigation techniques), but not continuously since incorrect hypotheses can sometimes be preferred to correct ones. The progression, therefore, takes place on different bases, as one theory can be refuted by another, more credible, or more significant. Also, science is cumulative (by adding new data to past findings rather than replacing them); but not always (KNELLER, 1978).

Unfortunately, scientific knowledge, technological development, and innovations bring consequences: Longo (2007) highlights the "macro-social impacts caused by recent changes in the human environment," which, being slow initially, were accelerated for human satisfaction; and, after the Second World War, they turned to the production of military advantages aimed at the development of political-economic power at a world level. Thus, science and technology became a central part of national policies and strategies in developed countries, with a new distribution of power. Sachs (2000) even takes a curious approach to the close relationship between "technological power" and national sovereignty.

Longo (2007) argues that such scientific-technological performance has been reflected in an acceleration of social changes unprecedented in human history. Governments have not been able to carry out the proper monitoring and planning on the subject, generating, among many other social impacts, a "management gap," capable of affecting the environment and people's health.

Regarding the systemic environment, the inferences in Kahn *et al*. (1976) are obsolete, for example, by the association of "green plants" to the production of oxygen – about the ocean, there was no comment – however, there is active participation of the sea in this process (KNELLER, 1978; MONIN and OZMIDOV, 1985; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; BERTUGLIA and VAIO, 2005; SKINNER and MURCK, 2011).

Kahn *et al*. (1976) also refute the idea of "environmental fragility" since "both the environment and most ecological systems must be resilient and largely self-correcting or self-healing" (KAHN *et al*. 1976), in the autors opinion. But about the particularities and the proportions of possible humans interferences in the earth system, there was no analysis (or measurement). Likewise, the action of unforeseen natural (geophysical) forces and processes was not envisaged (KAHN *et al*. 1976).

Kahn *et al*. (1976) disregarded the occurrence of "random events" of any kind (even the possibility of such circumstances – "undocumented") "because the underlying assumptions and conditions practically never happen" (KAHN *et al*. 1976).

However, concerning the "fragile envelope of the earth" (KAHN *et al*. 1976), for example, the "ground" may, unexpectedly, evaporate (MUKHERJEE, 2006; IDRISS and BOULANGER, 2008; SKINNER and MURCK, 2011) (FIGURE 01):

[1] By analogy, Kahn *et al*. (1976) relate "science" to magic – a supernatural gift obtained by an irreversible commitment (pact) to be obligatorily employed (at all costs) – A "Faustian bargain" (KAHN *et al*. 1976, p.164). It turns out that "magical action" (even if mystical) is deterministic – its effects are governed "because of the pact" "as law" and "exact and inviolable" (the cost for breaking the "law" would be "high"). According to scientific thought for the 21st century, science (which can be seen from a mystical perspective) has deterministic and also stochastic characteristics, explicitly "assuming 'without' law behavior governed entirely by law" (STEWART, 1997). By the conception, one accepts at first, a "certain" uncertainty (about the Creator "of all scientific laws, etc." *modus operandi*); but without bargaining – and with "certain" clarity (through flashes of revelation - which help the perception) and exposition about possible consequences (at least, through inferences).

Figure 1: Tilting of Apartment Buildings Caused by the 1964 Niigata Earthquake.

Source: National Information Service for Earthquake Engineering (University of California, Berkeley) apud Idriss and Boulanger (2008).

V. Final Considerations

While the high seas are an ideal location for autonomous underwater vehicle operations, a suitable mathematical model is necessary for a high-performance technology. Specifically, the ability to precisely maneuver in ocean space is an essential quality for this category of " robots" – the governance, controllability, and trajectory issues of such systems are complex (FOSSEN, 1994; GRIFFITHS, 2003; BREIVIK and FOSSEN, 2009; INZARTSEV, 2009; FOSSEN, 2011; FANELLI, 2020; YAN *et al*. 2021).

Regarding the structure and dynamics of complex systems chaos theory can be applied to provide insights into nonlinear phenomena (including random aspects). In chaos theory, determinism and chance are like two sides of the same coin, and there is no cause and effect relationship between them (GLEICK, 1987; ÇAMBEL, 1993; WILLIAMS, 1997; SPROTT, 2000; BERTUGLIA and VAIO, 2005; BEYERCHEN, 2007; LASKEY and COSTA, 2009).

When it comes to understanding the operational particularities of autonomous underwater technology, an essential and challenging facet to be considered (in addition to the desired results) concerns the marine environment – the ocean is limited in terms of observation and constantly changing (GILL, 1982; CHASSIGNET and VERRON, 1998; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; JUDD and HOVLAND, 2007; LOWRIE, 2007; INZARTSEV, 2009; BREIVIK and FOSSEN, 2009; SKINNER and MURCK, 2011; FOSSEN, 2011; ÖZSOY, 2020).

Numerical modeling of oceanic processes (ocean dynamics) involves the water masses dense structure that make up ocean basins, the radiative fluxes at their surface, the forces imposed on the ocean surface by the overlying atmosphere (the stress of wind and flows buoyancy), the astronomical tidal forces, in addition to the consideration of sea ice , and topographic information – "mid-ocean ridges and other topographic features important to the circulation of the basin, must be essential included in resolutions of numerical models". For reasons of efficiency and economy, most ocean circulation models can impose a limit on the depth of the model (a false bottom) (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b).

The domain of geophysical processes is broad, reaching all the subsystems of the planet, due to the systemic interaction: the atmospheric boundary layer is connected to the earth's surface, but also to the ocean surface – and the oceanic boundary is "visibly" related to the atmospheric layer; however, it is also in connection with the ocean floor (in hidden) (GILL, 1982; CHASSIGNET and VERRON, 1998; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; JUDD and HOVLAND, 2007; SKINNER and MURCK, 2011; ÖZSOY, 2020).

The scientific awareness is that dynamic geological processes drive the exchange of fluids (a wide range – of gases and liquids) at the "seafloor-seawater" interface. From coastal waters to deep ocean trenches, "it is remarkable how common is the flow of fluid on the seafloor" (JUDD and HOVLAND, 2007). "This interaction gives rise to flows that appear chaotic (turbulent) [...], and the resulting variability can be seen

in measurements of properties such as wind speed, temperature, and currents" (JUDD and HOVLAND, 2007) (including of under the influence of the submarine relief, or of the oceanic circulation itself, and tides) (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; JUDD and HOVLAND, 2007).

As the physical characteristics of the global ocean (in terms of shape and extent) are determined by tectonic forces, great topographical changes are challenges to ocean modeling (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; SKINNER and MURCK, 2011; ÖZSOY, 2020).

"One of the few geological activities of dynamic importance to the oceans are underwater earthquakes, which generate destructive tsunamis" (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; SKINNER and MURCK, 2011; MUKHERJEE, 2006; JUDD and HOVLAND, 2007; ÖZSOY, 2020).

Processes in the flow of geophysical fluids expose the vulnerability of human life (which occupies the surface layer of the crust, about the geosphere) – "possibly, the majority of the human population will increasingly be at the mercy of Nature for their sustenance" (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b).

Likewise, due to the systemic interaction of the seafloor (geosphere) with oceanic waters autonomous underwater technology (underwater, in focus) is vulnerable to geophysical fluid flows – its behavior is influenced by environmental forces (winds, waves, and ocean currents) (FOSSEN, 1994; GRIFFITHS, 2003; BREIVIK and FOSSEN, 2009; INZARTSEV, 2009; FOSSEN, 2011; FANELLI, 2020; YAN *et al*. 2021; JUDD and HOVLAND, 2007; INZARTSEV, 2009; SKINNER and MURCK, 2011; ÖZSOY, 2020).

Considering the problem related to the controllability of a "robot" in a fluid medium, it will be as efficient as the limit imposed by the application of its computational model about the intensity of turbulent flows and parameterizations (FOSSEN, 1994; GRIFFITHS, 2003; BREIVIK and FOSSEN, 2009; INZARTSEV, 2009; FOSSEN, 2011; FANELLI, 2020; YAN *et al*. 2021).

However, if immense geophysical processes occur that generate *sui generis* type of flows (earthquakes from the sea floor for example) – it is very unlikely that the controllability of such autonomous technologies can be effective (underwater, in focus) (LEIBER, 1998; JUDD and HOVLAND, 2007; LOWRIE, 2007; SKINNER, and MURCK, 2011; ÖZSOY, 2020; FERREIRA, 2021a; FERREIRA, 2021b).

The Global Risks report is published by the World Economic Forum, based on sources believed by the authors to be reliable regarding statements about known, unknown, uncertain, and other risks. Helpful information may not be limited to what is published (new perspectives may arise) (MCLENNAN *et al*. 2021).

Specifically about "environmental risks" McLennan *et al*. (2021) cite "major geophysical disasters" as the most critical threats to the world, as well as the most potentially harmful to people and the planet – however, considering them as "long-term risks."

It turns out that, to geophysical processes and disasters, events of this category still seem to occur "suddenly and without obvious warning" (despite the significant global effort put into investigations) (MUKHERJEE, 2006; SKINNER and MURCK, 2011; ÖZSOY, 2020). "Earthquake prediction is, without a doubt, the biggest challenge for geoscientists today" (MUKHERJEE, 2006), even, there may be changes in the variables that precede the occurrence of earthquakes (in relation to the thermosphere, ionosphere, and atmosphere of the Earth), as they "probably depend on the integrated cosmic environment and Sun-Earth" (CAPRA, 1982; CAPRA, 1983; MUKHERJEE, 2006; SKINNER and MURCK, 2011).

The Global Risks 2021 report (MCLENNAN et al. 2021) presents "weapons of mass destruction" as an "existential threat" (deployment of biological, chemical, cybernetic, nuclear, and radiological weapons), being one of the most impacting risks to the next decade.

In fact, "as technology has evolved, so has the need and desire to create better and more efficient weapons and associated launch systems that can break through or neutralize an opponent's defenses" (SLOFER, 2022). This is the case of autonomous technology (underwater, in focus) if used in a way that causes significant wear due to the possibility of penetrating the opposing defense (SPARROW and LUCAS, 2016; BAYLIS *et al*. 2018; PIOTROWSKI, 2018; FERREIRA, 2021a; FERREIRA, 2021b; SLOFER, 2022; NICHOLS *et al*. 2022; FERREIRA, 2022).

Specifically about nuclear weapons McLennan *et al*. 2021 point to the "small-scale" factor as a trend – a new technology that allows the proliferation of lower-powered warheads, which compromises deterrence structures; therefore, there is indeed apprehension about the conduct of a global nuclear war.

Considering only the proportion of an attack by the use of weapons of the nuclear category, the consequences for the earth system would already be "catastrophic" – however, there are empirical and antagonistic opinions on the conception of such a circumstance due to the relativization of its concept (KAHN *et al*. 1976; CAPRA, 1982; CAPRA, 1983; KAHN, 2007; BEYERCHEN, 2007; SKINNER and MURCK, 2011; BAYLIS *et al*. 2018; PIOTROWSKI, 2018; SLOFER, 2022; NICHOLS *et al*. 2022).

Indeed, there is a "self-regulation" feature of the Earth system (to its long-term dynamic equilibrium) however it is still not well understood by science mostly if the cause of the changes or disturbances are the human activities (SKINNER and MURCK, 2011). The human impact on the environment can overload the

system's resources, harming life (SKINNER and MURCK, 2011).

Interestingly, McLennan *et al*. (2021) emphasize the severe consequences of possible unwanted events in an "era of combined risks" (economic, environmental, geopolitical and technological) – also understood by the authors as a "cross between risks" (cross-risks).

From the remote possibility of a nuclear conflict a scenario can be imagined by the crossing of geopolitical and environmental risks (simultaneously), considering unexpected geophysical processes of immense proportion that generate *sui generis* flow of fluid (an earthquake coming from the sea, for example). As described, the concomitance between events would be very rare, however of "holistic" impact – and plausible – mainly if autonomous technology (underwater, in focus) is being used as a nuclear weapon or vector (WEICK, 1989; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; MUKHERJEE, 2006; JUDD and HOVLAND, 2007; KAHN, 2007; BEYERCHEN, 2007; SKINNER and MURCK, 2011; SPARROW and LUCAS, 2016; BAYLIS *et al*. 2018; PIOTROWSKI, 2018; GAUB, 2020; ÖZSOY, 2020; MCLENNAN *et al*. 2021; FERREIRA, 2021a; FERREIRA, 2021b; SLOFER, 2022; NICHOLS *et al*. 2022; FERREIRA, 2022).

Based on the scenario presented, the certainty that emerges concerns the harmful consequences to the Earth system even though scientifically the proportions of these damages are uncertain – because they are immeasurable (KNELLER, 1978; CAPRA, 1982; CAPRA, 1983; STEWART, 1997; LEIBER, 1998; SKINNER and MURCK, 2011; ÖZSOY, 2020).

As a support to productively deal with the discomfort, scenarios are helpful to reduce inconveniences and surprises about future situations (WEICK, 1989; GODET, 2000; VAN DER HEIJDEN, 2005; WADE and WAGNER, 2012; RAMIREZ and SELIN, 2014; SCHWARTZ, 1996; MINVIELLE and WATHELET, 2020; GAUB, 2020).

Sharing and putting a problem into perspective among stakeholders allows concrete ideas to be deduced by policymakers (GODET, 2000; VAN DER HEIJDEN, 2005; SCHWARTZ, 1996; MINVIELLE and WATHELET, 2020; GAUB, 2020; MCLENNAN *et al*. 2021).

In a conception of conflicts the use of previous simulations has accompanied the history of humanity - from Sun Tzu (for the creation of the game "*Wei Hai*") to World War II (by the use of simulation techniques, in the evaluation of possible results in operations, by Germans, Japanese, English, and Americans) (BRASIL, 2018). The importance attributed to the anticipation of scenarios became evident in conflicts, including the need to imagine a possible (or plausible) "element of surprise" (BRASIL, 2018; TALEB, 2007). In fact, during the Second World War, surprise (and unrestricted) Japanese tactics were employed (BRASIL, 2018; FERREIRA, 2021b):

[...] excerpt from a lecture given by AE W. Nimitz at the Naval War College in 1960 [...]: "The war with Japan had been simulated in the game rooms of this School by so many people, in so many different ways, that nothing that happened during the campaign in the Pacific was a surprise – absolutely nothing, except the *Kamikaze* tactics used at its end, which we had not visualized" (BRASIL, 2018).

Regarding the risk of war in a nuclear age, scenarios were indeed imagined, however, by a reductionist, simplistic, and already obsolete "scientific" bias (KANTH, 2007; KAHN *et al*. 1976). In a holistic and ecological scientific approach (referring to the 21st century), the dimension of the damage is "unimagined"[2]. Adding cross risks, all of them; and in the long term (KNELLER, 1978; CAPRA, 1982; CAPRA, 1983; WEICK, 1989; STEWART, 1997; LEIBER, 1998; GRIBBIN, 2004; BERTUGLIA and VAIO, 2005; KAHN, 2007; SCOTT, 2007; BEYERCHEN, 2007; SKINNER and MURCK, 2011; HORGAN, 2015; MCLENNAN *et al*. 2021).

Political decision-makers are alerted to the non-use of technology (underwater, in focus) as a weapon of mass destruction (or vector), due to the threat to the Earth system.

The limit (or frontier) of science reaches – in the end – the uncertainty (BUSH, 1945; KNELLER, 1978; CAPRA, 1982; CAPRA, 1983; STEWART, 1997; BERTUGLIA and VAIO, 2005; SKINNER and MURCK, 2011; HORGAN, 2015).

Indeed, about the scientific laws that govern the material world, uncertainty is dealt with, which does not imply a lack of knowledge or scientific understanding but "evidence of its breadth, complexity, and mutability" (KNELLER, 1978; CAPRA, 1982; CAPRA, 1983; SKINNER and MURCK, 2011).

Interestingly, "in a closed system, only energy, not matter, can cross the boundary" (SKINNER and MURCK, 2011). By characterizing the Earth as a "closed system" it is noted that: the sum of the energy of the system (internal energy) can be changed by the transfer of energy (its addition or its removal from the system),

[2] One can only "imagine" the despair of the survivors of a nuclear catastrophe – according to the relativization of the conceptual conception; or not – considering themselves as human beings in crisis or under pressure. There is a perception of a world government due to the belief in public policies (KAHN, 2007; KAHN *et al*., 1976), and indeed (in adverse circumstances), there will be an expectation of the survivors for a "salvation on Earth" referring to "on the Earth system" (SKINNER and MURCK, 2011). The human mind, "shaped by history and biology" would be easily manipulated (HARARI, 2018, p. 267). In Harari's (2018) perspective, "there is no authentic 'I' waiting to be freed from the shell of manipulation" (HARARI, 2018, p. 267).

as reported in Skinner and Murck (2011). Thus the plausibility of a "specific consideration of the 'output of the Earth system' in the form of energy (such as a rapture),"[3] may be inferred with hope for some people, by a conception "similar to the visions of mystics of all the times and traditions" (CAPRA, 1982; CAPRA, 1983), depending on "[...] how God plays dice" (STEWART, 1997).

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[3] "Popular and generalize discussions [...] that point to bleak prospects" (KAHN *et al*., 1976) – more appropriately: particular consideration about an apocalyptic event (as per theological inferences from the book "Revelation," Holy Bible). That it's like "bleak" in terms of being "mysterious, not fully revealed or exposed"; however, its outcome, fosters hope – "salvation" but from a metaphysical (transcendental) perspective, and victory (for some), and posteriorly, a "salvation of the Earth", referring to "the Earth system" (SKINNER e MURCK, 2011), or a renewal of all – from a mystical perspective. Another perspective, a widespread one, concerns "extraterrestrial beings" who abduct people – however, by a pseudo-scientific bias – in reality, theories must be: high in narrative rationality, self-consciously operated, deliberately separate as to validation, as well as being plausible; the expected result is by "knowledge growth by extension" – "when the relatively complete explanation of a small region is then transferred to the explanation of adjacent regions" (such as the gradual construction of a puzzle as more pieces become available) (WEICK, 1989).

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Using Remote Sensing and GIS to Investigate the Effect of Urban Sprawl on Health Facilities in Egbeda Local Government Area, Ibadan, Oyo State, Nigeria

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Abstract- The rapid rate of urbanization witnessed in the last century has produced more sprawls in the major cities of the world, particularly in developing countries where thousands of rural people move into the major cities at large proportion. Urban sprawl affects the landscape, the ecology of an area, travel patterns, resource consumption, health facilities and water discharge The aim of this research is to use remote sensing and GIS to investigate the effect of urban sprawl on health facilities in Egbeda Local Government Area, Oyo State, Nigeria with a view to determining how useful such information can be to planners, decision makers, health sector and private organization for effective urban management and sustainability. The research was conducted using remote sensing and Geographical information System at determining the spatial pattern and dynamics of the urban sprawl in Egbeda Local Government Area, Oyo State. The methods used includes: digitization, digital image processing and spatial analysis using an inverse distance weighted.

Keywords: *landuse, land cover, urban management, remote sensing, GIS, satellite imageries.*

GJSFR-H Classification: *DDC Code: 628.1682 LCC Code: TD653*

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Abstract- The rapid rate of urbanization witnessed in the last century has produced more sprawls in the major cities of the world, particularly in developing countries where thousands of rural people move into the major cities at large proportion. Urban sprawl affects the landscape, the ecology of an area, travel patterns, resource consumption, health facilities and water discharge The aim of this research is to use remote sensing and GIS to investigate the effect of urban sprawl on health facilities in Egbeda Local Government Area, Oyo State, Nigeria with a view to determining how useful such information can be to planners, decision makers, health sector and private organization for effective urban management and sustainability. The research was conducted using remote sensing and Geographical information System at determining the spatial pattern and dynamics of the urban sprawl in Egbeda Local Government Area, Oyo State. The methods used includes: digitization, digital image processing and spatial analysis using an inverse distance weighted. (IDW) technique, Maximum likelihood supervised classification and post classification change detection techniques were applied to Landsat imageries acquired in 1984, 2006 and 2018. Geographical Positioning System (GPS) was used to identify the health institutions and obtain the coordinates of the location of each identified health facilities. These were loaded on the imagery of Egbeda Local Government Area that was digitized from the images using the software of ArcGIS 10.2. Imageries were classified into built-up area, vegetation, bare surface, cultivation and water body. The results of the analysis obtained showed drastic change in built-up area which rose to 32.8% from 25.4% between 1984 and 2018 periods. To reduce the effect of urban sprawl on health facilities in the study areas, the government, stakeholders, policy makers and urban planner can make use of these techniques for effective city planning and sprawl control to attain and sustain future urban development.

Keywords: landuse, land cover, urban management, remote sensing, GIS, satellite imageries.

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I. Introduction

The rapid rate of the world's urban population every year is increasing by about 70 million, an equivalence of seven megacities (Jimoh *et al*. 2013). These need to be housed, fed and employed based on the carrying capacity of such urban centers. The bulk of these is in developing countries and, as a result, presents a number of logistic challenges for urban planning. Every month, the global urban population grows by 5 million; every day more than 100,000 people move to slums in developing countries, that is one person every second (Norwegian Refugee Council (NRC) 2015).

Today, 54 per cent of the world's population lives in urban areas, a proportion that is expected to increase to 66 per cent by 2050. Projections show that urbanization combined with the overall growth of the world's population could add another 2.5 billion people to urban populations by 2050, with close to 90 percent of the increase concentrated in Asia and Africa, (UN DESA report, 2015). In the late 1950s, urbanized areas in USA have extended outside rapidly during the suburbanization process of residence, industry and commerce, which encroached large amount of farmland and forest, brought negative effects to environment and caused more traffic problems. This pattern of urban development out of control has been regarded as urban sprawl (Yang and Liu 2005).

In Asia, despite its lower level of urbanization, it is home to 53 per cent of the world's urban population, followed by Europe with 14 per cent and Latin America and the Caribbean with 13 per cent. The world's urban population is expected to surpass six billion by 2045 (UN DESA report, 2015). African countries have higher rate of urbanization, but are less urbanized compared to countries in the developed world (Aluko and Amidu 2006). Research has also shown that 43 per cent of urban population of all developing regions lives in slums against only 6 per cent in developed regions (UN-HABITAT (2010). In Nigeria, 70% of the population resides in the rural areas and 30% in the urban areas (Kelly 2004). There is need for a very structured planning

procedure such that the development activities and infrastructure facilities such as schools, police stations, roads, healthcare facilities etc. are available at both rural and urban areas so as not to causing shift in population from the rural to the urban areas.

Urban sprawl is the less compact outgrowth of a core urban area exceeding the population growth rate and having a refusal character or impact on sustainability of environment and human (Basudeb Bhatta, 2010).

All cities in Nigeria are experiencing sprawl because of the scale and type of development around the cities which have affected most of agriculturally productive land. In the past decade, the city's built up area burst outward in an explosion of sprawl that consumed former agricultural land at a break-neck pace (Brueckner and Urban2020). Hence there is a need to examine the nature and the pattern of sprawl in the study area, for proper decision making and thereby, to enhance sustainable development. One of the prerequisites for understanding urban sprawl is successful land use change detection (Jain, 2009). Urban sprawl as a type of urban growth varies in terms of the pattern, density, and rate at which built-up land develops. This is however dependent on the way in which development occurs (Allen & Lu, 2003). Sprawl often occurs faster than the development of the infrastructure (e.g. schools, roads, sewer systems, hospitals, Police Stations and water lines) needed for support (Pohanka, 2004).

Monitoring urban sprawl is a vital part of assessing current trends with a view of improving urban quality of life in the future as sprawl affects man and his environment adversely (Alexakis, Hadjimitsis, Agapiou, 2012).

Atiqur(1999) studied the land use and land cover mapping in urban area using aerial photograph and satellite imageries of Jaipur (1983 and 1989), Coimbatore (1984), Ujjain (1985), Denhi (1987), Dehradun (1989), Banglore (1994) and Jammu (1995), on the basis of urban sprawl analysis of these cities they concluded that human settlements attend to expand in all directions of favorable conditions. Sulochana Shekhar (2005) studied changes space of pune – A GIS perspective with urban sprawl pattern and modelling using GIS on pune city according to her pattern of urban sprawl and analysis of spatial and temporal changes could be done cost efficiently and effectively using GIS and remote sensing data, they quantified the urban sprawl in terms of change in built up area. Aubrey Kanwendo (2008) studied the land cover and land use characteristics and change around Blantyre city in MALAWI and its surrounding rural area achieved by measuring the extent of urban sprawl in the city region over the period of 13 years (1989 - 2002). He found the built-up area increased rapidly from 5835 Hectares in 1989 to 15650 Hectares in 2002. Vemula *et al*, (2019) used Landsat MSS, SPOT and NISS 11 satellite data for mapping urban land use and urban sprawl of Hydrabad and Vishakhapattanam cities in Andhar Pradesh. Prasad *et al* (2020) worked on urban sprawl for Hydrabad city and its environments. They applied Shnnon's entropy approach to measure the degree of spatial concentration of geographical variables to demonstrate the utility of entropy to identify measure and monitor spatio- temporal pattern of urban sprawl.

The need to plan for growing population in term of healthcare facility's provisions becomes imperative in the cities, especially in the area that constitutes the urban sprawl within the city Egbeda Local Government Area, Ibadan. This is because the major population of Ibadan city currently concentrates in urban sprawl region of the city. Going by the Population census reports (2017), the Local Government Area has a population of (457,149) Four hundred fifty seven thousand, one hundred and forty nine people as at 1952, in 1963, it was (621,582) Six hundred and twenty one thousand, five hundred and eight two, in 1991, the population was (1,807,412) One million eight hundred and seven thousand, four hundred and twelve. In 2006 the population was estimated to be (2,567,668) Two million, five hundred and sixty seven thousand, six hundred and sixty eight while in 2016, the population rose to (3,231,967) Three million, two hundred and thirty one thousand, nine hundred and sixty seven. The haphazard growth and development of our cities make the healthcare facilities' planning a serious problem and therefore impact seriously the available healthcare facility within the city center. This study therefore underscores the need to evaluate the current situation of the healthcare facilities provision on the impact of urban sprawl on the available healthcare facilities. In investigating the level of provision of central facilities like healthcare, emphasis has shifted from mere provisions to the degree of accessibility of people to these facilities (Adewoyin 2018). According to Oyinloye (2015), health facility is one of the facilities that are mostly needed by everyone in the society. There had been many researches on Nigeria health challenges which include high child mortality rate, poor health delivery, poverty to pay for health services and lot more. Much work had been done on maternal and mortality rate, disease problems in Nigeria, and many other health related issues but nothing seems to have been done in the area of the accessibility of health facilities. This work aims to fill this gap, as it discusses the importance of accessibility to health facilities and its impact on urban sprawl.

The objectives of this study include to:

1. Analyze the land use and land cover change of the study area at different times (1984, 2006 and 2018).
2. Apply location-based analysis to identify the existing health facility in Egbeda Local Government Area using satellite imagery.

3. Determine the effect of urban sprawl on healthcare facility.

II. The Study Area

The study area is Egbeda Local Government Area of Oyo State. It is located on the Longitude 3^0 56' 54.753" E and 4^0 8' 58.585" E and Latitude 7^0 27' 23.532" N and 7^0 18' 34.578" N. The Local Government (Egbeda L.G.A.) shared boundary with Ona – Ara L.G., Lagelu L.G., Ibadan North East L.G. and Irewolede L.G. in the State of Osun (see Figure 1).

Egbeda is one of the oldest communities in the accient city of Ibadan that originated from Awaye compound / village. The Awaye people was known to be worriors, farmer, and accommodating in nature. The population of Egbeda Local Government Area, according to 2006 population census reached the size of 283,643 (NPC,2006). In projected2016 census, it rose to 398,500. This growth has been more phenomenal since the creation of the Local Government Area. . The annual average temperatures range between 23.9 and 28.3°C, and its mean annual relative humidity is about 77.1%. It is located within the tropical rain forest region of Nigeria where rainfall is high throughout the year. The area has an undulating terrain underlain by metamorphic rocks and characterized by two types of soils, deep brown clay soils and sandy soils. These soils have laudably supported the growing of cash crops such as cocoa, bread fruit, palms and cassava. Others common crops which are mostly, staple food include cocoyam, sugar cane, banana, plantain and vegetables. The topography of the area rises up to 500 meters and above the mean sea level in some places with the highest hill occurring in the northern part of the mapped area (Olatunji, 2022).

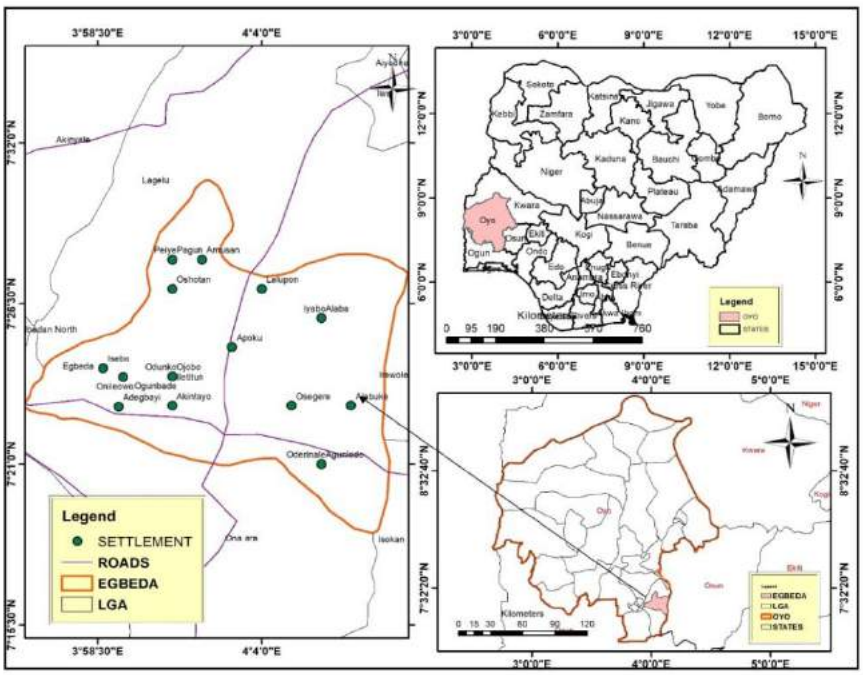

Figure 1: Maps of Nigeria showing Oyo State and Egbeda Local Government Area

III. Data Acquisition and Method

This study was interested in the urban land use and land cover change of Egbeda Local Government Area, Oyo state. The methods employed for data analysis include study area mapping, mapping from remotely sensed images of land use and land cover change, driving forces and future change/ development mapping using IDV analysis tool of geo-statistical interpolation. To achieve this, images of Egbeda Local Government Area, Oyo State were acquired for 1984, 2006 and 2018. The images are geometrically corrected and ground control point obtained through intensive ground surveys permitted the co-registration of all images to Universal Transverse Mercator (UTM). The Satellite imageries were made to pass through process of image enhancement, geo referencing, resampling, and image classification. A supervised classification with a Maximum Likelihood analysis was successful after creating five regions of interest with five training sites each. The map produced were: Land use/ cover 1984 from TM Landsat image, Land use/ cover 2006 from ETM+ Land sat image and Land cover 2018 from OLI Land sat image, based on built-up, cultivated land, bared land, natural vegetation and water body categories as regions of interest. Post classification was done using classified images for the purpose of confusion matrix, change detection and change statistics. Both classified and post classified images were converted to vector and exported to ArcMap 10.2

as shape files for statistical analysis and mapping. Also Geographical Positioning System (GPS) was used to identify the health institutions and obtain the coordinates of the location of each identified health facilities. These were loaded on the imagery of Egbeda Local Government Area that was digitized from the images using the software of ArcGIS 10.2.

IV. Results and Discussion

a) Land use/ Land Cover of the Study Area

The changes that occurred in Land use and Land cover in Egbeda Laocal Government Area, Oyo State for the past 34 years are shown in the following landuse and land cover maps of Figure 2 and Table 1. However, the total area of each of the landuse and land cover was calculated in 1984, 2006 and 2018. Table 1 is the summary of the area coverage in areas and percentage of land use and land cover types under study which includes the total area covered by the classification. Figure 2 shows the three years tend pattern from 1984 to 2018. In 1984, bare surface, cultivation, built up, vegetation and water body measures 0.0788%, 10.5660%, 9.8148%, 78.5841%, and 0.9563%, respectively. In 2006, bare surface lost from 0% to 0%, cultivation gained from 10.5660% to 13.4195%, built up also gained from 9.8148% to 21.4131%, vegetation lost from 78.5841% to 64.0343% while water body also gained from 0.9563% to 1.1331%. In 2018, bare surface remains the same, cultivation and vegetation lost from 13.42% to 3.6%, and 64.03% to 62.41% respectively, while built up and water body all gained from 21.41% to 35.80% and 1.13% to 1.23 % respectively.

It shows that there is a continuous increase in built up area from 25.4565Km^2 in 1984 to 84.5118Km^2 in 2018. This shows that land use from 1984 to 2018 with an increase of 59.0553Km^2, this shows that there is an increase of more than 50% within those years.

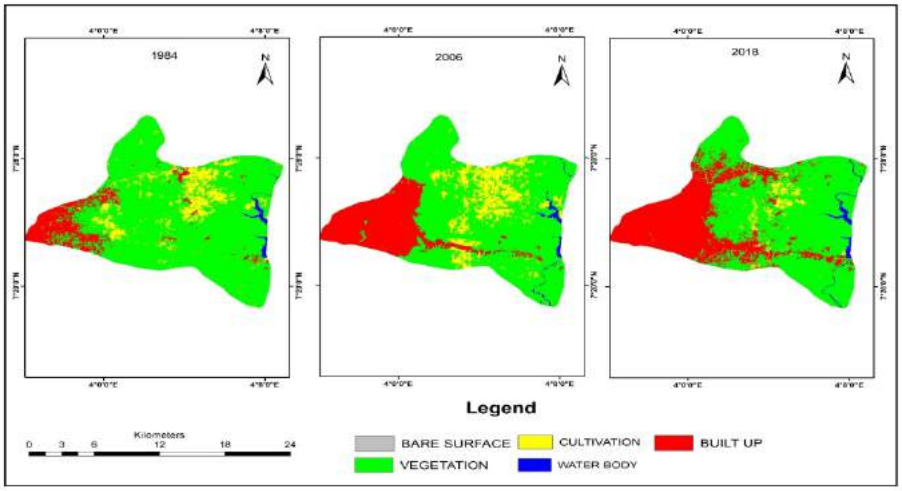

Figure 2: Classified Land use/ Cover Loss and Gain Map of the Study Area for 1984, 2006 and 2018

Table 1: Trend Showing the Landuse /Cover 1984, 2006 and 2018 (Km^2)

1984	Area(km^2)	Area (%)
bare surface	0.204	0.079
Cultivation	27.405	10.566
built up	25.457	9.815
Vegetation	203.823	78.584
water body	2.480	0.956
2006	**Area(km^{22})**	**Area (%)**
bare surface	0	0
Cultivation	34.575	13.419
built up	55.171	21.413
Vegetation	164.984	64.034
water body	2.919	1.133
2018	**Area(km^2)**	**Area (%)**
bare surface	0	0

Cultivation	9.177	3.562
built up	84.512	32.801
Vegetation	160.804	62.412
water body	3.157	1.226
Total	257.650	100

Source: Field work, 2018

b) Spatial Locations of Health Facilities in the study Area

Figure 3 shows healthcare facilities that were established from 1980 to 1984, namely Asejire healthcare facility (1982), Kajorepo healthcare facility (1984), Ayede healthcare facility (1982), Kumapayi healthcare facility (1981), and Kasumu healthcare facility (1982).

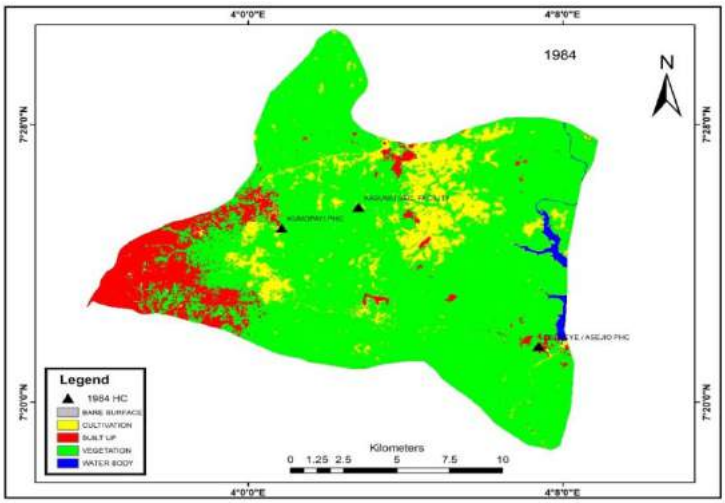

Figure 3: Map Showing Location of Health Facility in Egbeda Local Government Area Before 1984

Figure 4 shows the 5km buffering for all the 5 healthcare facilities established before 1984. The 5km buffers cover areas (wards) such as Agugu, Olubadan, Monata, Alakia, Iyana Church, Wakajaye, Olodo, Egbeda, Owo-bale, Olorunda, Erumu, Lalupon, Osengere, Ajia, and Abiri, leaving out areas (wards) such as Ajiwogbo, Lalupon Ward 3, Ejioku, Lalupon Ward 5, Ofaigbo, Lalupon Ward 2, Ayede, Agbora, and Ajia Ward 2.

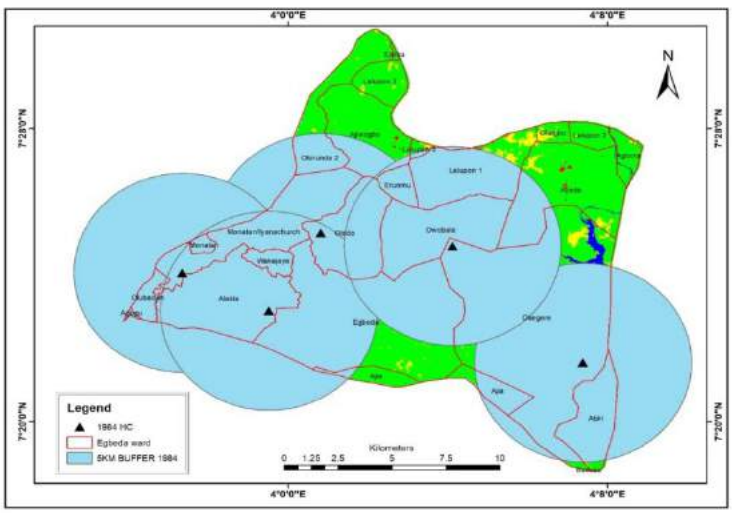

Figure 4: Map showing location of health facilities in Egbeda Local Government Area buffered at 5km before 1984

From Figure 5, shows the Threshold analysis that out of Twenty-four (24) Wards in Egbeda LGA, as at 1984, only Five Wards have Primary Healthcare facilities (i.e. Agugu, Osengere, Alakia, Iyana church and Olodo Wards) while Nineteen Wards do not have any Healthcare facility.

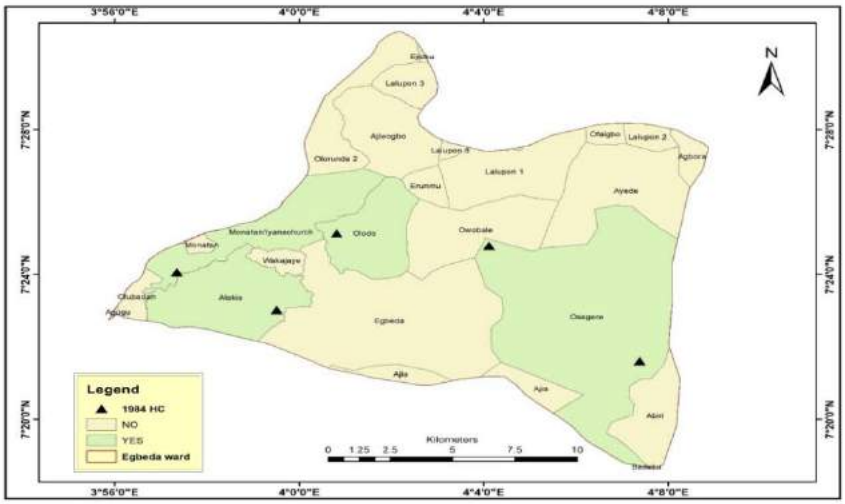

Figure 5: Threshold Analysis for Healthcare Facilities in 1984 in Egbeda LGA

Figure 6 shows the healthcare facilities that were established from 1985 to 2006, namely:- Ajiwogbo healthcare facilities (2000), Apete healthcare facilities (2001), Osengere healthcare facilities (2000), Alakia healthcare facilities (2002), Olode healthcare facilities (2004), Aged and Widow healthcare facilities (1999), Egbeda healthcare facilities (2002), SDP / Tuberculosis healthcare facilities (2004), Oremeji healthcare facilities (2002), Erumu healthcare facilities (2002), Wakajaye healthcare facilities (2000), Oloya healthcare facilities (2001), Kute healthcare facilities (1999), Owo Baale healthcare facilities (1995), Awaye healthcare facilities (2001).

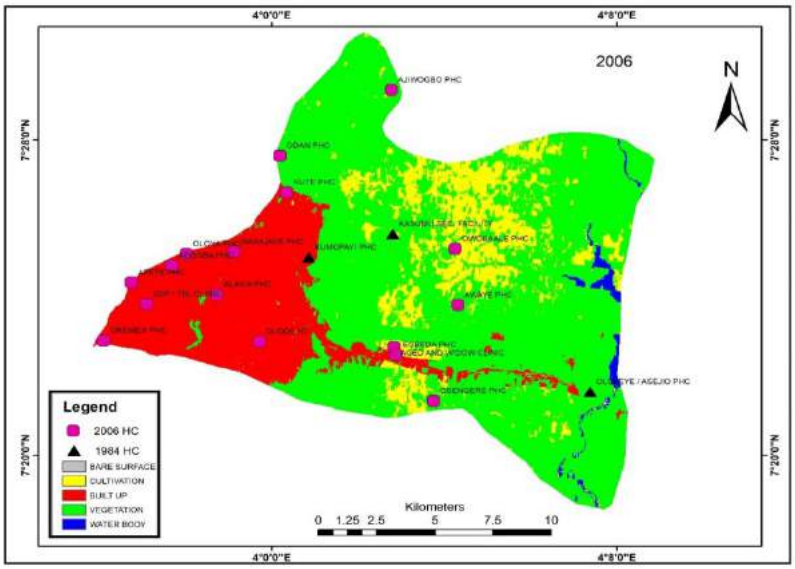

Figure 6: Map showing available healthcare facilities from 1984 to 2006

Figure 7 shows the 5km buffering for all the 16 healthcare facilities established within 1984 to 2006. The 5km buffering covers are such as Agugu, Olubadan, Alakia, Monatan, Iyana church, Wakajaye, Egbeda, Ajia, Osengere, Owo-baale, Erumu, Lalupon (Ward 1, 3, and 5), Olorunda (Ward 2) Ajiwogbo, olodo and Ejioku.

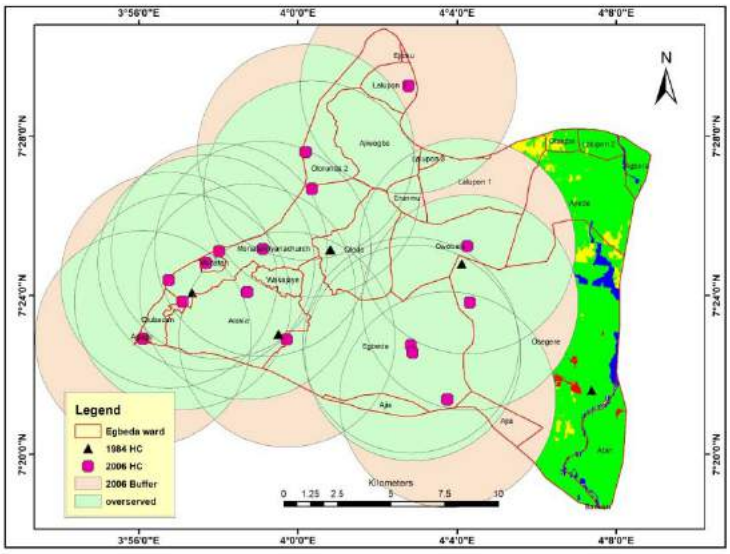

Figure 7: Buffering Analysis of healthcare facilities for 1984 and 2006 in Egbeda LGA

From Figure 8, shows the Threshold analysis that out of Twenty-four (24) Wards in Egbeda LGA, as at 2006, Six Wards was giving Healthcare facilities in additional to the existing Five Wards. The new Wards as at 2006 are Monata, Egbeda, Owo-bale, Lalupon Ward 3 and 5, Olorunda Ward 2, While the previous Wards are Agugu, Osengere, Alakia, Iyana church and Olodo.

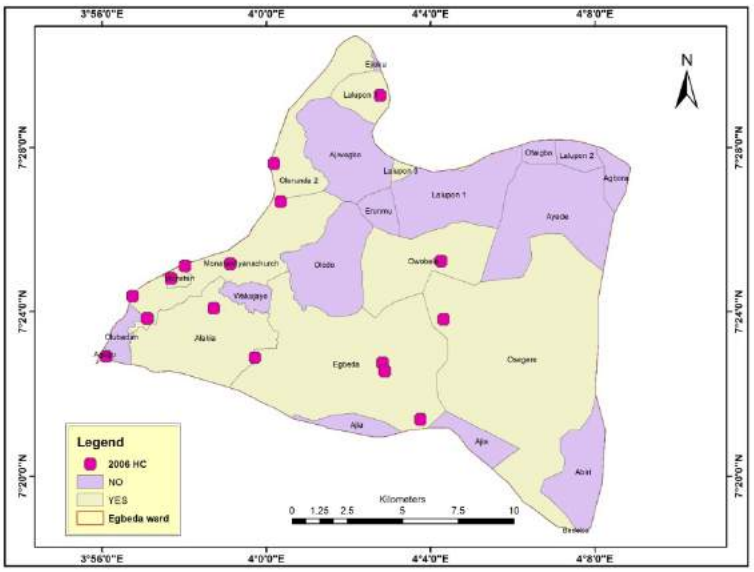

Figure 8: Threshold Analysis of Healthcare Facilities for 2006 in Egbeda LGA

Figure 9 shows healthcare facilities that were established from 2006 to 2018, namely: - Adeleye healthcare facilities, Ataan healthcare facilities, Olodo healthcare facilities, Pagun healthcare facilities, Odan healthcare facilities.

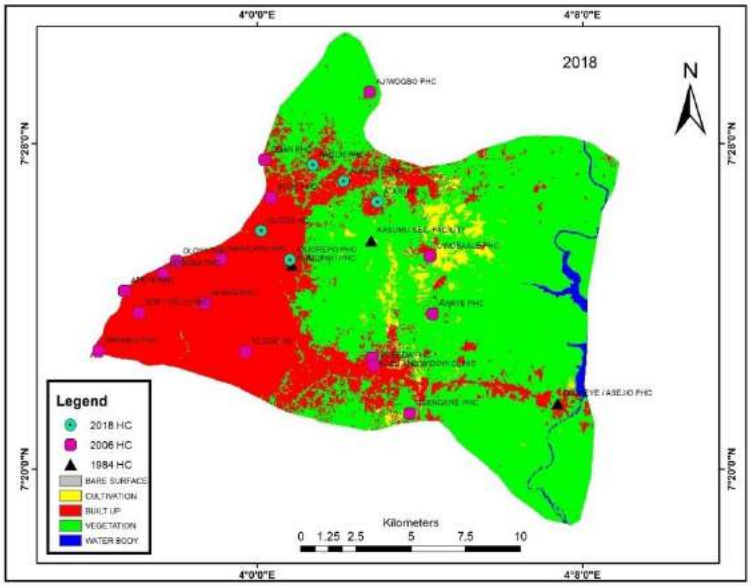

Figure 9: Map showing healthcare facilities established from 2006 to 2018

Figure 10 shows the 5km buffering of all the healthcare facilities established from 2007 to 2018. The 5km buffering covers areas (Wards) such as Alakia, Ajiwogbo, Monatan, Wakajaye, Egbeda, Iyana Church, Olodo, Owo-bale, Olorunda (Ward 2), Lalupon (Ward 1, 3 and 5). Figure 10 shows areas (Wards) where there is interests from the buffering and are classified to be over-served. Areas such as Ajiwogbo, Erumu, Iyana Church, Olodo, Olorunda (Ward 2), Owo-baale, Lalupon (Ward 1,3, and 5) and Wakajaye. Alakia, Egbrda, Monatan, were adequately served, while Abiri, Ayede, Agbora, Ajia (Ward 1), Ajia, Agugu, Ejioku, Ofagbo, Osengere, Olubadan and Lalupon (Ward 2) were under-served according to the 5km buffering done for 2018.

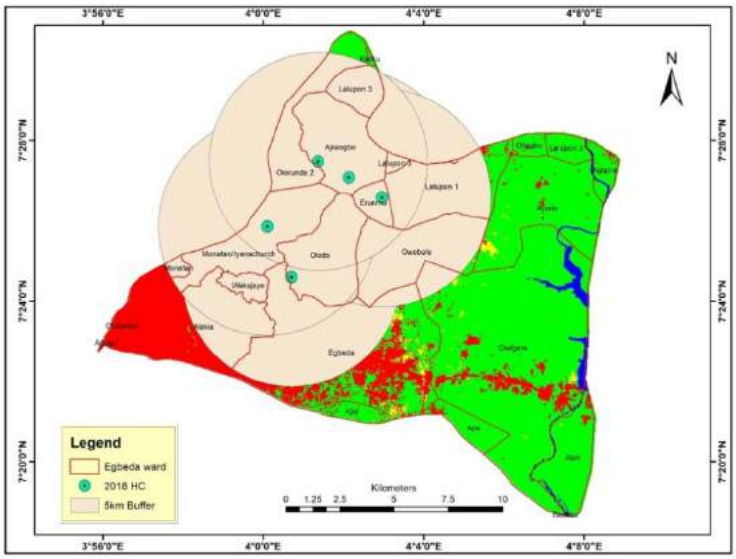

Figure 10: Buffering Analysis of Healthcare Facilities for 2018 in Egbeda LGA

Figure 11, shows the Threshold analysis that out of Twenty-four (24) Wards in Egbeda LGA, as at 2018, Two Wards were giving Healthcare facilities in additional to the existing Five Wards and Six Wards in 1984 and 2006 respectively, while some Wards have more than one healthcare facilities in them. The new Wards as at 2018 are Ajiwogbo and Erumu, While the previous ones are Monata, Egbeda, Owo-bale, Lalupon Ward 3 and 5, Olorunda Ward 2, Agugu, Osengere, Alakia, Iyana church and Olodo.I also shows that Fourteen Wards were giving Healthcare facilities, While Ten Wards do not have Primary Healthcare facilities. The Wards with Healthcare facilities are Alakia, Agugu, Ajiwogbo, Erumu, Egbeda, Owo-bale, Osengere, Olorunda (Ward 2), Olodo, Lalupon (Ward 1,3, and 5), Monatan and Iyana Church. While those Wards that do not have are Abiri, Ajia (Ward 1), Ajia, Ayede, Agbora, Baoku, Ofagbo, Lalupon (Ward 2) and Wakajaye.

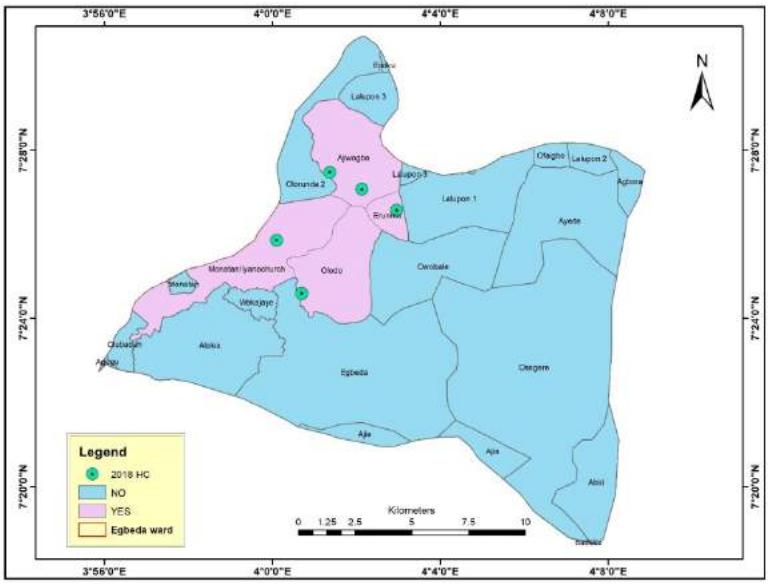

Figure 11: Threshold Analysis of Healthcare Facilities for 2018 in Egbeda LGA

Figure 12 shows the Spatio - temporal pattern of Urban Sprawl for three years, 1984, 2006 and 2018. It shows the direction and pattern at which the Urban Sprawl is taking. The Sprawl is mostly along the two (2) major roads towards the North and South of Egbeda L.G.A.

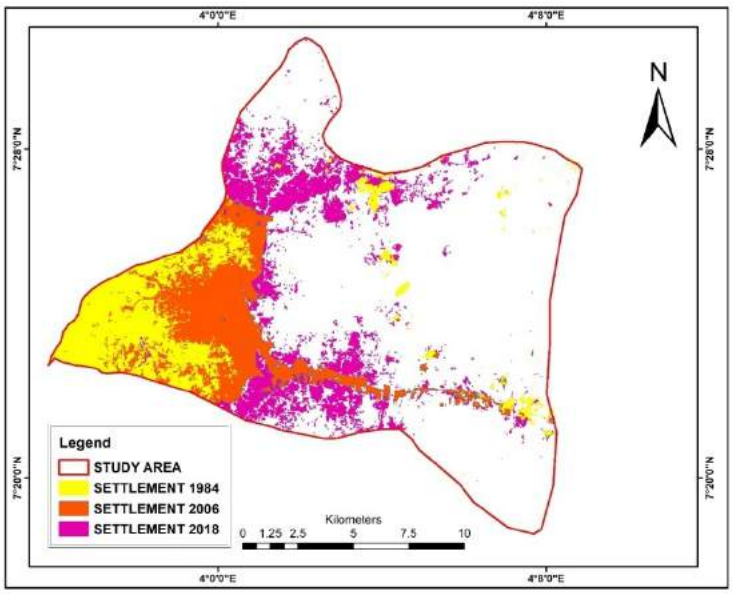

Figure 12: Classified Image Showing the Overlaying Built up Area in Egbeda L.G.A. from 1984 To 2018

Figure 13 shows that from the 2km ring buffering, the community developed from the City center (Awaye) towards the West of Central Business District in 8km buffering in 1984. In 2006, the Sprawl grows up in 8km ring buffering towards the North and along the two major roads. In 2018, the sprawl also grows towards both North and South along the two major roads to the extent of 18km ring buffering.

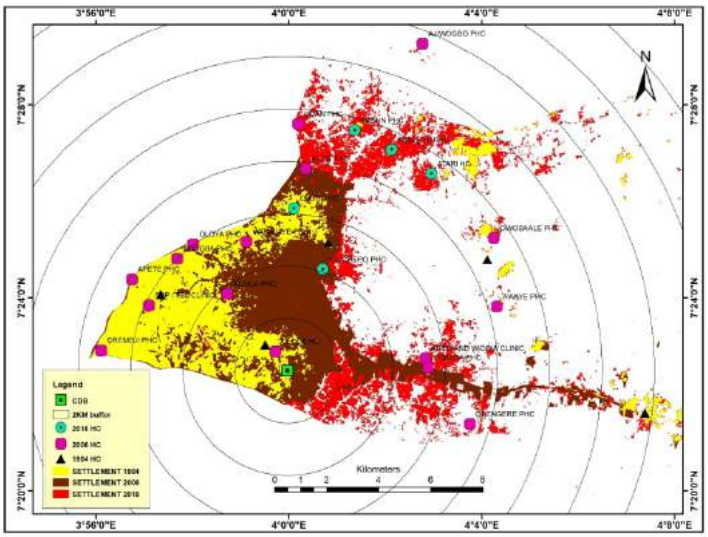

Figure 13: Buffering Analysis Map of Egbeda LGA showing Healthcare Facilities for the year 1984, 2006 and 2018

Figure 14 shows the road network analysis from facility(s) to areas (Wards). The 4 minutes drives from facilities to Wards will covers (Wards) like: Agugu, olubadan, Alakia, Monatan, Iyana Church, Wakajaye, Egbeda, Owo-bale, Erumu, Lalupon (Ward 1), and Lalupon (Ward 5), 10 minutes' drive from facility(s) to (Wards) will covers (Wards) like: Olodo, part of Egbeda, part of Osengere, Ayede, Ofaigbo, and Lalupon (Ward 2), while 20 minutes' drive facility(s) to (Wards) will cover (Wards) like: part of Osengere, Abiri, and Olorunda (Ward 2) and people living in (Wards) like: Abiri, Ajia (Ward 1), Ajia (Ward 2), Ajiwogbo, Agbora, Baoku, Ejioku, Olorunda (Ward 2), part of Ofagbo, and Lalupon (Ward 2) will travel 30 minutes to reach those healthcare facility(s) within their areas.

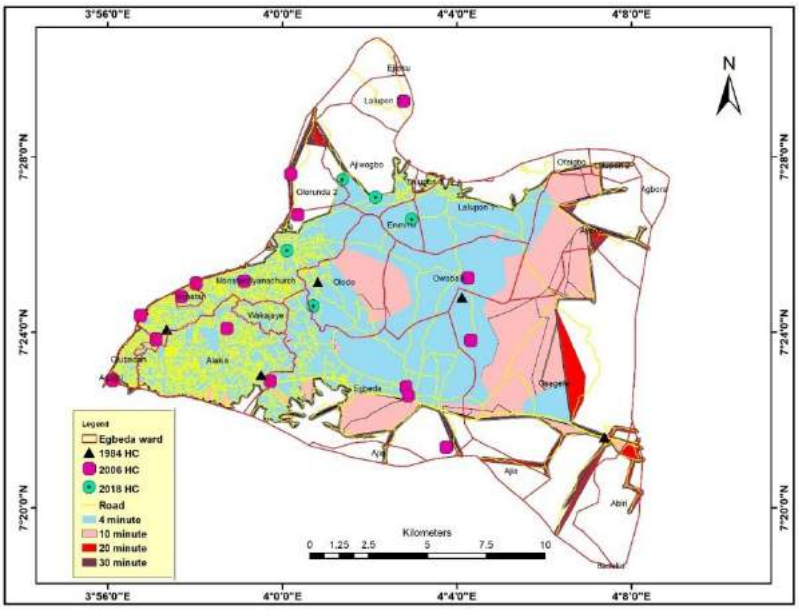

Figure 14: Road Network Analysis of Egbeda LGA for the Year 1984 to 2018

Figure 15 shows the impact of Urban sprawl on healthcare facilities. In 1984, the built – up was 25.4565 Km^2 while the numbers of Government Healthcare facilities were five (5) in number. In 2006, the built – up area was 55.1709Km^2 while the total numbers of Government Healthcare facilities were twenty-one (21), while in 2018, the built – up area was 84.5118Km^2 and the total numbers of Government Healthcare facilities was twenty-six in number. Also, from the Figure 15, it is clear that the Government Healthcare facilities have not been correlating from 1984 up to 2018

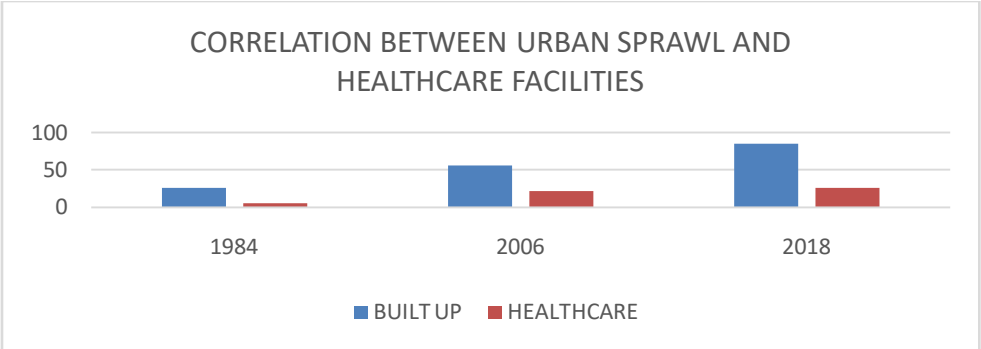

Figure 15: Impact of Urban Sprawl on Healthcare Facilities from 1984 to 2018 in Egbeda Local Government Area

V. Conclusions and Recommendations

The study has been able to determine the effect of urban sprawl on health facilities in Egbeda Local Government, Oyo State using remote sensing and geographical information system. The study also revealed that health effects of sprawl are unevenly distributed across the population. The study also shows that there is increase in the number of health facilities iin Egbeda Local Government Area from 1984 to 2018. The Threshold analysis shows that from 1984 to 2018, Thirteen (13) areas (Wards) have primary healthcare facilities while Ten (10) areas (Wards) do not have any healthcare facility. From the Road Network Analysis, Eleven (11) areas (Wards) will drive 4 minutes from facility(s) to their areas (Wards), Six (6) areas (Wards) will drive 10 minutes from their facility(s) to their various area (Wards), Three (3) areas (Wards) will drive 20 minutes from their healthcare facilities to their areas (Wards), while Ten (10) areas (Wards) will drive 30 minutes from their healthcare facility(s) to their areas (Wards).

The study therefore recommends that the ministry of Health should manage the health care facilities – location and capacity using a geodatabase which will enable efficient management of existing health care facilities and effective planning of new facilities.

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Validation of X-Ray Fluorescence Spectrometer Technique to Determine Heavy Metal Concentrations in Soil Samples

By Jessica Briffa, Renald Blundell, Emmanuel Sinagra & Joseph Grech
University of Malta

Abstract- Heavy metal soil pollution had increased in recent years and this has produced adverse effects to human wellbeing's health by being uptaken in the food chain. A potential threat of heavy metal pollution was suspected at the Government Farm in Għammieri. This is due to heavy traffic and fireworks causing concern to the farmers who cultivate fruit and vegetables in these fields. Soil sampling with an instrument that can give rapid results was needed to analyse the data and give the real-time in-situ mapping of heavy metal pollution in the soil. Comparison between an X-Ray Fluorescent (XRF) spectrometer and an Inductively Coupled Plasma – Mass Spectrometer (ICP-MS), both of which are conventional analytical techniques, was performed to measure the heavy metals in the soil by using laboratory and field work. This was performed to make sure that the XRF that was being used, would give accurate results before testing larger sample size. The XRF used was situated at the Department of Chemistry, at the University of Malta, whilst the ICP-MS was situated in Germany, at an accredited laboratory. Five samples were collected from around the whole field, where each sample was split into 2 identical batches.

Keywords: heavy metals, soil, pollution, X-Ray fluorescent spectrometer, inductively coupled plasma – mass spectrometer, validation.

GJSFR-H Classification: DDC Code: 628.5 LCC Code: TD172

Strictly as per the compliance and regulations of:

Validation of X-Ray Fluorescence Spectrometer Technique to Determine Heavy Metal Concentrations in Soil Samples

Jessica Briffa [α], Renald Blundell [σ], Emmanuel Sinagra [ρ] & Joseph Grech [ω]

Abstract- Heavy metal soil pollution had increased in recent years and this has produced adverse effects to human wellbeing's health by being uptaken in the food chain. A potential threat of heavy metal pollution was suspected at the Government Farm in Għammieri. This is due to heavy traffic and fireworks causing concern to the farmers who cultivate fruit and vegetables in these fields. Soil sampling with an instrument that can give rapid results was needed to analyse the data and give the real-time in-situ mapping of heavy metal pollution in the soil. Comparison between an X-Ray Fluorescent (XRF) spectrometer and an Inductively Coupled Plasma – Mass Spectrometer (ICP-MS), both of which are conventional analytical techniques, was performed to measure the heavy metals in the soil by using laboratory and field work. This was performed to make sure that the XRF that was being used, would give accurate results before testing larger sample size. The XRF used was situated at the Department of Chemistry, at the University of Malta, whilst the ICP-MS was situated in Germany, at an accredited laboratory. Five samples were collected from around the whole field, where each sample was split into 2 identical batches. Heavy metal concentrations were determined using the XRF by sample cup method and results were validated using the ICP-MS using aqua regi digestion. To identify heavy metals without processing the sample, XRF is the preferred method due to direct analysis of the sample and less analysis time. XRF analysis produced quantitative results which correlated with high linearity when compared to the accredited ICP-MS data using the Spearman correlation coefficient (R2 = 0.811).A strong positive relationship close to 1 for arsenic (R2 = 0.646) copper (R2 = 0.888), cadmium (R2 = 0.202), lead (R2 =0.837), nickel (R2 = 0.513) and zinc (R2 = 0.699) was observed, whilst no relationship of R2=0 for chromium and mercury. When using the binomial test, all the ρ-values exceeded the 0.05 level of significance, signifying that the mean XRF score is comparable and positively related to the ICP-MS data. The analysis showed that the ICP-MS validated the XRF results for heavy metal soil measurements and implies. that XRF is quicker and reliable to use when measuring heavy metals in soil compared to traditional methods.

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Keywords: heavy metals, soil, pollution, X-Ray fluorescent spectrometer, inductively coupled plasma – mass spectrometer, validation.

I. Introduction

Environmental pollutants and contaminants are chemicals found at a higher level than in any sector of the environment [1–4]. Industrialization has grown at an increased rate over the last few years. Thus, the request for utilization of the Earth's natural resources has increased at a careless rate, which has aggravated the Earth's problem regarding environmental pollution [5]. The environment has been critically polluted by several pollutants including inorganic ions, organometallic compounds, organic pollutants, radioactive isotopes, nanoparticles and gaseous pollutants .[2,4]

Heavy metals are defined due to their high density or high atomic weight. Currently the word 'heavy metal' is used to explain metallic chemical elements together with metalloids that are toxic to both the environment and to humans. Some light metals and metalloids are toxic, such as including arsenic, aluminium and selenium, though not all heavy metals are toxic such as gold[6–9].

Heavy metals have been present in the Earth's crust since the Earth's formation. Heavy metal use has increased exponentially and has resulted in a surge of metallic substances in both aquatic and terrestrial environments[5]. Anthropogenic activity is the prime cause of heavy metal pollution, primarily due to mining of the metals, smelting, foundries, and other metal-based industries, leaching of metals from a variety of sources like landfills, excretion, waste dumps, livestock manure, automobiles, roadworks, and runoffs. The secondary cause of heavy metal pollution is agriculture including pesticides, fertilizers, insecticides, and more. Natural activity is another source which can increase heavy metal pollution including volcanic activity, metal evaporation from land and water, metal corrosion, soil erosion and geological weathering. Unintended pollution of heavy metals is also possible these include shipwrecks, oil spills and fires. Intended pollution can take the form of waste disposable like industrial effluents and sewage disposal, and intended application of

biocides like vector controls. The movement of heavy metals in the Earth's spheres depends on temperature, direction and movement of surface waters, speed of wind and circulation of air mases. Other factors include partition coefficient, vapour pressure, polarity and molecular stability [1,2,4–6,10–12].

Deliberate soil pollution occurs through wastewater irrigation, the use of pesticides and fertilisers, animal manures, leaded paint, mine tailing, spillage of petroleum distillates, sewage sludge, coal combustion residues and waste dumping. Non-deliberate pollution can occur through the flooding or rivers and seas bringing sewage and contaminated waters to the land. This is in addition to accidents entailing vehicles conveying toxic chemicals. Microbial or chemical degradation cannot occur to heavy metals since they are non-degradable and thus remain in the soil for a very long time [1,2,4,13–16].

The ecosystem is in danger due to heavy metals entering the food chain. Their properties also affect the biodegradability of organic pollutants which causes them to become less degradable and consequently causing a twofold effect of polluting the environment. Heavy metals present in the soil cause all the biospheres to be at risk and are taken up through direct ingestions of the heavy metal or ingestions through food or water that contains the heavy metal after absorbing it. Uptake of the heavy metal may be affected by the soil property like pH, porosity, colour and natural chemistry [1,2,4,13–16].

Elements or chemicals which are not usually present, exist at higher level concentrations and cause damage to organisms, are termed as "soil pollutants". Modern technology such as agrochemical use, together with industrialisation, has caused several contaminants to be present in soil [17].

Soil contamination can be a deliberate action, such as using animal manure, fertilizers, wastewater irrigation, waste dumping, mine tailing, pesticides, sewage sludge and much more [1,2,13,15,16,18]. Watering agricultural land with untreated sewage and wastewater is one of the main complications of adding pollutants to the soil [15,18]. Some pollutants remain in the soil since they are non-biodegradable, thus they would not be able to undergo degradation even if it is chemical or microbial [2].

The soil's sorptive capacity is affected by the heavy metals' bioavailability. Metal can only be up taken in the ionic form by plants and soil biota. Due to the metal's affinity, they adsorb to surfaces of humus, calcium carbonate salts, iron and manganese hydrous oxides, together with clay minerals. Other metals can form complex compounds by having an affinity with organic molecules. A factor that affects the sorption process is pH, the less acidic the soil, the higher the sorption, whilst the higher the soil acidity, the more it is desorbed and released [17].

One of the ways to analyse the presence and concentration of heavy metals is through XRF spectrometry. Element analysis is recognised through the excitement of individual atoms through an external energy source, which goes on to release X-ray photons that emit energy or wavelength which is distinctive for each element. The energy released sets of several photons are used to identify and quantify the element present. Both solids and liquids can be analysed by the XRF, to analyse major and trace elements. Elements are identified under certain conditions through the release of distinctive radiation from the atom's inner electronic shells. Emitted quanta of radiation release X-ray photons which have specific energies, thus allowing for the atom's source to be identified. Since only the inner electron shells are involved during the X-ray emissions, the chemical bond is not taken into consideration. Samples have to be homogenous and refined to get good results when using powder form. Powder form has to be refined, as more than 50 μm in particle size can show errors of 50%. This is due to the variation of the extent of the X-ray penetration with energy [19,20].

II. Method and Materials

Five soil samples were collected from the fields of the Government Farm in Għammieri. A detailed map showing the location of the samples is given in figure 1. Each sample gathered comprised of a mixture of soil from five sites; the four corners of the plot together with the centre. The soil samples were placed in sterilized labelled plastic containers (A-E) and taken to the laboratory. The soil samples were air-dried at ambient temperature after being placed in plastic trays for 48 hours. These were then homogenised and sieved using a 45 μm mesh to remove any plant matter or stones that were present in the sample. Each of the five samples was then separated into two identical batches so that five were used for the XRF and the other identical five will be sent to be tested by the ICP-MS.

One set containing five samples was oven-dried for 24 hours at ~110°C using watch glasses. The process was carried out meticulously so that sample cross-contamination, as well as external contamination would not occur. The soil samples were then sieved again to make it more homogenous and finer and were then stored in sterilized plastic containers containing desiccators until further use.

Concentrations of arsenic, lead, cadmium, chromium, copper, nickel, mercury, thallium and zinc were determined using the S2 Ranger Energy Dispersive X-Ray Fluorescence (EDXRF) spectrometer situated at the laboratory of the Department of Chemistry, at the University of Malta. The XRF spectrometer was calibrated before each batch of the sample was placed in the instrument. A copper disc calibration was analysed first, followed by a quality check. Each sample

was prepared using the sample cup preparation. The sample cup was assembled using a 3.6 μm SpectroMembrane® Mylar® Thin-film. Each round consisted of around fourteen samples, where an average of 12 minutes was taken for each sample to be analysed. Each of the five samples was tested three times ensuring that the EDXRF was calibrated and provided reliable results. The data produced was semi-quantitative, and the elemental concentrations were then established by using a fitting method supplied by Bruker.

The second batch was tested at an accredited lab situated in Germany, using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The laboratory used was accredited according to DIN EN ISO/IEC 17025:2005 notification under the Deutsche Akkreditierungsstelle (DAkkS), the national accreditation body of the Federal Republic of Germany for testing. The standard ISO/IEC 17025:2005 stipulates, in both English and German, the general prerequisites for the competence to perform tests and/or calibrations, carried out using standard methods, laboratory-developed methods and non-standard methods[21]. The laboratory was (D-PL-14081-01-00) accredited. DIN EN 13657: 2003-01 standard was used for the aqua regia digestion which is the 'characterisation of waste - digestion for subsequent determination of aqua regia soluble portion of elements in waste'[22].

Statistical analysis was determined using the software package IBM® SPSS® Statistics 26 by comparing the results obtained by the two equipment. The data were compared by using the binomial test to calculate the ρ-value and its level of significance, and the Spearman correlation coefficient test which measured the strength of the relationship.

III. Results and Discussion

The five samples were analysed using both the XRF and ICP-MS. The quantification of the XRF data was attained by using the automatic Bruker S2 Ranger XFlash® technology which was equipped with an X-ray tube anode made of Palladium. Using tube voltages of 10 kV, 20 kV, 40 kV and 50 kV, for 180 seconds, at each voltage with a helium atmosphere, a current of 2 mA, and having a silicon drift detector. The elements detected in the soil samples were expressed as oxides. Calcium carbonate was used as a matrix to calculate the heavy metal oxides, while using the instrument's software, Spectra EDX Launcher, to read the data.

The XRF method provided a simultaneous result of 44 elements, though only As, Pb, Cd, Cu, Ni and Zn were used to compare the results with the same elements as those given in the ICP-MS report. Table 1 shows the comparison of the mean values between the XRF and the ICP-MS which were used to statistically test the data. The binomial test confirmed that the XRF data are positively related to the ICP-MS as all the ρ-values exceeded the 0.05 level of significance as seen in table 2. The Spearman correlation coefficient used to compare the relationship can be seen in figures 2-5 where figure 2 and 3 display a strong positive relationship close to 1 for arsenic (R^2 = 0.646) copper (R^2 = 0.888), cadmium (R^2 = 0.202), lead (R^2 =0.837), nickel (R^2 = 0.513) and zinc (R^2 = 0.699), whilst figure 4 displays no relationship of 0 for chromium and mercury. The overall correlation was a strong positive relationship where R^2 = 0.811.

The results indicated that the XRF and ICP-MS are comparable and that the XRF produces good results when compared to an accredited instrument. The ICP-MS when compared to the XRF can be seen to be a very reliable instrument that can accomplish limits of detections at many orders of degree lower. Although it has excellent accuracy, the ICP-MS has a disadvantage that the sample needs to be in a liquid form when being tested, thus requiring acid digestion and long preparation times, when comparing it to the other instrument. The ICP-MS also has a higher cost including the consumables. On the other hand, the XRF spectrometer is cheaper to use, easier, and uses a rapid technique when comparing it to other methods of analysis. It has the advantage of reading both the solid and liquid form [23].

The ICP-MS is a quantitative instrument and has been increasing in popularity compared to the other instruments. Its detection limits can reach below the single part per trillion of any element, and it can also achieve isotopic analysis. Determination of each element's concentrations in the sample is brought about by relating the counts measured of a definite isotope with an external calibration curve that was formerly created for that specific element [24,25].

The XRF is a semi-quantitative instrument. The data given ascertains the relative element concentrations between the samples though it does not give absolute concentration amounts. The results are calculated by analysing the area under the peak of interest. This proves why the results of both instruments are non-identical and not similar to the elements being tested as seen in Table 1[26].

When comparing the mean concentration of the elements (table 3), to the Government Decree on the Assessment of Soil Contamination and Remediation Needs the threshold limits for soil contamination [27]as seen in table 4, As, Pb and Cd proved to have a higher level than the threshold. These three heavy metals are used in everyday life and cause a number of adverse effects when present in high concentrations as in the study.

Anthropogenic pollution of As could be caused through the preservation of wood, certain insecticide formulations, particular glass manufacturing, doping agent in semiconductors like gallium arsenide which

was used to alter electric current into laser light; pyrotechnics and the production of bronze. Adverse effects of arsenic to humans can be subdivided into two. Inorganic arsenic toxicity can cause lung irritation, gastro-intestinal system irritation, skin alterations, reduction in production of red blood cells and white blood cells, lung irritation, infertility, miscarriages, brain damage, heart problems, suggestion of increased chances of carcinoma have been stated and damage to the deoxyribonucleic acid (DNA). Organic arsenic toxicity may cause stomach upsets and nerve damage (though it does not affect the DNA and is therefore not carcinogenic) [28–31].

Uses of lead which might have caused pollution are car lead-acid batteries, ammunition and projectiles, cable sheeting, sports equipment, screen sheets on computers for radiation safeguarding, lead crystal glass, roofing in buildings, stained glass windows, canister to hold corrosive liquids, lead piping and diver's weight belt. It has also been used in the past in hair dyes, insecticides and pottery glazes. Human uptake of high concentrations of lead may cause hypertension, still births, miscarriages, premature and low births, sperm damage, peripheral nerve damage, renal impairment, brain damage, pica, signs of encephalopathy, cognitive impairment, haemoglobin synthesis disruption causing iron deficiency and abdominal pain. Children may also suffer adverse effects due to high lead concentration uptake, which causes reduced intelligence, altered brain and CNS development, increase in anti-social behaviour, a reduction in attention span and an educational achievement decline [30,32–35].

Cadmium is used in pesticides, Ni-Cd batteries, phosphate fertilizers, nuclear reactors, pigmentation for glassware, corrosive-resistant plating and as a stabilizer in the production of plastic. The adverse caused in high concentrations affect mainly the kidneys causing nephrotoxicity. Other adverse effects can also be calcium metabolism alterations, bone fractures, osteoporosis, immune system deficiencies, CNS complications, psychological disorders, gastro-intestinal disorders, infertility due to reproductive system failure, DNA impairment, cancer, stated to be genetoxic and ecotoxic in animals, and Itai-Itai disease[30,36,37].

IV. Conclusion

Heavy metal soil pollution has been seen to contaminate agricultural fields due to increase in livestock and agriculture, sewage effluent, industrialisation, infrastructure, transport, urbanisation, fireworks, mining activities and warfare actions[4].Agriculture, industrialisation and fireworks are the probable cause for the farm to be polluted by these heavy metals. The results confirmed that the farm had high heavy metal pollution in As, Cd and Pb since the concentration was more than the threshold given by the Ministry of Environment in Finland. The XRF has been increasing in popularity especially since it is less time consuming, does not need any sample preparation, together with it being less costly. Samples are always 'neat' and do not need any preparation unlike the ICP-MS which needs chemical preparation of the sample. The study proved to validate the XRF and provide results that were similar and statistically significant to the ICP-MS, concluding that the XRF was reliable to test soil samples concerning heavy metals on a larger scale. This would be beneficial if it were to test agricultural soils making it be of use to help prevent heavy metal pollution from ending up being taken up by crops and thus, end up in the food chain.

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Evidence of Sediment Sterility and Benthic Quality as Deleterious Consequences after the 2019 Oil Spill in Northeastern Brazil

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Abstract- The worst environmental oil spill disaster ever recorded in any tropical coastal region globally happened in 2019; severely affecting one of Brazil most famous northeast tourist area South Pirangi Reef area in the state of Rio Grande do Norte (RN). The oil, a complex chemical mixture of hydrocarbon including heavy metals spilled on beaches, in estuaries, and reefs has spread between 50 cm and 1 m deep, occasionally sinking to the benthos. Death of oiled animals and Habitat destruction are acute and long-term consequences on ecological systems that rely on the now impacted environment for survival. Pirangi Reef which was subjected to the oil spill in October 2019, was previously studied in 2013 and 2014 with no spotting of oil patches in the 55 sediment or water samples at that time. After the oil spill, 25 new sites in the reef areas, sandy sediments and macroalgae substratum were sampled to compare temporal data after the disastrous event. Our findings show that more than 95% of the unconsolidated sediment samples, including some corals, had some evidence of oil in 2019 opposed to no evidence at all in 2013 and 2014. Data on benthic foraminiferal fauna show loss of 26 species including symbiotic species.

Keywords: *environmental disaster, crude oil, foraminifera, coral reef, baren zone, river.*

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Keywords: environmental disaster, crude oil, foraminifera, coral reef, baren zone, river.

I. Introduction

The worldwide production of crude oil and natural gas is at the peak, with an estimated worldwide production of 97 million barrels per day in 2020. Approximately half of this amount is transported by sea. As follows, worldwide marine coastal areas are exposed to the oil spills occurring as a result of accidents or illegal practices. Therefore, crude oil is already widespread primarily in marine sediments close to harbors and marinas, and oil spills alter the oil's chemical composition because it allows the breakdown of oil components. The release of thousands of tons of petroleum hydrocarbons (PHs) affects the marine environment and causes severe ecological and economical damage and can cause ocean acidification. The oil spill releases H_2S (hydrogen sulfide), ammonia and methane, causing the decrease in pH of the sediment and the decrease in the dissolved oxygen concentration in the water. Marine ecosystems are already subject to touristic activities and sewage pollution, and this unprecedented oil spill in 2019, declined biodiversity in the modern anthropogenic era. The evaluation of the damage for the local coastal communities and future generations, and the environmental quality of the marine and coastal region are in need of action. The continuous dissolution of benthic calcareous organisms will culminate with the total disappearance of microfauna at least one year after the accident, similar to what had been showed in Guanabara Bay, Rio de Janeiro, Brazil (Eichler et al., 2014). Dealing effectively with these impacts includes understanding how pollutants and contaminants in general are released and how they behave in the environment (Cedre, 2007). Hydrocarbon petroleum products are very reactive in aerobic environments via microbial and photochemical reactions (Varjani, 2017; Atlas & Hazen, 2011; Salminen et al.,2004; Widdel & Rabus, 2001), and the production of hydrogen sulphide (H_2S) is a result of the microbial breakdown of organic materials of crude oil in the absence of oxygen. Hydrogen sulphide is a gas without color, and is inflammable, poisonous and corrosive, noticeable by its rotten egg smell and with toxicity similar to carbon monoxide prevents cellular respiration. Monitoring and early detection of H_2S could mean the difference between life and death. The contamination impact in the medium and long term is a silent one caused by oil being partially degraded and absorbed by the environment. Concentrations of PAHs sufficient to affect individual health following oil spills are common and can remain for long periods in some habitats (Cherr et al 2017, Oros et al 2007). The polycyclic aromatic hydrocarbons (PAHs) present in oil are an immunotoxin to several wild aquatic species. While the origin of the oil

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remains a mystery, and any scientific effort to clarify that are welcome.

It is with urgent necessity to spotlight this tragedy in this unique and sensitive reef habitat experiencing ongoing damaging effects that include socio-economic resources losses not yet evaluated and addressed. More than 2 years later now; here we show that the dimension of these impacts, how long they are expected to last, anticipated collateral damages, and then propose mitigation options and mechanisms to reduce the magnitude of any future spill. As the oil becomes less and less visible to the naked eye, and the world is ravaged by new disasters (e.g. COVID-19 pandemic), and it is easy to let the largest oil spill in the South Atlantic fall into oblivion, leaving it to nature and for local human communities to bear its consequences for the decades to come.

Our paper deals with a specific site, the "Pirangi Reef area", which was subjected to the oil spill In October 2019, and was previously studied in 2013 and 2014 by Eichler et al (2019) and Eichler and Moura (2020) with no spotting of oil patches in the sediment or in the water. After the oil spill, we sampled new sites to compare and discuss questions on the human-induced changes on the reef system and in the symbiont-bearing species (SBS) of foraminifera; therefore, water and surface sediments were recovered from areas of small reef patches near tourism boating sites.

Here we also discuss impacts and evidence of the oil spill in this biodiverse area, which more than 2 years have passed and we still are uncertain about the type of oil or even culpability; and benthic communities are continuing to suffer consequences of these and other deleterious impacts now for decades. The release of hydrocarbons from oil spills into marine environments has immediate and acute effects on living organisms. In addition, chronic contamination has an effect over time as hydrogen sulphide, methane and ammonia are released in the environment acidifying even more the water-sediment interface.

II. Symbiont-Bearing Species

Numerous publications have shown that certain benthic foraminifera (in particular, species of *Amphistegina*) that thrive in and around coral reef habitats are affected by global or local environmental stresses the same way hermatypic corals are. These species belong to several families—both porcelaneous and hyaline—but they all act as hosts to diverse algal endosymbionts comparable to the zooxanthellae of corals. "The potential advantages of algal symbiosis to foraminifers lie in at least three major areas: a) energy from photosynthesis; b) enhancement of calcification; and c) uptake of host metabolites by symbiotic algae" (Hallock, 1999). As with hermatypic corals, these symbiont-bearing foraminifera (SBF) prefer nutrient-poor, shallow, warm-water environments (e.g., Hallock, 2000) and they also have a zooxanthella. Most reef-building corals contain photosynthetic algae, called zooxanthellae, that live in their tissues. The corals and algae have a mutualistic relationship, the same with the foraminifera specimen. The coral/foraminifera shell provides the algae with a protected environment and compounds they need for photosynthesis. In return, the algae produce oxygen and help the coral/foraminifera to remove wastes. Most importantly, zooxanthellae supply the coral/foraminifera with glucose, glycerol, and amino acids, which are the products of photosynthesis. The coral/foraminifera use these products to make proteins, fats, and carbohydrates, and produce calcium carbonate. The relationship between the algae and coral polyp/foraminifera facilitates a tight recycling of nutrients in nutrient-poor tropical waters. In fact, 90% of the organic material photosynthetically produced by the zooxanthellae is transferred to the host coral/foraminifera tissue. This is the driving force behind the growth and productivity of calcium carbonate. Sometimes when corals become physically stressed, the polyps expel their algal cells and the colony takes on a stark white appearance. This is commonly described as "coral bleaching". If the polyps go for too long without zooxanthellae, coral bleaching can result in the coral's death. The same occur with the larger foraminifera (SBS). Because of their intimate relationship with zooxanthellae, reef-building corals and foraminifera respond to the environment like plants. Reef corals and SBS require clear water so that sunlight can reach their algal cells for photosynthesis. For this reason they are generally found only in waters with small amounts of suspended material, or water of low turbidity and low productivity. This leads to an interesting paradox—coral reefs and SBS require clear, nutrient-poor water, but they are among the most productive and diverse marine environments. An investigation of historical trends in Brazil demonstrated the usefulness of this findings in tracking environmental changes related to ENSO events.

III. Study Area

The study area is located located on the southern coast of Rio Grande do Norte (RN) state (5° 58'S - 35° 06'W), in Northeastern Brazil (Figure 1) in the coastal zone of the Estuary Pium and inner shelf adjacent to the reef area Pirangi. Reef formation is around 2 Km long and 500m wide, part of a discontinuous reef system extending over the coast of the RN. The reef area is about 1 km^2 and approximately 800m far from the shoreline. During low tides, depth in the vicinity of the reef does not exceed 2m. Water temperature is relatively constant throughout the year (28 to 29°C) and tidal range varies from 0.1 to 2.7 m. Presence of shallow, clear, warm water throughout the

entire year and the relative proximity of the coast have provided and incentivized to marine tourism for over 20 years. The recreational tourist activity on the reef occurs throughout the year, with peaks in January, February and July.

IV. Methods

a) Field and Laboratory Methods

After the oil spill, 25 new sites were collected in the same Pirangi Reef, sandy sediments, and macroalgae substratum to compare temporal data after the disastrous event in October 2019. Stations 1 to 20 were sampled in the inner coast and stations 19 to 24 were sampled in the Pium River.

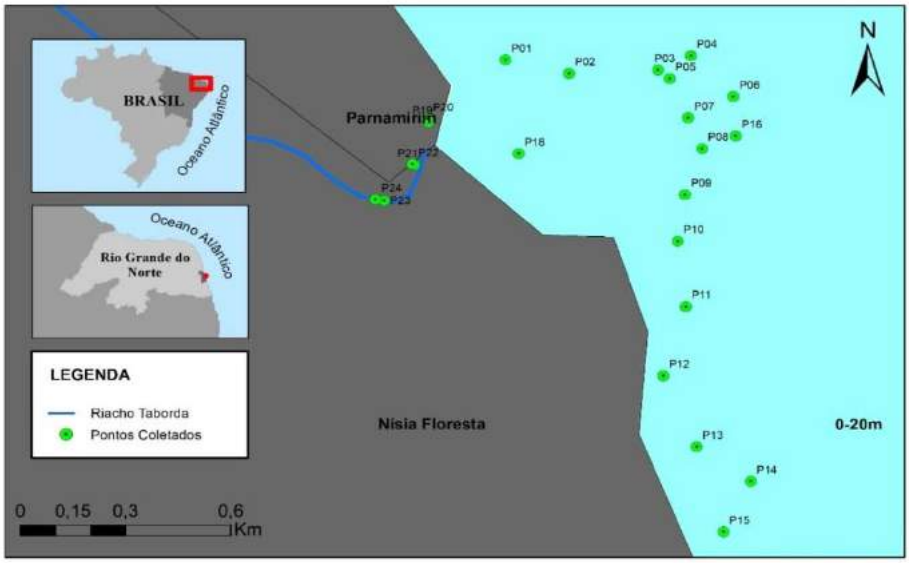

Figure 1: New Sites Collected in the Pirangi Reef in 2019. Station 16 Represents Stations 17 and 18

Data on water and sediment from 55 sediment sample stations in Pirangi Reef were previously studied in 2013 and 2014 and there was no mention of spotting of oil patches or other intrusions in the sediment or water at that time. Samples sites in 2013, 2014 and 2019 are showing on figure 2.

Figure 2: Collected Samples in 2013, 2014 and 2019. Yellow, Blue and White Dots are Showing Exact Location of Sampling in Different Years.

The uppermost 1 cm of each sample was subsampled for foraminiferal analysis. Samples were stored in a mixture of 1 g Rose Bengal diluted in l liter of ethanol for up to 72 hours to stain live specimens.

Processing of sediments followed standard procedures, where a fixed volume of 50 cm^3 of sediment was washed over a 63 μm sieve. After drying in an oven at 60°C for 48 hours, samples were split using a micro splitter into subsamples of at least 100 living foraminiferal specimens. Species identification and counting of dry specimens were done under an optical microscope. Our methods follow Eichler et al. (2007) for benthic analysis and Eichler et al. (2019) on the sampling of coral reefs using scuba divers, and Hallock (1999) were used as a taxonomic reference for symbiont-bearing foraminifera. Our data are based on living counts, even though there is a belief that Rose Bengal method can overestimate the abundance of living foraminifera (Bernhard et al., 2006). Scanning electron micrographs were obtained to clarify identifications. Field recording of water temperature, salinity, and oxygen were performed using a multiprobeMetler Toledo, but, within either area, they did not show any noticeable variations or trends.

b) Numerical Analyses

Univariate Techniques: Univariate data of Pielou Evenness (J'), Shannon-Wiener Diversity {H' (loge)}, and Simpson Dominance indices (Zar, 1984) were computed to assess changes in community structure.

Multivariate Analyses: Were applied to foraminiferal data [cluster analysis] producing a ''map'' of samples in which the placement of samples reflects the similarity of their biological communities and environmental patterns, rather than their simple geographical location.

The numerical procedures of diversity, dominance and evenness, and cluster were carried out using a University of Plymouth computer program PRIMER v6 (Plymouth Routines in Multivariate Ecological Research PRIMER-E Ltd., Plymouth) which is described in Clarke (1993), Clarke and Warwick (1994), and (Clarke and Ainsworth, 1993).

V. Results

Table 1 show sampling positions and depth at the time of collection of samples in 2019.

Table 1: Location and Depth of Collected Samples.

	x (Lat)	y (Long)	Depth
P01	265497,956	9338679,922	2
P02	265790,030	9338613,538	2
P03	266197,829	9338630,201	2
P04	266348,202	9338700,632	2
P05	266250,489	9338587,150	2
P06	266543,889	9338498,682	2
P07	266336,086	9338394,095	6
P08	266400,144	9338242,385	7
P09	266322,170	9338014,999	7
P10	266287,690	9337786,426	10
P11	266325,811	9337463,819	10
P12	266221,874	9337123,382	10
P13	266374,667	9336773,512	10
P14	266623,363	9336603,181	10
P15	266498,387	9336353,528	10
P16	266554,696	9338304,682	1
P17	266554,696	9338304,682	1
P18	265557,710	9338217,410	1
P19	265145,253	9338373,692	1
P20	265138,139	9338388,991	1
P21	265082,317	9338161,696	1
P22	265070,261	9338165,785	1
P23	264941,337	9337986,376	1
P24	264900,930	9337991,013	1

Table 2: Benthic Foraminifera´S Number of Species and Individuals. Stations P2, P3, P7, P8, P9, P12, P14, P18, P20, P21, P22 Presented Oil Spots in the Marine Sediment Collected for Foraminiferal Analysis.

Pirangi 2019 (after oill spill)	P1	P2*	P3*	P4	P5	P6	P7*	P8*	P9*	P10	P11	P12*	P13	P14*	P15	P16	P17	P18*	P19	P20*	P21*	P22*	P23	P24	P25
Amphisorus hemprichii			12	10		7	7	10		15	18		2		19			14							
Amphistegina gibbosa	8	20	14	9				8	25								20		39				26	25	28
Bolivina brevior								6						5				15							
Borelis schlumbergeri	7			7			7			14	26						9								
Carpenteria utricularis	9	7	5					8	9	17															
Cibicides sp.								9	4					3											
Cornuspira planorbis			5	9	12			9	30	17		6					32								
Dentalina sp.					15	18						2		4	18	45	12								
Glomospyra gordialis	8	5																							
Hyperamina sp.				18	16		7	12					7												
Miliolinella subrotunda								13																	
Nodosaria sp.						19	9	16					4												
Nonionoides grateloupii							6																		
Peneroplis carinatus	6																								
Quiqueloculina lamarckiana	32	34	23	35	27	16	45	35	37	35	25	30	17	60	34	18	15	23	27				26	23	24
Quiqueloculina patagonica								9					11												
Spiroloculina antillarum																	7								
Triloculina trigonula	15															9									
Tubinella funalis	14	18	16	10	16		14	13		15		32	10	70			9	17	18				21	17	20
TOTAL COUNTED	99	84	75	98	86	60	95	148	105	113	69	70	51	142	71	72	104	69	84	0	0	0	73	65	72
* oil spotted on shells																									

Table 2 show that more than 55% of the unconsolidated sediment samples, including some corals, had some evidence of oil in 2019 opposed to no evidence at all as previously studied 2013 and 2014. We have registered loss of 26 species including symbiotic species in 2019 if compared to 2013 and 2014. In according to Eichler et al (2019) and Eichler and Moura (2020) 44 foraminiferal species were recorded in 2013 and 2014, and in 2019 after the oil spill, only 20 species survived the effects of the accident, which includes loss of habitat and calcareous dissolution by the resulting acidic sediment contaminants. In addition, we observe that 59% of all species did not tolerate the new environment and have disappeared, whereas 50% of the symbiotic species were also extinct. This striking decrease in number of species after the oil spilling in 2019 shows that the scope of the contamination is much farther beyond what was previously assumed, since diversity decrease is very high among benthic species. It is important to notice that samples collected in the river mouth (20, 21, and 22) were barren, and were oil spotted. Samples 23, 24 and 25 also in the river realm presented very low numbers of individuals. For now, we have no estimate of the amount of oil that remains on marine sediments, estuaries or mangroves, or the amount that has infiltrated into the Brazilian sand beaches in this case.

Table 3: Number of Species (S), Number of Individuals (N), Evenness (J'), Diversity (H'), Dominance (Lambda).

	S	N	J'	H'(loge)	Lambda
P1	8	99	0.918213	1.909371	0.177431
P2*	5	84	0.877876	1.412886	0.276927
P3*	6	75	0.926268	1.65965	0.208889
P4	7	98	0.910543	1.771835	0.204082
P5	5	86	0.974801	1.568881	0.217685
P6	4	60	0.958272	1.328448	0.275
P7*	7	95	0.827549	1.610337	0.275346
P8*	12	148	0.946005	2.350735	0.112765
P9*	5	105	0.871253	1.402227	0.271293
P10	6	113	0.964297	1.727788	0.191793
P11	3	69	0.988655	1.086149	0.341315
P12*	4	70	0.745238	1.033119	0.400816
P13	6	51	0.901764	1.615744	0.222607
P14*	5	142	0.629141	1.012563	0.424023
P15	3	71	0.958738	1.053281	0.365205
P16	3	72	0.819448	0.900256	0.46875
P17	7	104	0.931873	1.813341	0.185281
P18*	4	69	0.985892	1.366736	0.260239
P19	3	84	0.956785	1.051136	0.364796
P20*	0	0		0	
P21*	0	0		0	
P22*	0	0		0	
P23	3	73	0.995622	1.093802	0.336461
P24	3	65	0.988412	1.085881	0.341538

After the oil spill in 2019, the number of species (S) varies from 3 to 12, number of individuals (N) varies from 51 to 148, evenness (J') varies from 0.62 to 0.99, diversity (H') varies from 0.90 to 2.3, dominance (Lambda) varies from 0.1 to 0.46. Among stations which presented oil spots (P2, P3, P7, P8, P9, P12, P14, P18, P20, P21, P22) we observed that there of them are barren (P20, P21, P22) which had never happened in 2013 and 2014. With the exception of station P8 which presented the highest diversity, all other stations presented low numbers.

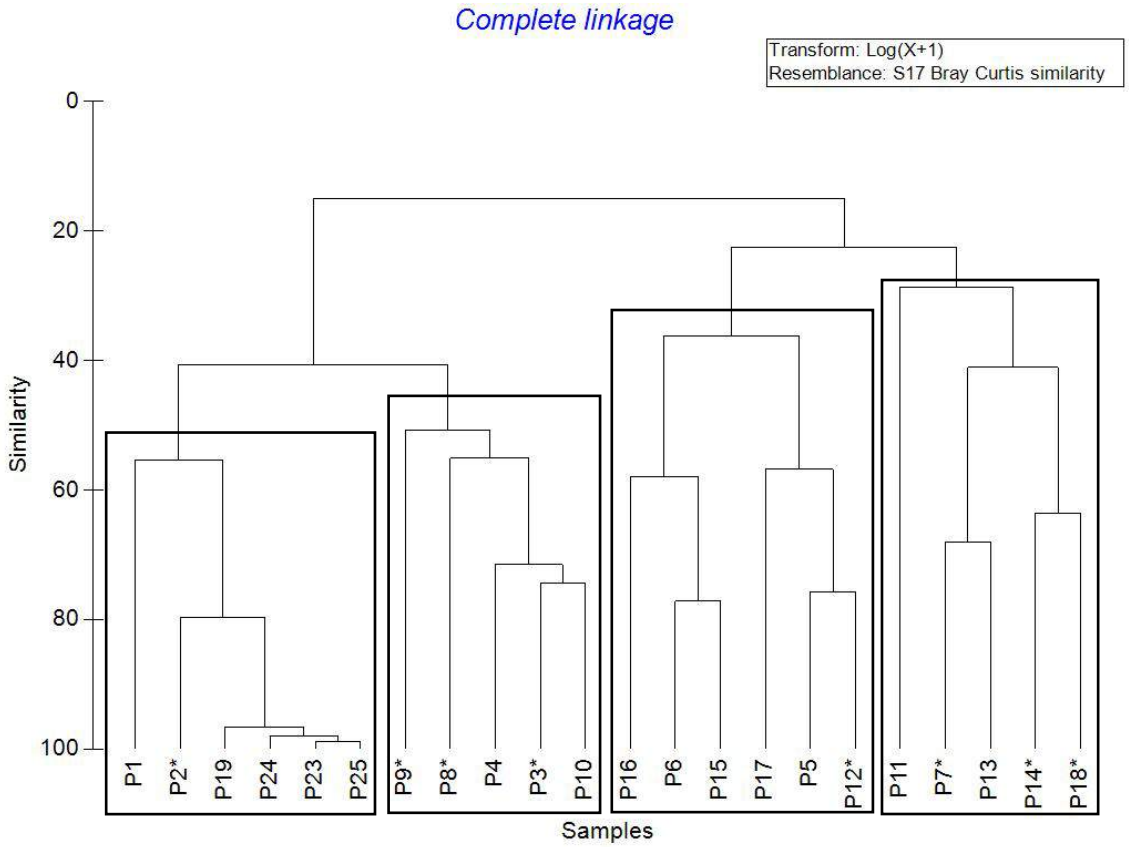

Figure 3: Cluster Revealing Four Groups of Stations Organized Based on the Number of Foraminifera Species.

Cluster analysis revealed in 2019 the formation of 4 groups: Group I: P1, P2*, P19, P24, P23, P25; Group II: P9*, P8*, P4, P3*, P10; Group III: P16, P6, P15, P17, P5, P12*, and Group IV: P11, P7*, P13, P14*, P18*. Group I encompass statios in the Pium River with the lowest diversities, Groups II and IV presents deeper stations with higher number of species and *Amphisorushemprichii* has higher proportions in those stations. Same result found in Pirangi 2013 and 2014 which groups were divided based on number of individuals and presence of symbionthic species SBS (Eichler and Moura, 2020).

VI. Discussion

Local variables such as high hydrodynamic characteristics and other reworking processes are influencing the faunal distribution of foraminifers in this portion of the inner shelf. However, Eichler and Moura (2020) proposed that, at Pirangi Reefal area, where boats dock, and tourists walk upon the reefs, they observe the absence of well-preserved living *Amphistegina*, as well as higher diversity values from smaller taxa and opportunistic species rather than from SBF suggesting that coral communities in these areas may be at risk.

The occurrence of oil spots in several stations at the moment of sampling (P2, P3, P7, P8, P9, P12, P14, P18, P20, P21, P22) revealed that the spill reached the bottom and the sediment and had immediate consequences for the benthic fauna. We therefore believe that Foraminifera data acts as reliable proxy for water quality and reef health at Rio Grande do Norte State sites. In addition, barren zones formed by stations P20, P21, P22, with no organisms, together with low evenness, probably dissolved due to the acidity due to the oil spill reaching the bottom in that specific area are overcome the already low numbered environment due to the transport and selection of tests by bottom currents, which prevent foraminifer settlement, suggesting that wave energy and exchange with open ocean waters are

also influencing foraminifera fauna, also seen by Narayan and Pandolfi (2010) in a similar subtropical estuarine environment.

Results from 2013 and 2014 show dominance of non-SBS *Quinqueloculina*, and SBS *Amphistegina*, and *Archaias* in shallow reef areas of Pirangi corroborated by Araújo and Machado (2008) that found low diversity and evenness at Abrolhos explained by dominance of *Quinqueloculina, Amphistegina*, and *Archaias* at shallow, low-energy stations. *Quinqueloculina* species have become the dominant taxa. After the oil spill in 2019 *Archaias* became extinct. The extinction of a genera is an acute response of the disaster that will continue to prevent healthy environment to reestablish for many decades. Also, a change from SBF to heterotrophic foraminifers such as *Quinqueloculina lamarckiana* like we have seen in 2019, after the spill, is also indicating of not well-developed ecosystem.

The already low frequency of stained foraminifers in Pirangireefal area that was determined by Eichler and Moura (2020) were described as related to the same factors listed by Bicchi et al. (2002), such as empty tests should be common in reef areas and/or most reef-dwelling foraminifers live attached to reefs, stalks and macro algae, and only empty tests should be found free in the sediment after a reproductive event. Thus, the assemblage, although modified by postmortem processes, is an averaged mosaic of spatially and temporally (at least the last year) varying communities, as shown by Wilson and Ramsook (2007) in the West Indies. In according to Eichler and Moura (2020), Pirangi has marginal environment for reef growth and is unsuitable for recovery after stress events according to the index interpretation proposed by Hallock et al. (2003).

This is true especially in areas with tourist activities; indicating stressed environments and that Pirangi is not suitable for coral reef growth, and the oil spill reached an already impacted area. The present study show that Foraminifera can be used as good proxy of reef health and can contribute to the managements plans of the Pirangi reefal area of the National Marine Park by applying knowledge of its foraminifer assemblage to the diagnosis of the region's environmental health, and by providing a first insight to the pattern in which organic matter is distributed in the sediment across depths.

By associating the foraminifer composition with the sedimentological data, we conclude that coarse and fine sand fractions are the controlling parameters on faunal composition at Pirangi, and that depositional energy plays an important role in the transportation and deposition of sediments and the foraminiferal habitat. The presence of reworked *Quinqueloculina* shows that changes besides the oil spill yet to be identified are occurring in the area and must be taken into consideration in further studies. These changes may be linked to erosion occurring at the beaches near the reefal area that is uncovering relict environments.

In the reef area close to the tourist sites and where oil reached the bottom there are low numbers of SBS individuals, and foraminiferal abundance; however, in non-reef areas, there are no individuals at all. Opportunists are dominant in coastal stations where people walk upon the reefs. This is the negative effect of trampling in the coral reefs and has been discussed by Kay and Liddle (1989), and similar consequences of anthropogenic changes are already seen at Pirangi (Eichler et al., 2019).

The dominance of smaller foraminiferal taxa, including stress-tolerant species, and minimal representation of BSB taxa, indicate unsuitable conditions in these reefal area. Anthropogenic disturbances in coastal marine environments are threatening marine life. Reefs in Pirangi that are trampled by tourists face an eminent coral and foraminiferal community death. Agricultural land use increases amount of sediment, nitrogen, phosphorus, and turbidity in nearby rivers. The oil spill happened on top of all of it.

The BSB Foraminifera Amphistegina gibbosa is present at both coastal and deeper stations, however, Amphistegina gibbosa is not found at sites where reefs are walked upon, whereas Amphisorus hemprichii is sometimes present because of its flattened morphology. If interpreted together with live observations, is a reliable tool to reconstruct changes in the coral reef's health in the past, and long-term assessments are needed in order to improve our knowledge regarding the distribution and ecological importance of Brazilian reef-dwelling foraminifers, as well as to extend the application of the Foraminifera science to large-scale monitoring of this and other reef ecosystems in the southwestern Atlantic. This is a proxy that can be used to evaluate coral reef health in the past, and in the present can be used to evidence areas where benthic communities are supposed to thrive.

Due to their proximity to the coast, the Pirangi reefs are vulnerable to anthropogenic effects. One of these is the trampling of the biological coverage by the visitors who frequent the reef each year with low to no consciousness. Thus, the data obtained in this study show that disturbances (natural or anthropogenic) can result in a different distribution of the benthic organisms in the reef area, as evidenced by the differences in foraminifera diversity and coverage percentage among the sampling stations. Moreover, these results allow us to infer that the area of Pirangi has undergone changes resulting from human activities and that the differences in biological composition can be used as an important indicator of the health of the Pirangi reef process and development.

VII. Conclusion

- Higher diversity values from smaller taxa and opportunistic species rather than from SBF suggests that coral communities are may be at risk.
- Oil spots in P2, P3, P7, P8, P9, P12, P14, P18, P20, P21, P22 revealed that the oil reached the bottom sediment with immediate consequences for the benthic fauna
- Barren zones formed by stations P20, P21, P22, are due to the acidity due to the oil spill reaching the bottom
- *Quinqueloculina* species have become the dominant taxa, and after the oil spill in 2019 *Archaias* became extinct.
- A change from SBS to heterotrophic foraminifers such as *Quinqueloculina lamarckiana* like we have seen in 2019, after the spill, is also indicating of not well-developed ecosystem.
- Pirangi has marginal environment for reef growth and is unsuitable for recovery after stress events, specially in areas with tourist activities; and the oil spill reached an already impacted area.
- The presence of reworked *Quinqueloculina* shows that changes besides the oil spill yet to be identified are occurring in the area and must be taken into consideration in further studies. These changes may be linked to erosion occurring at the beaches near the reefal area that is uncovering relict environments.
- The dominance of smaller foraminiferal taxa, including stress-tolerant species, and minimal representation of BSB taxa, indicate unsuitable conditions in these reefal area. Anthropogenic disturbances in coastal marine environments are threatening marine life.
- Reefs in Pirangi that are trampled by tourists face an eminent coral and foraminiferal community death. Agricultural land use increases amount of sediment, nitrogen, phosphorus, and turbidity in nearby rivers. The oil spill happened on top of all of it.
- *Amphistegina gibbosa* is not found at sites where reefs are walked upon, whereas *Amphisorus hemprichii* is sometimes present because of its flattened morphology.
- Due to their proximity to the coast, the Pirangi reefs are vulnerable to anthropogenic effects. Disturbances (natural or anthropogenic) can result in a different distribution of the benthic organisms in the reef area, allowing to infer that the area of Pirangi has undergone changes resulting from human activities and that the differences in biological composition can be used as an important indicator of the health of the Pirangi reef process and development.

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Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

INDEX

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