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CLIMATE CHANGE – PROBABLE SOCIO-ECONOMIC SYSTEMS (SES) IMPLICATIONS AND IMPACTS IN THE ANTHROPOCENE EPOCH

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***Abstract**: It is vital for security experts to learn from the historical records of global climate change as to how the human society has been impacted by its consequences in the "new" Anthropocene Epoch. Some of these consequences of global climate change include the perishing of several human settlements in different parts of the globe at different times, e.g., in 1700 B.C., prolonged drought contributed to the demise of Harappan civilization in northwest India. In 1200 B.C., under a similar climatic extremity, the Mycenaean civilization in present-day Greece (as well as the Mill Creek culture of the northwestern part of the present-day US state of Iowa) perished. Why did some societies under such climatic events perish while others survived? Lack of preparedness of one society and its failure to anticipate and adapt to the extreme climatic events might have attributed to their extinction. The authors will also analyze the extinction of one European Norse society in Greenland during the Little Ice Age (about 600 years ago), as compared to the still-surviving Inuit society in the northern segment of Greenland, which faced even harsher climatic conditions during the Little Ice Age than the extinct Norsemen. This is how the adaptability and "expectation of the worst" matter for the survival of a particular community against climatic "black swan" events (Taleb, 2007). Similar impacts in terms of sea-level rise expected by the year 2100 whereby major human populations of many parts of the world are expected to lose their environmental evolutionary "niche" will be discussed. Rising temperature will not only complicate human health issues, but also will it take its toll on the staple food producing agricultural belts in some latitudinal expanse. It will also worsen the living condition of the populace living in areas where climate is marginal.*
Through the Socio-Economic Systems Model provided by Vadineanu (2001), the authors will next consider the effect of extant policy-making "prisms" responding to climate change (such as the "Club of Rome" versus the "Club for Growth" visions) as concerns the ongoing process of globalization and survival of the nation-state.

Keywords: Climate Change, Anthropocene Era, "Black Swan" events, Human survival versus extinction (inputs/decisions/outcomes), Socio-Economic Systems Analysis (Vadineanu), Threat/Integry/Exchange Motivators (Boulding), varied scenarios/outcomes vis-à-vis globalization processes.

Introduction: humans taking over the nature's prerogative – the "golden spike" – start of Anthropocene marks the end of Holocene epoch? Time for redemption?

So far, global climate has been changing because of Short-term and Long-term forcing. While short-term grounds are shared by both man [1] and nature, the long-term reasons are exclusively nature-induced.

Humans started their journey of prevailing over Nature with the anthropologically induced extinction of Mega fauna like Mammoth about 50,000 years ago, perhaps another mega fauna Whale would have been extinct long ago but for their ancestors' switching niche from land to deep ocean abyss.

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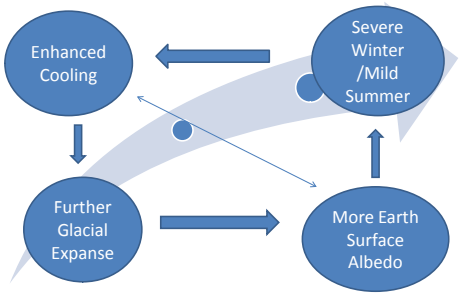
Think what would have happened to them without the whales in oceans. The exploding krill population (a whale's primary food) would have devastated the phytoplankton of the oceans leading to collapse of pyramid base of the food chain.
Let us now discuss a few lessons from the leaves of history. The following graphics would explain how the cooling begets a chain effect of a series of further cooling episodes. The first lesson deals with positive feedback leading to onset of a glacial regime:

Cooling –Initiation of Glacial Regime – The Chain Effect

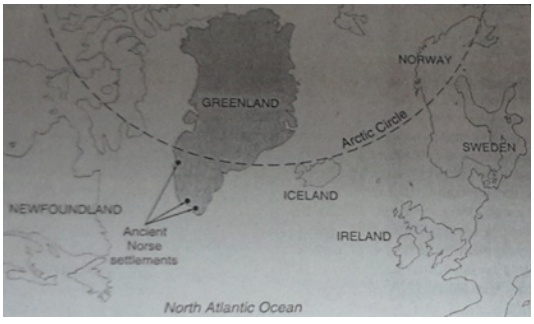


Source: Pal, D.K. (personal notes)

The "Little Ice Age" took its toll on Norsemen

The second lesson concerns the extinction of Norse society because of rapid climate change. In 930 A.D., Vikings finally settled in Iceland. An early inhabitant – Eric the Red, a problematic person, whose unremitting misdeeds got him banished from Iceland in 882 A.D. – led them. Sailing westward, he discovered a new land – he named Greenland, presumably to entice others to join him and his crew. Although it was in the midst of a relatively warm period, the only habitable land was 'small patches' between sea and massive glacial ice sheets. It was there that Eric founded the first Norse settlement. [2]

Norse settlements in Greenland before Little Ice Age



Source: Bryson, R.A., and Murray, T.J. 1977

Before too long the Vikings faced a deteriorating climate that ushered in wetter summers with poor haying conditions. Paucity of fodder resulted in major loss of livestock. With snowier and longer winters exacerbated even greater toll of livestock – especially the calves. The last straw got broken by the disruption of harp seal

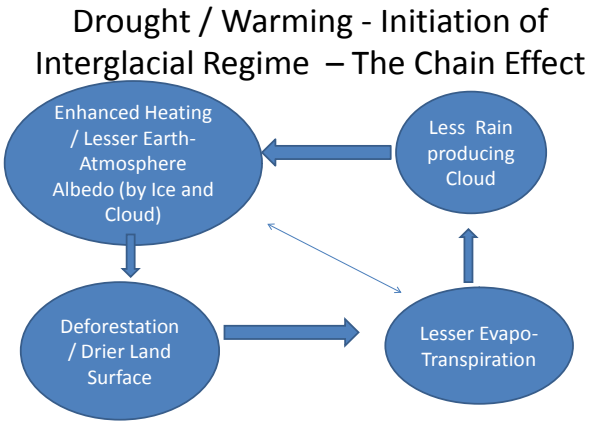
migration along with devastated caribou herds. To add salt to the injury of Norsemen, they later started facing competition for dwindling food sources with the more robust Inuit society (that had earlier started migrating southwards as a result of worsening climate further north). Eventually, hostilities erupted between the tribes; leading to the "survival of [only] the fittest". Consequently, the dwarfish, diseased Norsemen were killed and were thereby annihilated from both time and space.

Extinction of Norsemen vs. Survival of Inuit society - Lessons learned by Post-Mortem

This woe-some event occurred because the Norsemen were not ready for climatic extremities, failed to anticipate and lacked preparedness; clung to subsistence agriculture, failed to match the hunting skills of Inuit-men. When the normal food sources were ruined, superior hunting skills would have saved the society. Norse society failed to adapt with the changing environs; failed to migrate on time. At the same time, expanding sea ice-spread completely disconnected Norsemen to other European communities. Inuit people inhabiting northwards with better hunting skills, fighting skills, better adaptability; willing to migrate on time; survived by occupying the Norsemen Niche in the south of Greenland.

Drought/warming and the initiation of an interglacial regime – the chain effect

The following graphics will explain how our third lesson, abrupt global warming, begets a chain effect of a series of further warming episodes.



Source: Houghton, Jenkins, & Ephraums 1990 (Adapted)

Climate Change – Warming: Facing Drought–Annihilation of Ancient Civilizations

Some of these consequences of global climate change (warming) manifested in the disappearance of several human settlements in different parts of the globe at different times. In 1700 B.C., prolonged drought contributed to the demise of Harappan civilization in northwest India. In 1200 B.C., under a similar climatic extremity, the Mycenaean civilization in present-day Greece (as well as the Mill Creek culture of the north-western part of the present-day US state of Iowa) perished. [3]

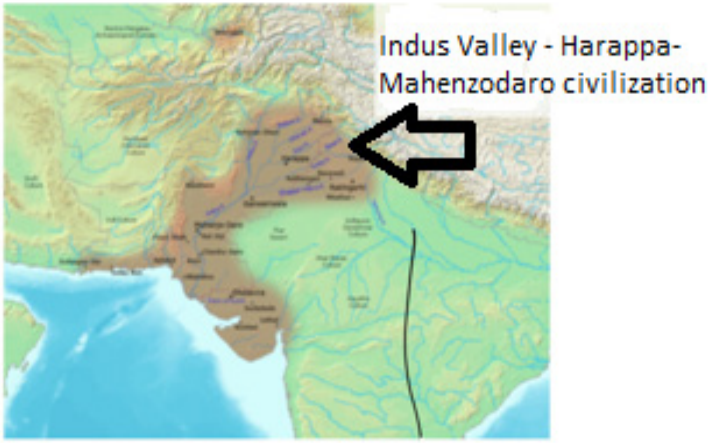
Drought Wipes out an Advanced Civilization: the Case of Mayan Collapse

Drought brought about the extinction of the advanced Mayan civilization. Furthermore, this extermination happened very rapidly (in just 100 years between 800 and 900 A.D.). This was in spite of the fact that the ancient Mayan civilization flourished for thousands of years in Mesoamerica (area now in control of Mexico and Central America).

Demise of Indus Valley / Harappan Civilization about 1700 B.C. –

The expanse of Harappa-Mahenjodaro civilization (about 1.25 MKm ^{2}) extended

from today's northwest Pakistan to northwest India and northeast Afghanistan. Harappa, being the most widespread one of the three old-world civilizations (placed along with Egypt and Mesopotamia), flourished from 3300–1300 B.C. in the basin of Indus river (shown in brown in the map below). The civilization grew to a population of over five Million, was adept in Handicraft, Metallurgy, Urban planning; had an elaborate water-drainage system, brick houses, as well as a water supply system. Let climate change led to drought and the collapse of the river system. (Archaeological Survey of India of British Raj discovered remnants of the civilization first in 1920s.)



Source: Kenoyer, J. M. (1991). "The Indus Valley tradition of Pakistan and Western India". Journal of World Prehistory 5 (4): 1–64.

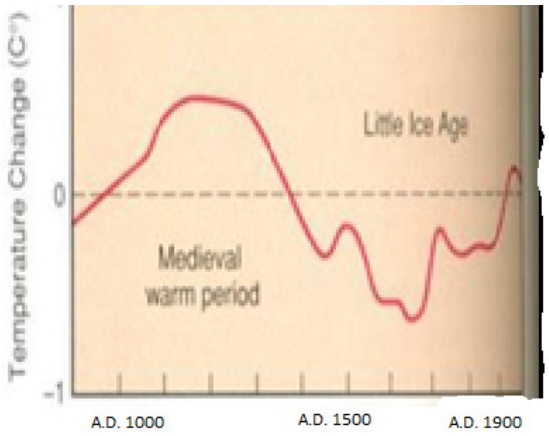
Demise of the Grand Mycenaean's, the First Greeks - By Mega Drought (Plus Earthquake); Demise of the Mill Creek Culture of Northwest Iowa by Drought

The Mycenaeans were instrumental in the legend of Trojan Wars as told in *The Iliad* and *The Odyssey*. This civilization abruptly ended by about 1200 B.C., marking the dark ages in Greek history. Similarly, in 1200-1250 B.C. the Mill Creek people of present-day northwestern Iowa in the USA faced climate change when the weather became too dry for the Mill Creek people to cultivate crops any longer, making them flee Iowa to move up along Missouri river. (Later on. they became part of the Middle Missouri tradition sites of the Dakotas.)

Defining 'semi-permanent climate change' vs. 'climatic swing'

The process of climatic optimum – moving from a medieval warm phase to a Little Ice Age [5] form examples of semi-permanent climate change. While The Great Plains drought in the 1930s, three Midwestern winters in late 1970s, and the devastating Sahelian droughts, on the other hand, are examples of temporary climatic fluctuations.

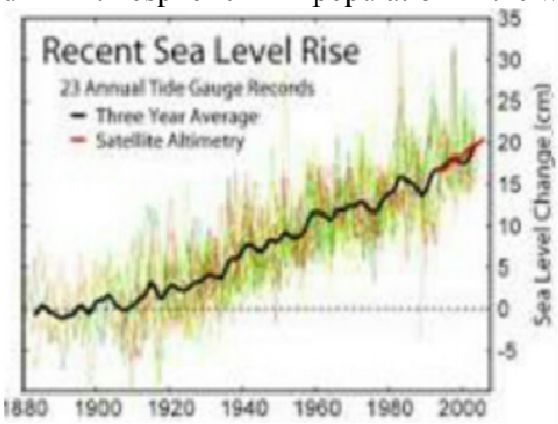
Evidently, communities living in areas where the climate is marginal are often vulnerable. Nevertheless, the economical prowess of the state becomes the key to the ultimate societal impact; e.g., impact of climate change on a US community and a Sahelian community is altogether different.



Source: Houghton, Jenkins, & Ephraums 1990 (Adapted)

Global warming: 'sea level rise; disease redistribution' on society

Current sea-level rise is about 3 mm /yr world wide – which, according to the National Ocean and Atmospheric Administration (NOAA), is significantly higher than average over several thousand years in the past – and at this rate is likely to affect most of the all coastal and island population in the world.



Source: Sea level in the 5th IPCC report (15 October 2013)

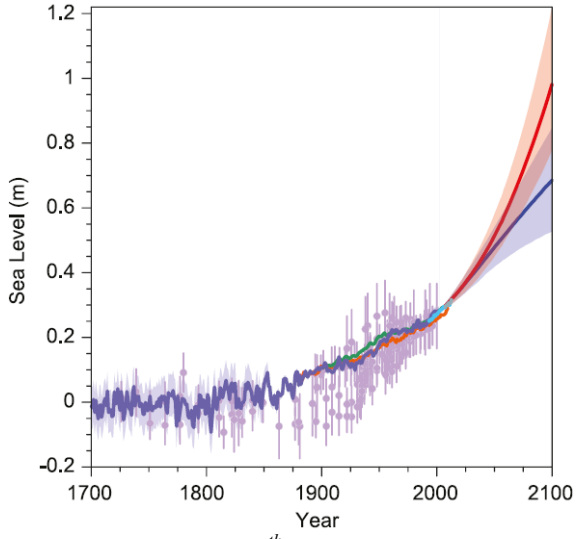
Reasons for this sea-level rise are – 1) melting ice sheets to increase the volume of water; and, 2) thermal expansion of water with a rise of temperature. However, the futures forecast from this data drastically vary from agency to agency.

Referring to the IPCC report: (1) the global sea-level is rising; (2) this rise has accelerated since pre-industrial times; and, (3) it will accelerate further into this century. The projections for the future are much higher and more credible than those in the 4th report, but possibly still a bit conservative, as we will discuss in more detail below. For the high emissions scenario, IPCC now predicts a global rise by **52-98 cm** by the year 2100, which would threaten the survival of coastal cities and entire island nations. Even with aggressive emissions reductions, a sea-rise by **28-61 cm** is predicted. Under this highly optimistic scenario, we might see over half a meter of sea-level rise, with serious impacts on many coastal areas, including coastal erosion and a greatly increased risk of flooding.

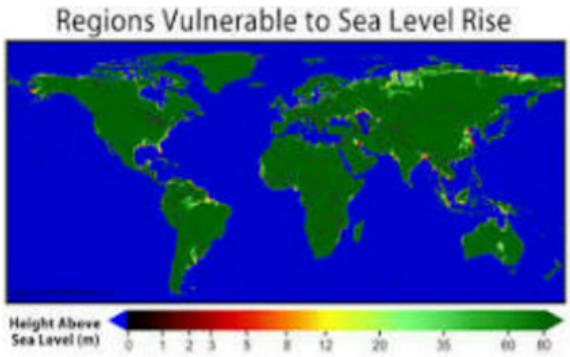
Multi-century sea-level records and climate models indicate [4] an acceleration of sea-level rise. A reconstruction of global sea level using tide-gauge data from 1950 to 2000 indicates a larger rate of sea-rise after 1993. Here, we extend the reconstruction of

global mean sea level back to 1870 and find a sea-level rise from January 1870 to December 2004 of 195 mm. If this acceleration remained constant, then the 1990 to 2100 rise would range from 280 to 340 mm, consistent with projections in the IPCC TAR.

According to the Inter Governmental Panel on Climate Change (IPCC) 5th assessment Report [5], the rise would be 26-82 cm by 2100 [6]; US National Research Council (2010) 56-200 cm by 2100; 3rd National Climate Assessment (May 6, 2014): 30-120 cm by 2100.



Source: IPCC 5th assessment report



Source: Sea level in the 5th IPCC report (15 October 2013)

Disease Crossing Latitudinal Niche

Disease vectors prevalent in tropics are moving to upper latitudes with global warming. Malaria, Dengue, Plague and Virus rooted Encephalitic syndromes are being affected with climate change – which then causes changes in epidemiology of infectious diseases. The speed of such change might indeed surpass the human power to adapt to the changing situation [7].

The varied ways scientists have construed "the environment" across time

Romanian ecologist A. Vadineanu (2001) argues that: "The concepts and methods dealing with the «environment» have been changed and improved as the ecological theory has developed from the early stage, usually described as «biological ecology», towards the current stage, which is more often and more appropriate[ly] defined as «systems ecology» . . . The identification and description of the natural, seminatural and human-dominated and created

environment has changed as well from a former conceptual model which defined the environment as an assemblage of factors; air, water, soil, biota and human settlements, to the most recent one, which considers that the environment has a «hierarchical spatio-temporal» organization"). [8]

The non-linear logic of ecological systems and hierarchies and their mis-matched development = cause of ecological crisis

When the natural-world hierarchy and the human-made world hierarchy do not develop in synchronization, Vadineanu claims that unpredictability follows: "The ecological systems, as organized units and components of the hierarchy, are described as self-organizing and self-maintaining systems or as life supporting systems. More recently, they have been described as non-linear dynamic systems with evolving productive and carrying capacity. The ecological hierarchy contains two main hierarchical chains of ecological systems which show a marked and evolving dichotomy in their spatio-temporal development, which in fact is the core of the so called «ecological crisis»". [9]

Natural ecological and human ecological systems compared

Vadineanu then compares natural ecological and human ecological systems delineated as such: "i. natural and seminatural ecological systems that are self maintained and provide a wide range of natural resources and services; ii. human-dominated ecological systems which depend in different degrees on comercial [sic] auxiliary energy and material inflow (e.g. agrosystems, intensive fish ponds) and human-made systems (e.g. urban ecosystems, industrial complexes), which are totally dependent on commercial energy and material inflow". [10]

NC and SES Detailed

Vadineanu contrasts Natural Capital (NC) and Social-Economic-Systems (SES) in this fashion: "The ecological hierarchy integrate[s] both the components of the Natural Capital and those of the Socio-Economic Systems."

I. NC
A. Natural
B. Seminatural
II. SES
A. Human-dominated
B. Human-created [11]

Vadineanu's Definition of "Biodiversity"

Moving along, biodiversity, to Vadineanu, is a tripartite system, of which he remarks: "I can say that the biodiversity consists in Natural Capital, Social and Cultural Capital and provides, on one side, the foot print which supports and feeds with resources and services the Socio-Economic Systems and, on the other side, provides the interface between Natural Capital and the Structure and metabolism of the «economic subsystem»)". [12]

The Balance of Natural Capital vis-à-vis Human Capital (Socio-Economic Systems)

Vadineanu presents a dynamic model (see Fig. 4) that well shows the interactions between elements, processes, input and outputs (both desired and not). He describes the elements and their functions (reprinted for clarity) in this way:

"A - The man-made physical capital: I - the infrastructure of the economic subsystem dependent on the renewable resources provided by the components of the Natural Capital; II - the industrial infrastructure of the economic subsystem dependent on «non-renewable» resources; III - Systems* for commercial energy production using as primary resources: fossil and nuclear fuels and hydro-power potential; IV - the human settlements infrastructure.

B - Social capital;

C - Cultural capital;

D - Man-dominated components of the Natural Capital;

E - natural and semi-natural components of [the] Natural Capital: 1 - flow of renewable resources; 2 - flow of raw materials; 3 - flow of fossil and nuclear fuels; 4 - flows of electrical energy; 5 - material and energy inputs (fertilisation, pesticides, agrotechnical works, irrigation, selection

etc.) to support [the] management of man-dominated systems; 6 - dispersion of heat of secondary products (wastes) in the troposphere and in the HGMU [Hydro GeoMorphic Unit] components."

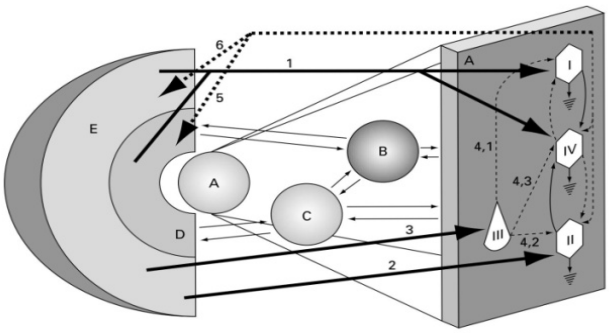


Fig. 4. The general physical model of the socio-economic system and its relationships with Natural Capital.
A - The man-made physical capital: I - the infrastructure of the economic subsystem dependent on the renewable resources provided by the components of the Natural Capital; II - the industrial infrastructure of the economic subsystem dependent on «non-renewable» resources; III - Systems* for commercial energy production using as primary resources: fossil and nuclear fuels and hydro-power potential; IV - the human settlements infrastructure. B - Social capital; C - Cultural capital; D - Man-dominated components of the Natural Capital; E - natural and semi-natural components of thr Natural Capital: 1 - flow of renewable resources; 2 - flow of raw materials; 3 - flow of fossil and nuclear fuels; 4 - flows of electrical energy; 5 - material and energy inputs (fertilisation, pesticides, agrotechnical works, irrigation, selection etc.) to support tje management of man-dominated systems; 6 - dispersion of heat of secondary products (wastes) in the troposphere and in the HGMU components.

Vadineanu's View on Ecological Methodologies and Scope

In Vadineanu's view, the study of our environment has followed a trajectory similar to the general move of scientific studies generally over the decades, *viz*. "[W]e notice very clearly in the last decade a rapid shift from the sectoral, reductionistic and inappropriate temporal (months and years) and spatial scale approach towards a holistic and long term approach (decades and centuries). Systems analysis and modeling are used more extensively for the identification and description of the ecological systems (including SESs) as large, complex, dissipative and dynamic systems". [13]

Vadineanu's View on Trending Ecological Topics and Approaches

Vadineanu's GST (General Systems Theory) approach colours his view of coming trends in both topics and approaches of ecological studies: "The relationships between «humans and nature» more recently referred to as «development and environmental» relationships or between «economy and ecology» should be further reformulated and recast as the mediated and dynamic relationships at local, regional and global scale between the structure and metabolism of Socio-Economic Systems, on one side, and the structure, productivity and carrying capacity of the natural, seminatural and human-dominated systems (NC), on the other side" .[14]

Vadineanu Speaks With the Voice of the "Club of Rome" Approach to the Environment

Following future-studies theorists of the "Club of Rome" ("Limits to Growth" school), Vadineanu sees that pure free-market economic approaches (based only upon "exchange" values) are not sustainable paths for development. He states: "Especially I am stressing the need for replacing «free market [s]», which [are] increasingly indebted to Natural Capital our Socio-Economic Systems, by «sustainable market», which, in fact, requires proper identification of the overall dynamic frame for «co-development», according with the structure, productivity and carrying capacities of the local, regional and global NC as well as with the ethical and moral criteria for sharing its resources and services within and among generations or among states and regions" . [15]

Concluding remarks

The authors conclude by pointing the reader to two items for thought. The first is a motto from futurist Kenneth Boulding, who stated: "There are only two things we know about the future. One is where and when eclipses will take place and the other is that a kitten will never grow up into a rhinoceros. Nevertheless, we have to worry about the future, simply because the greatest dilemma of mankind is that all knowledge is about the past and all decisions are about the future". [16]

What is the most important aspect of this study is the projection that in the current Anthropocene epoch the positive feedback effect of cooling or warming of earth will be man-induced rather than nature-induced.

At present we are in the midst of an interglacial regime, i.e., a period of warming in which anthropogenic emissions have the potential to drastically alter the pace of chain reactions, leading to unprecedented warming-sprint with concomitant race of sea-level rise, disease redistribution, agricultural adjustments; that might be beyond the capacity of humans to adapt to.

This stark observation leads the authors to a second provocative thought they would wish to leave with the reader; that is the short film, entitled simply "Man", that shows the ill effects that a dominating species like our own can have upon the earth's biosphere and built environment to the detriment of both other species and our own long-term survival.[17] As a number of security studies have indicated, climate change in the Anthropocene epoch will have numerous impacts that will surely have security implications. [18] With N. Taleb [19], the authors predict that more and more improbable "black swan" events with unpredictable serious consequences will mark our mid- and long-term future.

Acknowledgements

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[3] Summary of: Hodell, D.A., Curtis, J. H., and Brenner, M. 1995. Possible role of climate in the collapse of the Classic Maya Civilization. *Nature* 375: 391-394. , Retrieved: https://www.ncdc.noaa.gov/paleo/drought/drght_mayan.html (accessed 8 May 2015).

[4] Church, J.A. and White, N.J. 2006. A 20th century acceleration in global sea-level rise. *Geophysical Research Letter* 33(1).

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[6] Houghton, J.T., Jenkins, G.J., and Ephraums, J.J. (eds.), 1990. *Climate Change, The IPCC Scientific Assessment*. Cambridge [UK]: Cambridge University Press, p. 202.

[7] Atul, A. K., Atul, A. and Nettleman, M. D. Nov-Dec., 2005. Global Warming and Infectious Disease. *Archives of Medical Research*, Vol. 36(6): 689-96.

[8] Vadinleanu, A. 2001. Decision-making and decision support systems for balancing Socio-Economic and Natural Capital Development. *Observatorio Medioambiental* 4: 19-47; p. 21.

[9] *Op cit*., pp. 21-22.
[10] *Ibid*.
[11] *Ibid*.
[12] *Op cit*., p. 23.
[13] *Op cit*., p. 25.
[14] *Op cit*., p. 26.
[15] *Ibid*; To see discussion of the varied stances of the "Club of Rome" (which calls for limits to growth to obtain ecological balance since human-made climate change is real and serious) and the "Club of Growth" (which denies that climate change is serious even if human-induced) and its implications for the adoption (or not) of sustainability policies. (See: Owen, S. M. 2007. Project demonstrating excellence: Power, culture, and sustainability in the making of public policy in an Appalachian Headwaters Community; Thesis (Ph.D.), Union Institute & University). In it, Owen quoted Herman Daly (*Beyond Growth: The Economics of Sustainable Development* 1996, p. 215), who said that in the United States, limits-to-growth debates stopped "precisely when people [i.e., the economic elite] realized that limits to growth implied limits to inequality . . . [so] let us therefore reject the premise of finitude and entropy and return to the unlimited-growth vision that does not call for political impossibilities . . . [t]hat it called for physical impossibilities instead can be overlooked since most [US] voters have never heard of the laws of thermodynamics" (in Owen, p. 55).
[16] Boulding, K. E. 1971, May. The dodo didn't make it: survival and betterment. *Bulletin of the Atomic Scientists*. 19-22; 19. In Boulding, K. E. 1970. *A primer on social dynamics: History as dialectics and development* (New York: Free Press), Boulding introduced his "Threat/Integry/ Exchange schema, which argues that human behaviour is structured by concerns of harm (threat), concerns of tribe/family/friend relations (Integry) and concerns of individuals seeking to "rationally" optimise profits and lower costs (exchange). In Boulding's view, only a balanced vision of combined human motivation, tilted towards Integry, is ecologically sustainable.
[17] Cutts, Steve. "Man". Retrieved: https://stevecutts.wordpress.com/2012/12/27/man/ (accessed 8 May 2015).
[18] See, for example: Podesta, J., and Ogden, P. 2007. The security implications of climate change. *The Washington Quarterly* 31 (1): 115-38. They state, that however optimistic or pessimistic the science of climate change in the Anthropocene epoch may turn out, poor countries will bear most of the burdens: "That said, science only tells part of the story. The geopolitical consequences of climate change are determined by local political, social, and economic factors as much as by the magnitude of the climatic shift itself. As a rule, wealthier countries and individuals will be better able to adapt to the impacts of climate change, whereas the disadvantaged will suffer the most. An increase in rainfall, for example, can be a blessing for a country that has the ability to capture, store, and distribute the additional water. It is a deadly source of soil erosion for a country that does not have adequate land management practices or infrastructure" (pp. 115-16). Even so, publics in developed countries, the authors claim, face a unique danger driven by their media surplus of constant "scare" messages about climate change, of sensory overload and subsequent desensitization [if not outright disinformation]. "Ultimately, the threat of desensitization could prove one of the gravest threats of all, for the national security and foreign policy challenges posed by climate change are tightly interwoven with the moral challenge of helping those least responsible to cope with its effects. If the international community fails to meet either set of challenges, it will fail to meet them both" (p. 134).
[19] Taleb, N. N . 2007. The black swan: the impact of the highly improbable. New York: Random House.