Impact of Global Warming on Infectious Disease in Cyprus

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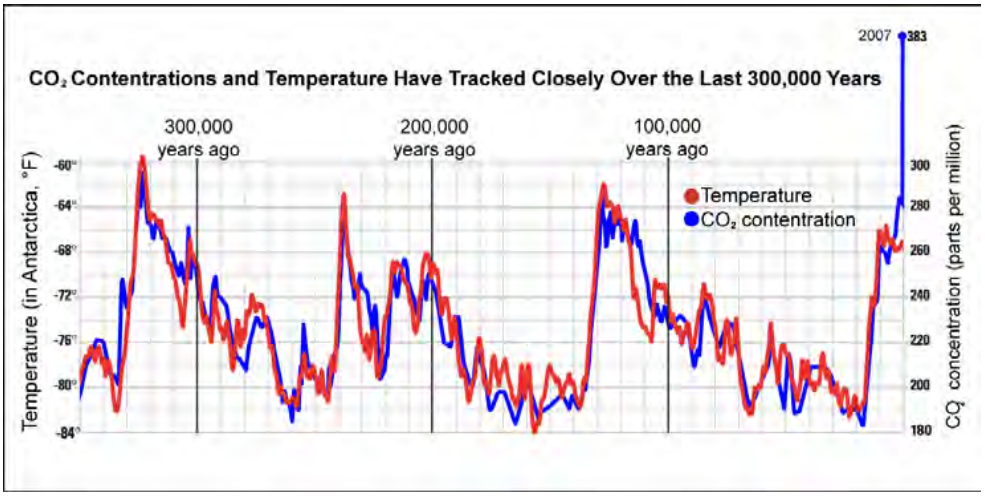
Global Climate Change

The formation of earth's climate is intricate process, involving solar radiation, atmospheric gases, plate tectonics, volcanism, ocean currents and the earth's orbital variations. The history of earth's climate is a complexity that is beginning to be understood by scientists. The National Ice Core Laboratory in Denver, Colorado traveled to Greenland for six weeks every summer from 1989 to 1993, taking ice core samples from the ice sheet. This data provides a record of at least the past 110,000 years, with even older records from Antarctica going back about 750,000 years (13). These records show that earth's climate since the existence of humans has been uncharacteristically inhabitable. Drastic changes in earth's climate occur extremely rapidly given specific "tipping points (13)." Professor of geosciences at the University of Arizona, Joellen Russell states that these "pops" of the system could be due to ocean current shifts, plate tectonics, or other catalysts of climate change, but regardless the climate system is sensitive.

The human contribution to climate change has been heightening ever since the industrial revolution. Scientists, such as Callendar and Keeling have been proving for over a century that our climate is changing do to rise in atmospheric CO_2. Keeling culminated the work of many preceding scientist to prove CO_2 has increased significantly since the industrial revolution, due to human burning of biomass and fossil fuels (Figure 1).

Figure 1 (4)



Regardless, scientists are seeing a shift in climate, which could lead to Joellen Russell's "pop" change in climate. The implications of such a change are immense. Hydrologists hypothesize ocean current changes, sea level rise, and low fresh water availability. The destruction of climate negative feedback loops will shift climate equilibriums, leading to uninhabitable environments. These effects are already beening seen on the island of Cyprus.

Climate Change in Cyprus

In recent years Cyprus has experienced severe drought, forcing water to be shipped in from Greece. Cyprus has also experienced natural disasters associated with its change in climate, such as forest fires and cyclones. Cyprus was once known as the "Green Isle" of the Mediterranean. Today 50% of Cyprus' forests have disappeared, because of drought and increased forest fires, rather than deforestation by land development (3).

A strikingly possible cause of all of these bizarre natural disasters is the shift in Cypriot climate. Data from Cyprus' temperature stations shows trends of annual mean temperature increase of 1°C/100 years (2). The temperature change is consistent with other areas of the globe, which lends to the conclusion that Cyprus is experiencing part of a larger global climate change.

Another study of Eastern Mediterranean climate change looked at 265 climate stations from 1951 to 1995. This study showed the weather change is not simply an increase in temperature, but that the decrease in overall rain fall will be accompanied by extreme episodes of rainfall, due to increased air temperature and atmospheric water vapor in the sea air (1). The Cypriot Meteorological Service confers the decease in rainfall showing a statistically significant decrease in overall rainfall in the past 30 years and a rate of about one millimeter per year (6), but the effects of this "paradoxical rain" are yet to be seen.

Climate Change and Infectious Disease

The implications of climate shift for infectious disease on the island of Cyprus are great. The distribution of infectious disease depends on an interaction between human host and infectious agents that is greatly dependent on climate conditions. Global climate change has the capacity to create population crowding, food scarcity, poverty, and local environmental decline, all factors which will facilitate the spread of infectious disease. Although it is impossible to know the exact risk that will be created by climate change, the scientific paper of *Khasnis and Nettleman* suggests small island states, like Cyprus will have increased cholera and dengue, along with loss of coastal land, leading to overcrowding and changes in the fish populations (5). Climate change in Cyprus has the capacity to facilitate the spread of infectious disease by the expansion of vector habitat, the increase in water-borne diseases, human migration, disease spread in livestock and reduced air quality.

Vector Habitat Changes Due to Climate Change

"Changing climate will spell boom days for parasites. They are good at solving problems, and because the reproduce so quickly, they always win (9)." The eminent increase in vector born disease which Dr. CK Cassel speaks of is a public health issue currently becoming realized on the Island of Cyprus. But climate change will have an effect, not only on disease distribution but on human population susceptibility. A variety of these factors are listed in Table 1. Important vector populations in Cyprus include malaria-bearing mosquitoes and potentially Schistosome-spreading snails, given the mass immigration of refugees from endemic regions.

Table 1: Factors affecting Arthropod-Borne Diseases

Vector factors	Host factors
Size of vector population	Size of host population
Proportion of vectors carrying disease	Susceptibility of existing hosts
Biting rate	Migration/creation of new susceptible hosts
Availability/requirement for intermediate host	Degree to which the host enters the vector environment
Ability of vector to survive the disease	
Lifespan/mortality rate of the vector	Mortality rate caused by the disease
Efficiency of transmission of the disease via the arthropod bite	Potential for prolonged immunity
	Availability/efficacy of vector control measures
Sustainability and renewal of infected vector population	Availability of disease control measures

(5)

The environmental factors which effect vector born disease distribution include temperature, precipitation, humidity, wind, solar radiation, vegetation, hosts and reservoir hosts availability. Research by The Hospital for Tropical Disease in London shows that climate change is very likely to alter the distribution of such parasitic diseases as Malaria, Filariasis, Leishmaniases, Schistosomiasis, and Trypanosomiasis(9). Climate is essential for the migration and survival of vectors which carry each of these parasites. For instance, Schistosomiasis is indigenous to Egypt and the parasite species *S.mansoni* uses only a snail of the genus *Biomphalaria* as its intermediate host. In the colder moths in Egypt the snail loses its infection and the incidence of Schistosomiasis drops rapidly in Egyptian population (9).

As the climate of Cyprus changes the island's susceptibility to the disease becomes clearer. A critical density equation, created by Maastricht University, Department of Mathematics in the Netherlands, shows that a low density of vectors, for such diseases as Schistosomiasis or Malaria, have the potential to create epidemics, given high population density and low total area of the land mass (10). A small island, such as Cyprus, therefore has high epidemic potential.

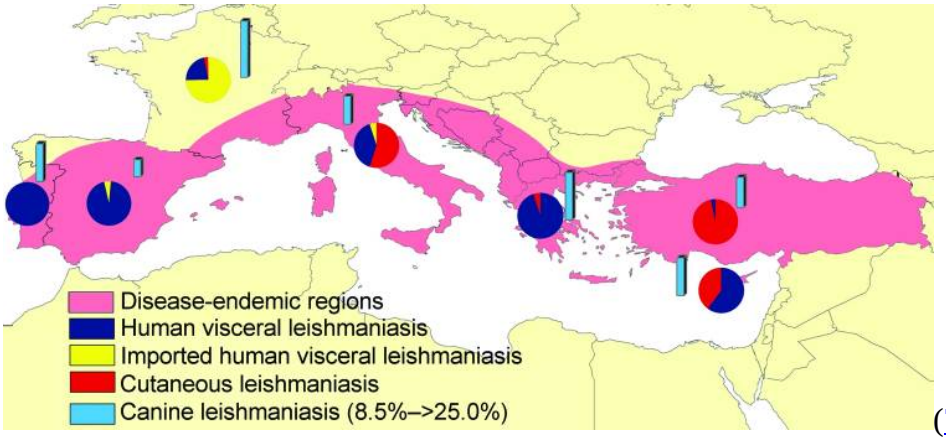
Malaria's potential to spread on the island is enhanced by many other factors. In the Suez Canal in Egypt, the *Anopheles* mosquito, the vector for Malaria is beginning to bread in salt mashes. As sea level rises and the water table will rise. Thus the creation of brackish water will provide immense areas of potential breeding ground for these mosquitoes. Paradoxically, the

water drought in Cyprus also provides breeding habitat for these vectors. In general the *Anopheles* mosquito requires a warm habitat with concurrent rainfall, but in Cyprus outdoor reservoirs store all the water for the summer months.

A recent study done to evaluate the current prevalence of Malaria in Cyprus was not promising for the irradiation of the disease from the island. To determine previous exposure to the Malaria parasite a spleen-rate is taken. This test was preformed on children in Cyprus from age 3- 15. Although the rates were low, around 5% for the average tested pollution, there are some places on the island were the "spleen-rate" reaches up to 20%, as in Famagusta, in Northern Cyprus (8). These results suggest that the political separation of Cyprus lends to the increase of Malaria on the Island. One suggestion for the higher prevalence of Malaria in Northern Cyprus is that refugees from Africa and the Middle East can more easily enter the North side of the island illegally and are potential carriers of the parasite (8).

Some parasitic diseases endemic to Cyprus will simply become exacerbated by climate change. Leishmaiasis is endemic to Cyprus, with a high prevalence of human visceral Leishmaiasis. The endemic zones in the image below (**Figure 2**) report over 3,950 cases a year (9). As climate changes, new species, such as *L. tropica* may colonize Cyprus, as well as the drug-resistant *L. infantum* (9).

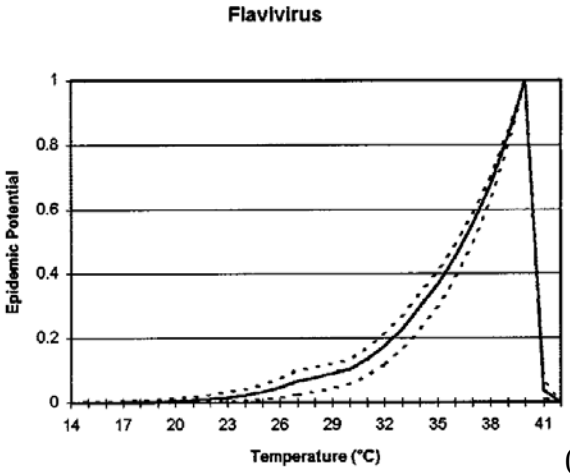
Figure 2



(7)

Vector born viruses will also become a problem in Cyprus due to climate change. West Nile is a Flavivirus carried by 43 mosquitoes, amd has had reported cases in Cyprus. This virus thrives in climates which maintain a higher temperature than mean average summer temperature in Cyprus of 36 °C. The heightened temperature needed for more efficient Flavivirus incubation (Figure 3) can easily be achieved by the current climate change estimates for the island (11).

Figure 3



(11)

The vector mosquitoes for the West Nile virus, primarily of the genus *Culex* are prominent in Africa and the Middle East. The principle host for the virus is Avian. As the climate changes the migration patterns of many of these birds be altered, increasing the prevalence of West Nile infected birds on the island nation of Cyprus. The virus can then easily spread in the human population, as the mosquito species needed to carry the virus are currently present on the island(10). Another vector associated virus, Yellow Fever, vectored by the *Aedes* mosquito, has an incubation period inversely proportional to the temperature. If vectors spread to zones with cooler winters, such as Cyprus, the disease may spread faster (9).

Waterborne Infectious Disease

Waterborne infectious disease, whether viral, bacterial or parasitic will increase due to sacristy of water, decline of human conditions and increase of pathogens created by global warming. For example, it is estimated that a 73% reduction in morbidity due to Schistosomiasis could be achieved by improving water quality and the availability of sanitation services, imagine the implications for the inverse scenario (11). Many waterborne diseases are associated either directly or indirectly, to the quantity and quality of the water supply. In countries, like Cyprus, where water is already a scarcity, global warming will drastically expand areas where sanitation is substandard (4). Organisms directly transmitted via contaminated water include Escherichia coli, Vibrio cholerae, Salmonella sp, hepatitis A and E (HAV and HEV), poliomyelitis, Giardia lamblia and Entamoeba histolytica. Scarcity of water creates opportunities for transmission of theses pathogens, due to inadequate hand-washing and personal hygiene. In Cyprus previous epidemics of Cholera, typhoid, plague, and typhus indicate the potential for these waterborne diseases to become major public health issues (14).

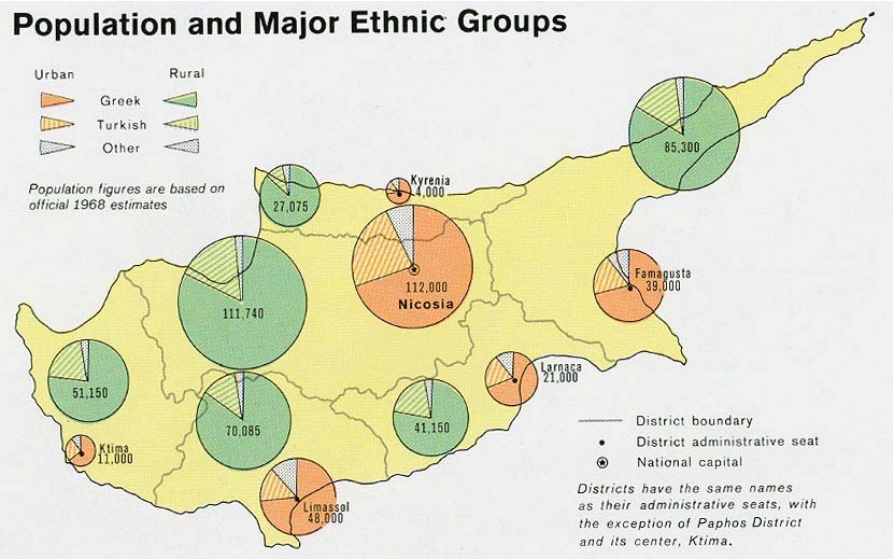
In past years, developing nations have undertaken great efforts to improve their water sanitation. Gundry et al. reviewed observational studies investigating this relationship, and showed that improved water supply and sanitation result in substantial reductions in morbidity from diarrhea (26%), ascariasis (29%), guinea worm infection (78%), Schistosomiasis (77%), trachoma (27%) and a median reduction of 65% in diarrhea-specific mortality and 55% in

general child mortality (5). The effects of global climate change would effectively reverse these results, not only for developing countries but for developed nations as well.

Human Migration

The growth in the human population, coupled with the increasing number of global climate change refugees will be a major proponent for the spread of infectious disease. With an estimate nine billion people on the planet in the year 2050, the increased population density will facilitate the spread of disease, while sanitation and water supplies continue to dwindle. The WHO estimated that migration will lead to 65% of the total world population, with 61% of the population in developing regions living in urban setting by the year 2025 (5). This increase in population urbanization will have great implication in Cyprus, where many areas are still rural (Figure 4). In Cyprus sea level rise will also condense the growing population away from the largely populated costal areas.

Figure 4



(12)

Human migration has been a major source of infectious disease epidemics, such as smallpox and the plague, throughout history. The human facilitated dispersion of non-native diseases can be devastating for an immunologically and genetically unprepared population. The population in Cyprus continues to increase due to the large influx of refugees and foreign workers. The infrastructure of the county is still stabilizing and a great shift in population and island migration may cause this infrastructure to buckle at the time of greatest need. Further stress on water resources, food (a majority of which is imported and costly), transportation and healthcare accessibility will certainly destroy the island's stability. Therefore, climate change has the ability to greatly increase the spread of infectious disease in Cyprus utilizing the in overcrowded in rapidly growing cities, the introduction of new infections and infrastructure destabilization.

Livestock and Infectious Disease

Such livestock infections as Malaria, swine flue, Rift Valley Fever, bird flue and Bluetongue Disease have potential to ravage the island of Cyprus given the correct environmental disturbances are driven by climate change. Many of these diseases can be transferred to humans, while others will simply devastate the livestock population. Malaria is an issue for livestock and domestic animals. Not only is the Malaria dangerous for the animals, but the livestock may also provide a reservoir for the parasite to infect human hosts (14). Swine flu and bird flu are other animal related epidemics that are caused by overcrowding and poor sanitation, which global climate change will cause (5). Another disease, specific to livestock that may be increased by global warming is Bluetongue Disease or Catarrhal Fever (15). The disease, previously seen in Cyprus, is a viral disease of sheep, cattle, goats and deer. The mosquito vectored disease kills animals within weeks of infection. The disease is not prevalent in Cyprus currently, but a shift in vector habitat, caused by global warming could ravage the livestock population of the island.

Reduced Air Quality

Increased temperature and humidity caused by climate change will increase pathogen prevalence in air in such areas as Cyprus. This change in air quality can increase the spread of such infectious disease as TB, pneumonia, meningitis, hanta virus influenza and fungal spores. Poor sanitation, created by the disturbances of global climate change, will also increase the concentration of these infectious agents in the air. Humidity is also an important component of disease spread. The US EPA states that by reducing the relative humidity level the growth of many sources of biological disease can be minimized. A relative humidity of 30-50 percent is generally recommended for indoor environments (16). According to the Meteorological Service of Cyprus relative humidity of the air is on average between 65% and 95% in winter and between 40% and 60% in summer (17). An increase in summer humidity would drastically increase the biological disease potential in the air.

People and Institutions Currently Working on Global Climate Change and Infectious Disease in Cyprus

There is no current research on the effect of global warming on infectious disease in Cyprus, but the following individual are researching climate change or Infectious disease separately in the island state.

- The government of Cyprus, especially the of the Medical Department has done research on Malaria in Cyprus in conjunction with the International Health Division of the Rockefeller Foundation. The Ministry of Health has not done any work on Climate Change and its implication for public health in Cyprus. http://www.moh.gov.cy/moh/moh.nsf/AdvancedSearch_en?OpenForm&q=&p=1&w=&t=&s=global%20warming&L=E&e=&i=1

- Panos Hadjinicolaou, Silas Michaelides and *Andreas Poyiadjis* work for the Cypriot Meteorological Service and have done regional modeling on climate change in Cyprus. They have looked at implication for water, land, sea level and migration, but not infectious disease. http://www.cost723.org/meetings/ws2/presentations/michaelidis-precis_sondes_sofia-1.pdf

- Cyprus Meteorological Service has a division on climatology which has done work recording and analyzing climate change data for Cyprus. http://www.moa.gov.cy/moa/MS/MS.nsf/DMLindex_en/DMLindex_en?opendocument

- Phoebe Koundouri is an Assistant Professor at DIEES (Department of International and European Economic Studies) at Athens University of Economics. Dr. Koundouri has done research in Cyprus analyzing drought management polices in irrigated agriculture by illustrating the importance of estimating the risk preferences in evaluating their impact. They have examined some implications of Global Warming for water scarcity, but none for infectious disease. http://mercury.soas.ac.uk/economics/staff/BenGroom/Docs/My%20Papers/NewAntle.pdf

- The government of Cyprus has a station for Climate, Global Warming, and Daylight Charts and Data to be taken at Laranca airport. http://www.climate-charts.com/Locations/c/CY17609.php

People and Institutions Who Should Work on Global Climate Change and Infectious Disease in Cyprus

Ministry of Health and the Cyprus Meteorological Service: The two ministries should unite to do research on climate change and infectious disease, instead of ignoring the implications of the other's research. The Meteorological Service has data on climate change specific for Cyprus

Cyprus International Institute: Experts in Public Health should be evaluating the effects of climate change on infectious disease. It is important that public health professionals be involved in the assessment of the effects as well as the discovery of ways to evade and prepare for the public health implications of global warming.

The Green Party of Cyprus: It is important that society be involved and educated on the possibilities of infectious disease epidemics in Cyprus. The Green Party is highly active in Cyprus and should unite with Northern Cypriot Green Party representatives to discover and publish articles for the public about infectious disease and climate change. It is important that the Green party also educated low income consumers. In Cyprus this is a particular issue because the lower income class is made-up of non-government represented foreigners (some illegal, many non-citizens) who have little to no right and often have language barriers.

Water Authority of Cyprus: Water shortages are a huge issue on the desert island of Cyprus. The production and maintenance of water quality is key focus for this island nation, as drought continues and the region warms. It is obvious that this party should be involved to voice its needs and concerns in the climate change arena.

Bi-communal evaluation by Medical Authority: It is important that doctors research the possibly spread of infectious disease to the entire island. It is for this purpose that a bi-communal research committee of medical professionals should research possible infectious disease epidemics, prevention (such as possible vaccinations) and emergency planning for the island.

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Research to Guide Public Policy

Figure 5

The data above shows a large degree of variability between members of the EU concerning the importance of global climate change (Figure 5). The greatest levels of concern occur in Mediterranean regions, with Cyprus included. The elevated concern in the Mediterranean region may be due to the early effects of climate change seen in there highly sensitive areas. The awareness of global climate change, combine with its geographical susceptibly to many infectious diseases makes Cyprus a perfect candidate to begin research and prevention techniques for infectious disease spread due to climate change. It should be noted that even though this awareness of global climate change exists Cyprus has low functioning public transportation and is currently using wasteful, oil-dependent desalination technology.

Research that should be conducted in Cyprus concerning possible outbreaks of infectious disease includes malaria outbreak prognosis, hidden vector habitat potential, changes in population demographics and their effect on disease prevalence. Research should also be done more specifically on global climate change and its implications for disease on the island. The potential sea level rise, human population shifts, and rainfall variation should all be researched and evaluated for their potential to increase infectious disease on the island. It is important that this research be a bi-communal affair, creating and evaluation for the entire island. The political barriers of Cyprus will not be recognized by disease and could create dangerous, unseen reservoir populations for disease. Research in these fields will not only guide public policy toward global warming and infectious disease prevention, but will also enhance policies concerning community properness and emergency strategy plans.

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