

Socioeconomic and Political Implications of Vertical Farming

**Elizabeth Reitano, Elizabeth Del Giacco, Sonia Touré, Greg Gin, Ivan
Ramirez**

**Medical Ecology
Spring 2006
Columbia University**

EXECUTIVE SUMMARY

- This study examines the socio-political implications of adopting Vertical Farming (VF).
- VF must be considered through five lenses: Geography, Economics, Government, Environmental Consciousness and Community
- Seven case studies were selected to represent variations within the five lenses. The locations are: Japan; Iceland; Beijing, China; Cuba; Mali; New York City; Floating Vertical Farms
- VF Will:
 - Revolutionize agricultural sectors of the economy
 - Minimize agricultural susceptibility to climate variability, improve environmental sustainability and regenerate ecosystem functions and services
 - Achieve governmental goals of poverty reduction and food security
 - Protect resources and foster environmental stewardship
 - Increase standard of living and socio-economic equality
- Issues for Consideration Include:
 - VF adoption will be region specific according to geography, economics, government and culture
 - Uncertainty about population projections
 - Challenges of obtaining funding
 - Involvement of traditional farmers, who could otherwise be hurt by vertical farms
 - Shift in politics with regard to agricultural sector of the economy – shift in trade and shipping
 - Locations for VF need to be planned in terms of risk from environmental disasters/hazards
 - Potential resistance from certain interest groups
- Future Outlook With Adoption of VF:
 - Population growth will stabilize
 - Agricultural sector of economy will be transformed
 - Global poverty will be eradicated
 - Food security will be achieved
 - Nutrition and health will be improved
 - Ecosystems will be restored
 - Energy innovations will decrease dependency on fossil fuels
 - Recent global warming will be reversed
 - Millennium Development Goals will be met

INTRODUCTION TO THE PROBLEM

Thinking globally... the influence of environment on cultural traditions is ancient. So, too, is the ability of our species to modify physical environments – visible faces of the Earth – on local and regional scales by the use of fire [and] agriculture.

- Lauret Savoy, "Stories of Land, Stories from Land"

Vertical Farming is an innovation that will not only revolutionize agriculture, but will also cause a resounding socio-political impact. Likewise, different socio-political climates will accept vertical farming more readily than others, depending on their differing perspectives, in particular: Geography, Economics, Government, Environmental Consciousness and Community-Level Activities.

DESCRIPTION OF THE PROJECT

This study examines both the acceptance and impact of vertical farming through five socio-political lenses; these are: Geography, Economics, Government, Environmental Consciousness, and Community-Level Activities. Using the aforementioned lenses we will analyze seven case studies of potential locations for vertical farms. The locations were chosen to be representative of various socio-economic levels, technological advancement, political histories, governmental systems and geographic characteristics. They are as follows: Japan, Iceland, China, Cuba, Mali, New York City, and a mobile floating farm. Through this careful analysis, we have identified and emphasized benefits of vertical

farming in context. We have also delineated suggestions for how vertical farming can be integrated into an assortment of governmental and economic systems. This study has also identified many positive impacts that vertical farming will have on the community level, such as improved health and nutrition.

DETAILED REPORT OF THE RESEARCH

POPULATION CRISIS

According to the United Nations Populations Division, the global population is projected to grow to approximately 8 billion people by 2025 and approximately 9.5 billion people by 2050. The current annual growth rate is approximately 80 million per year and should remain constant until 2015. Soon after, a gradual decline in the annual growth rate is expected to decrease to 50 million per year. The ten countries projected to contribute the most to population growth are India, China, Pakistan, Nigeria, Ethiopia, Indonesia, U.S., Bangladesh, Zaire, and Iran. The U.S. is expected to grow by 62 million in the next three decades and surprisingly Zaire, which few population experts would have predicted, is on the population watch list. Europe and Africa are expected to switch their current positions in their share of the global population by 2050. With dramatic shifts in populations globally, one would expect equal shifts in economies and social organization, resulting in shifts in demand and supply of resources and pressures on ecosystems. One study by the FAO projects that natural resources per head of the growing population will continue to decline into the future and yield growth potential of crops will become increasingly limited unless technology and human invention intervenes.

INDICES

When projecting possible locations for developing a vertical farm, a quantifiable measure is useful to generally compare one country to another. This study has derived a “Vertical Farm Viability Index” (VFVI) based on environmental, economic, and societal influences. The three indicators used for the VFVI are the Environmental Performance Index (EPI), gross domestic product per capita, and birth rate. The EPI, developed by the Center for Environmental Law and Policy at Yale University, measures a country’s environmental health and ecosystem vitality through six policy based categories. The EPI was chosen to reflect environmental consciousness and commitment. The second indicator, GDP per capita is used to measure the economic capabilities and resources of a country. The third indicator, birth rate, is used to assess reduction of population pressure and movement toward sustainability. The VFVI, based on these three categories, provides a basic tool in evaluating the practicality of a vertical farm in a given country. This study has also measured development throughout the world through a “Progress Index” (PI). The two indicators used for the PI are decline in birth rate and GDP growth rate. The decline in birth rate was calculated over a five year period from 2000 to 2005. The PI is a good reflection of a country’s dedication to development and possibly, its receptiveness to the vertical farm. A future project may be to divide the indices developed in this study into tertiles and produce a map displaying each country’s placement.

Then a map of hits produced by visits to the vertical farm website can be juxtaposed on the VFVI or PI map to compare interest in this project to viability or progress around the world. (See “Appendices”)

LENSES FOR ANALYSIS

In order to fully assess the successful implementation of the vertical farm in various global locations, five determinants are examined. These include geography, economics, government, environmental-consciousness and community impacts.

Geography

The geographic location and make-up of a country dictate how suitable the land will be for agriculture. Coastal countries have access to an irrigation system for farming along with a fishing industry while countries covered in desert lands struggle to sustain the population's food supply. In "The Geography of Poverty," Jeffrey Sachs cites a continuing trend of coastal lands being more developed than landlocked countries along with temperate climates maintaining a higher standard of life than tropical climates. The amount of arable land, access to trade and ubiquitous nature of infectious disease attribute to this difference between geographies. If geographic considerations affect the wealth of nations, they will surely affect the socio-political implications of a vertical farm. The prospect of vertical farming can prevent the ruin of crops from natural enemies such as hurricanes, typhoons, pests and droughts. It can provide sustainability in countries unsuitable for farming such as Iceland with its glaciers or Japan with its mountainous terrain. It would also allow over-farmed lands to replenish themselves. Yet the implementation of indoor communal farming will alter the population layout of a country. Their

placement in urban areas may cause an over-urbanization. City populations could potentially become too dense creating a host of new problems. Geography and climate are inherent to a country's position in our global community and must be accounted for in considering the future of vertical farming.

Economics

This section presents the economic implications from vertical farming beginning with a broad discussion of the scales of impacts and the major stakeholders involved followed by the evolution of the project as a course at Columbia University to the construction of the first commercial vertical farms in Japan and NYC in 2010, and finally its widespread adoption in major cities across the world in the 2050s.

VF is the second green revolution (GR) that has been called for by many scholars to address decreases in arable land area and the current rate of increase of crop yields, which is in decline, amidst an ever-growing population. The VF technology and philosophy can potentially surpass the achievements of the green revolution because unlike the GR, farmers utilize less land while increasing their capacity for crop output in an ecologically sustainable manner. The global economy will feel the influence of VF in incremental steps that begin in niche markets on local and regional scales and eventually reach the mainstream and world markets. Labor and trade shifts will occur, and food prices will be affected. The major stakeholders will be farmers, consumers, retailers

(supermarkets, grocery stores, street vendors, restaurants), distributors (food, agricultural inputs, equipment), agricultural-related service providers, landowners (non-farmers), states, and international organizations (IOs). Consumers and society will generally be the winners, but some unlikely winners and losers may arise from this revolutionary way of food production, waste management, and environmental thought.

The response to VF will vary from country to country and region to region. Developed countries may initially have the economic resources to invest in the first vertical farms and lead the way in the market, but the VF technology will diffuse to developing countries. In the long run, developing countries like China and less developed countries like Burkina Faso may achieve the comparative advantage of lower wages and large supplies of labor. On a local scale, since most VF projects are generally urban projects, a shift in migration patterns (labor driven) in the region will be observed from the rural areas with positive and negative outcomes. However, it is likely that economic needs and entrepreneurial spirit will drive innovation to conceive affordable vertical farms (i.e. mini-vertical farms at a fraction of the cost) in rural and geographically disadvantaged areas.

After several years of initial development in the Medical Ecology course at Columbia University, megalopolises such as Tokyo and New York City will launch the first commercial projects and test its viability. VF will be met with tough resistance from organic farmers and the

greenhouse farming industry, as it will initially compete with these niche markets. In 2005, the state of Colorado, which earns approximately 1.1 billion dollars from its greenhouse industry, would face a formidable challenge. Consumers would gain from these economic interactions, as the increasing competition would help to drive prices down for organic food products. Eventually the VF market would expand into the mainstream culture stimulating economic actions between all stakeholders as the concept of healthy foods, conservation of forests, and earning a profit becomes feasible.

VF would stimulate the reforestation market and afford farmers the option for alternative livelihoods by providing incentives (through government subsidies and private funding) for farmers to preserve forests and restore ecosystems on their plots of land. Farmers could tap into already existing financial and institutional programs such as carbon sequestration projects in developed countries and Clean Development Mechanism (CDM) projects, which facilitates participants in the Kyoto Protocol to offset their greenhouse gas emission output. In 2005, 164 CDM projects were registered globally (UNFCCC, 2005).

The commercial viability of VF and its global impact on the economy will be proven over several decades. Many major cities like Beijing, Havana, Bamako, and Reykjavik will adopt the VF technology as the investment costs decrease over time. Cities are likely to expand from shifts in migration driven by employment opportunities in the vertical farm

market and food product-related businesses (i.e. restaurants, groceries stores, distributors, farming equipment). Trade and regional and international trade agreements would be affected as certain states and possibly regions would minimize their dependency for imported food as it becomes economically efficient to grow their own food. Former “big” countries like the U.S. and Great Britain end up losing their share of the market. In contrast, states like Cuba and Iceland would likely gain from these outcomes.

Government

Institutions of national government, as well as vehicles for public participation in governmental decision-making, greatly impact the ability of a nation to adopt changing technologies. The governmental institution dictates the national budget, prioritizes plans for action and in many cases delineates land use. Local governments usually operate similarly to their national governments, but on a smaller scale. Therefore, governmental buy-in is necessary for a new project to best succeed and government buy-in should reflect the popular opinion.

The interest groups, political parties and the media are often key vehicles for expressing political behaviors and beliefs. Together, beliefs and behaviors can be considered the “political culture,” which in turn affect the public participation in government. Public participation varies in different political systems, such as: democracy, socialism, communism and constitutional monarchies.

In addressing the possibility of adopting vertical farming, nations must consider how best to “campaign” for a vertical farm in their given political climates. Questions that should be asked include: Who will pay for the vertical farm to be built? Will the vertical farm be publicly owned or privately owned? If privately owned, will any government subsidies be provided? If publicly owned, in what branch of government? Will the government be responsible for fair food distribution? All of these questions will lead to very different answers depending on the political culture. For example, a socialist or communist governmental system, such as Cuba or China, which have more control than say, democratic systems, might find it easier to organize leadership for vertical farms and distribution of crops from the vertical farms. In capitalistic democratic societies, such as the U.S., it might be better to have the farms privately owned in order to foster the economy. These questions will be addressed further in the discussion of the case studies to follow.

Environmental Consciousness

A large part of a nation’s receptiveness to the concept of vertical farming is its environmental consciousness, both on an individual and institutional level. To implement the ideas of vertical farming, a nation’s citizens, government, and private sector must accept a social responsibility for the environment. Each part of society will have a different role depending on the nation’s social structure. Most of a nation’s environmental consciousness is reflected in its policies. A clear indicator

of environmental consciousness is a nation's adherence to and progress toward the Millennium Development Goal of ensuring environmental sustainability. As stated in the 2005 Environmental Sustainability Index Report, a country's potential for environmental sustainability is increased by the extent that it has in place institutions and underlying social patterns of skills, attitudes, and networks that foster effective responses to environmental challenges. A nation is also more likely to be sustainable if it cooperates with other countries to manage common environmental problems. Therefore, when evaluating the environmental consciousness of a nation, it is important to look at the social and institutional capacity as well as its global stewardship.

Primary factors inhibiting environmental consciousness include short-term thinking and ignorance. To overcome these hurdles, a society must be educated in environmental awareness. Similar to the effects of Silent Spring by Rachel Carson, a "rude awakening" to the issues regarding sustainability must change current attitudes so that there will be an increased responsiveness to radical ideas such as the vertical farm. Awareness must be taught on a multi-level basis so that it covers all tiers of society.

Community-Level

In addition to improving the standard of living, vertical farming will significantly impact the economic and political structures of local communities.

In large urban cities like New York, a vertical farm would reduce the amount of harmful emissions in the air and consequently a lower the incidence of respiratory illness. Improved waste management practices that the vertical farm will employ will reduce vermin and household pests and ultimately improve the health of neighborhood residents, particularly children. A vertical farm will also lessen the disparity in access to healthy food sources in low income urban areas, which will help residents to achieve or maintain healthy eating habits.

In less developed countries, vertical farming will produce a reliable food supply which will decrease developing countries' dependence on surpluses from industrialized countries or food aid. It will also allow for a healthier lifestyle, decreased malnutrition and infant mortality and increased life expectancy.

The impact of HIV/AIDS has been identified as a main cause of continued food insecurity in developing countries, as families have to deplete their savings and assets to pay for the care and treatment of a family member which significant reduces their ability to adequately feed their family. Vertical farming can be incorporated into strategies addressing food insecurity and lessen the economic impact of HIV/AIDS.

Vertical farming also has the potential to reduce incidence of diseases related to unsafe water and poor sanitation. Additionally, because varieties of fowl could be raised on and marketed from vertical

farming, vertical farming can replace unsanitary fresh fowl markets thus eliminating the local threat of avian flu.

Vertical farming can also have an impact on local unemployment and income levels. It can also be used a site for vocational training and, in countries where women lack economic opportunities, vocational training can provide them with the ability to generate income and have more social status in the community. However, there will have to be a certain amount of social preparation in order to ensure that all community members will equally benefit from vertical farming. Without adequate social preparation increased yields cannot be apportioned in an equitable manner. Thus, in order to be successful, vertical farming will have to will have to go hand in hand with efforts to achieve social balance and gender equality to ensure that all strata of society will benefit.

CASE STUDIES

Case studies were selected to be representative of varying degrees of each specific lens. Since each lens affects the implications of vertical farming, it was important to see different examples of government, geography, economics, environmental consciousness and community characteristics displayed in each case study. Both socialist and capitalist economies were studied, for example, along with both island and landlocked nations.

Japan

Japan has a very unique geographic profile. It is an island country of over 3000 islands located in the Pacific Ocean off the coast of China. The country is dominated by mountains on 73% of its land area making the majority of Japan unsuitable for residential, industrial or agricultural use. Additionally, it is plagued by climatic variability, heavy rain, typhoons, earthquakes and landslides. Its location on the Pacific Rim of Fire makes it particularly vulnerable to earthquakes and tsunamis because it is at the juncture of three tectonic plates. Therefore, what little land available is vulnerable to environmental disasters, and the habitable areas (mostly coastal) have extremely high population densities. Indeed, worldwide, Japan is ranked the 18th most densely populated country.

Despite the fact that only 15% of the land in Japan is suitable for cultivation, the agricultural sector has enjoyed relative success. In fact, it has one of the highest levels of productivity per unit area in the world.

Still, the agricultural sector is small and must be highly subsidized and protected by governmental regulation that favors small-scale farmers. The most protected crop is rice, as evidenced by the government's high tariffs (up to 490%) and limitations on rice imports (only 3% of the total rice market can be imported). Nevertheless, Japan is dependent on imports for about 50% of other crops, such as soybeans, wheat and sorghum.

Japan is a highly technological country with a thriving economy, despite its downfall following the Second World War and is a leader of the East Asia fuel trading system. Throughout history, the economic sector has changed significantly in Japan. In the late 19th century, over 80% of employment was accounted for by three sectors: agriculture, fishing and forestry. These sectors continued to dominate until the 1940s. During the prewar period, employment in agriculture declined, yet still remained the largest employer with about 50% of the total work force. However, by the end of WWII, agriculture began its decline to relative unimportance and by 1988, it accounted for only 7.2% of employment. As agricultural employment decreased, remaining farmers also moved further from agriculture. It is estimated that by the late 1980s, 85.5% of Japanese farmers were employed in a supplemental occupation through which they earned the majority of their income.

Japan is classified as a constitutional monarchy and is ruled by an emperor, but governmental power is largely held by politicians, bureaucrats and business executives. This economic/governmental

profile would lend itself well to a privately owned vertical farm with government provided subsidies and tax incentives. To further involve the government, the farms could have a board of directors and on each board, one member of government.

Japan would be an ideal location for adoption of vertical farming because the nation is environmentally conscious and interested in environmental research and technology, especially in the private sector. On the community level, the fishing industry would not be impacted by vertical farming, because the farm cannot support salt-water fish, which is a favorite among the Japanese populace. However, the people do consume a great deal of vegetables and other seafood, which could be grown in the vertical farm. This would help to cut down on imports from other countries. Finally, the farm would be extremely attractive and therefore improve the attractiveness of the local environment, particularly in the cities, where the farms would ideally be built. It would also generate a revival of the agricultural sector of the economy.

Still, a few considerations must be kept in mind. First, Japan is already largely urbanized, and urban vertical farms might further urbanize the population. Second, building space is expensive in Japanese cities, so it might be difficult to find land on which to build the farms.

Iceland

Similar to Japan, Iceland is an island nation with little land available for agriculture. Over eleven percent of Iceland is a glacier and the interior

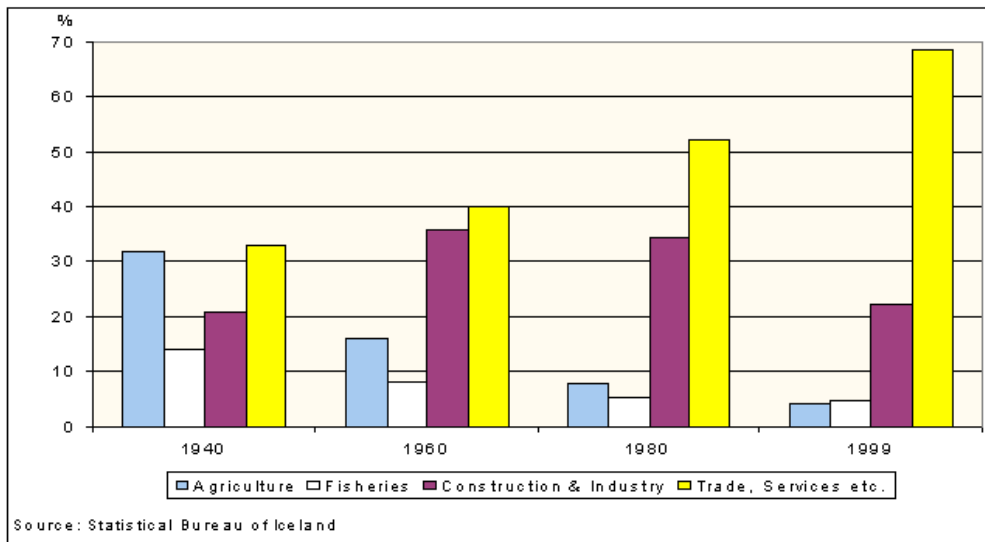
is a cold, uninhabitable desert. In fact, glaciers cover about 4500 square miles. This creates the threat of avalanches, particularly in the northwest, north and east. Because of this, the population along the coast is dense, but with almost four-fifths of the country uninhabited, Iceland nevertheless has a population density of only seven inhabitants per square mile, making it the most sparsely populated country in Europe.

The country benefits from its geography – it is a geological hotspot, which currently generates 99% of its electricity from geothermal and hydropower. By 2050, Iceland plans to generate all of its power from geothermal resources. This refusal to rely on fossil fuel exemplifies Iceland's environmental consciousness.

Common sayings in Iceland including “If you don't like the weather, just wait five minutes,” and “there is no weather in Iceland, only samples,” demonstrate the rapid fluctuations of weather in Iceland. The country's location causes polar fronts to separate air currents of tropical and polar origin, creating a cool temperate climate overall. The Arctic drift ice also impact the weather in Iceland, causing considerable temperature drops and decreases in precipitation making fluctuations in annual average temperature much more pronounced in Iceland. Another unique characteristic of Iceland's climate is that there is continuous daylight for two to three months in the summer. Contrastingly, from mid-November until the end of January, there are only three to four hours of daylight.

Because of the glaciated land, there is a very limited amount of land available for agriculture and that land is mostly used for growing grass to make hay for livestock. Indeed, as in Japan, the agricultural sector of the economy has been shrinking in Iceland and trade has increased, as demonstrated by the following graph.

Percentage division of manpower by industry 1940 - 1999



Agriculture in Iceland is based mainly on garden vegetables such as cabbage, rhubarb, potatoes and cauliflower, while other vegetables and southern fruits are mostly imported. Because the climate is harsh, a great deal of farming is done in greenhouses, especially for tomatoes, cucumbers, mushrooms, peppers and flowers. The greenhouses are heated using geothermal energy. This same energy could be extremely beneficial for powering vertical farms.

Like Japan, agriculture was a prominent occupation in the mid 19th century, with almost 80% of the nation engaged in farming, but by 2002, only 3.9% of the labor force was involved in farming. Today there is a

large discrepancy between demand of fruits and vegetables and the available supply. Because of this, much of the fruits and vegetables are imported, creating a very costly situation for consumers. Indeed, agricultural prices are much higher in Iceland than in other Nordic countries, and significantly higher than in the rest of Europe. Additionally, a great deal of treasury spending is used for government subsidies.

Fishing is important to Iceland and the Icelandic Ministry of Fisheries is responsible for maintaining sustainable fishing. In an effort to achieve this, the country is already involved in highly technological farm raising of fish, including Tilapia, which could be grown in vertical farms.

Due to Iceland's harsh interior climate, vertical farming would be very beneficial economically. It could decrease Iceland's import of fruits and vegetables and also increase the fish farming industry. It also would not be so different from the greenhouses already being used, because essentially the vertical farms could be marketed as stacked, sustainable greenhouses. Similar to Japan, the people of Iceland consume a great deal of fish, but largely prefer salt-water fish, so the culturally-revered fishing industry would again, not be negatively impacted by vertical farming. Iceland has also seen a move toward organic farming, which would be supported and fostered by vertical farming.

Ecological and organic production
 - No. of producers and processing plants*

	01.01.98	01.01.99	01.01.00
Producers - Ecological production	157	195	195
Producers - Organic production	28	30	30
Processing Plants - Organic production	5	7	7
*Units which the Ministry of Agriculture has certified for production and/or processing of ecological or organic products. Production quantity not available.			

Source: Ministry of Agriculture

Iceland has a considerable amount of governmental regulation of environmental priorities, therefore, the constitutional republic of Iceland could promote and organize the planning and organization of vertical farms, as well as monitor crop distribution. Iceland has a parliamentary government with a written constitution and a directly elected president, however, most of the power is held by the Government, which is elected every four years, separately from the presidential elections.

The Farmers Association of Iceland was established in 1995 and all farmers are members. The association is a vehicle for policy making and also provides information and recommendations to public authorities and Government. The Farmers Association could help to encourage the government to provide subsidies for building the farms.

While overwhelmingly beneficial, vertical farms in Iceland do present some considerations. Sunlight, for example, fluctuates greatly between summer and winter months in Iceland, so the farms will have to be built with lighting systems that can adjust for these changes. Vertical farms should also be built in areas that are not susceptible to avalanches. Additionally, Icelandic farming does generate excess for certain crops.

The benefit of vertical farming would be to grow those crops for which Iceland has become internationally dependent.

China

Beijing is the industrious capital of the People's Republic of China. At the turn of the 21st century, the population was approximately 14 million people. Studies show that this city's population will continue to grow in large increases--even though it is experiencing a low natural growth rate--because of its massive base population and increasing levels of migration to the city driven by a thriving market economy. This will prove challenging as the government is already facing issues of urbanization, environmental degradation, and loss of biodiversity.

Vertical farms will play an important role in addressing existing issues and thus, help maintain and boost the Beijing and Chinese economy as well as create sustainable energy practices in business and promote healthier societal habits. One possible impact will likely affect Beijing's grain output, which totaled 1.442 million tons in 2000. It is likely that the coupled efforts of the VF market and Beijing's massive labor supply will help facilitate an increase in its output capability. Unfortunately, land-use changes and consequential impacts (good and bad) will continue to occur as the population increases within the city and its suburbs. However, VF will profoundly impact the environmental consciousness of the Beijing community and support existing environmental movements like protecting ancient forests and galvanize

new movements such as the eradication of toxins in food.

Cuba

Cuba is the only state in the western hemisphere that is not a multiple democracy. Fidel Castro took over as prime minister of Cuba in 1959 and declared the Communist party the only legal party in 1961 in accordance with the alliance with the Soviet bloc. Castro's rule is about to come to an end though and he named his brother Raul as his successor. Whether the transfer of power will occur so smoothly remains in question. Cuba's domestic opposition seeks a full transformation and has gained momentum in their movement in recent decades. Since government runs and controls most means of production and employs 90% of the state, a change in government could cause many unforeseen problems. Since the Soviet collapse, there has been a recent increase in GDP throughout Cuba mostly due to new economic practices.

There exists a dual economy in Cuba between the peso and the dollar currency. The peso applies to most Cubans providing them with free education, healthcare and basic necessities of life. The dollar applies to the tourism, export and international sectors of the economy. With the dissolution of the Soviet bloc in the early 1990's, the GDP of Cuba fell about 35% and the economy fell into a dire recession. To help the market back to its 1989 state, Castro implemented many changes. He opened the country up to tourism, allowed foreign investments, legalized the dollar and authorized limited self-employment. Working against these changes

were the lower sugar prices, increased petroleum prices, the decreased tourism after September 11th and hurricane damage which only added to the food shortage. Current plans to revamp the sugar industry include closing many of the mills leaving thousands jobless. Much of the Cuban economy currently comes from exile remittances so along with tourism there was more dollar currency floating around. In order to capture the dollar back into the economy, Cuba set up dollar stores that sold food, household and clothing items. Due to the lack of availability of these goods in state-run stores, many of them are also bought on the black market.

Cuba would be ideal for implantation of vertical farming because it has already made great progress in the direction of alternative farming methods. The government was heavily dependent on Soviet subsidies for agriculture and there was a 50% reduction in oil, fertilizer and pesticide imports after the fall. Popular urban garden have become more common in Havana. They are small parcels of land which are state owned but cultivated by community groups to help with the food shortage. They cultivate fruits and vegetables along with spices and plants for medicinal purposes. Productivity has been achieved with few external inputs and organic farming techniques are utilized at low costs. Of course there are constraints such as the scarcity of water, the poor quality of the topsoil and urban litter but these are problems that are solved through implementation of vertical farming.

The effects of vertical farming in terms of government are very unclear. With a change of regime, the government subsidies to production and the urban farms could come to an end. Yet if 'fidelismo' continues after Fidel, his movement towards organic and government subsidized small farms could pave the path towards the implementation of vertical farming.

The economic recession caused a food shortage which would be greatly improved by the vertical farm. The country could revamp the agricultural sector and have less dependency on other nations for food imports. It could also create less dependency on the dollar so state-run farms could provide the population with food rather than dollar-stores. This could potentially close the ever-increasing gap between those who have the dollar and those who don't. Finally in terms of economics, the falling sugar industry could again become a mainstay crop. With thousands losing jobs at sugar mills, vertical farms would provide these sugar workers with new jobs. Sugar prices would again stabilize and help bring the economy out of recession.

Cuba's geography consists of arable rolling hills making it ideal for cultivation. Yet it is also an island country in the Caribbean making it highly susceptible to hurricanes and high winds. Vertical farming would allow for yearlong crop growth and would prevent natural disasters from destroying the fertile land. The island nation also has extensive biodiversity in its marine life and higher plants. With the overuse of land

and use of fossil fuels, this biodiversity is at risk. Vertical farming would allow for replenishment of land and would utilize alternative energy sources keeping the air and water clean.

Vertical farming is a distinct possibility in Cuba. While only 2% of Latin America's population lives in Cuba, 11% of its scientists reside there along with a well-developed research infrastructure. Prior to the Soviet Collapse, Cuba enjoyed a high per capita GDP, high life expectancy, low infant mortality and a highly cultural population. The implementation of vertical farming would help the economics and standard of living but would also bring a renewed solidarity and sense of purpose during this economic crisis.

Mali

Mali's geography and topography pose significant obstacles to agriculture production and its ability to sustain an adequate food supply for its people. Thus, it would be an ideal country in which to implement vertical farming. Mali is a landlocked country in West Africa with a total surface area of 1.22 million square km. with more than sixty percent of the country in desert or semi-desert zones. The average annual rainfall in the southern region is about 55 inches and only eight inches in the northern region. Less than four percent Mali's area can be classified as arable land.

Between 70 to 80 percent of Mali's labor force is engaged in farming and fishing. Agricultural production of cereals dominates 90% of

the 1.4 million hectares (3.4 million acres) under cultivation. Fishing is also an important economic activity; however because of pollution and the construction of dams the fishing industry has been in decline since the early 1980s.

Deforestation is a serious problem in Mali, as more than six million tons of wood are used annually to meet Mali's energy needs resulting an annual loss of 400,000 hectares of tree cover. Vertical farming would reduce Mali's reliance on timber wood for its energy needs for agriculture production.

Mali encourages foreign investments and joint ventures. Foreign investors do not face unfavorable tax treatment or discriminatory import/export policies, or tariff or non-tariff barriers. Mali guarantees the repatriation of capital and profit. Foreign investors can own 100 percent of any businesses they create.

The Chinese are major participants in the textile industry and in large-scale construction projects, including a bridge across the Niger and an expressway in the capital city of Bamako. Working with international investors, Mali is seeking to achieve self-sufficiency in cement and sugar, two commodities it currently acquires largely through imports (98 percent of cement and 80 percent of sugar are imported).

Mali is an independent republic with a constitution that provides for a multiparty democracy Mali's per capita gross domestic product (GDP) of

\$250 (2002) places it among the world's 10 poorest nations and its health and development indicators rank among the worst in the world.

Three decades of population growth, low rainfall, non-sustainable exploitation of natural resources, and a lack of environmental awareness has caused severe natural resources degradation and dramatic declines in agricultural production. Mali faces numerous environmental challenges, including desertification, deforestation, soil erosion, drought, and inadequate supplies of potable water.

The people of Mali face numerous health challenges related to poverty, malnutrition, and inadequate hygiene and sanitation and lack of access to safe drinking water. The people of Mali would greatly benefit from the evapotranspiration process used in vertical farming, as it would increase the availability of potable water.

According to a World Bank report, efforts to promote gender equality and empower women are a key component of the fight against poverty. Vertical farming would not only provide local employment, but it could also be used as a facility to provide vocational training, especially for women, increasing their income-generating potential and allowing greater participation in power structures and economic decision-making. These improvements in the socio-economic status women in Mali would improve household and community food security and reduce gender inequities.

In May 2002 the Government of Mali published its Strategic Framework for Poverty Reduction with the general objective of reducing

poverty by one third within six years. To achieve this objective, the strategy includes actions with the aims of ensuring strong and sustainable growth and wealth redistribution for the benefit of the poor, putting in place economic and human development policies centered on the needs of the poor, consolidating democratic and participatory governance, and promoting employment and social protection measures. The implementation of vertical farming in Mali could help the country reach these goals.

New York City

New York City's urban landscape and dense population make it an ideal setting for vertical farming. A sustainable food source within the city limits would help provide fresh produce to the community while reducing the transportation costs of importing food from outside farms. Vertical farming would also reduce the amount of waste produced by such a large population by converting it to energy. NYC's nearly 18,000 restaurants would be able to sell their waste to the vertical farms thereby generating additional income and spurring the economy. This efficient management of waste would also help control vermin by reducing the amount of organic byproducts sitting out on the streets. Vertical farms would also produce jobs for low income populations and bring people together through a shared project that benefits their community. From a public health standpoint, vertical farms may help reduce obesity, diabetes, and cardiovascular disease by providing healthier food choices at a lower

price. Vertical farms could not only educate people on sustainability and ecology but also on nutrition and healthy living. NYC, recently ranked in the top ten greenest cities in America, has an environment that is receptive to the concept of vertical farming and would foster the support of the community.

When planning a vertical farm in NYC, an important consideration to take into account is the cultural diversity of the population. A vertical farm's crops should satisfy a variety of diets or be modified to a specific community. A possible challenge of the vertical farm will be overcoming opposition from agro businesses. Lobbying from these interest groups will slow down legislation supporting the vertical farm. The use of vertical farms will also take away jobs and the livelihood of local farmers, who may not necessarily be able to move into NYC because of the already crowded conditions. These challenges must be overcome for successful implementation of vertical farms in NYC.

Floating Vertical Farm

Vertical farms do not necessarily have to be built on land. An extremely innovative revolution of vertical farming would be to built the farms at sea in the form of a ship. The ship could be based twelve miles off-shore in the tropics where the weather is calm. This would be necessary because of the continental shelf, and also to avoid dangerous weather conditions, such as hurricanes.

Floating vertical farms would provide a tremendous amount of benefits in addition to the benefits of traditional vertical farms. The power for the farm could be generated by the ocean. The difference in temperature between the surface (about 90 degrees) and the ocean floor (about 40 degrees) provides a power gradient, which would generate free energy to power the farm.

Another benefit is that the farms could be internationally owned (by the United Nations, for example) and be helpful in times of crisis or famine, when the farms could move to the affected location and provide nutritious food for the affected peoples.

Finally, if internationally owned, the floating vertical farms could be economically beneficial when not needed for crises situations: they could foster international trade and cooperation.

CONCLUSIONS

Adoption of vertical farming is a complex process that requires careful analysis and planning from the five perspectives delineated in this report (geography, economics, government, environmental consciousness and community). These responses must be understood and prepared for prior to the construction of vertical farms and the vertical farms must be tailored to fit the characteristics in their given locations.

Vertical farming will revolutionize the agricultural sector of the economy. It will also transform geography, minimizing agricultural susceptibility to climate variability, improving ecosystem sustainability and regenerating ecosystem function and service. Vertical farming will also aid government by helping to achieve governmental goals such as poverty reduction and food security. It will help to protect resources, improve waste management practices and foster environmental stewardship, as well as increase the standard of living and socio-economic equality. However, none of these benefits can be achieved if the five sectors described in this report do not work cooperatively to decide how best to run vertical farms in specific locations.

ISSUES

While the benefits of vertical farming are undeniable, a number of issues must be overcome before the farms can be successfully adopted in various locations. Vertical farming will be region-specific according to economics, geography, government and culture, as such, issues presented cannot be uniformly addressed. Some issues that each location must consider include: challenges of obtaining funding; how best to involve traditional farmers, who might otherwise be hurt by an influx of vertical farms; a probable shift in politics with regard to the agricultural sector of the economy, as well as a temporary shift in trade; farms must be situated in locations that are relatively free from risk of environmental hazards/disasters (such as avalanches in Iceland, or earthquakes in Japan).

Finally, certain interest groups may present opposition during the initial adoption of vertical farming for various reasons. They may believe that their livelihoods will be hurt, or perhaps they are opposed to such a dramatic move from traditional farming. These interest groups should be included in negotiations on how best to integrate vertical farming into their respective environments.

FUTURE OUTLOOK

Vertical farming will provide substantial long-term socio-political benefits that will improve the condition of the world. Based on this report, it is projected that vertical farming will: cause population growth to stabilize; transform the agricultural sector of the economy; achieve food security; improve nutrition and health; restore ecosystems; decrease dependency on fossil fuels; reverse recent global warming; and help to achieve the Millennium Development Goals. Indeed the goals are as follows:

1. *Eradicate extreme poverty and hunger*
2. *Achieve universal primary education*
3. *Promote gender equality and empower women*
4. *Reduce child mortality*
5. *Improve maternal health*
6. *Combat HIV/AIDS, malaria and other diseases*
7. *Ensure environmental sustainability*
8. *Develop a global partnership for development*

According to Jeffrey Sachs, meeting these eight goals are targets to cut poverty in half. In his book The End of Poverty, he limits “the end of poverty” to include to “end the plight of one sixth of humanity that lives in extreme poverty and struggles for daily survival” and “to ensure that all of the world’s poor, including those in moderate poverty, have a chance to climb the ladder of development (pg. 25).” He says:

Our generation is heir to two and a half centuries of economic progress. We can realistically envision a world without extreme poverty by the year 2025 because technological progress enables us to meet basic human needs on a global scale and to achieve a margin above basic needs unprecedented in history. The technological progress has been fueled by ongoing revolutions in basic science and spread by the power of

global markets and public investments in health, education and infrastructure.

- Jeffrey Sachs, The End of Poverty (pg. 347)

Sachs calls on our generation to do our part to promote social progress “in which science and technology could be harnessed to achieve sustained improvements in the organization of social, political and economic life (pg. 347)” through the following work:

- *To help foster political systems that promote human well-being based on the consent of the governed.*
- *To help foster economic systems that spread the benefits of science, technology, and the division of labor to all parts of the world*
- *To help foster international cooperation in order to secure a perpetual peace*
- ***To help promote science and technology, grounded in human rationality, to fuel the continued prospects for improving the human condition*** (pg. 352)

Vertical farming will help our generation to fulfill all of our aforementioned responsibilities, especially our responsibility of promoting science and technology to improve the human condition. Indeed vertical farming is the hope for the future of this planet to sustain our environment and ourselves.

REFERENCES

Beijing. United Nations Economic and Social Commission for Asia and the Pacific.

<<http://www.unescap.org/esid/psis/population/database/chinadata/beijing.htm>>. April 20 2006

Bureau of African Affairs US Department of State (April 2006)

<<http://www.state.gov/r/pa/ei/bgn/2828.htm>>.

Chaplowe, Scott G. (1996). Havana's Popular Gardens: Sustainable Urban Agriculture. World Sustainable Agriculture Association.

<<http://www.cityfarmer.org/cuba.html>>. April 20 2006

Clean Development Mechanism. United Nations Framework Convention on Climate Change. <<http://cdm.unfccc.int/>>. April 24 2006

College Board AP. "Government and Politics."

<http://www.collegeboard.com/prod_downloads/ap/students/govpol/ap-cd-govpol-0607.pdf>.

Cuba Sustainable Agriculture Study Tour. Washington State University: Center for Sustaining Agriculture and Natural Resources.

<<http://csanr.wsu.edu/Cuba/CubaTripReport2003-09-09.pdf>>. April 20 2006

Colorado Agriculture Brochure. State of Colorado Agricultural Department.

<<http://www.ag.state.co.us/mkt/brochures/coloag.html>>.

April 24 2006

Cuba. CIA Database.

<<http://www.cia.gov/cia/publications/factbook/geos/cu.html>>. April 20 2006

Cuba. Country Health Indicators. World Health Organization.

<<http://www3.who.int/whosis/country/indicators.cfm?country=cub>>. April 20 2006

Cuba's Economy.

<<http://www.globalsecurity.org/military/world/cuba/economy.htm>>.

April 20 2006

Esty, Daniel C., Marc Levy, Tanja Srebotnjak, and Alexander de Sherbinin (2005). *2005 Environmental Sustainability Index: Benchmarking National*

Environmental Stewardship. New Haven: Yale Center for Environmental Law & Policy.

The Farmers Association of Iceland. "Icelandic Agricultural Statistics 2000."
<<http://www.landbunadur.is/landbunadur/wgbi.nsf/key2/icelandicagric2000>>.

Heilig, Gerhard K. (1996). *World Population Prospects: Analyzing the 1996 UN Population Projections*. International Institute for Applied Systems Analysis.
<<http://www.iiasa.ac.at/Research/LUC/Papers/gkh1/chap1.htm>>.
April 20 2006

The Icelandic Brand Tilapia. <<http://www.icelandic.com/ss-tilapia.cfm>>.

Iceland Naturally. "Celebrating Over a Century of Icelandic Settlement in British Columbia." <<http://www.icelandnaturally.com/victoria.shtml>>.

Iceland Naturally. "Country information."
<<http://www.icelandnaturally.com/abouticeland.shtml>>.

Iceland Naturally. "The Fresh Foods of Iceland."
<<http://www.icelandnaturally.com/food.shtml>>.

Information Center of the Icelandic Ministry of Fisheries.
<<http://www.fisheries.is/>>.

Jeffrey Sachs, *The End of Poverty* (New York: Penguin Press, 2005)

Kipen, Nicki. "The Top Ten Greenest Cities."
<<http://www.homestore.com/homefinance/realestatenews/general/greencities.asp?gate=aolrealestate&source=a11461&poe=homestore>>.

Lauret Savoy, "Stories of Land, Stories from Land" in *The Earth Around Us, Maintaining a Livable Planet*, ed. Jill S. Schneiderman. W.H. Freeman and Company. New York, NY. 2000. pg. 28. UN World Food Programme, Food Security Overview, January 2006

Mali Ministry of the Environment
<http://www.mongabay.com/reference/country_profiles/2004-2005/Mali.html>.

The Ministry for Foreign Affairs of Iceland. "Agriculture."
<<http://www.iceland.is/economy-and-industry/agriculture//nr/29>>.

NYC and company.

<<http://www.nycvisit.com/memberSearch/searchRestaurant.cfm?pagePkey=17>>.

Peace Corps

<<http://www.peacecorps.gov/index.cfm?shell=learn.wherepc.africa.mali>>.

Prospects for aggregate agriculture and major commodity groups, Chapter Three. World Agriculture: Towards 2015/2030. Food Agriculture Organization.

<www.cema.edu.ar/~dm/Aspectos_Generales/FAO._Prospects_for_Aggregate_Agriculture_and_Major_Commodit.pdf>. April 20 2006

Rosset, Peter M. (2000). Cuba: A Case Study of Sustainable Agriculture. Cuba Organic Support Group. <<http://www.cosg.org.uk/rosset.htm>>. April 20 2006

UN Millennium Development Goals. "What are the Millennium Development Goals?" <<http://www.un.org/millenniumgoals/>>.

UN World Food Programme, Food Security Overview, January 2006

US Department of State. <<http://www.state.gov>>.

US Embassy in Mali <<http://w3.usa.org.ml/investment.html>>.

Waggoner, Paul E. (2004). Agriculture technology and its societal implications. *Technology in Society*. 26: 123-136

Wikipedia. "Agriculture, Forestry, and Fishing in Japan."

<http://en.wikipedia.org/wiki/Agriculture%2C_forestry%2C_and_fishing_in_Japan>.

Wollenweber B., Porter John R., Lubberstedt T. (2005). Need for multidisciplinary research towards a second green revolution. *Current Opinion in Plant Biology*. 8: 337-341

APPENDICES

Appendix A: Vertical Farm Viability Index

	EPI	EPI index	Birth Rate/1000	Birth Rate Index	GDP	GDP Index	Summation of Indices	VF Viability Index
Albania	68.90	0.6934	15.11	0.8385	4900.00	0.1029	1.6348	0.5449
Algeria	66.20	0.6501	17.14	0.7907	7200.00	0.1579	1.5987	0.5329
Angola	39.30	0.2183	45.11	0.1323	3200.00	0.0622	0.4128	0.1376
Argentina	77.70	0.8347	16.73	0.8004	13700.00	0.3134	1.9484	0.6495
Armenia	63.80	0.6116	12.07	0.9101	5300.00	0.1124	1.6341	0.5447
Australia	80.10	0.8732	12.14	0.9084	32000.00	0.7512	2.5328	0.8443
Austria	85.20	0.9551	8.74	0.9885	32900.00	0.7727	2.7162	0.9054
Azerbaijan	55.70	0.4815	20.74	0.7060	4700.00	0.0981	1.2856	0.4285
Bangladesh	43.50	0.2857	29.80	0.4927	2100.00	0.0359	0.8143	0.2714
Belgium	75.90	0.8058	10.38	0.9499	31900.00	0.7488	2.5044	0.8348
Benin	58.40	0.5249	38.85	0.2797	1100.00	0.0120	0.8165	0.2722
Bolivia	63.40	0.6051	23.30	0.6457	2700.00	0.0502	1.3011	0.4337
Brazil	77.00	0.8234	16.56	0.8044	8400.00	0.1866	1.8144	0.6048
Bulgaria	72.00	0.7432	9.65	0.9670	9000.00	0.2010	1.9112	0.6371
Burkina Faso	43.20	0.2809	45.62	0.1203	1200.00	0.0144	0.4155	0.1385
Burundi	51.60	0.4157	42.22	0.2003	600.00	0.0000	0.6161	0.2054
Cambodia	49.70	0.3852	26.90	0.5610	2200.00	0.0383	0.9845	0.3282
Cameroon	54.10	0.4559	33.89	0.3964	1900.00	0.0311	0.8834	0.2945
Canada	84.00	0.9358	10.78	0.9404	32900.00	0.7727	2.6490	0.8830
Central African Republic	57.30	0.5072	33.91	0.3960	1100.00	0.0120	0.9151	0.3050
Chad	30.50	0.0770	45.73	0.1177	1800.00	0.0287	0.2235	0.0745
Chile	78.90	0.8539	15.23	0.8357	11300.00	0.2560	1.9456	0.6485
China	56.20	0.4896	13.25	0.8823	6300.00	0.1364	1.5082	0.5027
Colombia	80.40	0.8780	20.48	0.7121	7100.00	0.1555	1.7456	0.5819
Congo (Republic of the)	49.40	0.3804	42.57	0.1921	700.00	0.0024	0.5749	0.1916
Costa Rica	81.60	0.8973	18.32	0.7629	10100.00	0.2273	1.8875	0.6292
Côte d'Ivoire	57.50	0.5104	35.11	0.3677	1500.00	0.0215	0.8997	0.2999
Cuba	75.30	0.7961	11.89	0.9143	11600.00	0.2632	1.9736	0.6579
Cyprus	78.40	0.8459	12.56	0.8985	21600.00	0.5024	2.2468	0.7489
Czech Republic	86.00	0.9679	9.02	0.9819	18100.00	0.4187	2.3684	0.7895
Democratic People's Republic of Korea	75.20	0.7945	10.00	0.9588	20400.00	0.4737	2.2270	0.7423
Democratic Republic of the Congo	46.30	0.3307	43.69	0.1657	800.00	0.0048	0.5012	0.1671
Denmark	84.20	0.9390	11.13	0.9322	33400.00	0.7847	2.6559	0.8853
Dominican Republic	69.50	0.7030	23.22	0.6476	6600.00	0.1435	1.4942	0.4981
Ecuador	75.50	0.7994	22.29	0.6695	3900.00	0.0789	1.5478	0.5159
Egypt	57.90	0.5169	22.94	0.6542	4400.00	0.0909	1.2620	0.4207
El Salvador	63.00	0.5987	26.61	0.5678	5100.00	0.1077	1.2742	0.4247
Ethiopia	36.70	0.1766	37.98	0.3001	800.00	0.0048	0.4815	0.1605
Finland	87.00	0.9839	10.45	0.9482	30600.00	0.7177	2.6499	0.8833
France	82.50	0.9117	11.99	0.9120	30000.00	0.7033	2.5270	0.8423
Gabon	73.20	0.7624	36.16	0.3430	5800.00	0.1244	1.2298	0.4099

Gambia	52.30	0.4270	39.37	0.2674	1800.00	0.0287	0.7231	0.2410
Georgia	61.40	0.5730	10.41	0.9492	3300.00	0.0646	1.5868	0.5289
Germany	79.40	0.8620	8.25	1.0000	29800.00	0.6986	2.5605	0.8535
Ghana	63.10	0.6003	30.52	0.4758	2400.00	0.0431	1.1191	0.3730
Greece	80.20	0.8748	9.68	0.9663	22800.00	0.5311	2.3722	0.7907
Guatemala	68.90	0.6934	29.88	0.4908	5200.00	0.1100	1.2943	0.4314
Guinea	49.20	0.3772	41.76	0.2112	2200.00	0.0383	0.6266	0.2089
Guinea-Bissau	46.10	0.3274	37.22	0.3180	800.00	0.0048	0.6503	0.2168
Haiti	48.90	0.3724	36.44	0.3364	1600.00	0.0239	0.7327	0.2442
Honduras	70.80	0.7239	28.24	0.5294	2800.00	0.0526	1.3060	0.4353
Hungary	77.00	0.8234	9.72	0.9654	16100.00	0.3708	2.1596	0.7199
Iceland	82.10	0.9053	13.64	0.8731	34900.00	0.8206	2.5990	0.8663
India	47.70	0.3531	22.01	0.6761	3400.00	0.0670	1.0962	0.3654
Indonesia	60.70	0.5618	20.34	0.7154	3700.00	0.0742	1.3514	0.4505
Iran (Islamic Republic of)	70.00	0.7111	17.00	0.7940	8100.00	0.1794	1.6845	0.5615
Ireland	83.30	0.9246	14.45	0.8540	34100.00	0.8014	2.5800	0.8600
Israel	73.70	0.7705	17.97	0.7712	22300.00	0.5191	2.0608	0.6869
Italy	79.80	0.8684	8.72	0.9889	28400.00	0.6651	2.5224	0.8408
Jamaica	74.70	0.7865	20.82	0.7041	4200.00	0.0861	1.5767	0.5256
Japan	81.90	0.9021	9.37	0.9736	30700.00	0.7201	2.5958	0.8653
Jordan	66.00	0.6469	21.25	0.6940	4800.00	0.1005	1.4413	0.4804
Kazakhstan	63.50	0.6067	16.00	0.8176	8800.00	0.1962	1.6205	0.5402
Kenya	56.40	0.4928	39.72	0.2592	1200.00	0.0144	0.7663	0.2554
Kyrgyzstan	60.50	0.5586	22.80	0.6575	1800.00	0.0287	1.2448	0.4149
Lao People's Democratic Republic	52.90	0.4366	35.49	0.3588	1900.00	0.0311	0.8265	0.2755
Lebanon	76.70	0.8186	18.52	0.7582	5300.00	0.1124	1.6893	0.5631
Liberia	51.00	0.4061	44.77	0.1403	900.00	0.0072	0.5536	0.1845
Madagascar	48.50	0.3660	41.41	0.2194	900.00	0.0072	0.5925	0.1975
Malawi	56.50	0.4944	43.13	0.1789	600.00	0.0000	0.6733	0.2244
Malaysia	83.30	0.9246	22.86	0.6561	10400.00	0.2344	1.8151	0.6050
Mali	33.90	0.1316	49.82	0.0214	1000.00	0.0096	0.1626	0.0542
Mauritania	32.00	0.1011	40.99	0.2293	2000.00	0.0335	0.3639	0.1213
Mexico	64.80	0.6276	20.69	0.7072	10100.00	0.2273	1.5620	0.5207
Mongolia	48.80	0.3708	21.59	0.6860	2200.00	0.0383	1.0950	0.3650
Morocco	64.10	0.6164	21.98	0.6768	4300.00	0.0885	1.3817	0.4606
Mozambique	45.70	0.3210	35.18	0.3661	1300.00	0.0167	0.7038	0.2346
Namibia	56.50	0.4944	24.32	0.6217	8200.00	0.1818	1.2979	0.4326
Nepal	60.20	0.5538	30.98	0.4649	1500.00	0.0215	1.0402	0.3467
Netherlands	78.70	0.8507	10.90	0.9376	30600.00	0.7177	2.5060	0.8353
New Zealand	88.00	1.0000	13.76	0.8703	24200.00	0.5646	2.4349	0.8116
Nicaragua	69.20	0.6982	24.51	0.6172	2400.00	0.0431	1.3585	0.4528
Niger	25.70	0.0000	50.73	0.0000	800.00	0.0048	0.0048	0.0016
Nigeria	44.50	0.3018	40.43	0.2425	1000.00	0.0096	0.5538	0.1846
Norway	80.20	0.8748	11.46	0.9244	42400.00	1.0000	2.7992	0.9331
Oman	67.90	0.6774	36.24	0.3411	13400.00	0.3062	1.3247	0.4416
Pakistan	41.10	0.2472	29.74	0.4941	2400.00	0.0431	0.7844	0.2615
Panama	76.50	0.8154	21.74	0.6824	7100.00	0.1555	1.6534	0.5511
Papua New Guinea	55.50	0.4783	29.36	0.5031	2400.00	0.0431	1.0245	0.3415
Paraguay	66.40	0.6533	29.10	0.5092	4900.00	0.1029	1.2653	0.4218
Peru	65.40	0.6372	20.48	0.7121	6100.00	0.1316	1.4809	0.4936

Philippines	69.40	0.7014	24.89	0.6083	5100.00	0.1077	1.4174	0.4725
Poland	76.20	0.8106	9.85	0.9623	12700.00	0.2895	2.0624	0.6875
Portugal	82.90	0.9181	10.72	0.9419	18600.00	0.4306	2.2906	0.7635
Republic of Moldova	62.90	0.5971	15.70	0.8246	2100.00	0.0359	1.4576	0.4859
Romania	56.90	0.5008	10.70	0.9423	8400.00	0.1866	1.6297	0.5432
Russian Federation	77.50	0.8315	9.95	0.9600	10700.00	0.2416	2.0331	0.6777
Rwanda	57.00	0.5024	40.37	0.2439	1300.00	0.0167	0.7630	0.2543
Saudi Arabia	68.30	0.6838	29.34	0.5035	12900.00	0.2943	1.4816	0.4939
Senegal	52.10	0.4238	32.78	0.4226	1700.00	0.0263	0.8726	0.2909
Sierra Leone	49.50	0.3820	45.76	0.1170	900.00	0.0072	0.5062	0.1687
Slovakia	79.10	0.8571	10.65	0.9435	15800.00	0.3636	2.1643	0.7214
Slovenia	77.50	0.8315	8.98	0.9828	21000.00	0.4880	2.3023	0.7674
South Africa	62.00	0.5827	18.20	0.7658	12100.00	0.2751	1.6236	0.5412
Spain	79.20	0.8587	10.06	0.9574	25200.00	0.5885	2.4047	0.8016
Sri Lanka	64.60	0.6244	15.51	0.8291	4300.00	0.0885	1.5420	0.5140
Sudan	44.00	0.2937	34.53	0.3814	2100.00	0.0359	0.7110	0.2370
Suriname	72.90	0.7576	18.02	0.7700	4100.00	0.0837	1.6114	0.5371
Swaziland	53.90	0.4526	27.41	0.5490	5500.00	0.1172	1.1188	0.3729
Sweden	87.80	0.9968	10.27	0.9524	29800.00	0.6986	2.6478	0.8826
Switzerland	81.40	0.8941	9.71	0.9656	35300.00	0.8301	2.6898	0.8966
Syrian Arab Republic	55.30	0.4751	27.76	0.5407	3400.00	0.0670	1.0828	0.3609
Taiwan	79.10	0.8571	12.56	0.8985	26700.00	0.6244	2.3801	0.7934
Tajikistan	48.20	0.3612	32.65	0.4256	1200.00	0.0144	0.8011	0.2670
Thailand	66.80	0.6597	13.87	0.8677	8300.00	0.1842	1.7116	0.5705
Togo	52.80	0.4350	37.01	0.3230	1700.00	0.0263	0.7843	0.2614
Trinidad and Tobago	76.90	0.8218	12.90	0.8905	12900.00	0.2943	2.0066	0.6689
Tunisia	60.00	0.5506	15.52	0.8289	7600.00	0.1675	1.5469	0.5156
Turkey	72.80	0.7560	16.62	0.8030	7900.00	0.1746	1.7336	0.5779
Turkmenistan	52.30	0.4270	27.61	0.5443	6100.00	0.1316	1.1028	0.3676
Uganda	60.80	0.5634	47.35	0.0796	1700.00	0.0263	0.6693	0.2231
Ukraine	71.20	0.7303	8.82	0.9866	6800.00	0.1483	1.8652	0.6217
United Arab Emirates	73.20	0.7624	18.96	0.7479	29100.00	0.6818	2.1921	0.7307
United Kingdom	85.60	0.9615	10.71	0.9421	30900.00	0.7249	2.6284	0.8761
United Republic of Tanzania	59.00	0.5345	37.71	0.3065	700.00	0.0024	0.8434	0.2811
United States	78.50	0.8475	14.14	0.8613	42000.00	0.9904	2.6993	0.8998
Uzbekistan	52.30	0.4270	26.36	0.5737	2000.00	0.0335	1.0341	0.3447
Venezuela (Bolivarian Republic of)	74.10	0.7769	18.71	0.7538	6500.00	0.1411	1.6718	0.5573
Viet Nam	54.30	0.4591	16.86	0.7973	3000.00	0.0574	1.3138	0.4379
Yemen	45.20	0.3130	42.89	0.1846	800.00	0.0048	0.5023	0.1674
Zambia	54.40	0.4607	41.00	0.2290	900.00	0.0072	0.6969	0.2323
Zimbabwe	63.00	0.5987	28.01	0.5348	2100.00	0.0359	1.1694	0.3898

VF Viability Index

1	Norway	0.9331
2	Austria	0.9054
3	United States of America	0.8998
4	Switzerland	0.8966
5	Denmark	0.8853

6	Finland	0.8833
7	Canada	0.8830
8	Sweden	0.8826
9	United Kingdom	0.8761
10	Iceland	0.8663
11	Japan	0.8653
12	Ireland	0.8600
13	Germany	0.8535
14	Australia	0.8443
15	France	0.8423
16	Italy	0.8408
17	Netherlands	0.8353
18	Belgium	0.8348
19	New Zealand	0.8116
20	Spain	0.8016
21	Taiwan	0.7934
22	Greece	0.7907
23	Czech Republic	0.7895
24	Slovenia	0.7674
25	Portugal	0.7635
26	Cyprus	0.7489
27	Democratic People's Republic of Korea	0.7423
28	United Arab Emirates	0.7307
29	Slovakia	0.7214
30	Hungary	0.7199
31	Poland	0.6875
32	Israel	0.6869
33	Russian Federation	0.6777
34	Trinidad and Tobago	0.6689
35	Cuba	0.6579
36	Argentina	0.6495
37	Chile	0.6485
38	Bulgaria	0.6371
39	Costa Rica	0.6292
40	Ukraine	0.6217
41	Malaysia	0.6050
42	Brazil	0.6048
43	Colombia	0.5819
44	Turkey	0.5779
45	Thailand	0.5705
46	Lebanon	0.5631
47	Iran (Islamic Republic of)	0.5615
48	Venezuela (Bolivarian Republic of)	0.5573
49	Panama	0.5511
50	Albania	0.5449
51	Armenia	0.5447
52	Romania	0.5432
53	South Africa	0.5412
54	Kazakhstan	0.5402
55	Suriname	0.5371

56	Algeria	0.5329
57	Georgia	0.5289
58	Jamaica	0.5256
59	Mexico	0.5207
60	Ecuador	0.5159
61	Tunisia	0.5156
62	Sri Lanka	0.5140
63	China	0.5027
64	Dominican Republic	0.4981
65	Saudi Arabia	0.4939
66	Peru	0.4936
67	Republic of Moldova	0.4859
68	Jordan	0.4804
69	Philippines	0.4725
70	Morocco	0.4606
71	Nicaragua	0.4528
72	Indonesia	0.4505
73	Oman	0.4416
74	Viet Nam	0.4379
75	Honduras	0.4353
76	Bolivia	0.4337
77	Namibia	0.4326
78	Guatemala	0.4314
79	Azerbaijan	0.4285
80	El Salvador	0.4247
81	Paraguay	0.4218
82	Egypt	0.4207
83	Kyrgyzstan	0.4149
84	Gabon	0.4099
85	Zimbabwe	0.3898
86	Ghana	0.3730
87	Swaziland	0.3729
88	Turkmenistan	0.3676
89	India	0.3654
90	Mongolia	0.3650
91	Syrian Arab Republic	0.3609
92	Nepal	0.3467
93	Uzbekistan	0.3447
94	Papua New Guinea	0.3415
95	Cambodia	0.3282
96	Central African Republic	0.3050
97	Côte d'Ivoire	0.2999
98	Cameroon	0.2945
99	Senegal	0.2909
100	United Republic of Tanzania	0.2811
101	Lao People's Democratic Republic	0.2755
102	Benin	0.2722
103	Bangladesh	0.2714
104	Tajikistan	0.2670
105	Pakistan	0.2615

106	Togo	0.2614
107	Kenya	0.2554
108	Rwanda	0.2543
109	Haiti	0.2442
110	Gambia	0.2410
111	Sudan	0.2370
112	Mozambique	0.2346
113	Zambia	0.2323
114	Malawi	0.2244
115	Uganda	0.2231
116	Guinea-Bissau	0.2168
117	Guinea	0.2089
118	Burundi	0.2054
119	Madagascar	0.1975
120	Congo (Republic of the)	0.1916
121	Nigeria	0.1846
122	Liberia	0.1845
123	Sierra Leone	0.1687
124	Yemen	0.1674
125	Democratic Republic of the Congo	0.1671
126	Ethiopia	0.1605
127	Burkina Faso	0.1385
128	Angola	0.1376
129	Mauritania	0.1213
130	Chad	0.0745
131	Mali	0.0542
132	Niger	0.0016

Appendix B: Progress Index

	Birth Rates 2000	Birth Rate 2005	change in BR	BR Index	GDP growth rate	GDPGR Index	Progress Index
Afghanistan	41.82	46.60	0.11	0.63	8.00	0.5618	0.60
Albania	19.47	15.11	-0.22	0.84	5.50	0.4682	0.65
Algeria	23.14	17.14	-0.26	0.86	6.00	0.4869	0.67
Andorra	10.58	8.71	-0.18	0.81	4.00	0.4120	0.61
Angola	46.89	45.11	-0.04	0.72	19.10	0.9775	0.85
Antigua and Barbuda	19.6	16.93	-0.14	0.79	3.00	0.3745	0.58
Argentina	18.59	16.73	-0.10	0.76	8.70	0.5880	0.68
Armenia	10.97	12.07	0.10	0.64	13.90	0.7828	0.71
Australia	13.08	12.14	-0.07	0.74	2.60	0.3596	0.55
Austria	9.9	8.74	-0.12	0.77	1.80	0.3296	0.55
Azerbaijan	18.08	20.74	0.15	0.61	19.70	1.0000	0.80
Bahamas	19.54	17.57	-0.10	0.76	3.00	0.3745	0.57
Bahrain	20.61	17.80	-0.14	0.79	5.90	0.4831	0.63
Bangladesh	25.44	29.80	0.17	0.59	5.40	0.4644	0.53
Barbados	14.45	12.71	-0.12	0.78	2.50	0.3558	0.57
Belarus	9.27	11.16	0.20	0.57	8.00	0.5618	0.57
Belgium	10.91	10.38	-0.05	0.73	1.50	0.3184	0.52
Belize	32.29	28.84	-0.11	0.77	3.80	0.4045	0.59
Benin	44.81	38.85	-0.13	0.78	3.90	0.4082	0.60
Bhutan	36.22	33.65	-0.07	0.74	5.30	0.4607	0.60
Bolivia	28.15	23.30	-0.17	0.81	3.40	0.3895	0.60
Bosnia and Herzegovina	12.92	8.77	-0.32	0.90	5.30	0.4607	0.68
Botswana	29.63	23.08	-0.22	0.84	3.30	0.3858	0.61
Brazil	18.84	16.56	-0.12	0.78	2.40	0.3521	0.56
Brunei Darussalam	20.81	18.79	-0.10	0.76	1.70	0.3258	0.54
Bulgaria	8.06	9.65	0.20	0.58	5.70	0.4757	0.53
Burkina Faso	45.26	45.62	0.01	0.70	4.50	0.4307	0.56
Burundi	40.46	42.22	0.04	0.67	4.50	0.4307	0.55
Cambodia	33.48	26.90	-0.20	0.82	6.00	0.4869	0.65
Cameroon	36.6	33.89	-0.07	0.75	3.70	0.4007	0.57
Canada	11.41	10.78	-0.06	0.73	2.90	0.3708	0.55
Cape Verde	29.67	24.87	-0.16	0.80	5.50	0.4682	0.63
Central African Republic	37.52	33.91	-0.10	0.76	2.50	0.3558	0.56
Chad	48.81	45.73	-0.06	0.74	18.00	0.9363	0.84
Chile	17.19	15.23	-0.11	0.77	6.00	0.4869	0.63
China	16.12	13.25	-0.18	0.81	9.30	0.6105	0.71
Colombia	22.85	20.48	-0.10	0.76	4.30	0.4232	0.59
Comoros	40.05	36.93	-0.08	0.75	3.00	0.3745	0.56
Congo (Republic of the)	38.61	42.57	0.10	0.64	8.00	0.5618	0.60
Costa Rica	20.69	18.32	-0.11	0.77	3.30	0.3858	0.58
Côte d'Ivoire	40.78	35.11	-0.14	0.79	0.80	0.2921	0.54
Croatia	12.82	9.61	-0.25	0.86	3.50	0.3933	0.62
Cuba	12.68	11.89	-0.06	0.74	5.50	0.4682	0.60
Cyprus	13.27	12.56	-0.05	0.73	3.70	0.4007	0.57
Czech Republic	9.1	9.02	-0.01	0.71	4.80	0.4419	0.57
Democratic Republic of the Congo	46.44	43.69	-0.06	0.74	6.50	0.5056	0.62

Denmark	12.16	11.13	-0.08	0.75	2.80	0.3670	0.56
Djibouti	40.98	39.53	-0.04	0.72	3.50	0.3933	0.56
Dominica	18.27	15.27	-0.16	0.80	-1.00	0.2247	0.51
Dominican Republic	25.15	23.22	-0.08	0.75	6.50	0.5056	0.63
Ecuador	26.51	22.29	-0.16	0.80	3.00	0.3745	0.59
Egypt	25.38	22.94	-0.10	0.76	4.70	0.4382	0.60
El Salvador	29.02	26.61	-0.08	0.75	2.90	0.3708	0.56
Equatorial Guinea	38.13	35.59	-0.07	0.74	18.60	0.9588	0.85
Eritrea	42.71	34.33	-0.20	0.82	2.00	0.3371	0.58
Estonia	8.45	10.04	0.19	0.58	7.40	0.5393	0.56
Ethiopia	45.13	37.98	-0.16	0.80	7.00	0.5243	0.66
Fiji	23.48	22.55	-0.04	0.72	2.00	0.3371	0.53
Finland	10.8	10.45	-0.03	0.72	2.20	0.3446	0.53
France	12.27	11.99	-0.02	0.71	1.60	0.3221	0.52
Gabon	27.6	36.16	0.31	0.51	2.10	0.3408	0.42
Gambia	42.28	39.37	-0.07	0.74	5.50	0.4682	0.61
Georgia	10.87	10.41	-0.04	0.73	7.00	0.5243	0.63
Germany	9.35	8.25	-0.12	0.77	0.90	0.2959	0.53
Ghana	29.81	30.52	0.02	0.69	4.30	0.4232	0.55
Greece	9.82	9.69	-0.01	0.71	3.30	0.3858	0.55
Grenada	20.96	20.88	0.00	0.70	2.50	0.3558	0.53
Guatemala	35.05	29.88	-0.15	0.79	3.10	0.3783	0.59
Guinea	40.08	41.76	0.04	0.67	2.00	0.3371	0.51
Guinea-Bissau	39.63	37.22	-0.06	0.74	2.80	0.3670	0.55
Guyana	17.94	18.28	0.02	0.69	-2.50	0.1685	0.43
Haiti	31.97	36.44	0.14	0.61	1.50	0.3184	0.47
Honduras	32.65	28.24	-0.14	0.78	4.00	0.4120	0.60
Hungary	9.26	9.72	0.05	0.67	3.90	0.4082	0.54
Iceland	14.86	13.64	-0.08	0.75	6.50	0.5056	0.63
India	24.79	22.01	-0.11	0.77	7.60	0.5468	0.66
Indonesia	22.6	20.34	-0.10	0.76	5.40	0.4644	0.61
Iran (Islamic Republic of)	18.29	17.00	-0.07	0.74	4.80	0.4419	0.59
Iraq	35.04	31.98	-0.09	0.75	-3.00	0.1498	0.45
Ireland	14.51	14.45	0.00	0.70	4.70	0.4382	0.57
Israel	19.32	17.97	-0.07	0.74	4.70	0.4382	0.59
Italy	9.13	8.72	-0.04	0.73	0.20	0.2697	0.50
Jamaica	18.51	20.82	0.12	0.62	1.50	0.3184	0.47
Japan	9.96	9.37	-0.06	0.74	2.40	0.3521	0.54
Jordan	26.24	21.25	-0.19	0.82	5.90	0.4831	0.65
Kazakhstan	16.78	16.00	-0.05	0.73	9.00	0.5993	0.66
Kenya	29.35	39.72	0.35	0.48	5.20	0.4569	0.47
Kiribati	32.43	21.94	-0.32	0.90	1.50	0.3184	0.61
Kuwait	22.04	39.72	0.80	0.20	5.60	0.4719	0.34
Kyrgyzstan	26.39	30.65	0.16	0.60	2.00	0.3371	0.47
Laos	38.29	35.49	-0.07	0.75	7.20	0.5318	0.64
Latvia	7.8	9.24	0.18	0.58	8.30	0.5730	0.58
Lebanon	20.26	18.52	-0.09	0.75	0.50	0.2809	0.52
Lesotho	31.74	24.75	-0.22	0.84	0.80	0.2921	0.56

Liberia	47.22	44.77	-0.05	0.73	8.00	0.5618	0.65
Libyan Arab Jamahiriya	27.68	26.49	-0.04	0.73	8.50	0.5805	0.65
Liechtenstein	11.83	10.21	-0.14	0.79	11.00	0.6742	0.73
Lithuania	9.77	8.75	-0.10	0.77	6.70	0.5131	0.64
Luxembourg	12.45	11.94	-0.04	0.73	3.50	0.3933	0.56
Macedonia	13.73	12.02	-0.12	0.78	3.70	0.4007	0.59
Madagascar	42.92	41.41	-0.04	0.72	6.00	0.4869	0.60
Malawi	38.49	43.13	0.12	0.62	1.00	0.2996	0.46
Malaysia	25.3	22.86	-0.10	0.76	5.20	0.4569	0.61
Maldives	38.96	34.18	-0.12	0.78	-5.50	0.0562	0.42
Mali	49.23	49.82	0.01	0.69	5.50	0.4682	0.58
Malta	12.75	10.22	-0.20	0.82	1.50	0.3184	0.57
Marshall Islands	45.17	33.05	-0.27	0.87	1.00	0.2996	0.58
Mauritania	43.36	40.99	-0.05	0.73	5.50	0.4682	0.60
Mauritius	16.66	15.43	-0.07	0.75	3.10	0.3783	0.56
Mexico	23.15	20.69	-0.11	0.77	3.00	0.3745	0.57
Micronesia	27.09	24.68	-0.09	0.76	1.00	0.2996	0.53
Monaco	9.94	9.19	-0.08	0.75	0.90	0.2959	0.52
Mongolia	21.53	21.59	0.00	0.70	5.50	0.4682	0.58
Morocco	24.6	21.98	-0.11	0.77	1.30	0.3109	0.54
Mozambique	37.99	35.18	-0.07	0.75	7.20	0.5318	0.64
Namibia	35.23	24.32	-0.31	0.89	4.20	0.4195	0.66
Nepal	33.93	30.98	-0.09	0.75	2.50	0.3558	0.56
Netherlands	12.12	10.90	-0.10	0.76	0.70	0.2884	0.53
New Zealand	14.28	13.76	-0.04	0.72	2.50	0.3558	0.54
Nicaragua	28.26	24.51	-0.13	0.78	4.00	0.4120	0.60
Niger	51.45	50.73	-0.01	0.71	3.80	0.4045	0.56
Nigeria	40.16	40.43	0.01	0.70	5.60	0.4719	0.58
North Korea	20.43	15.54	-0.24	0.85	1.00	0.2996	0.57
Norway	12.79	11.46	-0.10	0.76	3.70	0.4007	0.58
Oman	38.08	36.24	-0.05	0.73	1.90	0.3333	0.53
Pakistan	32.11	18.03	-0.44	0.97	7.80	0.5543	0.76
Palau	19.88	29.74	0.50	0.39	1.00	0.2996	0.34
Panama	19.53	21.74	0.11	0.63	4.90	0.4457	0.54
Papua New Guinea	32.68	29.36	-0.10	0.76	1.10	0.3034	0.53
Paraguay	31.27	29.10	-0.07	0.74	3.40	0.3895	0.57
Peru	24.48	20.48	-0.16	0.80	5.80	0.4794	0.64
Philippines	27.85	24.89	-0.11	0.77	4.60	0.4345	0.60
Poland	10.13	9.85	-0.03	0.72	3.50	0.3933	0.56
Portugal	11.49	10.72	-0.07	0.74	0.80	0.2921	0.52
Qatar	16.07	15.56	-0.03	0.72	8.80	0.5918	0.66
Republic of Moldova	12.86	15.70	0.22	0.56	7.50	0.5431	0.55
Romania	10.76	10.70	-0.01	0.70	4.50	0.4307	0.57
Russian Federation	9.02	9.95	0.10	0.64	5.90	0.4831	0.56
Rwanda	34.78	18.02	-0.48	1.00	4.80	0.4419	0.72
Saint Kitts and Nevis	19.06	40.37	1.12	0.00	-1.90	0.1910	0.10
Saint Lucia	22.19	19.68	-0.11	0.77	3.30	0.3858	0.58
Saint Vincent and the Grenadines	18.25	16.18	-0.11	0.77	0.70	0.2884	0.53

Samoa	15.59	16.43	0.05	0.67	5.00	0.4494	0.56
San Marino	10.88	10.02	-0.08	0.75	7.50	0.5431	0.65
Sao Tome and Principe	42.98	40.25	-0.06	0.74	6.00	0.4869	0.61
Saudi Arabia	37.47	29.34	-0.22	0.84	6.50	0.5056	0.67
Senegal	37.94	32.78	-0.14	0.79	5.20	0.4569	0.62
Serbia and Montenegro	13.55	12.11	-0.11	0.77	5.00	0.4494	0.61
Seychelles	17.99	16.03	-0.11	0.77	-3.00	0.1498	0.46
Sierra Leone	45.63	45.76	0.00	0.70	5.50	0.4682	0.58
Singapore	12.79	9.34	-0.27	0.87	5.70	0.4757	0.67
Slovakia	10	10.65	0.07	0.66	5.50	0.4682	0.56
Slovenia	9.35	8.98	-0.04	0.72	4.00	0.4120	0.57
Solomon Islands	34.79	30.01	-0.14	0.79	5.80	0.4794	0.63
Somalia	47.7	45.13	-0.05	0.73	2.40	0.3521	0.54
South Africa	24.56	18.20	-0.26	0.86	4.60	0.4345	0.65
South Korea	15.12	10.00	-0.34	0.91	3.90	0.4082	0.66
Spain	9.22	10.06	0.09	0.64	3.40	0.3895	0.52
Sri Lanka	16.78	15.51	-0.08	0.75	5.00	0.4494	0.60
Sudan	38.58	34.53	-0.10	0.77	7.70	0.5506	0.66
Suriname	21.08	18.02	-0.15	0.79	2.00	0.3371	0.56
Swaziland	40.64	27.41	-0.33	0.90	1.80	0.3296	0.62
Sweden	10.01	10.27	0.03	0.68	2.60	0.3596	0.52
Switzerland	10.4	9.71	-0.07	0.74	1.80	0.3296	0.54
Syrian Arab Republic	31.11	27.76	-0.11	0.77	4.50	0.4307	0.60
Taiwan	14.42	12.56	-0.13	0.78	3.80	0.4045	0.59
Tajikistan	33.56	32.65	-0.03	0.72	8.00	0.5618	0.64
Thailand	16.86	13.87	-0.18	0.81	4.40	0.4270	0.62
Togo	38.02	37.01	-0.03	0.72	2.50	0.3558	0.54
Tonga	24.92	25.37	0.02	0.69	1.40	0.3146	0.50
Trinidad and Tobago	13.84	12.90	-0.07	0.74	7.00	0.5243	0.63
Tunisia	17.38	15.52	-0.11	0.77	4.80	0.4419	0.60
Turkey	18.65	16.62	-0.11	0.77	5.10	0.4532	0.61
Turkmenistan	28.88	27.61	-0.04	0.73	11.00	0.6742	0.70
Tuvalu	21.78	22.18	0.02	0.69	3.00	0.3745	0.53
Uganda	48.04	47.35	-0.01	0.71	9.00	0.5993	0.65
Ukraine	9.03	8.82	-0.02	0.71	2.40	0.3521	0.53
United Arab Emirates	18	18.96	0.05	0.67	6.70	0.5131	0.59
United Kingdom	11.76	8.82	-0.25	0.86	1.70	0.3258	0.59
United Republic of Tanzania	40.17	37.71	-0.06	0.74	6.80	0.5169	0.63
United States of America	14.2	14.14	0.00	0.70	3.50	0.3933	0.55
Uruguay	17.42	13.91	-0.20	0.83	6.10	0.4906	0.66
Uzbekistan	26.18	26.36	0.01	0.70	7.20	0.5318	0.61
Vanuatu	25.93	22.72	-0.12	0.78	1.10	0.3034	0.54
Venezuela (Bolivarian Republic of)	21.09	18.71	-0.11	0.77	9.10	0.6030	0.69
Viet Nam	21.62	16.86	-0.22	0.84	8.40	0.5768	0.71
Yemen	43.44	42.89	-0.01	0.71	2.40	0.3521	0.53
Zambia	41.9	41.00	-0.02	0.71	5.00	0.4494	0.58

Zimbabwe	25	28.01	0.12	0.62	-7.00	0.0000	0.31
----------	----	-------	------	------	-------	--------	-------------

	Progress Index
1 Angola	0.85
2 Equatorial Guinea	0.85
3 Chad	0.84
4 Azerbaijan	0.80
5 Pakistan	0.76
6 Liechtenstein	0.73
7 Rwanda	0.72
8 China	0.71
9 Armenia	0.71
10 Viet Nam	0.71
11 Turkmenistan	0.70
12 Venezuela (Bolivarian Republic of)	0.69
13 Bosnia and Herzegovina	0.68
14 Argentina	0.68
15 Algeria	0.67
16 Singapore	0.67
17 Saudi Arabia	0.67
18 Kazakhstan	0.66
19 Ethiopia	0.66
20 South Korea	0.66
21 India	0.66
22 Uruguay	0.66
23 Sudan	0.66
24 Namibia	0.66
25 Qatar	0.66
26 Cambodia	0.65
27 Uganda	0.65
28 Albania	0.65
29 Libyan Arab Jamahiriya	0.65
30 Jordan	0.65
31 South Africa	0.65
32 Liberia	0.65
33 San Marino	0.65
34 Peru	0.64
35 Tajikistan	0.64
36 Lithuania	0.64
37 Mozambique	0.64
38 Laos	0.64
39 Cape Verde	0.63
40 Bahrain	0.63
41 Trinidad and Tobago	0.63
42 Solomon Islands	0.63

43	Chile	0.63
44	Iceland	0.63
45	United Republic of Tanzania	0.63
46	Dominican Republic	0.63
47	Georgia	0.63
48	Croatia	0.62
49	Democratic Republic of the Congo	0.62
50	Senegal	0.62
51	Thailand	0.62
52	Swaziland	0.62
53	Uzbekistan	0.61
54	Indonesia	0.61
55	Sao Tome and Principe	0.61
56	Botswana	0.61
57	Andorra	0.61
58	Turkey	0.61
59	Kiribati	0.61
60	Malaysia	0.61
61	Serbia and Montenegro	0.61
62	Gambia	0.61
63	Madagascar	0.60
64	Tunisia	0.60
65	Cuba	0.60
66	Bhutan	0.60
67	Mauritania	0.60
68	Philippines	0.60
69	Egypt	0.60
70	Syrian Arab Republic	0.60
71	Congo (Republic of the)	0.60
72	Bolivia	0.60
73	Sri Lanka	0.60
74	Honduras	0.60
75	Nicaragua	0.60
76	Benin	0.60
77	Afghanistan	0.60
78	Colombia	0.59
79	Iran (Islamic Republic of)	0.59
80	Taiwan	0.59
81	United Kingdom	0.59
82	Israel	0.59
83	United Arab Emirates	0.59
84	Macedonia	0.59
85	Ecuador	0.59
86	Belize	0.59
87	Guatemala	0.59
88	Nigeria	0.58
89	Marshall Islands	0.58
90	Mongolia	0.58

91	Sierra Leone	0.58
92	Norway	0.58
93	Zambia	0.58
94	Mali	0.58
95	Eritrea	0.58
96	Antigua and Barbuda	0.58
97	Latvia	0.58
98	Costa Rica	0.58
99	Saint Lucia	0.58
100	North Korea	0.57
101	Czech Republic	0.57
102	Cameroon	0.57
103	Malta	0.57
104	Mexico	0.57
105	Ireland	0.57
106	Bahamas	0.57
107	Slovenia	0.57
108	Belarus	0.57
109	Romania	0.57
110	Cyprus	0.57
111	Paraguay	0.57
112	Barbados	0.57
113	Lesotho	0.56
114	Suriname	0.56
115	Brazil	0.56
116	Slovakia	0.56
117	Burkina Faso	0.56
118	Mauritius	0.56
119	Comoros	0.56
120	El Salvador	0.56
121	Estonia	0.56
122	Denmark	0.56
123	Luxembourg	0.56
124	Russian Federation	0.56
125	Central African Republic	0.56
126	Samoa	0.56
127	Djibouti	0.56
128	Niger	0.56
129	Poland	0.56
130	Nepal	0.56
131	Ghana	0.55
132	Canada	0.55
133	Guinea-Bissau	0.55
134	Republic of Moldova	0.55
135	Australia	0.55
136	Burundi	0.55
137	Austria	0.55
138	United States of America	0.55

139	Greece	0.55
140	Japan	0.54
141	Brunei Darussalam	0.54
142	Somalia	0.54
143	Vanuatu	0.54
144	Côte d'Ivoire	0.54
145	New Zealand	0.54
146	Morocco	0.54
147	Hungary	0.54
148	Panama	0.54
149	Togo	0.54
150	Switzerland	0.54
151	Germany	0.53
152	Papua New Guinea	0.53
153	Ukraine	0.53
154	Finland	0.53
155	Oman	0.53
156	Tuvalu	0.53
157	Fiji	0.53
158	Yemen	0.53
159	Saint Vincent and the Grenadines	0.53
160	Grenada	0.53
161	Bangladesh	0.53
162	Micronesia	0.53
163	Bulgaria	0.53
164	Netherlands	0.53
165	Belgium	0.52
166	Sweden	0.52
167	Monaco	0.52
168	France	0.52
169	Lebanon	0.52
170	Portugal	0.52
171	Spain	0.52
172	Dominica	0.51
173	Guinea	0.51
174	Tonga	0.50
175	Italy	0.50
176	Jamaica	0.47
177	Kyrgyzstan	0.47
178	Kenya	0.47
179	Haiti	0.47
180	Malawi	0.46
181	Seychelles	0.46
182	Iraq	0.45
183	Guyana	0.43
184	Gabon	0.42
185	Maldives	0.42
186	Palau	0.34

187	Kuwait	0.34
188	Zimbabwe	0.31
189	Saint Kitts and Nevis	0.10

Appendix C: Calculations

VFVI calculations

$$\text{EPI index} = (\text{EPI value} - \text{EPI min}) / (\text{EPI max} - \text{EPI min})$$

$$\text{Birth Rate Index} = 1 - [(\text{BR} - \text{BR min}) / (\text{max BR} - \text{min BR})]$$

$$\text{GDP per capita index} = (\text{GDP} - \text{GDP min}) / (\text{GDP max} - \text{GDP min})$$

$$\text{VFVI} = (\text{EPI index} + \text{BR Index} + \text{GDP per capita index}) / 3$$

PI calculations

$$\text{Change in Birth Rate} = \text{BR 2000} - \text{BR 2005}$$

$$\text{CBR Index} = 1 - [(\text{CBR value} - \text{CBR min}) / (\text{CBR max} - \text{CBR min})]$$

$$\text{GDP growth rate Index} = (\text{GDPGR} - \text{GDPGR min}) / (\text{GDPGR max} - \text{GDPGR min})$$

$$\text{PI} = (\text{CBR index} + \text{GDPGR index}) / 2$$