An ISGP White Paper:
Food Sustainability

Introduction

By the year 2050 the world's population is predicted to increase from 6.8 billion to 9 billion. The addition of more than 2 billion individuals to the global population in combination with changing dietary habits is expected to require a doubling of the amount of food, feed and fiber currently produced. Our ability to grasp the magnitude of this issue, and its consequences, requires analyses that link credible scientific understanding and technological options with the "actionable decisions" needed to formulate and implement practical policies. Sustainable development as reflected in economic progress, national security, and quality living standards depends on reliable access to adequate supplies of safe, nutritious and wholesome foodstuffs in essentially all countries. In this White Paper, the **Institute on Science for Global Policy** (ISGP) undertakes a preliminary examination of the issues related to ***Food Sustainability*** (i.e., specifically, safety and security of supply) by summarizing the current realities, the scientific and technological (S&T) challenges and opportunities, and some of the related domestic and international policy issues facing societies and their governments.

The ISGP Approach

Many of the most significant global challenges for 21st century societies are directly related to the profound S&T achievements of our time. Success in fostering safe, secure, and prosperous societies often reflects how well societal and governmental institutions recognize the opportunities and consequences associated with existing, emerging, and "at-the-horizon" S&T and how effectively governmental policies balance short-term challenges requiring immediate attention with the need for long-term investments in transformative research and development. Unfortunately, large gaps too often exist between S&T understanding and the governmental policies that emerge from the political processes within a society.

The ISGP seeks to significantly improve the capability of governments to effectively bridge these gaps and to help shape the relevant domestic and international policies. ISGP programs use a unique format based on multiple conferences designed to address specific aspects (e.g., water availability and food production, advancing food safety, climate change impacts on agriculture, enhancing agricultural productivity via remote sensing, global food supply networks, etc.) of a broad S&T topic (i.e., ***Food Sustainability***) previously vetted as a priority with participating governments. While each ISGP program focuses on a specific S&T topic (e.g., energy, infectious diseases, food safety and security, or cyber security), the ISGP is positioned to examine several S&T topics simultaneously through parallel programs.

Each ISGP conference focuses almost exclusively on critical debates and caucuses involving highly credible, articulate scientists chosen by the ISGP and an international group of policy makers from the United States, Europe, and Asia selected by the participating governments. The ISGP selects a few (6-8) S&T experts for each conference to prepare concise, focused written documents describing their views and to participate in the critical debates led by a global group of decision makers. Emphasis remains on specific "actionable decisions" and their foreseeable consequences. Separate caucuses held during each ISGP conference provide opportunities for governmental and societal representatives to discuss next steps, both domestically and internationally.

In preparation for each conference, the ISGP staff interviews or corresponds with a wide range of globally recognized subject matter experts from academia, industry, and the non-governmental community. These discussions seek to elicit the interviewee's opinions concerning the relevant S&T realities, challenges, and options that should be considered by governments. To ensure a comprehensive understanding of these issues, the ISGP also reviews the relevant international reports, statements, and S&T publications. Taken together, these materials and information are used by the ISGP to prepare a **Strategic Roadmap** which not only summarizes all the findings, but also describes the content and structure of a series of 6-8 conferences to be convened by the ISGP on the S&T topic (e.g., food safety and security) over a two- or three-year period.

The global character of the ISGP is reflected not only through the engagement of the United States, European, and Asian governments, but also in its international network of affiliated universities. Students and professors from these affiliated institutions participate in ISGP programs and are involved in real decision-making processes occurring at each ISGP conference (fundamentally a "practical policy laboratory"). ISGP programs also seek to foster public respect for the role of S&T in policy, and obviously, to help shape strategic public policies worldwide.

Food Sustainability

This **ISGP White Paper** has been developed to characterize the critical scientific understanding and policy issues that make ***Food Sustainability*** an appropriate topic to be examined through a comprehensive, two- or three-year ISGP program. It is based on a review of some of the relevant published material and on discussions with a selected group of S&T professionals versed in agricultural and related food production issues through their work in academic, private sector, and non-governmental settings. While these individuals were asked for their opinions, they did not author or formally endorse this **ISGP White Paper on *Food Sustainability,*** which remains wholly a product of the ISGP.

In a two- or three-year, comprehensive study, the ISGP would examine ***Food Sustainability*** using the multiple conference procedures and critical debate format described above. This would involve a much larger number of interviews with subject matter experts and policy makers chosen internationally and would lead to the preparation of a **Strategic Roadmap on *Food Sustainability*** that would be reviewed by participating governments before it is implemented.

Efforts to establish strategies to meet the world's future food needs must be predicated on an accurate understanding of the consequences of both our actions and our inactions. Identifying effective domestic and international policies connected to the "actionable decisions" that underlie sustainable solutions requires conscientious deliberation rooted in the credible S&T options. Such solutions will represent a mosaic of near-, mid-, and long-term approaches. Effective near-term policies must obtain international consensus and establish measurable, enforceable agreements affecting both domestic and international policies. Mid-term policies are likely to be derived from evolutionary S&T developments. Long-term approaches are anticipated to become apparent only after research and development (R&D) efforts identify revolutionary S&T advances. To formulate and implement policies without informed discussion and debate of all three types of options risks the simultaneous possibility of widespread famines throughout the least developed nations and an epidemic of obesity and related health consequences in developed nations.

Current Realities - Overview

By the year 2050, 2.3 billion individuals are expected to be added to the world's population. The resultant 9+ billion global population, as well as the changing dietary habits that generally promote chronic diseases, are expected to require that the amount of food, feed and fiber produced be doubled over current levels.

Sixty years ago the world faced a similar seemingly intractable food crisis. In Central and South America, as well as countries in Asia, population growth was rapidly outpacing the ability of societies to produce even an adequate supply of food, healthy or not. The prospect of large scale and sustained famines dominated the expected futures in many areas. In 1945, what would come to be known as the Green Revolution began to fundamentally change this potentially catastrophic trajectory. By combining new strains of maize and rice with improved pesticide use, irrigation, and synthetic fertilizers, many of the countries at risk experienced dramatic increases in agricultural productivity. These advances contributed to the 250% increase in the world grain production between 1950 and 1984.

Ensuring that there are adequate supplies of safe, nutritious and wholesome foods for future generations is a critical challenge facing individual countries and the international community. Current trends in population growth and agricultural productivity suggest that despite nearly half a decade of increasing agricultural productivity we are on the verge of a new agricultural crisis that will not only imperil developing countries, but will likely threaten the stability of developed nations across the globe.

Current Realities – Food and Human Health

Human health is intimately connected with the availability of not only an adequate but also an appropriate supply of safe, nutritious and wholesome food. Currently the global production of food calories is sufficient to sustain today's global population. Despite this fact, in less developed nations millions die or are debilitated every year by hunger or malnutrition, while developed nations are experiencing an epidemic of over-nutrition. Hunger and malnutrition, particularly in mothers and children, are most prevalent in low-income and middle-income countries. According to recent comprehensive analyses, maternal and child under-nutrition is the underlying cause of 3.5 million deaths yearly. Under-nutrition in children is also associated with stunting, less schooling and reduced economic productivity. Under-nutrition in adults and children also renders individuals more susceptible to infectious diseases and in the case of HIV/AIDS, significantly diminishes the impact of drug therapy.

In contrast, the over abundance of high caloric foods is causing an epidemic of obesity throughout the developed world. Obesity is an underlying factor in most burdensome non-communicable chronic diseases including diabetes, heart disease, and stroke. While this is particularly evident in developed nations, it is predicted that by 2020 over 60% of the disease burden in developing nations will result from diseases for which obesity is an exacerbating influence.

In addition to malnutrition, human health is impacted by the safety of the food that is consumed. Food-borne diseases are estimated to affect 30 percent of the population in developed nations and cause over 2 million deaths in developing countries. The health consequences of food related illness is expected to increase in the future due to the growing proportion of older, more vulnerable individuals.

Furthermore, globalization of the food supply including concentration of food distribution and processing activities increases the likelihood that food-borne diseases will result in large and potentially global outbreaks. Recent adulteration of a variety of food products by melamine was a very public example of the potential impact of intentional adulteration of food supplies. In addition to potential adulteration for economic gains there is the very real concern that the global food supply presents an attractive target for terrorist organizations.

Current Realities – Increased Food Requirements through 2050

The majority of the increase in the world's population toward 9 billion by 2050 will occur in less developed regions where aggregate populations are projected to rise from 5.4 billion in 2007 to 7.9 billion in 2050. In contrast, the population of developing nations is expected to remain relatively constant at 1.2 billion. By 2020, population growth and changing dietary habits are expected to require a 40% doubling in cereal production for food and feed needs and livestock production is expected to double. By 2050, global rice production will need to double to keep up with population driven demand. Similar projections hold true for nearly all other food, feed and fiber related foodstuffs. Such differential population growth will result in uneven distribution of food demand. For instance, the demand for livestock products is predicted to double by 2050 in sub-Saharan Africa and South Asia and increase in South America and countries of the former Soviet Union to levels similar to developed nations.

Unfortunately, much of the increased demand for foodstuffs will occur in regions of the globe that are currently struggling to adequately feed their populations. According to the Food and Agricultural Organization of the United Nations (FAO) World Agriculture Interim report (2006), there are 32 countries that currently have rates of undernourishment between 29 and 72 per cent. These 32 countries will be responsible for nearly a third of the expected population growth that is predicted to occur between now and 2050.

Current Realities – Declining Productivity

For most of the last century the earth has experienced a period of relative climate stability. The result has been the development of regional agricultural practices that are based upon relatively predicable weather patterns. This stability has influenced the choice of crops, planting schedules, pest management practices, and the development of established practices for the application of agricultural inputs (e.g., fertilizers, and pesticides). This predictability in combination with advances in technology and related factors (e.g., investment, education, extension programs and improved farm management) resulted in dramatic increases in agricultural productivity. Thus over the past 50 years, the supply of food commodities has grown faster than the demand despite growing population and improving living standards.

Between 1910 and 2002, the U.S. agriculture output grew at an annual rate of 1.8 per cent while total demand grew by only 0.36 per cent. Much of this striking growth in agricultural productivity and increases in efficiency occurred between 1950 and 1989. Similar advances in agricultural productivity took hold in most regions of the globe (Africa remains the notable exception) as the agricultural practices advanced during the Green Revolution were employed. Production of maize, wheat, and rice in developed and developing countries alike showed dramatic increases from 1960's through the 1989.

Unfortunately in the years between 1990 and 2002 these growth rates have dropped by as much as 50 per cent, in developing and developed nations alike. It is unclear whether these downturns represent unalterable limitations like yield ceilings imposed by plant physiology or whether the advances in technology and related factors can continue to yield significant increases in agricultural productivity.

Current Realities – Climate Change

Evidence of global warming for most informed observers is irrefutable. Recent analyses suggest that many of assumptions regarding the rate of climate change that appeared valid only five years ago were overly optimistic. It appears that the impact of climate change will be felt more rapidly than earlier predicted. It is now clear that climate change will impact regions of the globe differently. Regardless of whether a particular region becomes more or less productive, the rapidity with which these changes are expected to occur and the connectivity of the food production and supply network can result in considerable disruption to the availability of food.

Currently, half of the world's croplands are dedicated to the production of wheat, rice, and maize and an additional third is dedicated to seven other cereal grains, legumes, and oilseeds. Over the past fifty years, monoculture agriculture has been developed as highly efficient systems by taking advantage of relative stability and predictability of seasonal temperature and rainfall patterns. The near-term impact of climate change is likely to increase climatic variability including an increase in the frequency and severity of extreme weather related events (e.g., droughts, floods, heat waves, etc). These changes are anticipated to increasingly threaten the global agricultural production regime that evolved during a much more stable climatic period.

Climate change is also predicted to cause long-term changes in regional precipitation patterns including over-all drying in the subtropics and intercontinental regions across the globe. Decreases in rainfall will have a profound impact on agricultural productivity. Efforts to offset decreased precipitation using irrigation are likely to accelerate the depletion of fresh water sources including aquifers. Ultimately, these trends could result in less sustainable agricultural practices and increased competition for fresh water, both regionally and internationally.

Current Realities – Increasing Energy Costs

The production and distribution of agricultural products is highly dependent upon the cost of energy which currently means fossil fuels. This dependence includes not only the cost associated with using fossil fuels, but also manifests itself in the diversion of agricultural products like corn and sugar cane to the production of biofuels. Direct agricultural use of fossil fuels involves the operation of farm equipment, irrigation sources, and crop drying mechanisms while indirect uses include the manufacture of inorganic fertilizers, transportation and production of pesticides used by farmers.

Between March 2007 and March 2008, global food prices increased an average of 43 percent, according to the International Monetary Fund. The causes of this increase are complex. However, two significant contributors are directly related to rising fuel prices caused by increasing demand in emerging markets like China and India and a significant diversion of corn production in the United States to the production of biofuels.

Fuel costs are very likely to increase as the international community struggles with how to effectively integrate the environmental cost associated with the production and consumption of fossil fuels. The policy shifts that are likely to accompany these changes can have unforeseen consequences. For instance, significant diversion of corn into the production of biofuels and the intensive deforestation occurring in Indonesia and Malaysia to accommodate the production of oil seed crops for the European market are recent examples. Whether these changes benefit or hinder global production of foodstuffs remains to be seen, but regardless, these changes will introduce new sources of potential economic and social instability.

Scientific Challenges and Opportunities – Improving Agricultural Productivity and Managing Resources

Successfully reversing the downward trend of agricultural productivity will require increased investment in agricultural R&D and improved methods for sharing the resultant information through extension programs. The dramatic growth in agricultural productivity that developed and developing countries enjoyed during the later half of the 20th century is ending. From 1990 to 2002 productivity increases have dropped by as much as 50 percent. This decrease has paralleled falling investments in publicly funded agricultural research and development. Improvements in agricultural productivity had diminished the sense of urgency of new research. Currently, research investments related to agriculture in developing nations have been shifted away from R&D related to increasing productivity towards concerns about the environmental effects of agriculture, food safety, food quality, and other industrial and energy uses of agricultural commodities.

More efficient and effective utilization of agricultural inputs including water, soil, fertilizers, and pesticides will be required if gains in agricultural productivity are to be sustained. The development of successful management practices will require planning, development and implementation of new and novel strategies. These management practices will be dependent upon the availability of reliable data to ensure that the specific practices promoted are appropriate to the local site, the region, surrounding communities, as well as for the domestically and internationally connected ecosystems. Farmers will need to more precisely tailor planting schedules and fertilizer use to changing local soil, water, and climate conditions. Communities will need to select crops on the basis of preserving groundwater and aquifer as sustainable resources. Policy makers will play critical roles in this shifting process by developing practical, environmentally sound regional and international programs for controlling resource sharing.

Climate change is perhaps the most significant threat to today's agricultural system. Every aspect of crop growth, livestock development and aquaculture is expected to be affected by changes in the climate. For the majority of people on the globe the impact of climate change will first be felt through changes in the availability of water. Fresh water is a finite resource upon which nearly every human activity is dependent. Rain-fed agriculture accounts for 80% of global croplands and is a major component of the livelihood of most of the world's poor.

Other sources of fresh water are also vitally important. For example, up to 70 per cent of the water in the Ganges River comes from the Gangotri glacier could disappear by 2030 as temperatures rise. Increasingly reliable climate models indicate that widespread disruption to precipitation patterns will occur over the next forty years. For example, over-all drying is expected to occur through out the subtropics, including regions of Africa, Australia, Asia, Central America and the Mediterranean Basin, while high latitude regions are expected to see increased precipitation. Effectively managing these changes will be essential to increasing agricultural productivity.

Scientific Challenges and Opportunities – Improving Models and Remote-Sensing Capacities

Successfully integrating the ability to predict, prepare, and mitigate the impact of weather related activities is essential to improving agricultural productivity. The deployment of weather stations, remote-sensing satellites and various other high and low tech methodologies that can monitor water use and capture agricultural data has significantly improved productivity in developed nations. Investment in national meteorological services is typically associated with economic returns ranging from a factor of five in many regions to a factor of almost 70 in China during 2006.

Effectively deploying similar technologies into regions that currently operate without these tools can be expected to improve productivity. This type of information can also improve sustainability by decreasing harmful environmental effects including fertilizer run off and soil erosion. Improved forecasting ability allows farmers to optimize yields by using predicated precipitation patterns to modify planting, harvesting and fertilizer applications. Improving both immediate term forecasting (up to seven days) and seasonal climate forecasts (precipitation and temperature modeling for month-long periods) offers the possibility of significant improvements in productivity. Framers in Zimbabwe and Bangladesh have demonstrated such improvements.

Scientific Challenges and Opportunities – Pest Management

Successfully developing strategies for preventing, mitigating, and reversing the damage associated with agricultural and livestock diseases and pests are another essential element for improving agricultural productivity. Fungal blights like wheat stem rust and rice blast or livestock diseases like bovine spongiform encephalopathy (BSE) and foot and mouth disease threaten to reduce productivity across large regions of the globe. While individual threats are important, there is growing concern that the techniques associated with high intensity monoculture agriculture and the large scale production of animal protein are reducing biological diversity and undermining the natural resiliency of environmental systems. Climate change is also expected to reduce natural diversity through changes in regional weather patterns and increased temperatures. These changes are likely to increase the disease and pest burden by altering the geographical distribution of such pests by increasing of their dispersal and causing weeds to develop more extensive root and nodule networks that could decrease the effectiveness of herbicides.

For example in 1999, a previously unknown black stem rust was observed in Uganda. Designated Ug99, this particular strain of *Puccinia graminis tritici* attacks most wheat varieties and can result in up to 100 per cent crop loss. Since first being identified, Ug99 has developed resistance to most of the major gene determinants associated with wheat's ability to resist stem rust, a development that potentially threatens world-wide wheat production. Successful strategies for combating the threats posed by pests and diseases will likely draw from multiple different approaches to ensure the efforts are successful and sustainable.

Policy Issues

The increasingly urgent societal issues to be addressed when considering food needs and agricultural sustainability are two-fold. First, governments need to provide security and prosperity for their citizens. Second, they must ensure sustainability for the planet. Striving to achieve the former without succeeding at the latter will be a short-lived gain.

Fulfilling the world's requirements for safe, nutritious and wholesome food is a task of global proportions. Actionable decisions require policies based on clear understanding of the broad scope of S&T issues, and international cooperation. Solutions are likely to contain a mixture of near-term, implementable and measurable actions, mid-term plans using evolutionary advances based on current S&T understanding, and investments in the R&D needed to generate transformational S&T discoveries.

Areas of S&T Consensus

It is evident that improvements in agricultural productivity will be required to meet growing food demands. In order to meet these needs, the trend of lower agricultural productivity observed since the 1990's must be reversed. Improving crop yields globally will require new investments in agricultural R&D.

In less developed nations, investments in agricultural productivity will have to be accompanied by increased investment in agricultural extension programs. These extension programs are relatively inexpensive ways of quickly improving agricultural productivity. They include a wide range of activities designed to provide rural farmers with access to information from different disciplines, including agricultural production, management, and marketing, as well as environmental sustainability. Establishing robust and effective methods for communicating with farmers particularly small and subsistence farmers in less developed countries will be essential for improving global agricultural productivity and sustainability. Unfortunately, many of the farmers that would most benefit from access to information and technological improvements are the hardest to reach and least like to be able to adopt new or different technologies.

Effective educational out reach in the form of agricultural extension programs were a key component of the productivity gains that occurred during the Green Revolution. Investment in these types of extension activities will go a long way in improvising the adoption of current best practices. The adoption of existing and proven technologies could double current crop yields on many of the rain-fed lands currently farmed by the world's poor. Wide scale adoption of drip irrigation techniques and other targeted water delivery technologies can be expected to improve agricultural productivity and conserve water.

The adoption of no-till farming practices can improve soil management practices by reducing water and wind erosion, enhancing soil quality, and increasing and/or maintaining the carbon content of the soil. Additionally, no-till farming reduces the greenhouse gas emissions associated with fuel use and significantly reduces the labor necessary to prepare and plant fields. When combined with appropriate fertilizer and pesticide use, no-till farming can be expected to dramatically increase the agricultural productivity of small and subsistence farms in Africa.

Widespread adoption of other sustainable agricultural practices can increase productivity while potentially decreasing the need for unsustainable levels of agricultural inputs. For example, the use of cover crops, crops grown and then incorporated by tilling into the soil before reaching full maturity, have been shown to stabilize the soil, prevent runoff, add organic material, help with weed and pest management, and in general, improve soil fertility and quality.

Changes to agricultural practices like utilizing drip irrigation and other practices can also help mitigate the effect of disease and pests. Many of the methods employed after the 1950's exacerbate the current impact of fungal pests. Plants are grown at much higher densities increasing the likelihood that crop diseases spread. Additionally, high density planting decreases the loss of water to evaporation and results in much higher moisture content in and around wheat fields which increases the susceptibility of these crops to fungal blights.

Evolutionary S&T Achievements

Agriculture is dependent upon large amounts of water, and a small improvement in the efficient use of water translates into large agricultural gains. Indeed, improving water resource management may be the most critical challenge that needs to be addressed to ensure that the growing demand for food is met. Agriculture in the United States is responsible for nearly 80% of the consumptive use of water and includes the amount of withdrawn water that is lost through evaporation, plant transpiration, incorporation in products or crops, or consumption by humans and livestock.

Development of significantly more effective management practices that recognize the value of watersheds, wetlands, lakes, flood plains and deltas will be required. Advances in the understanding of how to effectively and efficiently utilize these resources will require scientific and technological innovation.

Improvements in water resource management utilizing remote-sensing techniques can lead to more sustainable and better-informed agricultural practices. Satellite imagery can be combined with other monitoring data to measure and predict evaporation and other processes that consume water. These technologies are capable of helping accurately measure water usage from the regional level all the way down to individual fields. This type of data has been used in the western United States to help resolve disputes between states, conserve water by helping scientists and ranchers constructively withhold water from certain growing areas, resolve issues regarding salinity levels, and help evaluate invasive species control measures. Wide scale adoption and implementation of this technology can help mitigate and manage water related conflicts that will manifest themselves as global climate change continues to impact precipitation. Scientific and technological improvements in wastewater treatment and reclamation practices can also enhance water supplies and will be useful in reducing the competition between urban, commercial, and agricultural water use.

Similar applications of remote-sensing technology can lead to improvements in sustainable land and resource management. For instance, efforts to utilize satellite imagery to measure crop yields, crop stress, CO_2 uptake, and land cover can improve the timing and effectiveness of fertilizer and pesticide application. Such improvements can lead to more sustainable agricultural practices.

Revolutionary Scientific Understanding and Technological Ingenuity

Over the next 40 years, the ability of the planet to produce sufficient food supplies capable of feeding a growing population will be tested. Climate change, international efforts to control the emissions of green houses gases, and burgeoning populations in less developed nations will all have to be considered as nations and international organizations consider how best to meet growing food demands. Novel agricultural practices, including those that are currently impractical, will increasingly become viable as the impact of climate change is felt.

The development and utilization of perennials including trees, shrubs and palms for the production of food offers a number of unique advantages. First, perennial crops store significantly higher amounts of carbon in the form of biomass than do clear weeded, annually tilled crops. Proposals to use these types of crops to feed livestock could have significant impact on carbon sequestration and improved land management techniques. Currently, one third of the global cereal crop production is used to feed livestock, and as such, this is an important arena for potential innovation

Significant scientific R&D, as well as technological innovation, will be required to exploit perennial crops. Perennial crops are more difficult to breed because of their longer generation times. However, investment in R&D focused on improving these methods could also potentially have significant impact on the amount carbon that is withdrawn from the atmosphere and stored in biomass.

Fish, particularly from fish farming, will be an essential element in ensuring the availability of sufficient food globally. Aquaculture, when done properly, is significantly more efficient in the use of feed and water inputs than other livestock options. Aquaculture currently provides upwards of 42 percent of the world's seafood and is significantly less energy intensive than traditional fish capturing methods. Investment in the development of techniques that minimize or eliminate the environmental impacts of aquaculture can increase the utility of this important food product.

The development of plants that can withstand the impact of decreased or increased precipitation will be essential in mitigating the effects of climate change. Traditional breeding programs as well as biotechnological and genetic modification of agricultural plants are likely to be needed to meet this demand. However, it is increasingly likely that the rate of climate change will outpace the speed with which traditional breeding programs can be deployed. In these cases, the use of biotechnology can significantly increase the speed with which strains with beneficial properties can be developed. For instance, biotechnology derived drought resistant strains of crops are being developed that are designed to thrive in an increasingly arid environment, while flood resistant strains of rice are currently being developed to counter losses arising from increased flooding associated with altered precipitation patterns.

Similarly the use of biotechnology, genetic sequencing, and genetic modification of agricultural plants may improve the ability to modulate or decrease the amount of pesticides and increase the efficiency of fertilizer use. The successful development of such traits should significantly decrease the environmental impact of pesticide and fertilizer use leading to more sustainable agricultural practices.

The use of biotechnology also offers the possibility of moving beneficial traits from one plant species to another, something that traditional breeding programs can not generally achieve. For instance, there are no known stem rusts that impact rice. The identification of the genetic determinants of this resistance and the successful transfer to wheat could help mitigate the growing threat to the global wheat supply. Recently, the identification of the gene that affects the resistance of rice to rice-blast fungus, coupled with biotechnology, may allow the development of blast resistant strains of rice that are palatable, a goal that has not been, and is unlikely to ever be, achieved using traditional breeding techniques.

Conclusion

This **ISGP White Paper** attempts to assess and characterize some of the significant S&T options and policy issues that surround ***Food Sustainability***, with a focus on food safety and security of supply. The urgent need to identify “actionable decisions” that lead to practical policies is apparent. The realities are potentially dire, the challenges significant, and while the S&T opportunities are encouraging, almost all require further maturation and an expansion of our physical and societal infrastructure.

Overall, potential solutions contain elements of near-, mid-, and long-term planning based on integrated domestic and global policies. The most attractive near-term options capitalize on currently accessible approaches that require support by consensus. Mid-term options need to harness evolutionary progress, largely involving S&T research and development often already underway. In the foreseeable future, these mid-term options are likely to have the largest impact on optimizing the world’s ability to produce sufficient supplies of safe, nutritious and wholesome foods. Long-term options can be realized only from investments in R&D that challenge the existing S&T understanding and fundamentally change the technological opportunities available to transform our access to more efficient and productive methods for obtaining food. Policy decisions need to consider how to integrate all three types of options into a globally supported direction since no single S&T approach can be expected to be sufficient to meet the scale of the recognized challenges associated with ***Food Sustainability***.

A comprehensive ISGP study of ***Food Sustainability*** would examine the topic in detail, develop a Strategic Roadmap from extensive interviews and a through review of the literature, and utilize the ISGP’s unique format of critical debates and caucuses extending over a two-three-year series of interviews and international conferences to help shape domestic and international policies.

