

EXECUTIVE SUMMARY

Guam is a small island with a dedicated and well-respected education and research community in the midst of a vast Pacific sea and at the edge of the deepest place on earth (Marianas Trench). Modern development, technology, and climate change are impacting this resilient island that is only 209 square miles. Guam has a rich research terrain, from tropical island environment to coral reefs to ocean depths resources. Many of the marine plants and animals can be found nowhere else on earth.

Guam's residents originate from all parts of the Asia-Pacific region in addition to the U.S. mainland. In addition to Guam's indigenous Chamorro people, who comprise approximately 47% of the population, large numbers of mainland Americans, Filipino, Chinese, Japanese, and South Koreans constitute the majority of Guam's population. There are also substantial numbers of Micronesian islanders, Vietnamese and East Indians. Guam's diverse population makes it one of the most cosmopolitan communities in the Western Pacific. According to the 2010 U.S. Census, Guam's 2010 population estimate was 159,358. This represents a 2.9% increase over the 2000 U.S. Census tabulation of 154,805, which was in turn a 16.3% increase over the 1990 population of 133,152.

The social and cultural tapestry of the region retains traditions and practices from before western contact and colonization; Pacific Islanders excelled at open ocean navigation long before Magellan had traversed the western hemisphere and established a metric base for global navigation. Guam has been impacted by modernization, yet it remains resilient with rich biodiversity, cultural survival, and environmental integrity.

Guam is an island surrounded by a sensitive marine environment and time sensitive issues. Once the marine and terrain assets are depleted, damaged or destroyed, there is no replacement. Researchers in Guam are charged with not only leveraging their assets, but ensuring that the assets remain for generations to come.

Within an island environment the physical assets are what mold the social and cultural aspects. Guam's biggest strengths are also its biggest weaknesses. Remoteness has allowed Guam to maintain its rich cultural heritage, and also, to a certain extent, it's pristine land and water environment. However, remoteness has contributed to its inability to retain human capital, and to obtain physical and



Figure 1. Ancient boat building methods allow small craft to navigate hundreds of miles between islands

financial assets as readily as other larger and more centrally located population centers.

To determine the direction and focus of this plan, the plan coordinating team enlisted leading specialists and experts from organizations that are involved in Science, Technology, Engineering, and Math (STEM) education and research. Directors of government agencies and Guam's business communities also were engaged at the Steering Committee level to give their input into their

needs and expected deliverables from the education and research community. An outreach STEM needs survey was distributed to business and government entities to solicit their input for this report. It was well received by the community, with responses from 104 organizations across the island eager to have their voices heard.

A general consensus was reached during multiple facilitated meetings; Guam has incredible potential for STEM achievements and contributions to the global research community. Guam has a tradition and history of innovation, but Guam still lacks the resources to implement a world class STEM plan with accompanying funding sources that is cohesive, communicated well, and maximizes technology.

Guam's strength is in its resourcefulness. Limited resources and inaccessibility due to Guam's isolated location dictate that the islanders create and modify available resources for functionality. Because resources are scarce, they are maximized and shared by the group.

Another strength is Guam's ability to effectively collaborate between and among the key stakeholders in academics, business and government in the application of innovation. Transfer of knowledge from research into actionable innovation in the business community is efficient and swift because of the small size of the island and its close-knit community.

Goals for the development of science and technology were agreed to by the local STEM academic community as well as Guam's STEM Steering Committee. They are articulated below:



Figure 2. Science & Technology Advisory Committee Members.



Figure 3. S&T Committee Meeting, April 8, 2015

GOAL 1: MICRONESIA INTERNATIONAL RESEARCH HUB

Develop global recognition as the facilitator for studying sustainability related issues and knowledge for Guam and the surrounding Micronesia Region.

GOAL 2: STEM CAPACITY BUILDING

Produce a STEM-competent Micronesia-centric workforce by providing a holistic, place-based education pipeline to meet the localized sustainability needs of the government and the private sector while encouraging and supporting local entrepreneurial efforts.

GOAL 3: STEM INFRASTRUCTURE

Provide the infrastructure that will allow Guam access to facilities and equipment that support needed research; as well as enhance connectivity among government, educational and academic institutions.

GOAL 4: COMMUNICATION

Increased communication in the Micronesia region to facilitate informed decision-making, knowledge sharing and continuing education that helps develop a regional community of life-long STEM learners.

Each goal is supported by objectives, from which activities were developed and measurement methods were determined.

I. INTRODUCTION

The island of Guam is endowed with a lush and vibrant landscape; both above and below the water. Guam lies within 3 ½ hours from major population segments in the Philippines, Korea, and Japan. Our island has recently been granted a visa waiver program for Russian tourists and is currently engaged in dialog that may result in less restrictive visa requirements for Chinese tourists. This translates into a forecast of even more stress on the island, its people and its natural resources.

Because of our geographic location and the island's physical attributes, Guam attracts more than 1.3 million tourists a year. This amount of traffic puts stress on both the natural and physical elements of the island. Guam also is regarded as “the tip of the spear” for the military in the Asia Pacific region because of its status as an unincorporated US territory and its proximity to Asia. These are our two largest “industries”, with expansion in both forecasted for the next 5 years.

Guam's biggest strength, its geographic location is also its biggest weakness with regards to acquisition of human capital. The island is highly reliant on electronic and cyber infrastructure for communication and contact with “the outside world.” It is a 7 ½ hour flight west from the nearest US state (Hawaii). Hawaii is an additional 5 hours of flight-time from the west coast of the United States.

But, because Guam is so small and isolated, the island has always faced the issue of having to “import” expertise in a variety of fields and knowledge areas, versus being able to “grow our own.” The island's remoteness has also contributed to a “brain drain” in the STEM areas since many of Guam's young people with the most potential in the STEM areas have left the island for education and career opportunities, never to return.

Today's technology and well-developed online environment provides for a variety of flexible learning programs that allow individuals access to knowledge, information and credentialing without having to physically leave the island. This same environment allows for telecommuting and employment opportunities that do not require the individual to leave the island. This technology and island wide access to an on-line environment is critical to be able to grow local individuals here on Guam to meet the needs of the island's academic, research and business communities. The resiliency of the people, the remoteness and isolation of the island community, and the intense reliability on technology for communication should be studied as a precursor to long-duration space exploration.

Because of its relative isolation for most of its history, Guam's culture and physical assets have been well preserved compared to other less isolated populations and geographic locations. This is changing quickly and drastically due to current

technological advancements and must be addressed now to put into place programs that protect and sustain these resources.

Because of Guam's remote geographic location and diminutive size, Guam faces many challenges. Historically, Guam has relied on federal and local funding sources, but has not taken advantage of certain federal programs, such as the EPSCoR and National Institutes of Health Institutional Development Award Programs (NIH IDeA) programs, Guam is a perfect candidate for these programs, which serve locations that are historically underfunded for research (addressed by the EPSCoR program) as well as lacking funding for biomedical research (addressed by the NIH IDeA programs).

These sources of funding are a critical component for Guam's S&T Plan, as without the financial resources it will be impossible to develop a high level science and technology program.

Guam established eligibility for National Science Foundation (NSF) programs only three years ago. Currently Guam has applied for an EPSCoR grant and has been awarded two planning grants to fund the work on developing their application for an RII Track 1 implementation grant for approximately \$13million dollars. Guam is eligible for the NIH IDeA programs and will be establishing a relationship with the organization in the near future as well as seeking an NIH IDeA award.

Guam's government and business community also are beginning to embrace "green" technology and policies. The potential for collaboration between the academic and business community has never been better. It is critical that we work together as one community to develop policies and business ventures that maximize the resources we have on Guam while minimizing the impact to our environment.

In 2014, recycling has taken hold with aluminum, cardboard, and plastics. But there is considerable room to grow with glass, paper and metal recycling. Used tire shredding for recycling is in its infancy with one permanent shredder located on-island. The island also hosts an annual Sustainability Conference with the University of Guam (UOG) and Guam EPA as prominent sponsors, along with many private environmental firms.

Recently, a subsection of the American Water Works Association was formed on Guam to bring together professionals, professors, students, and industry leaders with interest in improving water and wastewater conditions on the island. An



Figure 4. Jim Adkins, President of Green Things, Inc. and inventor of "The Green Thing" a garbage/trash reduction machine. The machine shreds, and takes out the water volume by 80% while reducing weight by 65 to 75%. Mr. Adkins is a long time Guam resident and the machine is being used at a Guam shopping mall.

inaugural conference was held in April 2015 with a surprising large turnout. Over 100 participants from various islands in Micronesia turned out to share ideas and help solve the critical environmental issues facing all the islands. It is apparent this subsection immediately filled a gap in the technology and environmental fields that was sorely needed.

A. ECONOMIC OVERVIEW

Guam's private sector and government leaders have stressed the importance of developing a knowledge based economy. Contributing factors that necessitate this include:

- Guam's location - Because of our isolation in the middle of the Pacific Ocean (Guam is 3,700 miles southwest of Honolulu, 1,500 miles east of Manila, 1,500 miles southeast of Tokyo, and 3,100 miles northeast of Sydney), Guam has to be self-sufficient and innovative. Guam's distance to other locations demands that all transportation of materials and equipment be by ship or air.
- Guam's unique needs - it is critical that Guam's public and private sector continue to focus on shared knowledge because although affiliated with the US, our proximity, and cultural profile better fits an Asian model.
- Guam's limited land base - Guam must maximize the usage of all land (the island is 37 miles long and 8 miles wide at the widest point, for a total of 212 sq. mi.) while minimizing the impact to the fragile environment. There is limited usable area due to mountains, rugged cliffs, and dense tropical jungle.
- Guam's high cost of living - physical transportation of materials, equipment and expertise to the island is expensive.

Although Guam is blessed with natural beauty, it is not blessed with natural mineral resources that would contribute to Guam's economic base.

The following industries and areas are Guam driving economic forces:

THE U.S. MILITARY

Recent world events have increased recognition of Guam's strategic military value that could result in increasing military presence in Guam and its contribution to the Guam economy. In January 2012, the U.S. Department of Defense indicated the importance of a strong U.S. military presence in Asia-Pacific region. A strong U.S. presence in the Pacific demonstrates active support for Japan, South Korea, Australia and other Pacific Rim allies and supports U.S. economic and security

interests. Guam is positioned geographically to constitute an extended homeland defense perimeter, protecting the U.S. west coast and Hawaii from acts of aggression. Military bases on Guam can support forward deployed capabilities in Asia and allow rapid response to any threat to stability of the Asian region or any threat to the U.S. originating in the Asian region. Other advantages of Guam's military activity include:

- Geographic location: closer to potential flashpoints of conflict in Asia and the Middle East.
- U.S. Sovereign territory: no need for host nation consent to pre-position war munitions, to deploy weapons or to conduct operations.
- Air Force, Navy and Marine Corps, Coast Guard, National Guard and Reserve facilities with substantial munitions, fuel supply, communications, command and control capabilities.
- Unencumbered air and sea space for live fire and special operations training including EOD, SEALs and other joint war fighting and operational readiness initiatives.
- Deep-water harbor with 17,000 linear feet of wharfage with ability to handle three million pounds of ordnance (net explosive weight).
- Significant airfield capability including dual, two mile long runways with contingency, mobilization and surge capable civilian airfields on Guam and CNMI.
- Repair capabilities for surface vessels, submarines, aircraft and combat equipment at the Intermediate Maintenance Facility, the privatized ship repair facility, the submarine tender, Naval Base Guam and Andersen Air Force Base and civilian facilities.

Military Personnel

The level of active duty military personnel in Guam increased slightly from 2007 to 2010. In late July 2010, the Joint Guam Program Office of the Department of the Navy released its Final Environmental Impact Statement (the "EIS") pertaining to the proposed U.S. military build-up on Guam, and in September 2010 the Department of Defense ("DoD") issued its Record of Decision pertaining to the EIS. At the time the EIS was released, it was anticipated that the military build-up would have three major parts: relocation of part of the Third Marine Expeditionary Force from Okinawa, Japan, creation of the infrastructure for an aircraft carrier berthing, and installation of an Army Air and Missile Defense Task Force. Together, these were anticipated to add approximately 32,000 permanent residents

to the island, and to create a peak population increase of approximately 79,000 people in 2014.

In the years following 2010, Guam began to experience a decrease in military personnel as a result of the delay in the relocation of the Third Marine Expeditionary Force from Okinawa and Iwakuni, Japan to Guam. Concerns regarding the high cost of the relocation, delays in relocating U.S. military personnel and facilities currently within Japan, and the U.S. budget deficit have extended the implementation timeframe for the relocation of the U.S. Marines from Japan. The proposed U.S. military build-up now is not expected to occur until after 2018. In addition, the expected size of the build-up has decreased. In particular, the relocation of part of the Third Marine Expeditionary Force from Okinawa, Japan, is now expected to result in the relocation of approximately 4,700 marines with approximately 1,300 dependents over a 12-year period, rather than the approximately 8,600 marines and 9,000 dependents originally expected. In April 2014, the DoD released a draft Supplemental Environmental Impact Statement (2012 Roadmap Adjustments) (the “Draft SEIS”), which identified potential impacts associated with several alternatives for the cantonment/family housing component of this relocation, as well as for the live firing training range complex. A Record of Decision, which will identify the final locations for additional bases and facilities to accommodate the marines, is expected to be issued in the first quarter of 2015. It is expected that the costs related to the development and construction of facilities accommodating the build-up will be funded by the federal government and the government of Japan. The bulk of related construction is currently expected to occur in 2017-2018, depending on the Record of Decision.

The Government cannot predict whether, when or to what extent such increase may occur. Regardless, there currently exists significant United States military missions on Guam.

The U.S. Air Force hosts a rotating presence of bomber, tanker and fighter aircraft and permanently stationed RQ-4 Global Hawk unmanned aerial reconnaissance assets in addition to a variety of aircraft and contingency response training events. The U.S. Navy has home-ported three fast attack submarines in Guam: the USS Oklahoma City, the USS Chicago and the USS Key West.

The U.S. government may choose to relocate military fleets, equipment and personnel from time to time in ways that either increase or decrease the U.S. military presence on Guam, and the Government cannot predict whether or when such adjustments may occur. However, military presence on Guam is expected to increase.

The Record of Decision on the buildup is expected to be publicly released in June 2015. This is the plan that would outline the magnitude of the military buildup.

Military Expenditures

The table below provides a breakdown of military expenditures on Guam during Fiscal Years 2004 through 2010. Periodic changes in these figures reflect deployment of Guam-based troops to active duty in other locations. The U.S. Bureau of Census ceased publication of military salary data in 2011 due to budgetary constraints.

Table 1. Department of Defense Expenditures on Guam

<u>Fiscal Year</u>	<u>Active Military</u>	<u>Inactive Military</u>	<u>Civil Service Employees</u>	<u>Coast Guard Employees</u>	<u>Total Salaries</u>
2004	\$206,570	\$20,533	\$38,776	\$167	\$266,046
2005	211,239	23,544	55,291	159	290,233
2006	233,475	18,986	56,065	144	308,670
2007	233,521	11,290	58,381	149	303,341
2008	101,303	13,880	60,794	157	176,134
2009	114,218	85,938	66,224	215	266,595
2010	241,496	15,751	72,923	225	330,395

An increase in Department of Defense procurement contracts results from the loss of civil service personnel. As the private sector carries out functions previously performed predominantly by civil service personnel, federal spending under procurement contracts generally increases. Expenditures also increased as the military undertook various projects in support of current missions and relocation from Okinawa including a new Naval hospital. The table below provides data for Department of Defense procurement contracting on Guam for Fiscal Years 2006 through 2012. Periodic changes in these figures reflect deployment of Guam-based troops to active duty in other locations.

**Table 2 Department of Defense Procurement Contracts for Guam
Fiscal Years 2006-2013
(In Thousands)**

<u>Fiscal Year</u>	<u>Department of Defense Procurement</u>
2006	\$270,843
2007	341,933
2008	392,553
2009	342,630
2010	666,023
2011	663,806
2012	310,102
2013	491,569

⁽¹⁾ Data derived from USASpending.gov. Data available from USASpending.gov is generally updated every six months and can result in changes in previously published amounts. Department of Defense procurement data reflects actual expenditures.

⁽²⁾ Reflects procurement information based on contract award amounts as collected and maintained by GEDA in an independent database derived from information reported on various military websites supplemented with data from the Naval Facilities Engineering Command Contracting Office.

Sources: USASpending.gov and Guam State Data Center, Bureau of Statistics and Plans; Guam Economic Development Authority.

Congressional authorizations for appropriations for military construction and family housing projects are depicted in Table 3 below. Steady growth in such authorizations was evident from Fiscal Year 2007 to Fiscal Year 2010. Fiscal Year 2011 saw a significant decline in appropriations due to delays as a result of environmental and land acquisition issues associated with the relocation of Marines from Japan to Guam. This decline has continued for 2012 and 2013 as the impact of the relocation of Marines is still being studied and Department of Defense still needs to meet certain Congressional requirements. The Department of Defense studies are currently scheduled for completion in early 2014. The National Defense Authorization Act for federal fiscal year 2014 authorized \$495 million for military construction in Guam, subject to the satisfaction of certain requirements.

**Table 3 U.S. Military Construction Authorizations for Guam
Fiscal Years 2007-2013
(In Thousands)**

<u>Year</u>	<u>Total Authorizations</u>
2007	\$208,746
2008	290,700
2009	179,100
2010	737,614
2011	246,030
2012	116,600
2013	101,904

Source: Guam Economic Development Authority.

Of the \$116.6 million appropriated in Fiscal Year 2012, \$33 million is conditioned on certain actions to be taken by the Marine Corps, the Secretary of Defense, and other federal agencies. While the Government believes progress is being made to satisfy these conditions, no assurance can be given as to when or if such conditions will be satisfied. Fiscal Year 2013 construction projects recently authorized by Congress include upgrade of the Defense Logistics Agency Fuel Pipeline (\$67.5 million); North Ramp Utilities at Andersen Air Force Base Guam (\$25.9 Million); and the Guam Army National Guard Joint Force Headquarters (\$8.5 million). Fiscal Year 2014 has already proven to be a very active year in terms of Department of Defense spending. In December, Naval Facilities Engineering Command (NAVFAC) Marianas awarded a \$52 million contract for construction of a new fuel transfer pipeline and upgrade of an existing fuel transfer pipeline. In May, the Navy

awarded task order projects for the construction/engineering of modular storage magazines and for the design and construction of an aircraft maintenance hangar, an undertaking of \$42 million and a \$53.7 million respectively. Other Fiscal Year 2014 projects submitted for Congressional approval include: Broad Area Maritime Surveillance (BAMS) Forward Operational and Maintenance Hangar (\$61.7 million); Dehumidified Supply Storage Facility (\$17.17 million); Emergent Repair Facility Expansion (\$35.86 million); Sierra Wharf Improvements (\$1.17M); X-ray Wharf Improvements (\$53.42 million); Pacific Airpower Resiliency (PAR) - Fuel Systems Hardened Buildings (\$20 million); PAR - Strike Tactical Missile Mx Facility (\$10.53 million); PAR - Tanker GP Mx Hangar/AMU/Sqd Ops (\$132.6 million); PRTC RED HORSE Airfield Operations Facility (\$8.5 million); and PRTC SF Fire Rescue and Emergency Management (\$4.6 million).

TOURISM

Tumon Tourist Zone

Tourism has represented the primary source of income for Guam's economy for over twenty-five years. Visitor arrivals rose to over 1,000,000 travelers for the first time in 1994 and have remained near or above that level ever since.

Annual visitor arrivals averaged 1,175,648 from 2005 to 2012. There was a small decline in visitor arrivals in 2006 and then a marginal increase in 2007. Arrivals for 2008 declined due to the global recession. Arrivals for 2009 declined relative to 2008 due to a spike in diagnoses of the H1N1 virus in Japan in early 2009. Visitor arrivals increased approximately 14% from 2009 to 2010. Arrivals for 2011 declined following the natural disasters in Japan in March 2011. The overall effect was less than expected due to increased arrivals from South Korea and Taiwan. Calendar year 2012 saw arrivals at the highest level in recent years, with a 2.6% increase in arrivals relative to 2011 through November 2012. During 2013 tourism grew to 1.334 million visitors with numbers not seen since the mid-1990's. Tourist numbers for 2014 totaled 1,341,171, a 3% increase over 2013. (Guam Visitors Bureau) Today, tourists are attracted to Guam for such sporting events as the Guam International Marathon, the Xterra Race, and the incredible SCUBA diving and snorkeling.

Tumon Bay, located on Guam's west coast, is the heart of Guam's tourist industry. The hotels that line Tumon Bay provide lodging to the majority of visitors to Guam. During the 1990s and early 2000s, Guam's inventory of hotel rooms increased over 100% with substantial growth in the number of hotel rooms occurring from 1991 to 1993 and from 1995 to 2001. As of January 2012, there were 33 hotels in Guam, including many notable international hotel operators, with an inventory of over 8,900 rooms. Guam's annual weighted hotel occupancy rate improved from 60% in 2006 to 68% in 2007, but declined to 64% in 2008 and to 60% in 2009. In calendar year 2010, annual weighted hotel occupancy rates

increased to 71%, then to 72% in 2011. The weighted average room rate during the period from January to December 2011 also increased to \$114 from \$111 during 2010. As of October 2012, the weighted average hotel occupancy rate and room rate was 77% and \$110 respectively. The first half of 2013 showed the average occupancy rate for that period decreased by 1% compared to 2012, but the average room rate increased from \$119 to \$131, an increase of 10%. Increases to tourism can result in environmental challenges because of the heavier load on natural resources.

Limited existing infrastructure, roads, sewers, water, that need to be repaired, replaced or augmented due to the stress of increased demand can be addressed through additional STEM related industries.

Furthermore, the earthquake and tsunami events in Sendai, Japan in March 2011 have added to the struggles facing Guam's major source market. About 90% of all Guam visitors are from Asia, with the balance made up of visitors from the United States, neighboring Pacific islands, and other areas. Visitors from Japan comprise the largest share of Guam's market mix with close to 80% of all arrivals to Guam. Guam's market share in 2010 was 5.4 % of the Japanese tourist market, a total of 16.6 million outbound travelers. Guam Visitors Bureau's purchasing power in source markets has been seriously impacted by the yen's 27% rise in value against the U.S. dollar during the period of April 2008 to April 2011. This increase in the yen's value has limited its advertising and public relations expenditures, especially in Japan. The global economic recession of 2008 also played no small part in diminishing international travel arrivals from major source markets to Guam.

ECONOMIC UPDATE

The Bureau of Labor Statistics report by the Guam Department of Labor website indicates there are 62,480 jobs on Guam, representing a slight increase from 61,910 jobs a year earlier. By employer, 46,730 or 75% of the jobs were provided by the private sector, 4,130 or 6% jobs by the federal government, and 11,620 or 19% by the Government of Guam. By economic sector, 17,160 or 38% of the employed individuals were in Service; 2,470 or 6% were employed in Finance, Insurance and Real Estate; 11,850 or 27% of individuals were employed in Retail Trade; 2,120 or 11% in Wholesale Trade; 4,990 or 0.016% were in Transportation and Public Utilities (STEM related); 1,380 or 3% in Manufacturing; 6,540 or 15% in Construction (STEM related); and 220 or 0.4938% were in Agriculture (STEM related).

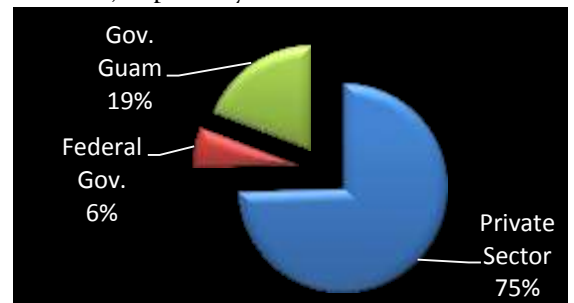


Diagram 1. Employment by Government and Private Sector in 2014

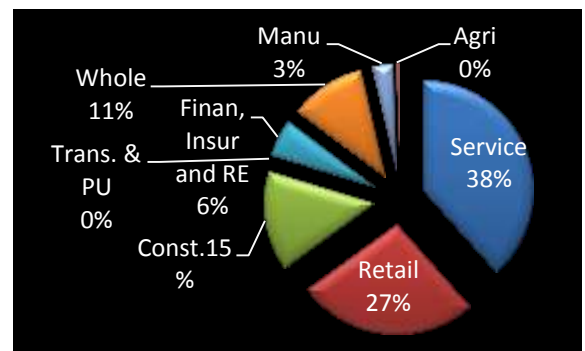


Diagram 2. Employment by Industry created by Private Sector in 2014

Guam experienced a prolonged period of investment-driven growth through the 1980's and early 1990's. During this period, the private sector overtook the public sector in economic importance. Growth in employment and output in Guam dropped significantly in the latter part of the 1990's and continues to drop into the 21st century.

Average annual individual income for residents of Guam has increased from \$26,730 in 2003 to \$32,700 in 2013, a compound annual growth rate of 2% according to the US Department of Labor Bureau of Labor Statistics.

Guam's unemployment rate was recorded at 7.4% as of March 2014. The number has gone from 9,730 in March 2013 to 5,350 as of March 2014. More than 45,000 people are on Public Assistance. Guam is considered a 100% Historically Underutilized Business Zone (HUB Zone) under the Small Business Administration guidelines. This program promotes economic development and employment growth in distressed areas by providing access to more federal contracting opportunities through the establishment of preferences. (SBA.gov webpage)

Guam has seen a precipitous reduction in revenues from the three major sectors of the economy (tourism, military/federal, other). As a result of this drop, total government revenues have dropped 49% from \$660 million in the mid-1990 to an estimated \$340 million in 2010. This condition has led to very serious shortcomings in the delivery of basic public services and raises major concerns in public safety, health, education, and employment. Other economic indicators paint an equally dismal picture. Reduction in government expenditures has not kept pace with the island's shrinking economy.

In December 2013, the U.S. Department of Commerce, Bureau of Economic Analysis (BEA) released its estimates of Guam's GIP (gross island product) showing that the economy slowed in 2011 but regained momentum in 2012, back to the 2010 level of \$4.06 billion (in real terms, using 2005 prices). With BEA estimating Guam's population at 159,800 in 2012, this translates to a per-capita income of \$25,388. (First Hawaiian Bank Economic Forecast 2014 Guam-CNMI Edition)

Guam's economic forecast for the next year is positive, as presented by the Bank of Guam on April 9, 2015. Excerpts from the Economic Forecast by Mr. Joseph Bradley, Senior Vice President/Chief Economist and Business Continuity Officer at Bank of Guam:

Guam is finally seeing stronger tourism growth – Through February, visitor arrivals are up by 4.5% from last year; Japanese arrivals are still weak, but other markets, especially Korea are growing fast.

- Japanese arrivals are down by 5,270 (3.6%) to 139,164, with a market share of 57.0%.
- Korean arrivals are up by 18,627 (35.9%) to 70,522, with a market share of 28.9%.
- China arrivals are off by 1,405 (16.0%) to 7,387, 3 0% of the market
- Russian arrivals are off 2,777 (76.8%) to 840, 0.3% of the market.

Guam's tourism industry in 2013 increased in numbers and diversity of the tourism market. With the approval of the Russia visa waiver, Guam welcomed a new and rapidly growing Russian tourist market. Businesses catering to this market have appeared in the central tourist area of Tumon (examples include Russian restaurants, establishments with signage in Russian welcoming Russian customers, etc.). Visitor arrivals were up in 2014 over 2013 by 9,000, however, in 2015, the Russian economy has declined, bringing fewer tourists to Guam.

Although federal spending and military contract spending was down during 2013 and the first half of 2014, these spending areas picked up in 2014 to \$1,242,045, with total funding awarded in FY 2015 at \$521,807 due to the increased military spending on a variety of projects, some which are related to the realignment plan.

The U.S. Senate has finally approved the funding for the relocation of the Marines from Okinawa to Guam and the FY 2015 National Defense Authorization Act has passed, which authorizes projects on the island, including \$51 million to establish a Marine Task Force on Guam.

Consumer prices remained stable, with the 4th quarter Consumer Price Index for Guam at 1.8% higher than it was in December of 2013.

Private sector projects in 2015 that are ongoing or have just been completed include the Dusit Hotel, the Guam Regional Medical Facility, American Medical Center. There also is a hotel in the design phase.

Public sector projects include infrastructure utility projects initiated by the Guam Power Authority and Guam Waterworks Authority, such as the wastewater treatment facility in the south. (Variety News, Wednesday, Jan. 28, 2015, "Local economist sees positive economic outlook for Guam".)

The March 2014 Current Employment Report showed increased employment in the private sector and a slight decrease in the number of jobs in the public sector.

The March 2014 report showed 520 more jobs in the private sector compared to the March 2013 report. Most of these jobs are in the construction industry.

Wholesale and retail also reported increases. There was a decrease in hotel and lodging employees, however that is expected to change based on the opening of the Dusit Thayne Hotel and expected hiring of 300+ employees.

The public sector showed a marginal decline of employment and the federal government was flat. Wages increased by 4.1% from an average of \$12.87 per hour to \$13.40 per hour. (Variety News, Monday, May 19, 2014, "Service industry jobs decrease")

B. POSITION OF GUAM'S STEM FIELDS

PHYSICAL CHARACTERISTICS

Guam, as the westernmost territory of the United States, is the largest and southernmost island in the Mariana Archipelago, and was the first Pacific island discovered by the Western World. The island was formed through an uplift of undersea volcanoes and is surrounded by coral reefs. It is composed of two distinct geologic areas of approximately equal size. The northern part of the island is a high coral limestone plateau rising approximately 200 feet above sea level. This area contains the Northern Guam Lens Aquifer, the main source of fresh water for Guam. Apra Harbor, one of the largest protected harbors in the Pacific, is located on the west central side of the island. The southern portion of the island is composed of volcanic deposits, which form low-lying mountains and rivers, that direct surface run off either to Fena Reservoir or the ocean.

Guam's climate is tropical with temperatures ranging between 75 and 86 degrees, and a mean annual temperature of 81 degrees. May and June are the hottest months, with the most rainfall occurring from July through October. The average yearly precipitation is approximately 90 inches. Constant trade winds blow from the northeast during the dry season, December through April. Drought-like conditions can occur during the dry season; however, Guam's subterranean water lens is capable of supplying fresh water in excess of the island's present needs.

SOCIO-CULTURAL PROFILE

Since becoming an unincorporated territory of the United States in 1898, the island's population has grown from 18,000 to the present population through a mixture of in-migration and one of the highest birth rates in the U.S. (1.96% as of 2008). With this steady increase in population and the attendant economic expansion such growth portends, significant social changes have occurred. These social changes, while creating even greater diversity, have also caused detrimental effects to the community as a whole. One of the negative results of Guam's rapid population has been the erosion of its traditional family structure. The greatest

threat to the island's family structure has been in large part the economic growth which has also improved the overall standard of living. Subsistence farming has given way to a wage based economy which has created a new array of expectations and desires. While over time, the island has improved its standard of living; in real economic terms, that same progress has created significant challenges to traditional family values. Loss of these family values has been blamed for rising crime rates, drug use, child abuse, senior citizen abuse, as well as increased poverty, welfare dependence, and high school "drop out" rates.

The goal to revitalize traditional family values in island homes and communities has continued through the establishment of cultural programs offered by various public and private organizations. Young people today are subjected to tremendous pressure to conform to modern values that often run counter to the traditional values of local families. This clash of values has often created dislocation and confusion, which has reinforced dysfunctional behavior.

For these reasons, the preservation of the Chamorro culture is sought. Among the cultural needs identified are: the preservation of the language through the study of Chamorro within a scholastic framework; preservation of traditional fishing practices and art forms; exploration of sustainability-based indigenous technologies; use of indigenous names in public places; development of an authentic Chamorro village; establishment of a permanent Guam Museum facility; reconstruction of the Governor's Palace; and the recovery of Chamorro artifacts from local and foreign sources.

Another reason that Chamorro culture has attracted much attention in recent years reflects a shift in strategy in the Guam Visitors Bureau (GVB) to rebrand Guam's image as a tourist destination and to emphasize the importance to visitors of the "experience" from their visit to Guam, including their experience of the local culture. This has been referred to as "a sense of place." Programs such as the Hafa Adai Pledge, the painting of village murals, the Hāgatña Revitalization (the restoration of Guam's capital), and the Maila ta fan Boka ("Come Let's Eat") program highlights the local culture through its food, art, and hospitality.

POPULATION

Guam's latest official population based on decennial census data released by the U.S. Census Bureau is for the year 2010. Guam's 2010 census population was 159,358 people. Guam's population increased 2.9 percent from its 2000 census population of 154,805 people. Its population growth was significantly less than the 16.3 percent increase that occurred between 1990 and 2000. In addition, Guam's population growth was significantly lower than the population estimates made by the U.S. Census Bureau that were based upon an annual growth rate of 1.5 percent. The impact of Guam's slow economic growth between 2000 and 2010 is

evident by its slow population growth rate during the same period. It is suspected that there was a high out migration of Guam residents as they sought greater economic opportunities in Hawaii or the continental United States.

This richness in diversity is an opportunity to research cultural competency, practices that cut across global culture and strategies that succeed with communities that have merged over vast oceans and continents.

ENVIRONMENTAL SITUATION

In general, Guam has a high quality physical environment. The Guam Environmental Protection Agency conducts various programs that monitor the status of the environment on a regular basis. The U.S. Environmental Protection Agency's regulations apply to Guam; in some cases, Guam's own laws are more stringent than those of the USEPA.

As a relatively small and high density island, Guam's marine environment is a key litmus test for the overall environmental impact of human activity on the land. The quality of marine waters has been found to be generally excellent across all indicators. At the confluence of Pago River and its receiving marine waters, however, a high nitrate level is evident in violation of federal EPA standards. This is attributed to nutrient loading by leachate from the island's Ordot Dump, which has recently been closed and replaced by a new municipal sanitary landfill at Layon.

Solid waste landfills are an area of concern in Guam given the limited land area. The amount of solid waste continues to rise each year. These problems are magnified as the standard of living changes and increase in population and industrial activity bring more goods and commodities to the island. After decades of violating the Clean Water Act by allowing harmful leachates to be discharged, the U.S. District Court issued a Consent Degree in 2004, outlining the necessary actions needed to close the Ordot Dump and construct a new Municipal Solid Waste Landfill Facility. Due to non-compliance, a receiver was appointed to work with the Solid Waste Management Division to ensure that the necessary actions were taken.

To reduce the volume of garbage going into the landfill, a policy was issued banning items such as cardboard and organic waste. Through collaboration between community organizations private businesses, and the local government, some headway has been made in recycling solid waste, including the creation of the "i recycle" program by local businesses to recycle aluminum cans with the proceeds going to local schools.

The Layon landfill on Guam is limited in size, which limits its ability to accept solid waste over the long-term. Recent environmental issues involving the island's deteriorating infrastructure are threatening to place a high burden on the landfill. The water and sewer pipelines on the island were built following WWII using then popular materials. These materials, predominately asbestos-cement piping, have surpassed their useful life and must be replaced. Replacement causes potential removal and disposal of a hazardous waste (asbestos). Although the landfill was designed to accommodate permanent disposal of asbestos, such volumes as may be seen due to replacement of the aged infrastructure will seriously impact the landfill's ability to contain island wastes for the long-term. Solutions to this upcoming problem will require STEM related technologies.

The pollution of marine waters near all of Guam's wastewater treatment plants is also of concern to federal EPA. A Stipulated Order has been issued to bring Guam's wastewater system into compliance with the Clean Water Act. As a result, effluent prior to being discharged into the marine environment by the island's wastewater treatment plants is being required to undergo secondary treatment. Permits have been issued by EPA to establish treatment levels. Employing a phased approach, Guam initially began implementing primary wastewater treatment using chemically enhanced settling at the two largest wastewater treatment plants; Northern District and Hagatna. Since implementation, these plants have complied with the U.S. District Court Stipulated Order. Secondary treatment, currently in the planning stages, is an advanced process that requires a heightened level of STEM.

Erosion of soil is associated with construction activity and natural erosion occurs in poorly vegetated areas of southern Guam. Frequent grass fires also subject areas to increased erosion. Soil erosion is an area of special concern in southern Guam since sediment run-off negatively impacts the reef in areas where rivers discharge into the receiving waters of the ocean. Past sedimentation has resulted in the destruction of coral reefs and associated organisms in areas adjacent to the mouths of rivers.

Aside from sedimentary run-off, the National Oceanic and Atmospheric Administration (NOAA) identify climate change, recreational use, and the proposed Military Buildup as threats to Guam's coral reefs. NOAA's strategic plans include reducing sedimentation and pollution from fires, development, recreation, and agriculture and protecting fisheries by management based on conservation. NOAA is also working on mitigation measures to prevent damages to the coral reefs due to the construction of a wharf for a transient nuclear-powered aircraft carrier. According to the September 2010 Record of Decision published by the Department of the Navy and Department of the Army, the Department of the Navy has postponed the selection of a site, but still considers Apra Harbor as the best alternative since it is the only site deep enough for a wharf.

The quality of the surface water system has been found to be generally good, but problem areas have been identified with specific river systems. The most common violation of water quality standards is related to elevated fecal coliform levels. In addition, elevated readings regarding nutrient loading readings are chronic for certain river systems.

The quality of air is very high with prevailing winds removing air contaminants (e.g., sulfur dioxide), which are mainly associated with point sources burning of fossil fuels to generate electricity for the Guam Power Authority. The use of high sulfur fuel is allowed under a waiver of the U.S. EPA air pollution guidelines. Future use of Liquid Natural Gas (LNG) is being studied. The U.S. EPA is considering placing GPA under a consent decree to reduce high sulfur emissions.

Guam's primary water supply, the Northern Guam Lens Aquifer, may be subject to potential contamination. In 2010, the U.S. Department of Environmental Protection Agency issued a statement in response to the Draft Environmental Impact Statement (DEIS) for Department of Defense, expressing concerns of how construction due to the proposed Military Buildup may negatively affect the Northern Aquifer. According to the statement, the DEIS addressed issues concerning water supply but did not adequately address the issues of increased chloride levels due to saltwater intrusion, removal of vegetation in surrounding watershed protection areas, storm water drainage, and contaminant movement in the aquifer. According to the Final Environmental Impact Statement (FEIS), released in July 2010, DoD is working with the Guam Environmental Protection Agency (GEPA), the U.S. Environmental Protection Agency (EPA), and the Guam Waterworks Authority to ensure the protection and management of the aquifer. The United States Geological Survey (USGS) conducted a Northern Guam Lens Aquifer study that establishes a planning strategy for minimizing saltwater intrusion and maximizing the use of ground water production during droughts. Findings from this study were available during preparation of the draft SEIS for the proposed military buildup. Furthermore, after much study, the Guam EPA declared that the Northern Guam Lens Aquifer is not considered groundwater under direct influence of surface water. However, development above the aquifer has significantly encroached in areas adjacent to the existing groundwater wells. Development places pressure on the wells to avoid contamination and a wellhead protection program and contingency plan is currently being studied.



Figure 5. Guam overlooking Northern Guam Lens Aquifer

Hazardous and toxic waste has a great potential to adversely impact Guam's environment. In recent years, this potential has increased significantly, as evidenced by the growth in the number of on-island hazardous waste generators, solid waste treatment, storage, and disposal facilities. While increasing quantities of hazardous materials are imported into Guam by the commercial sector, the military continues to be the largest importer and user of hazardous materials. As hazardous materials become waste, disposal requires special handling in accordance with Guam's Hazardous Waste Management Regulations. The cost for packaging, transporting and disposing of hazardous waste at an EPA approved site continues to rise.



Figure 6. Fadian Point during a recent storm.

NATURAL RESOURCES

While vast ocean resources surround Guam, the island itself is not endowed with substantial natural mineral resources, other than its people, beautiful beaches and scenery. Mining, other than for coral to use as aggregate for roadways and concrete, is non-existent. Forestry has not been widely practiced, except for harvesting firewood, since World War II when sizeable areas of Guam's hardwood forests were destroyed through shelling and the resulting fires. Development has crowded out large numbers of undomesticated animals with the exception of deer, wild boar, carabao and dogs. While fish are reasonably abundant in Guam's coastal waters, the cooler ocean waters surrounding the island are relatively barren in comparison to the equatorial waters located a few hundred miles to the south. The more popular pelagic fish species are concentrated there, supporting commercial fishing activity.

There are no rivers on Guam large enough to provide significant hydropower. However, there is a natural, large deep water harbor that is protected from typhoons that frequent Guam. The harbor is located on the central leeward side of the island, in reasonably close proximity to the island's business district. The harbor is very advanced relative to other infrastructure in Guam and the Western Pacific, having been extended and improved over the years by both the military and civilian governments.

Guam's small size and distance from other substantial land masses, combined with a small population is unable to meet the market size requirements to obtain specialties in commodities, products and service. For example, Guam's physical size is approximately the same as Singapore (such as square miles), yet Singapore is home to more than 1.2 million persons, compared to Guam's small resident base. Singapore also has the added advantage of proximity to China as well as other substantial population bases.

Guam faces serious challenges regarding its ability to compete for knowledge worker contracts because of its physical location and the cost of transportation of materials and equipment from the mainland. Guam is heavily dependent on technical expertise from outside the island.

SOCIAL SYSTEMS AND TECHNOLOGY

Because of Guam's distance from the US mainland and its small population, Guam lacks specialists in many of the critical health care and medical treatment areas. Guam has begun to explore the use of telesurgery a viable alternative to physically transporting medical experts to the island for consulting and surgery. Telesurgery requires high-speed networks to transmit real-time audio, video, and health data.

Telesurgery is already being used successfully. An off-island doctor was able to remotely operate on a patient undergoing a life-saving heart operation. The doctor supervised the operation from Tripler Army Medical Center in Honolulu located 3,500 miles away from Guam. Although this service is currently available at one clinic, it is not available throughout Guam's other medical facilities or research centers. As Guam's cyber network capability grows, it is expected that this type of activity will increase.

Improved broadband and technology would benefit Guam's community. Currently, Guam's prisoners requiring medical attention are accompanied by two prison guards to the clinics, hospitals or even the surgery center to obtain medical assistance. The prison has very limited medical facilities and difficulty with staffing the clinic making telemedicine/telesurgery a viable alternative to physical transportation of prisoners for medical diagnosis and treatment on Guam. Korea currently uses healthcare technology as part of their health care and treatment program in their prison system. Specialized doctors in collaboration with the prison doctor can treat the prisoners with the use of telemedicine/telesurgery.

Education K – 12

In May 2003, the Guam Education Policy Board adopted the Guam Department of Education District Action Plan (DAP) which establishes the directions and details for improving academic performance. Standards and Assessment, one of seven components of the DAP, focuses on what is needed to be done to increase student achievement as students' progress across each content area.

A major activity in the current DAP includes the review and revision of the Guam Department of Education (Guam DOE) K-12 Content Standards and Performance Indicators. These standards and indicators reflect current educational practices, national standards and what the local community believes is valuable and necessary for students to be competent, productive, and responsible citizens in society and in the world.

The goals for the standards revision included 1) rigor: the standard's ability to measure against other standards across the nation; 2) depth: the levels of cognition, the affective levels and the psychomotor levels – the level of skill students are expected to produce; 3) breadth: content coverage, how wide of a scope is being covered in that area; and, 4) coherence: how they provide seamless transition. The decisions made by the cadre included the following 1) determining essential and core content; 2) determining reasonable and achievable indicators; 3) standard development across the grades; 4) consistency of performance indicators with content standards. The cadre determined whether the standards were appropriate.

Guam Community College

Guam Community College offers associate degrees, certificates, and industry certification in more than 50 fields of study. It also offers an apprenticeship program in conjunction with nearly 100 island employers. The college also offers Adult Basic Education, an Adult High School Diploma program, GED testing and preparation, and English as a Second Language courses. It also has a Memorandum of Understanding (MOU) with GDOE to offer CTE programs in the 5 GDOE high schools, utilizing GCC faculty and curriculum mutually designed by GCC and GDOE.

To date, the college has 3 program-to-program articulation agreements with UOG: AA IAS to BA IAS, AS CJ to BA CJ, and AA Education to BA Education. The college also has dual credit programs, both in General Education (DEAL) and CTE (DCAPS) that allow for high school students to earn college credit while in high school.

Guam Community College also offers Liberal Arts, Continuing Education and Workforce Development courses. These are primarily skill-oriented and are designed to meet the specific training needs of those seeking to upgrade skills in their workplaces, as well as those seeking to develop work skills for entry or re-entry into the workforce. The courses vary in length, depending on the breadth and depth of the skill to be taught. The mission of Continuing Education and Workforce Development is to be responsive to the needs and interests of the community by providing courses, programs, and training that enhance the College's occupational, technological, and academic offerings. The College's Workforce Development programs are supported and guided by local industry advisory groups that meet to review and develop new programs, and provides guidance for ensuring credible certification for graduates.

An example of collaborative, ongoing workforce development efforts is the program titled, "Keep Your Guard Up", a program that was launched in 2014 by the governor, the Guam National Guard, and Guam Community College. At the end of the program, participants get a career readiness certificate and academic credit

for the program. This program is a pilot program for Army National Guard soldiers who have returned from their one-year deployment to Afghanistan.

Guam Energy and Power

While the cost of the oil used for making electricity has fluctuated greatly on price, and concerns over the climate changes grows, the Guam Power Authority (GPA) produces enough power to serve the island economically and meet the steady demands of our growing standard of living. Currently, GPA is exploring alternative ways of producing power that are both economical and environmentally responsible.

Residual Fuel Oil (RFO) Supply will provide a reliable and secure source of fuel between shipments. RFO is stored in GPA tanks prior to use at the power plants. Meanwhile, the need to continue with maintenance and investing in power plant improvement projects must complement GPA's effort to deliver on alternative energy resources to diversify and lessen our reliance on imported fossil fuel(s).

The Wind Turbine project demonstrates renewable viability on Guam to support the transition from oil to jobs. This project in turn will aid in improving our economy and the island quality of life for residents and businesses on Guam. This project is not only a partnership for renewable energy, but also an economic stimulus for Guam, as approximately 110 jobs will be involved with construction of the wind turbines and 27 new jobs to support daily operations.

The wind turbine pilot project installed in the coastal region of Yona will produce wind generated power to serve approximately 25 residential homes. Through this pilot project, GPA hopes to gain experience in the construction management, operation, maintenance and grid interconnection of wind turbines. It is estimated that over 900,000 barrels of oil is replaced with renewable energy within the next 20-25 years. The output of renewable power onto the power grid will serve nearly 2200 homes.

The Smart Grid (SG) Project allows use of alternative fuels and renewable power from solar and wind installations. Smart Grid will also facilitate electric vehicle charging stations and allow Guam to be ready to use other new technologies and more innovations in the future. Guam's SG Project uses new advanced digital meters which provide accurate energy consumption, outage information and outage location as well as voltage quality to customers and GPA.

GPA will provide career opportunities to our youth through apprenticeship programs, scholarships and internship experiences. GPA partners with accredited local institutions of higher learning and off island technical and educational institutions in licensed programs.

II. STRENGTHS AND OPPORTUNITIES FOR GUAM

A. GUAM SCIENCE AND TECHNOLOGY INNOVATION ASSETS

ETHNO BOTANY

Ancient Chamorro healing knowledge and practices are still being used today, in spite of all the disasters, wars and attempts to disrupt the cultural activities of the Chamorro people. These practices have been maintained and passed through oral traditions by the Chamorro population.

Today's generation of Chamorros throughout the Mariana Islands have kept the traditional knowledge of medicine-making alive through a renewed interest and sharing with Chamorro families and interested people of the Marianas. Interviews with *surhãnos* and *surhãnas* throughout the Marianas have led to a compilation of medicinal knowledge in books, videotapes, compact discs and websites for future generations.

A contemporary group of community-recognized *suruhãnos* and *suruhãnas* have led training sessions and conferences on traditional medicine and practices. Present day *suruhãnas* practice traditional herbal medicine-making and healing alongside medical doctors and continue to fill a niche in Guam's sources of health care services.

Protecting native traditional knowledge and practices now means sharing the information with the world.

SOCIAL SCIENCES

Guam Humanities Council

Public Humanities provide the important connection between academic disciplines and the larger public in better understanding the relevance of the humanities to the current conditions of everyday life. By connecting the ideas and traditions of diverse communities with the methods and skills of humanities scholars, public humanities programs help to broaden the ways that we understand our cultural heritage and traditions at the local, regional and national level. The underlying goal of humanistic disciplines is to engage public life by rethinking our perspectives, investigating our assumptions, and raising questions about human thought, history, and culture.



Figure 7. Passing on Traditions. Photo provided by Guahan Magazine, David Castro

Guampedia

Guampedia, Guam's Online Encyclopedia, is a community project to create a comprehensive online encyclopedic resource about the history, culture and contemporary issues of Guam.

Guampedia Foundation, Inc. is an independent non-profit organization. The creation of Guampedia was funded through grants from the National Endowment for the Humanities, Guam Preservation Trust, the Bank of Guam, the U.S. Department of the Interior, Gannett Foundation, Guam Council on the Arts and Humanities Agency and other sources. The project was founded by the Guam Humanities Council in 2002. In 2009 a new non-profit organization, Guampedia Foundation, Inc. was incorporated and Guampedia became independent of the Council.

Guampedia, which receives funding from the Government of Guam, is being developed with the cooperation of the University of Guam under the Richard F. Taitano Micronesian Area Research Center and many other community institutions and organizations, including the Department of Chamorro Affairs, the Guam Museum, the Guam Public Library, the Guam Department of Parks and Recreation's Division of Historic Resources, the Archdiocese of Agana and Micronesian Seminar.

SUSTAINABILITY

Center for Island Sustainability (CIS)

The Center for Island Sustainability (CIS) is to create and implement renewable and sustainable technologies that are suitable for island use and communities that will also incorporate indigenous aspects and alternatives, and allow for replicable research and adaptation to meet the needs of the region's island communities in the areas of Environment, Economy, Society, and Education.

The Western Pacific Coral Reef Institute, funded by NOAA, is within the CIS umbrella, and contributes research funding for community and management projects that address the Human Dimension of Marine and Ocean research.

The CIS also supports the Guam Energy Task Force and the Guam Science and Technology Committee as vital hubs for the coordination and dissemination of research and policy.

B. ACADEMIC RESEARCH INSTITUTIONS

The University of Guam is the major four-year institution in the region and is a centralized headquarters for a variety of research groups and organizations. It is an

open-admissions, semester-based, U.S. land-grant public comprehensive university offering 15 master's degree programs, 35 bachelor's degree programs, and one (1) associate's degree program in nursing. These programs are administered by the College of Liberal Arts and Social Sciences ("CLASS"), the College of Natural and Applied Sciences ("CNAS"), the School of Business and Public Administration ("SBPA"), the School of Education ("SOE"), and the School of Nursing and Health Sciences ("SNHS"). In addition, continuing education unit (CEU) classes, professional development training, and English language training are offered through the Office of Professional and International Programs ("PIP"). The University of Guam has conferred more than 14,550 degrees during the past 60 years. Below is a list of research groups at the UOG:

Sea Grant

A partnership between universities and the federal government's National Oceanic and Atmospheric Administration (NOAA). This unique model brings to bear the expertise of the academic community in essential but practical research and outreach activities that address society's changing needs. The Sea Grant model allows for quick, effective transfer of science-based information: informing citizens, allowing ocean-related businesses to grow, and empowering policy makers to formulate well-informed decisions.

Sea Grant directs federal resources to pressing problems in local communities. Sea Grant invests in high-priority research, addressing issues such as population growth and development in coastal communities; preparation and response to hurricanes, coastal storms and tsunamis; understanding our interactions with the marine environment; fish and shellfish farming; seafood safety; and fisheries management. The results of this research are shared with the public through Sea Grant's integrated outreach program, which brings together the collective expertise of on-the-ground extension agents, educators, and communications specialists. The goal is to ensure that vital research results are shared with those who need it most and in ways that are timely, relevant, and meaningful.

UOG Sea Grant has expanded to fund Community Coastal Development research since 2013. Funds are directed by research priorities which can be found at uog.edu/seagrant. Annual Request for Proposals (RFP) is released in Fall of each academic year and up to \$12,000 is made available to students engaged in graduate research at UOG. The program is currently in the process of revamping funding mechanisms to expand funding opportunities in order to be responsive to emerging research issues that affect community coastal development. The 2014 funding cycle funded five graduate students to conduct research in broad areas relating to the health and survival of Guam's major economic driver, its thriving coral reef ecosystems.

Micronesian Area Research Center (MARC)

Throughout our history we have strived to preserve links to the past and connections among our colleagues, patrons, and visitors. MARC acquires, preserves, and provides access to collections of archival maps, photographs, texts and cultural materials. The MARC enters into a period of renewed engagement with field archaeological research to serve the community through environmental and archaeological consulting.

Marine Laboratory

The laboratory, established as a research unit of the university in 1970, serves the greater Micronesian region, including the Territory of Guam, the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia (Yap, Chuuk, Kosrae and Pohnpei), the Republic of Palau and the Republic of the Marshall Islands. The mission is trifold: to perform basic and applied research on the biology of tropical marine organisms, emphasizing conservation and management of coastal marine resources; to provide community service through environmental assessments, technical reports, educational materials, public lectures and expertise on marine issues; and to assist with teaching biology and environmental science at the university.

Herbarium

The University of Guam Herbarium specializes in research on the insular floras of Guam, the Northern Mariana Islands and Micronesia, a region in the western tropical Pacific of over 2000 islands in an area the size of the continental United States. Important collections include those of P H Moore, A F Rinehart, B C Stone and R T Tsuda. The Herbarium contains over 57,000 specimens (with 46,000 phanerogams and pteridophytes) and is listed in the Index Herbariorum, the world directory of public herbaria.

Water and Environmental Research Institute of the Western Pacific (WERI)

WERI's mission is to seek solutions through research, teaching and outreach programs, to issues and problems associated with the location, production, distribution, and management of freshwater resources.

WERI is one of 54 similar water research institutes set up by U.S. Congressional legislation at each Land Grant University in the United States and in several territories. The Institute is now in its 40th year of operation. It recently ranked in the top eight of the nation's 54 water resources research institutes, and its faculty and students have recently received national recognition for high-quality research relevant to local needs. WERI carries several federal and local mandates.

The Institute provides its regional stakeholders (Guam, CNMI, and FSM) with technical expertise in water resources related fields spanning the entire natural water cycle and spectrum of human water use, including tropical climatology,

surface water hydrology, rainfall catchment systems, groundwater modeling and management, water distribution systems, soil erosion and mitigation strategies, watershed management, and various aspects of water quality. Faculty members contribute significantly to both undergraduate and graduate teaching programs at the University of Guam (UOG) and conduct vigorous research aimed at improving economic conditions and the quality of life for citizens of Guam and the regional island nations.

The specialties of WERI faculty are meant to address the elements of the natural hydrologic cycle and human water use, i.e., precipitation, surface stream flow, groundwater recharge and flow, drinking water production, and water quality management, to include storm water management, wastewater treatment, and discharges of surface, ground, and waste waters into the coastal zone.

Center for Excellence in Developmental Disabilities Education, Research, and Service (CEDDERS)

The Center serves as a training and technical assistance provider in the Pacific Basin region. It is the largest training, service, and technical assistance center at the University. Guam CEDDERS has evolved into a dynamic organization that aims to build bridges with partners to create stronger linkages, programs, services, and supports to positively impact the quality of life of individuals with developmental disabilities and their families.

Western Pacific Tropical Research Center (WPTRC)

The University of Guam is the largest land-grant institution in the Western Pacific. As such, the University's mandate is to assist in safeguarding the region's environmental, social, and economic resources. The Western Pacific Tropical Research Center is the research division within the College of Natural and Applied Sciences associated with the national Land Grant System.

Scientists working at WPTRC are finding solutions to issues faced by the people and ecosystems of Guam. Island residents benefit from this research in the form of new and improved foods and plants, a healthy and safe environment, and enriched lifestyles and communities. Research conducted through WPTRC underlies both academic and extension programs.

WPTRC specializes in research designed to:

- Enhance agricultural profitability
- Stimulate economic development using natural resources
- Improve the quality and safety of food products
- Sustain and protect the environment with ecologically sound practices
- Improve the quality of life for the people of Guam

University of Guam Telecommunications and Distance Education Operation (TADEO)

The TADEO office utilizes a high frequency (HF) radio to broadcast daily news and weather to Micronesia. Recent upgrades have enabled HF modem/wave mail capability for remote island dispensaries. Previous and ongoing telecommunication projects are focused on communication improvement for solar, wifi and satellite internet connections. Ultimately, reliable and sustainable communications will help support distance education efforts.

Pre-Engineering Program

The University of Guam currently parallels the first two years of study in engineering programs offered at other colleges and university. UOG is undergoing a \$20M construction for a new Engineering center and intend to increase the program to a full 4-year program.

C. COLLABORATION CAPABILITIES

Guam has several established platforms for multi-institutional collaboration, including:

GLOBAL COLLABORATION

Collaborative research in the tropical islands domain is ongoing with UT-Austin, University of Hawaii, University of Okayama, Iowa State University, University of Wisconsin, University of Georgia, Mapua Institute of Technology, R.P., University of Patras, Greece, University of Ljubljana, Slovenia, among others.

REGIONAL COLLABORATION

University of Guam & University of Hawaii Cancer Center Partnership

Americans of Pacific Islander ancestry are a highly underserved minority with a significant burden of cancer health disparities. Americans of Pacific Islander ancestry are also highly underrepresented among cancer researchers and cancer health care professionals. In 2009, the University of Guam Cancer Research Center partnership with the University of Hawaii Cancer Center received a five-year \$12.5 M grant from the National Institutes of Health, National Cancer Institute. Just over \$8 M of that amount will be spent on Guam by local investigators to address some of these issues with a focus on the following:

- Increase the cancer research activities and the number of faculty engaged in cancer research at UOG.
- Increase the number of minority scientists of Pacific Islander ancestry engaged in cancer research and provide pertinent undergraduate, graduate, and post-graduate education and training opportunities for Pacific Islander students.

- Further strengthen the research focus at UHCC on cancer health disparities with particular emphasis on aspects of particular relevance for the people of Hawaii and the Pacific.
- Enhance the awareness of cancer and cancer prevention and, ultimately, to reduce the impact of cancer on the population in the Territory of Guam, neighboring U.S.-associated Pacific Island jurisdictions, and Hawaii.

Pacific ENSO (El Nino-Southern Oscillation) Applications Climate Center (PEAC)

The PEAC is funded by the NOAA National Weather Service (NWS) and works closely with the Weather Forecast Office on Guam (WFO Guam) to issue year-long rainfall, typhoon, and sea level forecasts for all Micronesia and American Samoa. Scientists at the PEAC and WFO Guam collaborate on applied climate research for the US-Affiliated Pacific Islands.

Small Business Development Center

The Pacific Islands Small Business Development Center Network housed at the University of Guam, is federally funded and is area's resource for expert business advice and guidance in all areas of business management, including pre-venture feasibility, business plan development, marketing, record keeping, financial and human resource management, operations management, and access to capital (loans & investors), as well as specialized areas such as international trade and technical services.

LOCAL COLLABORATION

Guam’s business community partners with the various academic institutions to develop instructional materials based on local sustainability efforts.

An example of this is the collaboration between the CEO of Coast 360 Credit Union and a business professor from University of Guam on a case study that was published in an international business journal, based on the construction of Guam’s private sector’s first LEED Gold building. The business school currently includes the case in the instructional materials for entrepreneurial and management majors to showcase the feasibility of using sustainable building methods and materials in construction on Guam.

D. OPPORTUNITY FOR GROWTH

NATURAL RESOURCE ENDOWMENT

Guam’s abundance in beaches, beautiful scenery, natural forests and marine life, and its strategic location has made it an attractive site for tourism, military operations and for research and development. Opportunities exist in developing



Figure 8. Professor Karri T. Perez, UOG, and John Arroyo, former CEO, Coast360 Federal Credit Union, and UOG Regent. The Coast360 building is the first LEED certified building on island. The credit union was awarded Gold certification in LEED by the United States Green Building Council. The case study is used as instructor material for the entrepreneurial program at UOG’s School of Business and Public Administration.

ecotourism that cater to all three segments of consumers, tourist, military and local residents. The availability of land, along with government incentives to use it productively, points to a continuous evaluation of prospects for expanding the agricultural sector. Of course, as natural resources are used to support economic activities, there is a need for effective management of natural resources in order to preserve their quality and sustain their usefulness. Guam has a long history of community activism to ensure that uses of natural resources are kept in check.

MULTICULTURAL SOCIETY

As mentioned above, Guam's population is composed of a multicultural society. One advantage of having a multicultural society is that the island becomes a melting pot of different ideas and talents. It also possesses richness in culture, which provides opportunities to incorporate "experience" in tourism, and a greater understanding and appreciation for diversity. All of these create flexibility and economic resilience. On the other hand, challenges arise as they are many differing opinions, perspectives and approaches, thus making reaching a consensus more difficult and time-consuming.

III. Challenges, Weakness and Threats

A. WORKFORCE DEVELOPMENT

Workforce development and a lack of knowledge based workers is a serious threat to Guam's ability to provide quality research and innovation in the STEM areas. Guam's workforce lacks the basic and advance skills in STEM areas that employers in a "knowledge based" work environment need for innovation, growth and success. Retaining qualified and competent STEM skilled employees and academics on Guam is a serious challenge.

Guam's workforce development agencies and organizations include:

Agency for Human Resource Development (AHRD)

Under the Workforce Investment Act (WIA), AHRD has developed three programs (Dislocated Worker Program, Adult Program and Youth Program).

Dislocated Worker Program provides for individuals who have been terminated or laid off the opportunities to acquire new and updated job skills and assist them in job placement. The Adult Program provides opportunities for adults to acquire job skills and assist participants in job placements. The Youth Program provides academic and career skills for at-risk youths.

GCA Trades Academy

GCA Trades Academy offers a wide variety of training programs in fields ranging from carpentry and automotive technology to project management and safety. With classes open to all abilities and levels, the GCA Trades Academy strives to improve skills and empower the region's workforce.

The GCA Trades Academy was established to provide a nationally recognized industry skills training center, support U.S. Department of Labor recognized apprenticeship training programs, and to support the skilled labor needs of construction contractors and related industries doing business on Guam.

The GCA Trades Academy is closely associated with the Guam Contractors Association.

University of Guam Professional and International Programs

The Professional and International Programs (PIP) program Responds to the educational, training, and employment needs of our community through a wide array of programs and services. Business, industry and professional organizations partner with UOG to provide training for their employees.

These agencies and organizations provide skills and training in a variety of fields, but none are focused on building local capacity in STEM skills, knowledge and abilities. Guam also lacks workforce skills forecasting data in general.

DEVELOPING A "STEM CAPABLE" WORK FORCE

Because of a lack of local STEM skills needs data, a STEM employer survey was developed and administered in June of 2013. It was critical to have the information to determine the current status and needs of employers for STEM-related skills. The survey also reported on the difficulty in obtaining candidates with the skills and knowledge in these areas, and the current competency level of those candidates who are hired with degrees in the STEM areas.

Responses were received from 104 key employers from a wide variety of businesses and private and public organizations on the island of Guam. It was critical to ascertain their opinion of the employment candidate pool in the STEM areas and areas for opportunity and improvement. The complete survey and results are attached as Appendix I and Appendix II.

Key findings included:

Businesses needed individuals with degrees in the following areas:



Figure 9. GCA Trades Academy Board Members and affiliates

- Math -40%
- Science - 31%
- Engineering - 69%
- Technology - 58%

More than 50% of all businesses have difficulties recruiting candidates in these areas and more than 65% of the businesses have to further educate and train their employees in the STEM areas even though the employees have degrees. It is important to note that less than 10% of businesses who needed employees in the STEM areas did NOT have a difficult time recruiting candidates in this area.

As the numbers indicate, there are many opportunities on the island of Guam to improve and grow education in the STEM areas to allow Guam employers to recruit locally and avoid having to import expertise from outside the island for permanent positions. Increasing the amount and quality of job candidates in the STEM areas also will help with building local capacity, limiting the need for off-island training of employees and the hiring of off-island consultants.

One of the more recent developments in Guam's employer profile over the past few years is the introduction of more alternative green technology companies into Guam's business community. This trend offers opportunities for employment of individuals with skills and knowledge in this specific area, but it also is a challenge for academic institutions to include more instruction in this specific STEM area.

B. CLIMATE CHANGE

Guam is located in one of the most dynamic climate zones on the planet. While it is already an important contributor to climate science, the island is poised to become a major laboratory for climate change. Anticipated impacts from climate change range from rising sea level, rising sea temperature, rising ambient air temperature, increasing ocean acidification, and the potential for increased extreme weather events. Some oceanic islands such as Guam will experience higher annual precipitation, but often in bursts that are destructive to upland terrain and tropical coral reefs from increased erosion and sedimentation. Other islands, especially many of the atolls, will experience significantly less rainfall. This, along with the rising sea levels, will eventually make many of the atolls uninhabitable. This will add another stress to the region; that of migration. Rising sea level has already impacted taro ponds/patches in low-lying atolls throughout Micronesia in places such as the Mortlock Islands in Chuuk State and the outer islands of Ulithi and Woleai in Yap State, and on the numerous atolls of the Republic of the Marshall Islands.

Guam depends on tourism and its unique strategic location in the western Pacific for cyber connectivity and US military posture. These are the principal drivers of

the economy. However, in the very near future there could be increased migration from the drowning islands and economies of Micronesia, a deteriorating environment from coral reef decline and upland soils degradation, fisheries depletion, and climate stresses from heat and typhoons. Guam must face the challenges of climate change and adapt to their impacts physically, culturally, economically, and strategically.

C. RESOURCES AND CAPABILITIES

Due to lack of a cohesive STEM plan and limited financial resources, Guam’s STEM community has not been able to reach its maximum potential with regards to discovery and innovation.

Diagram 3 depicts the current state of Guam’s STEM resources and capabilities.

With the cohesive and comprehensive STEM plan that has been developed, the STEM community will be able to respond to the local, regional and global needs and opportunities for discovery and innovation.

Diagram 4 represents the full realization of Guam’s potential in the STEM universe.

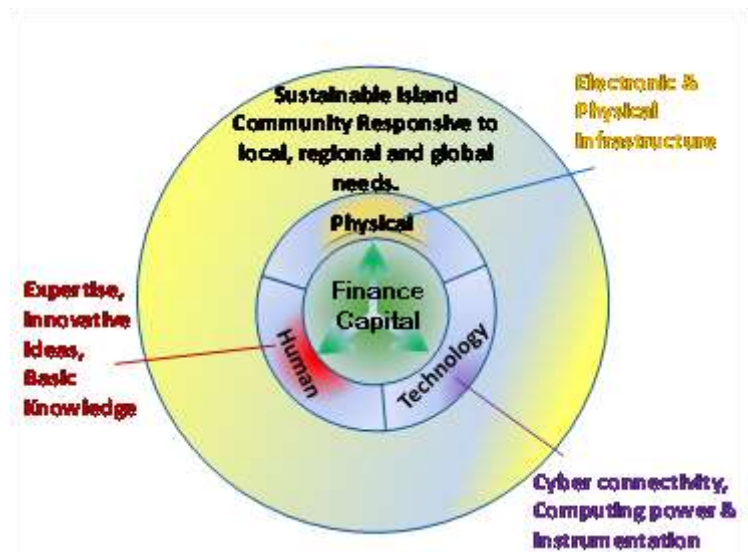


Diagram 3. Current state of Guam’s STEM resources and capabilities.

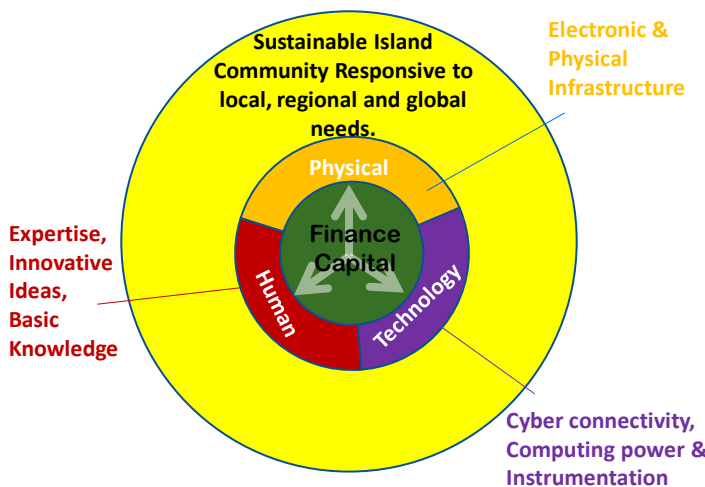


Diagram 4. Envisioned future state of Guam’s STEM resources and capabilities

IV. STRATEGIC OBJECTIVES

Guam is not only poised to implement a comprehensive STEM-based actionable plan for the community, but also to contribute substantial and critical discovery-based research to the global community. While much research will be translated into action and innovation, Guam has the unique ability to discover and document unknown or undiscovered species for the scientific community at large.

V. IMPLEMENTATION PLAN

Guam's goals to be implemented over the next five years include:

GOAL 1: MICRONESIA INTERNATIONAL RESEARCH HUB

Develop global recognition as the facilitator for studying sustainability related issues and knowledge for Guam and the surrounding Micronesia Region.

OBJECTIVE 1: RESEARCH AND IDENTIFY WHAT IS UNIQUE TO THE MICRONESIA AREA, SPECIFICALLY IN THE STEM REALM

ACTIVITY1: Develop and implement research and education programs that are focused on delivering knowledge to the local and global community on unique species and renewable energy sources.

ACTIVITY2: Conduct and support constant meteorological monitoring and wind studies with federal and local agencies.

MEASURE OF SUCCESS: Number and quality of publications incorporating traditional/cultural knowledge in relating academic STEM knowledge to community needs and solutions

OBJECTIVE 2: SERVE AS A CHAMPION/GUARDIAN TO PROTECT AND PROMULGATE THE MICRONESIAN NATURAL RESOURCES (BIOLOGICAL, GEOLOGICAL, HYDROLOGIC, AQUATIC, ARCHEOLOGICAL, AND INTELLECTUAL PROPERTY) THAT ARE GERMANE TO OUR AREA

ACTIVITY1: Explore what is out there (knowledge generation). Research, compile and consolidate Indigenous Resources, Technology and Knowledge (as comprehensively and legally as possible, and with information linked to physical samples) relating to Micronesia natural resources.

ACTIVITY2: Create archives to consolidate, document and catalogue regional physical materials and indigenous resources.

ACTIVITY3: Provide online tools that make accessible to the world Guam and Micronesia's indigenous resources, technology, and knowledge of cultural tenants.

ACTIVITY4: Implement science and technology incubator that supports innovations stemming from research findings.

MEASURE OF SUCCESS: The development of a master plan that addresses storage of physical and electronic Indigenous Resources, Technology and Knowledge Resources of all natural resources found on Guam and throughout our region.

OBJECTIVE 3: EXPLORE CLIMATE AND ENVIRONMENTAL CHANGES AND THEIR IMPACTS ON OUR NATURAL RESOURCES

ACTIVITY: Prioritize, plan and implement strategies that increase sustainability and reduce vulnerability to a wide-spectrum of climate and environmental change impacts.

MEASURE OF SUCCESS: The identification of climate change as a priority by the Government of Guam and the implementation of strategies such as outreach activities to ensure the resilience of the community to climate change impacts including: the increase use of hybrids or alternative fueled vehicles; implementation of advance technologies in area-wide drinking water production and conservation; and implementation of alternative energy sources.

OBJECTIVE 4: RESEARCH ENABLES INFORMED DECISION MAKING AND PROMPT ACTION TO TIME SENSITIVE ISSUES.

ACTIVITY: Develop research projects that focus on solutions to critical and time-sensitive issues that affect the quality of life on Guam and surrounding Micronesia.

MEASURE OF SUCCESS: A series of research projects defined and plotted for study within a reasonable time frame that addresses: (1) invasive species (brown tree snake, rhino beetle, etc.); (2) construction designs that adhere to the Tropical Energy Code (materials, sustainable practices in construction, energy efficiency in new homes, and affordability); (3) increase in LEED-recognized construction on-island; (4) recycling, solid waste management and protection of limited landfill space; (5) non-point source pollution caused by sedimentation and erosion, un-detained storm water discharges, sanitary sewer overflows caused by the aging infrastructure and Fats, Oils and Grease (FOG) in the system, all of

which impacts water quality and the health of the coral reef. Increased student enrollment in college related STEM coursework.

GOAL 2: STEM CAPACITY BUILDING

Produce a STEM-competent Micronesia-centric workforce by providing a holistic, place-based education pipeline to meet the localized sustainability needs of the government and the private sector while encouraging and supporting local entrepreneurial efforts.



Diagram 5. Knowledge Pyramid

OBJECTIVE 1: PRODUCE GUAM-CENTRIC STEM CURRICULUM THAT IS IMPLEMENTED AT EVERY ACADEMIC LEVEL

ACTIVITY1: Guam's STEM Expertise Panel (including educators) will review the current STEM courses and programs and make suggestions for revisions, to include local STEM issues.

ACTIVITY2: Infuse teacher preparation modules that will ensure teachers are prepared to teach STEM competencies beginning in kindergarten.

ACTIVITY3: Develop a "Transforming Research Into Your Classroom" course/program.

ACTIVITY4: Develop connection programs with the private sector to educate students on the applicability of STEM to real world solutions.

MEASURE OF SUCCESS: Increased performance levels in national testing programs, participation in regional and national competition opportunities, as well as increased interest in STEM study by teachers and students. Implementation of a program that connects all academic coursework with applications of STEM in the workforce. Increased participation in a Continuum of professional development opportunities that promote cutting edge approaches to teaching and learning.

OBJECTIVE 2: REVIEW AND REALIGN EDUCATION GOALS TO SUPPORT REGIONAL EFFORTS TO PROMOTE SUSTAINABILITY

ACTIVITY1: Include mechanisms to be more responsive to STEM workforce needs in concert with island sustainability goals.

ACTIVITY2: *Develop regional STEM curriculum for schools aligned to needs of the workforce and natural resource protection.*

ACTIVITY3: *Provide ongoing support and training for education leaders, policy makers and teachers.*

ACTIVITY4: *Conduct a professional census and workforce forecast and compare actual available professionals to forecasted needs.*

ACTIVITY5: *Survey STEM career interest of students, beginning in middle school.*

ACTIVITY6: *Identify school community partnerships available and/or needed throughout Micronesia that will provide hands on learning opportunities for our growing students.*

MEASURE OF SUCCESS: Participation rates of teachers at professional development activities that build competency sets on how to infuse the adopted regional curriculum. Participation rates of students and teachers at STEM related professional conferences and symposiums. Results of STEM career interest by students. Complete list of school community partnerships providing learning opportunities for STEM. Clearly articulated goals and programmatic targets at the various academic benchmark levels (8th grade, 12 grade 1st year college, etc.); and updated professional/industry workforce forecast. Implementation of a successful STEM curriculum centered on workforce needs which yields an increasing list of student graduates in STEM fields.

OBJECTIVE 3: DEVELOP 21ST CENTURY RESEARCHERS COMPETENT IN CURRENT TECHNOLOGY ORIENTED TOWARDS DIGITAL COMMUNICATIONS, GLOBAL MARKETS, CLIMATE CHANGE AND ENERGY SUSTAINABILITY (COLLEGE LEVEL)

ACTIVITY1: *Provide a yearly STEM symposium for graduate students and postdoctoral fellows to facilitate the sharing of research findings from Guam and the Micronesia region*

ACTIVITY2: *Provide research opportunities for teachers and students.*

ACTIVITY3: *Establish government and private partnerships in funding STEM-based research.*

ACTIVITY4: *Develop pathways to STEM PhD programs.*

ACTIVITY5: *Increase graduate enrollment in STEM study.*

MEASURE OF SUCCESS: Number of participants in the symposium (annual increases in participants). Satisfaction of participants discovered by survey, research project completion, pre and post-testing, participation of industry in research funding.

OBJECTIVE 4: DEVELOP CROSS-DISCIPLINARY APPROACH TO COMMUNITY COLLEGE /UNIVERSITY EDUCATION THAT ADDRESSES REAL WORLD REGIONAL AND GLOBAL ISSUES AND SOLUTIONS.

ACTIVITY1: Collaborate with business professors to guide students into STEM fields and opportunities.

ACTIVITY2: Provide guest lecturers from the STEM areas for entrepreneurial classes.

ACTIVITY3: Implement project based learning as a requirement for graduation.

MEASURES OF SUCCESS: Implementation and growth of program.

OBJECTIVE 5: INCREASE REPRESENTATION FROM UNDERREPRESENTED MINORITY GROUPS IN INSTRUCTION IN STEM KNOWLEDGE AREAS (ALL EDUCATIONAL INSTITUTION LEVELS)

ACTIVITY: Develop a recruitment and retention program for underrepresented minority instructors in the education system (all educational institution levels).

MEASURES OF SUCCESS: Pre-program diversity profile compared to the post-program profile.

GOAL 3: STEM TECHNICAL INFRASTRUCTURE

Provide the infrastructure that will allow Guam access to facilities and equipment that support needed research; as well as enhance connectivity among government, educational and academic institutions.

OBJECTIVE 1: ASSESS OUR CURRENT ISLAND-WIDE INFRASTRUCTURE

ACTIVITY1: Conduct a survey to identify existing and planned electronic infrastructure that would support STEM- based research.

ACTIVITY2: Forecast gap analysis between existing and planned infrastructure and that needed to support research.

ACTIVITY3: *Develop a gap analysis.*

ACTIVITY4: *Implement a plan to reinforce existing and planned infrastructure to meet the needs of research.*

ACTIVITY5: *Create a website that will serve to keep the community abreast of all projects and updates. Utilize all forms of Social Media to reach the community and demographic we target – youth.*

MEASURE OF SUCCESS: Completed survey of accessibility and standards of infrastructure throughout our island. Infrastructure is strengthened throughout the island resulting from the implementation of the gap analysis plan. Publication of studies and reports on capital improvement needs including sources of funding.

OBJECTIVE 2: INCREASE AND IMPROVE NETWORK CONNECTIONS TO SUPPORT A STRONG CYBER INFRASTRUCTURE ON GUAM FIRST THEN MOVE GLOBALLY.

ACTIVITY1: *Establish a Research and Development (R & D) network hub on Guam.*

ACTIVITY2: *Coordinate the expansion of cyber infrastructure for the island of Guam.*

ACTIVITY3: *Physical –Identify all parts of the workforce which are more technical.*

ACTIVITY4: *Prioritize professions that will enhance scientific, medical and educational research.*

ACTIVITY5: *Develop external connections for research, medical and educational purposes (super computers, etc.).*

MEASURE OF SUCCESS: Accessibility of cyber infrastructure to students and teachers located throughout Guam.

OBJECTIVE 3: DEVELOP A STEM MARKETING PLAN THAT WILL STIMULATE, TAG, EXCITE, AND MOTIVATE THE COMMUNITY IN STEM.

ACTIVITY: *Conduct annual island-wide STEM conference showcasing all possible employment possibilities derived from STEM.*

MEASURE OF SUCCESS: Create an increase in STEM related employment on the island.

GOAL 4: COMMUNICATION

Increased communication in the Micronesia region to facilitate informed decision-making, knowledge sharing and continuing education that helps develop a regional community of life-long science and technology learners.

OBJECTIVE 1: INCREASE COMMUNICATION WITHIN THE MICRONESIA REGION TO DETERMINE TRENDS, SHARE BEST PRACTICES AND EXPAND STEM RELATED EDUCATIONAL OPPORTUNITIES TO DEVELOP AN INFORMED CITIZENSHIP.

ACTIVITY: Provide tools using all available media for citizens to engage in discourse and decision-making processes.

MEASURE OF SUCCESS: Increased participation in STEM activities throughout the island.

OBJECTIVE 2: INFORM PUBLIC ON STEM ISSUES PERTINENT TO GUAM AND THE MICRONESIA REGION

ACTIVITY: Provide a research focused outreach exhibition center.

MEASURE OF SUCCESS: Community utilization of the facility.

OBJECTIVE 3: FACILITATE PRIVATE AND PUBLIC PARTNERSHIPS WITH A STEM EDUCATIONAL FOCUS (TO SET UP INCUBATORS THAT WILL LEVERAGE INNOVATIVE IDEAS AND SKILLS FOR OUR ECOSYSTEM)

ACTIVITY: Establish an internship program with private and public partners that would allow students the opportunity for workforce experience during their academic pursuits.

MEASURE OF SUCCESS: Established incubators that continuously welcome study and reflection on STEM.

OBJECTIVE 4: PROVIDE AN ONGOING PROGRAM OF PUBLIC INFORMATION AND A WELL-RECOGNIZED STEM EXPERTISE PANEL FOR GUAM-MICRONESIA

ACTIVITY1: Establish a STEM Expertise Panel for Guam.

ACTIVITY2: Build on the STEM steering committee and make the task force a permanent committee.

ACTIVITY3: Regionally increase Guam's participation in national and regional networks.

MEASURE OF SUCCESS: Formation of the Stem Expertise Panel. Community acceptance and involvement of the panel in community issues (survey, document evidence).

VI. STATUS OF IMPLEMENTATION PLAN

GOAL 1: MICRONESIA INTERNATIONAL RESEARCH HUB

Develop global recognition as the facilitator for studying sustainability related issues and knowledge for Guam and the surrounding Micronesia Region.

No Update on Goal 1 and its objectives and activities

GOAL 2: STEM CAPACITY BUILDING

Produce a STEM-competent Micronesia-centric workforce by providing a holistic, place-based education pipeline to meet the localized sustainability needs of the government and the private sector while encouraging and supporting local entrepreneurial efforts.

No Update on Goal 2, Objectives 1, 4, 5 and 6 with corresponding activities.

OBJECTIVE 2: REVIEW AND REALIGN EDUCATION GOALS TO SUPPORT REGIONAL EFFORTS TO PROMOTE SUSTAINABILITY

ACTIVITY5: Survey STEM career interest of students, beginning in middle school.

Goal 2, Objective 2, Activity 5 update

The Engineering Societies on Guam realize that introducing engineering to middle and high school students is critical to the sustainability of the island. Individual professional engineers collaborated to make presentations to students during Engineer's Week in February 2014 and again in February 2015. During the week:

- 17 professional engineers participated.
- 57 different classroom presentations were made, addressing 2,029 middle and high school students. The STEM message presented reinforced the benefits of a career path in science and engineering.

OBJECTIVE 3: DEVELOP 21ST CENTURY RESEARCHERS COMPETENT IN CURRENT TECHNOLOGY ORIENTED TOWARDS DIGITAL COMMUNICATIONS, GLOBAL MARKETS, CLIMATE CHANGE AND ENERGY SUSTAINABILITY (COLLEGE LEVEL)

ACTIVITY1: Provide a yearly STEM symposium for graduate students and postdoctoral fellows to facilitate the sharing of research findings from Guam and the Micronesia region

Goal 2, Objective 3, Activity 1

The American Water Works Association held their Western Pacific Region Water and Wastewater conference on April 13-14. They offered technical presentations to water professionals advocating for safe and sustainable water. They shared their knowledge in the workshop “Challenges of Operating Water and Wastewater Systems in a Pacific Island Environment”.

The Coral Reef Symposium was held on April 14, 2015. The symposium was about managing land based sources of pollution, heritage preservation and environmental conservation, managing reefs in a changing climate and assessing relative resilience potential of coral reefs in Saipan, Tinian and Rota. Faculty and graduate students presented their research findings to the audience in hopes to move the islands to a more sustainable future.

The 2015 Island Sustainability Conference was held on April 15-16, 2015 at the Hyatt Regency Guam Hotel. Its theme is “Building Resilient Island Communities”. The keynote speaker, Virginia Burkett, Chief Scientist for Climate and Land Use Change at the U.S. Geological Survey spoke on the trends, project and impacts on low-lying coasts and small islands. The conference included Plenary panels and speakers along with faculty and grad students presenting during the breakout sessions.

Fig. 10 - 2015 Sustainability Conference



Romina King, Isa Baza presented “Crafting a Sustainability Policy for the Island of Guam.”

Fig. 11 - 2015 Sustainability Conference



Capt. Douglas W. King, Civil Engineer Corps Executive Officer, NAFVAC Marianas & Eric Palacios, Administrator, Guam Environmental Protection Agency – Plenary Panel I

GOAL 3: STEM TECHNICAL INFRASTRUCTURE

Provide the infrastructure that will allow Guam access to facilities and equipment that support needed research; as well as enhance connectivity among government, educational and academic institutions.

No Update on Goal 3, Objectives 1 and 3 with corresponding activities.

OBJECTIVE 2: INCREASE AND IMPROVE NETWORK CONNECTIONS TO SUPPORT A STRONG CYBER INFRASTRUCTURE ON GUAM FIRST THEN MOVE GLOBALLY.

ACTIVITY2: Coordinate the expansion of cyber infrastructure for the island of Guam.

Goal 3, Objective 2, Activity 2

The Guam Telephone Authority (GTA) met with UOG and discussed their upcoming SEA-US fiber submarine cable. The submarine cable length will be about 15,000km with the landing points at Davao - Philippines, Hemesa Beach - California, Manado – Indonesia, Oahu – Hawaii and Piti-Guam. The expected deadline for completion will be late 2016. This cable line may also connect to Yap and Palau, if GTA decides to do so. This is a GTA project.

GOAL 4: COMMUNICATION

Increased communication in the Micronesia region to facilitate informed decision-making, knowledge sharing and continuing education that helps develop a regional community of life-long science and technology learners.

No Update on Goal 4, Objectives 1, 2 and 3 with corresponding activities.

OBJECTIVE 4: PROVIDE AN ONGOING PROGRAM OF PUBLIC INFORMATION AND A WELL-RECOGNIZED STEM EXPERTISE PANEL FOR GUAM-MICRONESIA

ACTIVITY1: Establish a STEM Expertise Panel for Guam.

Goal 4, Objective 4, Activity 1 and 2

ACTIVITY 1 – A PACSTEM Committee has been created and includes the STEM Expertise Panel for Guam

ACTIVITY 2 - The current S&T Committee was created and acts as the STEM Steering Committee for the governor. It also acts as the advisory committee for the EPSCoR Research Infrastructure Improvement Program Track-1 (RII Track-1) team.

VII. CONCLUSION

Guam and Micronesia's natural resources are invaluable and irreplaceable. Guam not only has the potential for STEM innovation; they have incredible potential for discovery of the yet unknown. The importance of discoveries of new plants and animals is unimaginable, not only in terms of new knowledge and information, but also in their application to the problems and challenges of mankind.

Guam and Micronesia face serious threats and challenges in the area of sustainability due to climate change. Despite Guam and the region's history of resiliency in the face of external challenges, climate change may have such a large and permanent damaging impact on the region that what once was could be forever lost. Guam does not have the luxury of time; the climate changes are already affecting the islands and the region. Our immediate priority is to protect that which is disappearing and develop strategies to minimize the current and future impact to our island resources.

The Science and Technology Steering Committee has created and developed goals, objectives, activities and measures of success and encapsulated them in Guam's S & T plan. It is understood that this is a "living" document, and as we meet current objectives we will re-assess our goals and adapt our tactics to the ever changing needs of the STEM community and our environment.

Guam, a U.S. Territory whose population is a plurality of minorities has experienced economic stability for 2013 and is poised for promising growth in 2014. Tourism is increasing and the military realignment is moving forward with the building resuming. Although several companies and government agencies have begun working diligently in conjunction with UOG and other federal agencies to create STEM internship programs and employment opportunities, funds are limited, restricting advancement in the STEM areas. The EPSCoR/IDeA funded programs are imperative to provide the financial foundation for future growth in the STEM areas.

Guam's culture and history is one of teaming and partnership; because of distance, size and isolation the people have historically relied on themselves, nature and innovation. Through developing and sustaining collaborative relationships with STEM-based organizations and agencies, Guam will be able to maximize its contributions locally, regionally and globally.