David Lassner
President

UNIVERSITY of HAWAI'I® SYSTEM

DEPT. COMM. NO. 126

December 13, 2019

The Honorable Ronald D. Kouchi,
President and Members of the Senate
Thirtieth State Legislature
Honolulu, Hawai'i 96813

The Honorable Scott Saiki, Speaker
and Members of the House of Representatives
Thirtieth State Legislature
Honolulu, Hawai'i 96813

Dear President Kouchi, Speaker Saiki, and Members of the Legislature:

For your information and consideration, the University of Hawai'i is transmitting one copy of the Report on a Strategy for Students to Learn About Modern Farming (Senate Resolution 51 SD1 (2019)) as requested by the Legislature.

In accordance with Section 93-16, Hawai'i Revised Statutes, this report may be viewed electronically at: https://www.hawaii.edu/offices/government-relations/2020-legislative-reports/.

Should you have any questions about this report, please do not hesitate to contact Stephanie Kim at 956-4250, or via e-mail at scskim@hawaii.edu.

Sincerely,

David Lassner
President

Enclosure

2444 Dole Street, Bachman Hall
Honolulu, Hawai'i 96822
Telephone: (808) 956-8207
Fax: (808) 956-5286
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UNIVERSITY OF HAWAIʻI SYSTEM REPORT

REPORT TO THE 2020 LEGISLATURE

Report on a Strategy for Students to Learn About Modern Farming

Senate Resolution 51 SD1 (2019)

December 2019

MODERN FARMING PRODUCTION

I. Introduction

Agriculture in Hawai‘i is practiced on 7,328 farms over 1.135 million acres with an average farm size of 155 acres (1). The median farm size is about 5 acres. However, average farm size does not tell the complete story of Hawai‘i agriculture as small farms are the norm in Hawai‘i. Sixty-six percent of the farms are less than 10 acres in size; while 89% of all farms are less than 50 acres. Likewise, 88% of Hawai‘i farms gross less than $50,000 per year (1). While there are few useful statistics, other than how many farmers have approved Conservation Plans, on the kind of farming that is accomplished on Hawai‘i farms, it would be safe to say that about 60% to over 88% are probably not using a high degree of modern farming technology as defined below.

Senate Resolution 51 SD1 (2019) (SR 51) requests the Hawai‘i Department of Agriculture, Hawai‘i Department of Education (HIDOE), and College of Tropical Agriculture and Human Resources, University of Hawai‘i at Mānoa to:

1. create a strategy for students to learn about modern farming; along with a strategy for new curriculum appropriate for public school system grades six through twelve;

2. provide a strategy to address long-term land tenure issues;

3. develop a strategy to include information gathered from other countries; and,

4. submit a report on its findings.

While those requests are valuable and valid, this report is not able to meet all requests itemized in SR 51 due to limits in time and personnel. However, we have attempted to provide a basic level of information on request 1 with the expectation that this can form the basis for developing additional information in the future. The first step is to define Modern Farming. The definition is provided below:

Modern Farming definitions with a focus on production:

1. is farming based on the best knowledge from rigorous science, and use of the most modern technologies. The best knowledge from science refers to farming methods that have been developed, tested and verified through critical evaluation via the scientific method; and,

2. uses farming models that seek to maximize profit through reducing inputs, while maintaining or enhancing ecosystem services (such as increasing soil carbon, reducing irrigation, reducing dependence on pesticide use, reducing fertilizer use).

For agriculture in Hawai‘i to become truly “modernized”, and for “Modern Farming” to become an integral component of Hawai‘i agriculture, the methods that define farming should be applicable to the demography of Hawaiian farms. Hawai‘i farms will be as modernized as each farm’s particulars will allow – like land tenure that allows longer

time horizons, access to capital, location, market knowledge, and organization. Economic viability is the controlling factor in all Modern Farming Systems. Developing a profitable system in Hawai‘i is a function of land tenure characteristics, access to capital, location, scale of operation, market knowledge, the chosen crop(s), efficiency of operation, and ability of the land manager.

II. Definitions of Practices and Technologies Characteristic of Modern Farming

The best knowledge gained from rigorous science that define Modern Farming includes the practices and technologies below:

1. Conservation Tillage is “Any of several farming methods that provide for seed germination, plant growth, and weed control yet maintain effective ground cover throughout the year and disturb the soil as little as possible. The aim is to reduce soil loss and energy use while maintaining crop yields and quality. No-till is the most restrictive (soil-conserving) form of conservation tillage. Other practices include ridge-till, strip-till, and mulch-till” (2). “No-till” is when the crop is direct-seeded into the untilled soil. Strip till is where only the area of soil that will be planted as a row is tilled and the rest of the field is not tilled. Conservation tillage is possible because of select herbicides that control weeds, but do not harm the target crop. In some cases, the crop is genetically modified to be resistant to a specific herbicide. Beyond the advantages mentioned above, the greatest advantage of conservation tillage is it allows for the maintenance, and the increase, of soil organic matter by avoiding tilling – the major cause of soil and soil organic matter loss. Conservation tillage is not appropriate for all crops.

2. Crop Rotation is defined as a “system of cultivation where different crops are planted in consecutive growing seasons to maintain soil fertility” (2). Rotating crops is intended to install different nutrient and carbon cycling regimes on the same acre over time in order to provided economic advantages; for example: breaking pest cycles and building soil fertility.

3. Intercropping is the “growing of two or more different species of crops simultaneously, as in alternate rows in the same field or single tract of land” (2). The major goal of this type of farming is to acquire the greatest yield by capturing the most resources provided by the soil. Additional advantages of this farming system are that it is a component of Integrated Pest Management where one of the crops may be a trap or repellant crop for non-beneficial insects or host beneficial insects that can impact pests on various crops. While listed as a modern farming technique, its success rate is mixed.

4. Cover Cropping/Green Manure is when plants are “grown between periods of regular production of the main crop for the purposes of protecting the soil from erosion and improving soil productivity, health and quality” (2). The potential advantages of cover cropping include managing soil water, reduction of point-source

pollution from run-off, control of pests, and providing wildlife feed. A cover crop can be also be a cash crop, but that is not a necessary requirement.

5. Composting is the addition of composted organic material to the soil to increase organic matter. Composted material is from the "biodecomposition of organic material, such as animal wastes, plant residues or sludges, in the presence of air, by controlled methods including mechanical mixing and aerating" (2). In some farming systems composted material is added to the soil to improve nutrient, water and microbial relations that benefit crop growth. Unfortunately, if tillage is involved, which often is, this can increase CO_2 release from organic matter decomposition.

6. Use of improved seed developed via traditional and non-traditional breeding techniques (selection breeding, backcrossing, hybrid breeding, mutation breeding, molecular marker assisted selection, pedigree breeding, genetic engineering, gene editing) brings genetic manipulation into agricultural practices. Seed selection is an important component of any farming operation and will determine the ultimate success of the crop based on its resistance to pests, appropriateness for the soil and climate conditions, and growth characteristics.

7. Integrating livestock and crops within a farming operation on separate acres, or over time on the same acre. In this approach livestock grazing is a component of a cropping rotation system; or livestock waste is an integral component of the soil fertilization regime. This approach reduces risk of growing just one crop. It reduces commercial fertilization by imposing an increased nutrient cycle. It improves soil organic matter and, based on the effect it has on soil structure and organic matter, water infiltration is increased while soil erosion is reduced; particularly when combined with conservation tillage.

   When crops follow livestock, suitable time periods must be followed. The National Organic Program regulations require raw animal manure be incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles; or not less than 90 days when a products edible portion does not have direct contact.

8. Integrated Pest Management (IPM) is "a systematic approach in which pest populations are monitored to determine if and when control methods are required. IPM uses biological, chemical, physical, cultural and/or genetic control methods to minimize pesticide use, reduce production costs, and protect the environment" (2). Mutually compatible pest suppression methods are used in an effective IPM program when possible.

9. Smart Farming Systems is a "management concept focused on providing the agricultural industry with the infrastructure to leverage advanced technology – including big data, the cloud and the internet of things for tracking, monitoring, automating and analyzing operations. Also known as precision agriculture, smart farming is software-managed and sensor-monitored" (3). Technology often associated with Smart Farming Systems are GPS controlled tractors for field

operations and sampling, drones, field and remote sensors to schedule operations, and artificial intelligence. This system can be applied to any of the other Modern Farming Systems defined here.

10. Protected Agriculture / Protected Cultivation is growing crops in an area that is closed off from the outside in a protected environment. It can include low tunnels, high tunnels, shade houses, greenhouses; to name some of the structures. Its advantages include reduced pest problems, increased water efficiency, increased production, reduced use of pesticides and efficient fertilization. Disadvantages could be the level of capital investment, knowledge of operation and upkeep.

11. Hydroponics is "the growing of plants in a soilless environment where nutrients are provided by the application of nutrient solutions" (2).

12. Aquaculture is "the cultivation of aquatic animals and plants, including freshwater and marine species, for food or other purposes" (4).

13. Aquaponics is the combination of aquaculture and hydroponics.

If history is a guide, the application of any or all of these techniques to Hawaiian agriculture will depend on sufficient experience where proof-of-concept is shown, which includes documenting Hawai'i-scale farm thresholds that make each technique economically feasible.

III. Summary of Existing HIDOE Curriculum and Modern Farming

Modern Farming, as defined in this report, integrates the established criteria of best knowledge from rigorous science into the HIDOE system of instruction through Science and Career and Technical Education (CTE) standards-based content.

HIDOE K-12 science education should:

- Prepare all students to apply the practices of science, including analytical thinking, argumentation, and communication, in any post-secondary pursuit;

- Engage all students as local, national, and global citizens who are literate consumers of scientific information related to applications, such as food production, health, environmental conservation, energy generation and usage, climate change, and natural disaster remediation; and

- Raise interest in, and readiness for post-secondary STEM (Science, Technology, Engineering, and Mathematics) education and careers.

Students in grades 6-12 (Appendix #1) experience science through four topics: physical science, life sciences, earth and space science, and engineering design. The definition of modern farming intersects with all four science topics.

CTE grades 9-12 integrates academics with career and industry experiences.

CTE Core Principles (Appendix #2)

- Provides the context in which real-world experiences can be integrated with school-based learning, work-based learning, and current technological learning as well as formal academic curriculum.

- A focus on the whole child strengthens many of the skills that people use every day including:
  - Solving problems creatively
  - Thinking critically
  - Working cooperatively in teams
  - Using technology effectively
  - Empathy and valuing life-long learning
  - Building positive relationship with others

- Economic productivity of our society is intimately linked to the academic, social, employability, and technological skills of our workforce.

- Essential concepts that seamlessly matriculate from one level of learning to the next in a P-20 system.

IV. Improvement Strategy for Students to Learn Modern Farming

In order to meet the State's aspirations for increased food security and self-sufficiency, the number of local farms and farmers, and the amount of food produced for local markets, will need to increase significantly. Agriculture education is key to the development of future farmers and to a society that values and understands the vital role of agriculture, food, fiber, and natural resource systems in advancing personal, local, and global well-being.

Implementation of the Coordinated Framework of Support for P-20 Agriculture Education in Hawai‘i requires:

Teacher Development: Prioritize teacher training in agriculture and food systems education at all levels (P-20) for those preparing to become teachers ("pre-service teachers"), as well as additional professional development for those already in classrooms ("in-service teachers").
Courses and workshops for pre-service and in-service teachers should include the following:

- ‘Ike Hawai‘i, or the integration of indigenous knowledge and culture and their contributions to food system sustainability, climate change resilience, social equity, and ‘āina-based education;

- Immersive experiences in agriculture and food systems through which the teachers can experience firsthand where food comes from and how it grows; (Teacher Externships)

- Curriculum development and integration around agriculture, food systems, and garden-/farm-/ocean-based learning that connects to national and state educational standards in core subjects;

- Outdoor classroom management skills and best practices for safety;

- Nutrition, wellness, and health integration; and

- Environmental/peace/sustainability education.

Curriculum Integration: (Support Project Based Learning. See HIDOE Learning Design website) Integrate agriculture education into the core curriculum in all subject areas at all levels (P–20). Agriculture education (including garden-/farm-/ocean-based learning) offers students the engaging opportunity to connect to real-life learning in a variety of academic subjects including STEAM (science, technology, engineering, arts, and math), nutrition, food science, Hawaiian studies, language arts, health, social studies, and more. Garden-based learning is also associated with increased social emotional skills among students.

Meaningful curricular integration can be achieved within all levels of education by these means:

- Increasing access to and awareness of available curricula;

- Supporting further curriculum development; and

- Expanding collaborative efforts to increase coordinated professional development opportunities for teachers at all levels.

Coordination and support of Agriculture Educators: Establish and fund positions at the state, community, and school levels that directly support teacher development and curricular integration around agriculture and food systems.

Examples are provided for existing [E] and proposed [P] agriculture educator positions. Of the agriculture educators that currently exist, many are privately funded. There is a need for increased state investment in this area.

- Agriculture Educators, State-Level:
  - P-20 Agriculture Education Coordinator [P]
  - UH CTAHR Statewide Master Gardener Coordinator [E]
  - HIDOE Career and Technical Education (CTE) Resource Teacher (Agriculture, Food and Natural Resources Career Pathway) [E]
  - HIDOE School Garden Education Specialist [P]

- Agriculture Educators, Community-Level:
  - UH CTAHR Extension Agents (complex-area level) [P]
  - HIDOE CTE/STEM/Science Resource Teachers [E]
  - HIDOE Agriculture/Sustainability Resource Teachers [P]
  - Farm to School/Food Systems Coordinators (district/complex-area level) [P]

- Agriculture Educators, School-Level:
  - CTE Agriculture Teachers (Grades 6–12) [E/P; growth needed] School Garden
  - Coordinators (Grades PreK–12; oversee garden-based learning at schools as a part -time teachers or full-time licensed teachers) [E/P; growth needed]

V. Literature Cited

(1) 2017 Census of Agriculture of Agriculture NASS.USDA.gov

(2) USDA Viewed 2019 Glossary of Agricultural Terms – Alphabetical List. https://agclass.nal.usda.gov/mtwdk.exe?s=1&n=1&y=0&l=60&k=glossary&t=2&w=intercropping

(3) Internet of Things Agenda. Viewed 2019. https://internetofthingsagenda.techtarget.com/definition/smart-farming

Appendix #1. HIDOE Science Content Grades 6-12

Middle School Grade 6-8

Life Science	Earth & Space Science	Physical Science
Middle School Life Science Introduction	Middle School Earth & Space Science Introduction	Middle School Physical Science Introduction
MS-LS1 From Molecules to Organisms: Structures and Processes	MS-ESS1 Earth's Place in the Universe	MS-PS1 Matter and Its Interactions
MS-LS2 Ecosystems: Interactions, Energy, and Dynamics	MS-ESS2 Earth's Systems	MS-PS2 Motion and Stability: Forces and Interactions
MS-LS3 Heredity: Inheritance and Variation of Traits	MS-ESS3 Earth and Human Activity	MS-PS3 Energy
MS-LS4 Biological Evolution: Unity and Diversity		MS-PS4 Waves and Their Applications in Technologies for Information Transfer
Middle School Engineering Design Introduction		
MS-ETS1 Engineering Design		

High School Grades 9-12

Life Science	Earth & Space Science	Physical Science
High School Life Science Introduction	High School Earth & Space Science Introduction	High School Physical Science Introduction
HS-LS1 From Molecules to Organisms: Structures and Processes	HS-ESS1 Earth's Place in the Universe	HS-PS1 Matter and Its Interactions
HS-LS2 Ecosystems: Interactions, Energy, and Dynamics	HS-ESS2 Earth's Systems	HS-PS2 Motion and Stability: Forces and Interactions
HS-LS3 Heredity: Inheritance and Variation of Traits	HS-ESS3 Earth and Human Activity	HS-PS3 Energy
HS-LS4 Biological Evolution: Unity and Diversity		HS-PS4 Waves and Their Applications in Technologies for Information Transfer
High School Engineering Design Introduction		
HS-ETS1 Engineering Design		

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<tr><td>Modern Farming Practices and Technologies (CTAHR)</td><td>HIDOE science courses that include content to understand modern farming practices and technologies, Grades 6-12.</td></tr>
<tr><td>1. Conservation tillage
2. Crop rotation
3. Intercropping
4. Cover cropping/Green Manure
5. Composting
6. Integrating livestock and crops
7. Integrated Pest Management
8. Smart Farming Systems
9. Protected Agriculture / Protected Cultivation
10. Hydroponics
11. Aquaculture
12. Aquaponics</td><td>Middle School
• Science Grade 6
• Science Grade 7
• Science Grade 8

High School
• Science required course for graduation
o Biology 1
• Science electives 2 credits for graduation
o Biology 2
o Microbiology
o Survey of Botany
o Botany
o Survey of Zoology
o Survey of Human Physiology
o Physical Science
o Chemistry
o Physics
o Integrated Science
o Marine Science
o Plants and Animals in Hawaii
o Zoology
o Introduction to Biotech</td></tr>
</table>

HIDOE CTE Program Grades 9-12

CTE courses are organized into six career pathways. A high school will generally offer a selection of pathways but not all six.

1. Arts and Communication
2. Business
3. Health Services
4. Industrial and Engineering Technology
5. Natural Resources - 38 high schools offer CTE courses in the natural resources pathway
6. Public and Human Services

Within a pathway are programs on different topics. The natural resources pathway includes the following programs which are comprised of a two to three course sequence. All programs begin with the same core introductory course.

- Animal Systems
  - Natural Resources Career Pathway Core
  - Animal System I
- Environmental and Conservation Sciences
  - Natural Resources Career Pathway Core
  - Environmental Resource Management
  - Natural Resources Conservation
- Environmental Resource Management
  - Natural Resources Career Pathway Core
  - Environmental Resource Management
- Fisheries
  - Natural Resources Career Pathway Core
  - Environmental Resource Management
  - Fisheries
- Forestry
  - Natural Resources Career Pathway Core
  - Environmental Resource Management
  - Forestry
- Natural Resource Business Development
  - Natural Resources Career Pathway Core
  - Natural Resources Product I
  - Natural Resources Business Development
- Natural Resources Biotechnology
  - Natural Resources Career Pathway Core
  - Natural Resources Biotechnology I
- Natural Resources Production
  - Natural Resources Career Pathway Core
  - Natural Resources Product I
  - Natural Resources Product II
- Plant Design and Management
  - Natural Resources Career Pathway Core
  - Plant Systems I
  - Plant Systems II
- Plant Systems
  - Natural Resources Career Pathway Core
  - Plant Systems I

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<tr><td>Modern Farming Practices and Technologies (CTAHR)</td><td>HIDOE CTE courses that include modern farming practices and technologies, Grades 9-12 but can start in 8th grade.</td></tr>
<tr><td>1. Conservation tillage
2. Crop rotation
3. Intercropping
4. Cover cropping/Green Manure
5. Composting
6. Integrating livestock and crops
7. Integrated Pest Management
8. Smart Farming Systems
9. Protected Agriculture / Protected Cultivation
10. Hydroponics
11. Aquaculture
12. Aquaponics</td><td>Natural Resources Pathway
• Natural Resources Career Pathway Core – included in all Natural Resources programs as an introductory course
• Natural Resources Production course – included in the following CTE Natural Resources programs
o Natural Resource Business Development
o Natural Resources Production
• Environmental Resource Management included in the following CTE Natural Resources programs
o Fisheries
o Environmental Resource Management</td></tr>
</table>

Appendix #2 HIDOE CTE Natural Resources Programs

Grades 9-12

Program	Core Course (Level 1)	Cluster Course (Level 2)	Concentration Course (Level 3)
Natural Resource Business Development	Natural Resources Career Pathway Core	Natural Resources Product I	Natural Resources Business Development
Natural Resources Production I	Natural Resources Career Pathway Core	Natural Resources Product I	None
Natural Resources Production II	Natural Resources Career Pathway Core	Natural Resources Product I	Natural Resources Product II
Animal Systems I	Natural Resources Career Pathway Core	Animal System I	None
Animal Systems II	Natural Resources Career Pathway Core	Animal Systems I	Animal Systems II
Environmental and Conservation Science	Natural Resources Career Pathway Core	Environmental Resource Management	Natural Resources Conservation
Environmental Resource Management	Natural Resources Career Pathway Core	Environmental Resource Management	None
Fisheries	Natural Resources Career Pathway Core	Environmental Resource Management	Fisheries
Forestry	Natural Resources Career Pathway Core	Environmental Resource Management	Forestry
Plant System I	Natural Resources Career Pathway Core	Plant Systems I	None

Program	Core Course (Level 1)	Cluster Course (Level 2)	Concentration Course (Level 3)
Plant Design and Management	Natural Resources Career Pathway Core	Plant Systems I	Plant System II
Natural Resources Biotechnology I	Natural Resources Career Pathway Core	Natural Resources Biotechnology I	None
Natural Resources Biotechnology II	Natural Resources Career Pathway Core	Natural Resources Biotechnology I	Natural Resources Biotechnology II
Entrepreneurship	Natural Resources Career Pathway Core	Any Natural Resources Program of Study Cluster Course	Entrepreneurship