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The Agricultural Skills Chasm: Curriculum Reform for Precision Farming and Sustainable Protein Systems in TVET

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Abstract

The agricultural industry of the globe is challenged more than ever before with the need to produce more food given the limitations of climate change, scarcity of resources and the changing preferences of the market. Technical and Vocational Education and Training (TVET) is one of the key measures in terms of developing a skilled labor force to meet these demands but in most developing countries, its potential is not fully utilized. Nigeria has a high gap between skills taught in the Agricultural TVET institutions and the competencies demanded by a modernizing livestock industry. To reduce this "skills chasm" this paper recommends a tripartite framework to streamline the fundamental curricular reoriented approach to two paradigm shifts Precision Livestock Farming (PLF) and Sustainable Protein Systems (SPS). This conceptual paper, through systematic review of the literature and the synthesis of the available research, suggests a framework of curriculum reform that incorporates PLF and SPS by: (1) Curriculum Revitalization, integrating knowledge of IoT, data analytics, and alternative sources of protein such as insect meal; (2) Immersive Pedagogical Integration, using on-campus innovation hubs and problem-based learning; and (3) Strengthened Multi-Stakeholder Partnerships. Implementation issues such as infrastructure, cost and faculty capacity are critically discussed and strategic suggestions made. The article believes that such a framework will generate a new breed of agricultural professionals not just job hunters but innovators, business persons and make the Nigerian livestock sector most productive, sustainable and competitive globally. The model can be used to offer a replicable model of how agricultural TVET can be transformed into an agent of a sustainable and competitive agri-food sector in other similar contexts around the world.

Keywords: Precision Livestock Farming, Agricultural Education, Curriculum Development, Entomophagy, Skills Gap, Nigeria and Sustainable Development.

Introduction

The combined challenges of population growth, climate change and environmental degradation pose a daunting challenge to the world food security (Godfray et al., 2010). Livestock industry which plays a key role in nutrition and livelihoods is also the major cause of this menace, contributing large portions of greenhouse gas, and land use (Steinfeld et al., 2006). The population of the most populous country in Africa, Nigeria, is experiencing a fast-growing demand of animal protein and it is being limited by the inefficiencies, high costs of inputs, and outdated ways of

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production (FAO, 2023). This cannot be solved by a workforce that possesses the knowledge of yesterday, but the capacity to handle the challenges of farming in the future.

Technical and Vocational Education and Training (TVET) is commonly considered as a key tool in the formation of such a labor force, where practice, innovation, and entrepreneurship are developed (UNESCO-UNEVOC, 2020). Nevertheless, in most developing economies, like in Nigeria, the systems of Agricultural TVET are usually left to exist in anachronic curricula that pose a serious threat of creating a critical skills gap (World Bank, 2019). This gap exists between the abstract graduates in terms of theoretical aspects and the reality-based, technology-driven skills needed in a responding agri-food industry. This mismatch makes TVET less useful in the fulfillment of its purpose as a sectoral transformation engine and economic development.

At the same time, there are two disruptive technologies that are transforming animal farming in the world. First, Precision Livestock Farming (PLF) is the application of new technologies such as sensors, data analytics, and automation to handle single animals or micro-environment to optimize production, welfare, and resource utilization (Berekmans, 2017). Second, Sustainable Protein Systems (SPS) search has become more active, and entomophagy (eating insects and feeding them to livestock) is an alternative approach that is likely to be used. Insects are a very effective, low-environmental-impact source of protein that can turn organic waste into useful biomass (van Huis et al., 2013). Although, studies in these directions are booming, which is observed, among others, in the articles on enzyme supplementation (Osinowo et al., 2018), on chelated minerals (Ayoola et al., 2022), or on alternative feeds (Adegbenjo et al., 2020; Adebiyi et al., 2018). On the other hand, their implementation in vocational education is still at an early stage.

This is the gap that this conceptual paper tries to fill. It claims that to upscale Agricultural TVET to the global level of competitiveness, introducing the principles of PLF and SPS into the main curriculum of Agricultural TVET is necessary to be systematic. The aim is to suggest and hypothesize a workable model of this integration and how it can enable TVET graduates to develop the skills needed to propel a more productive, sustainable, and resilient livestock sector in Nigeria and other parts of the world.

The TVET Disconnect and the Imperative for New Skills.

The presence of consistent skills-gap in Agricultural TVET.

The failure of TVET in most of the settings is documented. This is due to the slowness of the curricula to keep up with the changes in the industry as well as being too theoretical and have no relation to the industry requirements (Majaid, 2010). It is indicative of a wider inability to match education to the future of work, which in agriculture is becoming more and more digitalized and sustainable (World Bank, 2019). An example is the Nigerian environment, in which TVET tends to have graduates knowledgeable in traditional animal husbandry, but who do not possess the knowledge to interpret data, solve technological issues, or apply the principles of the circular economy. This skills deficiency restricts their workability in the progressive agribusinesses and their ability to be innovative.

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The Precision Livestock Farming (PLF) Emerging.

PLF is a paradigm shift of the herd level management to an individual level animal monitoring. It comprises a set of technologies, which include:

a. Sensors and IoT: To monitor the environmental parameters (temperature, humidity, gas emissions) and the biomarkers of specific animals (activity, weight, temperature) live (Tullo et al., 2019).
b. Information Sensing and Decision Support Systems: Applying machine learning and data mining to transform sensor data into actionable information to predict health warnings, optimized feeding and resource management (Vale et al., 2008).
c. Automation and Robotics: When automated feeding, cleaning and milking are involved, the labour requirements will be minimized, and consistency will be increased.

The advantages are significant: the productivity is expected to be high, animal welfare will be improved, the footprint will be reduced, and farm management will become more accurate (Berekmans, 2017). Its implementation, however, will depend on a human resource that can work and interpret these sophisticated systems. Importantly, PLF can be regarded as a highly effective toolset to address fundamental problems in animal science as connected to nutrition, physiology, and health, rather than substitute basic knowledge.

Sustainable Protein Systems (SPS) such as Entomophagy.

There is no sustainability in the environmental cost of conventional protein sources such as soyabean meal and fishmeal (van Huis et al., 2013). One potential alternative to SPS, especially insect farming (e.g. black soldier fly, mealworms), is viable. The feed efficiency of insects is high, they can be reared on organic waste streams, and the insects need little land and water (Osinowo et al., 2018). Studies have shown that they are effective as a partial substitute of fishmeal in poultry and fish diets (Veldkamp et al., 2012). The introduction of SPS into agriculture leads to a circular economy as the waste is minimized, and additional value chains are established. Although there is potential, knowledge of insect rearing, processing and nutritional science is not in the mainstream agricultural training.

A conceptual Framework of incorporating PLF and SPS into Agricultural TVET.

In a bid to overcome the skills chasm, we recommend a tri partite model foundational on theories of situated learning (Lave and Wenger, 1991) and competency-based learning. It is a framework that is meant to contextualize learning, make it practical and industry relevant.

Pillar 1: Content Integration and Revitalization of Curriculum.

The basic curriculum should be dynamically changed to capture the reality of contemporary agriculture. This involves:

(i) Creation of New Learning Modules: Development of stand-alone modules or incorporation of the topics into the existing ones. One such example module would be a Digital Livestock Management one that includes IoT sensor networks, data literacy, and farm management software. One of the modules would be a Sustainable Feed Resources focused on the biology, nutrition, and economics of designing insect meal production and use. There is an urgent need to ensure that these advanced modules are supported by a

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solid base of basics in core animal sciences including Animal Nutrition, Physiology, and Genetics such that the application of core principles is perceived as a tool in integrating to apply the basics, rather than as an isolated discipline.

(ii) Cross-Disciplinary Approach: The incorporation of ideas related to information technology, data science, and environmental science into the conventional animal science and agronomy classes. This is in a way indicative of the interdisciplinary nature of the contemporary agricultural issues.

Pillar 2: Immersive Pedagogical Integration and Experiential learning.

Theoretical learning must be anchored in practical, experiential approaches.

(i) On-Campus Innovation Hubs: The setup of functional and technologically-driven units within TVET campuses. A "Smart Livestock Unit", that has environmental sensors and weighing mechanisms which are automatic, would also be a PLF lab. There would be an Insect Bioconversion Unit, which would show how to reared the black soldier flies on campus food waste, generate protein in the livestock unit, and thereby complete the nutrient cycle, which would provide a visible illustration of the circular economy.

(ii) Problem-Based Learning (PBL): The transition to lecture-based teaching and learning to PBL. Students might be given a challenge of diagnosing and mitigating a heat stress event in a broiler flock using sensor data or creating a small business plan around a small-scale insect farming business and this encourages critical thinking and skill to solve problems.

(iii) Stackable Micro-Credentials: To enable faculty to become more flexible and relevant, TVET should offer short, certified courses in high-demand niches (e.g., "PLF Technician," "Insect Farming Specialist" and so on).

Pillar 3: Enhanced Multi-Stakeholder Partnerships.

It should be a cross-classroom implementation to be implemented so that it is sustainable.

(i) Public-Private-Research Partnerships (PPRPs): Institutionalizing partnerships with agri-tech companies, commercial farms, and research institutions (e.g. the Federal University of Agriculture, Abeokuta). These alliances may be used to help in the donation of equipment, guest lectures, internship placements, and co-curriculum development to make certain that it matches industry requirements.

(ii) Policy Advocacy to Investment: TVET leaders should lobby the government and other development stakeholders to invest in digital infrastructure and teaching resources that could help in implementation of this modernized curriculum. This makes TVET institutions more than learning institutions, but at the same time, the drivers of agriculture in the region.

Implications, Challenges and Implementation Strategies.

The adoption of this framework has a great potential in changing the agricultural nature in Nigeria. The sector can make a step-change into efficiency by generating graduates with knowledge of PLF to transition to the generalized management approach to interventions directed at savings and yield-enhancement targets. Knowledge on SPS will enable graduates to create and operate the

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circular economy that will reduce dependence on externally sourced feed ingredients and alleviate environmental harm while understanding the connection between the system and environment.

This is in direct line with several Sustainable Development Goals (SDGs), such as SDG 2 (Zero hunger), SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible consumption and production). Moreover, the technologically competent population renders the country more appealing to an investment in high-tech agriculture to supply it more effectively into the global value chains and to increase its general economic viability. The framework will make TVET graduates not just job seekers, but change agents, entrepreneurs that can initiate tech-enabled farming businesses, consultants that can provide advice on sustainability, and a labor force that can lead to an agricultural revival in Nigeria.

How to overcome the Implementation Problems.

Although the proposed framework conceptually is sound, the key to its successful implementation lies in its proactive efforts to overcome major implementation obstacles.

1. Infrastructure and Cost: PLF technologies (sensors, connectivity, software), as well as setting up bioconversion units are costly investments in terms of capital. The model of phased implementation is suggested, and the process starts with one, well-equipped demonstration unit. The TVET institutions must vigorously be aggressive to engage Public-Private Partnerships (PPPs) where industry partners can supply equipment in exchange to access to trained graduates or onsite testing facilities. Strategic targeting should also be done on grant funding by the national and international development agencies that are aimed at innovation of agriculture and education.
2. Faculty Capacity Development: The existing group of TVET lecturers might be ill-equipped in data analytics and IoT systems as well as insect rearing. An extended, comprehensive faculty development program is thus an uncompromising requirement. This could involve:

a. "Train-the-Trainer" Workshops: These workshops are organized with help of university researchers and industry technologists.

b. Sabbaticals in Industry: The lecturers can also do a sabbatical leave in an agri-tech company or a well-developed commercial farm to have practical knowledge.

c. Integration of Industry Experts: Formal: Get practitioners to co-teach new modules with formal adjunct faculty.

3. Scalability and Contextual Adaptation: The model should be able to adapt to the heterogeneous nature of TVET institutions in Nigeria. It is not feasible to use a one-size-fits-all approach. In the case of well-endowed urban institutions, it is possible to carry out the tripartite framework fully. In the case of rural or under-resourced colleges, a lite version may concentrate on less technical SPS (e.g. small-scale insect farming) and simple data collection and analysis with smartphones and basic spreadsheets, so that the base skills can be expanded later.

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Conclusion and recommendations.

This paper has outlined the unsustainable mismatch between the outputs of the current Agricultural TVET programs and the demands of a modern, sustainable livestock sector in terms of skills. In its turn, it has offered a conceptual framework of a systematic integration of the transformative disciplines of Precision Livestock Farming and Sustainable Protein Systems into TVET curriculum. This framework is a viable way of closing the skills gap due to the revitalization of content, the adoption of immersive pedagogies and the establishment of strong multi-stakeholder collaborations. Discussion of implementation issues will give a practical roadmap on how to overcome the practical barriers of implementation.

The stakeholder recommendations are as follows:

1. To the TVET Institutions: Start the curricular review in order to include Indicators of PLF and SPS, invest in establishment of on campus innovation centers and lay more emphasis on a continuous faculty development programmes.

2. To the Policymakers: You need to focus on funding agricultural education technology, create an enabling environment where the industry and TVET can work together, and embrace the staged implementation models.

3. To Industry Partners: Actively participate in the work of TVET institutions by providing equipment and other forms of support, internship opportunities, co-creating the curricula and by taking faculty members on industrial attachments.

4. To Researchers: Do more empirical researches to prove and perfect this framework, create context-based teaching and learning resources and observe the long-term effects of these integrations on graduate achievements and industry performances.

The upscaling Agricultural TVET is an urgent task. Through innovation, human investment, and inculcation of a culture of life-long learning and collaboration, Nigeria can generate a row of agricultural experts who can restore food security, environmental sustainability, and global competitiveness in the 21 st century.

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