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"Connected researches" in "smart lab bubble": A lifeline of techno-society space for commercial agriculture development in "new normal"

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ABSTRACT

Execution of a well-defined program of research targeting the commercial agriculture sector could be considered as a strategic change towards keeping a country on the track of achieving the second sustainable development goal (SDG), i.e. 'zero hunger by 2030'. To make this a reality, analyzing of drawbacks of the present research environment and finding solutions through digital interventions is warranted. This paper elaborates on those issues faced by researchers who are isolated from human-to-human physical contact in carrying out research in commercial agriculture, especially in COVID-19. Further, a conceptual model to connect and practice research beyond physical presence by digital transformations of organization design of research institutes under these circumstances is suggested. The framework proposed characterizes a connected lab complex – designated as the "Smart Lab Bubble", to examine its potential in meeting the real needs of a researcher in a disconnected society to produce impactful research for the agriculture sector. It emphasizes the fact that this kind of model shall resiliently be adopted in technological sciences, with the backing from those non-technological sciences like economics, humanities, and management, to make the concept of a "society-friendly innovative research culture" a reality. In light of this, it would expect to leverage technologies to create new services and values for various stakeholders including the agriculture community during this pandemic. The digitally endorsed performance management envisaged under this framework, along with relevant policy measures, is supposed to be building an agile architecture that would not incur technical debt in a newly formed cultural position.

1. Introduction

Society once presumed to be relatively stabilized in its basic requirements such as food and shelter through conscious planning and production on par with the various economic models has now in a kind of disruption that was not anticipated before, at the hands of the coronavirus disease 2019 (COVID-19) pandemic (Galanakis, 2020; Ejeromedoghene et al., 2020). The most affected need of the society in this COVID-19 period other than health would be the food production for the society (Boyacı-Gündüz, Ibrahim, Wei, & Galanakis, 2021; Aday & Aday, 2020).

Food production in the modern context is directly attributed to the large contribution from commercial agriculture which in turn plays a major role in achieving the no. 2 Sustainable Development Goal (SDG) - Zero Hunger by 2030 (Sunderland et al., 2019; Guenette, 2019; Gassner et al., 2019; UNCTAD, 2017; Bhavani & Rampal, 2020). Targets associated with agriculture initiatives to reduce poverty and hunger and enhance economic and household income growth are set by SDGs 2, 3, 6, 7, 8, 12, 13,14,15, 17 (FAO, 2019).

Despite this, records show the world is off-track in ensuring access to safe, nutritious, and sufficient food for all people all year round, and eradicating all forms of malnutrition (FAO; IFAD; UNICEF; WFP; WHO, 2020). This is mainly due to complex social interaction and interdependence associated with food production that could not be ignored by any means. Research in commercial agriculture is one such interaction and interdependence that directly affects the quality and quantity of food production in any economic model in existence (Henry, 2020). Therefore, research development in commercial agriculture should be

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promoted and well facilitated within a good research culture that directs all research to be productive in accomplishing food security for the society (Garcia, Osburn, & Jay-Russell, 2020; Stephens, Jones, & Parsons, 2018; Ingram, Gregory, & Izac, 2008).

Research has its unique planning process, resource consumption, and implementation mechanisms that are supported and linked by a decision-making process to be successful in delivering its outputs for commercial agriculture development. However, it implies that the way research is practiced so far is not going to work anymore in a disconnected research culture, which is also extremely stressed and shocked by the COVID-19 pandemic.

1.1. Problem: disconnected research culture in commercial agriculture development

Two main reasons that cause this disconnected research culture to be evolved in this manner in the present context of agriculture development, in which developing research towards innovative commercial agriculture holdups its full potential in making impactful research to the society are as follows.

I) The lack of connected research data and information for better decision-making in research development.
II) The lack of an interconnected pool of resources that could be deployed to facilitate research based on the above decision makings.

We argue that these two issues should be solved simultaneously as the two issues seem to have tight inter-relationships with each other when solutions to them are sought.

Digital humanities would provide good solutions for the first issue. Then, the second issue is expected to be solved by a physical network that interconnects all resources in real-time and allows the respective stakeholders to access them round the clock. Digital humanities and the interconnected network should make such interactions that allow each other to share strengths in coexistence to facilitate impactful research toward the expectations of all stakeholders including the society.

1.2. Why existing research implementation mechanisms, strategies, and solutions are not adequate

There are many challenges faced by the commercial agriculture industry during the COVID-19 pandemic in complex ways, especially in emerging economies (Hamid & Mir, 2021). The major challenges are as follows:

1 Difficulty in producing agriculture products on a mass scale due to intensified labor deployment.
2 Quality of the products becomes less, as new improvements and innovations are not developed frequently as expected for the agriculture products.
3 Food safety, especially in the latter part of the supply chain, is at risk as safety precautions required for safeguarding food from being contaminated with diseases become difficult to practice especially in developing countries.
4 Supply chain disruptions due to technology barriers enforced by new normal conditions exist at every level with a disturbed supply of food to markets.
5 COVID-19 pandemic caused food production more vulnerable to climate-related and disease-related issues, as remedial measures are not practiced as usual. This is because the new technological interventions have not progressed as expected to match the rapid change requirements.

Item number two and five in the above list are expected to have a significant effect on food security and are directly affected by the quality and quantity of research in the commercial agriculture field (O'Sullivan, Bonnett, McIntyre, Hochman, & Wasson, 2019). Research in commercial agriculture indirectly supports reducing the impact caused by challenges listed in items number one, three, and four of the above list. Therefore, the importance of improving research towards commercial agriculture is well justified even in a period like the COVID-19 pandemic. However, research in commercial agriculture is a challenging task even in developed countries and normal conditions with so many facilities available. The task of research institutes to carry out research on commercial agriculture development becomes even more challenging with the additional threat of the COVID-19 pandemic which has caused the isolation of research institutes and researchers to a great extent (Yasmi, Dawe, Zhang, Balie, & Dixie, 2020; Department of Economic and Social Affairs, 2020).

Commercial agriculture research is carried out by academicians in universities, researchers in research institutes, employees in labs of the research unit of a commercial product/ service development organizations, and students or scholars either in above any institutes to achieve key performance drives of research development for commercial agriculture (Abeysiriwardana & Jayasinghe-Mudalige, 2021).

Three kinds of research could be observed in any research culture as follows.

1 Researchers who involve with normal research work that directly aligns with the objectives of research institutes.
2 Researchers who involve directly in the research work on the COVID-19 virus and its effects (This may be in addition to their normal research agenda).
3 Researchers who have adapted their research to coexist with the studies on the COVID-19 virus and its effects.

Existing solutions have not been adequate to address the challenges faced by stakeholders of commercial agriculture development, especially during the COVID-19 pandemic, and existing systems are supposed to facilitate research in a limited manner to meet the requirements of research implementation towards innovative commercial agriculture development. While practicing the above types of research work, the following limitations could be identified in existing systems in fulfilling the expectations of the research agenda that works towards commercial agriculture development.

- Difficulty in managing the existing resources in an optimum manner for commercial agriculture research

The survey carried out by (Walker, Brewster, Fontinha, & Haak-Saheem, 2020) found that researchers felt their confidence was undermined in applying for certain grants to solve other major challenges that humanity faces when research society would be in usher to find a solution for COVID-19 by utilizing the resources as much as possible from all fields of research. This has caused a huge negative impact on the researchers that work in research fields like commercial agriculture.

- Researchers are forced rather than voluntarily to communicate their research practices remotely

COVID-19 lockdown forces researchers to adopt remote working for their research with almost no alternatives and with poor facilities. In these situations, traditional online communication increases the amount of time taken to prepare material and requires more material to achieve similar tasks in remote locations. Some kinds of research are impossible or need to be changed in heavy procedures in conducting remotely due to limitations of the available lab facilities. The researchers are also forced to avoid human touch under psychological stress and thus the century-long practice of person-to-person communication has been skipped. These naturally occurring person-to-person communication networks are something that human beings cannot avoid and ignore for centuries to come (Allen, 1977). However, humankind has been forced to avoid it in the COVID-19 calamity making them wildly looking for similar kinds of communication networks that simulate physical touch possibly through technological innovation.

- Adherence to heavy precautionary methods in conducting the commercial agriculture research

Almost every researcher faces many problems in light of the adherence to the procedures in following the safety processes relevant to COVID-19 (Gewin, 2020; Makoni, 2020).

- Researchers are forced to adjust their research scope beyond its tolerable limits

It is very well known that thousands of labs in a variety of research fields are reconsidering their planned studies and not all projects could be easily put on freeze (Servick, Cho, Guglielmi, Vogel, & Couzin-Frankel, 2020).

- Lack of cultural facilitation for disciplined research innovations in commercial agriculture development

A well-formed research culture would progress on behaviors, values, expectations, attitudes, and norms of research conduct. That culture then paves the way for innovative best-practiced research to be initiated by the researchers (Casci & Adams, 2020). Lack of interactions among researchers, many types of collaborations, and weakened exposure in such interactions and their effects on the research integration process make researchers deny guided, committed, transparent, and disciplined research development in commercial agriculture.

There are several types of SMART labs in existence at the commercial level as well as for academic purposes, which use internet/ IoT devices and other network equipment to manage the workflow of the research. However, they are not in full capacity to request resources in other labs in real-time, lack intelligently driven policy directives to deal with the management of other labs, do not have the potential to integrate research in several labs, and share resources of several labs to conduct particular research in real-time. They also do not have the capacity to make intelligent decisions to manage specific research needs required for particular research and advocate for a more flexible approach that could be adapted and succeeded in a highly dynamic environment.

Researchers may have many concerns before starting their research as depicted by the following questions.

I What kind of research should be conducted to deliver impactful research for the commercial agriculture industry?
II Has a similar kind of research been done before? Then, is it necessary to do the same kind of research again?
III Does Return on Investment (ROI) justify the conducting of this research?
IV Does the research make a societal contribution as well as commercially viable?
V Once finalized the research project scope, could it be done using existing resources in the research lab?
VI What are the best methodologies, the available experience, and the most recent developments in the research field that could be obtained from the literature of past successful and failed research projects to be applied and used in ongoing research projects to be successful?

The answer to all of those questions would be a system that facilitates decision-making based on pieces of evidence that come out from the literature available at proper repositories. Therefore, reliable and timely information on already conducted research as well as ongoing research is desired. This information is usually stored in the research literature or as metadata of particular research. However, when those works of literature are not stored in one place or not recorded at least and scattered at different places, they could not be retrieved properly and analyzed for good decision-making. In addition, it would be time-consuming to retrieve stored research data manually in research institutes all over the country or the world. To make sure that research could be conducted within the budget and time frame, information on facilities and resources should be readily available to be viewed by the researchers. To make all of this information readily visible, data and information should be retrieved from every available source as soon as that information is stored for processing. To achieve this kind of SMART (Specific, Measurable, Achievable, Realistic, and Timely) data retrieval mechanism, data and information should be digitized, connected in real-time in a centralized manner, and available in real-time through electronic systems. Digital humanities would gracefully involve studies of sorting, prioritizing, upgrading (using historical research data), and making these research data and research-related metadata converted into value-added consumable data in the decision-making process of research development towards innovative commercial agriculture. In literature, we could not find any existing modern SMART lab that involves commercial agriculture research and reports this kind of digital humanities intervention in its implementation mechanisms.

1.3. The proposed solution: "smart lab bubble" powered by digital humanities

Considering the above difficulties and thriving on the situations created by COVID-19, extensively interlinked research institutes and their lab spaces are supposed to play a significant role in connecting and empowering researchers to do their research in the commercial agriculture field effectively and efficiently.

In considering all of these aspects in view of proposing an alternative technology interface for researchers in the commercial agriculture field, four important requirements are proposed to be considered to stimulate such physical touch while all resources and facilities are being provided within a simulated natural research environment of having substances of virtual existence.

1 A technologically savvy physical system that provides all necessary facilities and resources to researchers without any interruptions.
2 A controlling system that links every component of the research process to make a single network of research programs and their subcomponents.
3 Performance management of every research activity to achieve optimum performance out of scarce resources and facilities available in many flexible situations.
4 Need for a mediating role to be played in the new cultural position formed by technological systems. Continuous studies and changes made on it would further improve the cultural values created by such technology-savvy systems. This would also facilitate identifying the pain points in the new cultural positions created by physical distance and intensified technology interventions. Ultimately, remedial actions would be proposed to ease such pain points.

The drawbacks of practicing traditional research culture hinder expected results from commercial agriculture research. Traditional performance management systems practiced within such cultures are not strong enough to monitor and manage resource inputs for optimum research outputs in a disconnected research environment. As a solution to these issues and to eliminate the drawbacks of traditional research implementation mechanisms, a framework of automated smart labs connected in a network with remote control facilities through emerging ICT technologies, such as the Internet of Things is proposed. This framework is unique to previous IoT solutions in a way that similar kinds of labs are further proposed to interconnect in a systematic way to form a conceptual lab bubble. The proposed lab bubble is supposed to have more advantages than a single isolated smart lab that could only provide limited interconnections and resources to a researcher in a period like the COVID-19 pandemic. Thus, the delegation of research work can be further extended, improved, and controlled by using the facilities available in the other labs in a particular bubble.

The proposed "Smart Lab Bubble" is, therefore, a new concept encompassing all aspects of a logically networked pool of human resources and other physical resources. This enables the resources to be location independent and available in real-time for the execution of research anywhere with intelligent capacities. The integrated mechanism is thus expected to be adapted for conducting any kind of research without human interventions. Here we proposed how this kind of lab should be conceptualized and how such a lab in existence will be instrumental in reaping the benefits from integrated research practices and research culture.

This lab complex is supposed to provide a seamless human-machine interface with connected real-time actions along with automated inventory management and project management functionalities associated with research processes enabling a fast track to research realization. This plethora of different complex human-human, human-machine, and machine-machine interactions in a Human-Machine Network (Tsvetkova et al., 2017) go beyond the context of technology-based sciences and deem a study on a new culture that could be mediated, supported, and the role played by non-technology sciences like social sciences, management, and humanities (Sporleder, Bosch, & Zervanou, 2011). Therefore, this paper will highlight such human-techno interventions and impacts on positioning a new research culture in addition to the technology-based digital transformation caused by the Smart Lab Bubble.

2. Methodology to setup connected research network in commercial agriculture

Given that a set of requirements are resulted by research practices that are forced to be conducted remotely, a digitally empowered experimenting environment with the following two components is envisaged.

I Interconnected physical network with all research equipment and processes that are controlled through machine interventions rather than onsite human participation.

Here all lab processes would be controlled virtually without any limits of distance through the assistance of machine intelligence by researchers who are in the field of commercial agriculture. The system is supposed to satisfy all of the above-mentioned requirements of a such system and would address all of the issues faced by researchers sufficiently in conducting their research during a period like the COVID-19 pandemic.

II Non-technological interventions like digital humanities to promote sustainable and socially responsible research culture.

Here we discuss how Smart Lab Bubble would work in a newly created network that consists of many actors including the researchers and the intelligently manipulated resources that help the researchers in commercial agriculture research to innovate. We further highlight how these interactions would pave the way for a new research culture that could be promoted by non-technology sciences like arts and humanities as follows.

I Research that could be improved by non-technology sciences like arts and humanities would be expected to be augmented in a Smart Lab Bubble environment. This would result in providing value-added research products that are equipped with extra benefits such as environmentally friendly characteristics, etc that lead to the improvement of the quality of life in society.
II The mix of ubiquitous research fields would further influence the interactions of actors in the Smart Lab Bubble to stimulate a cultural transformation that would provide a conducive environment for maintaining highly sophisticated digital interactions and communications.
III Further, non-technology sciences like arts and humanities would promote creative, innovative, and cultural research industries associated with scientific research in an enjoyable research environment facilitated by the Smart Lab Bubble.

2.1. “Smart Lab Bubble” – connected laboratory complex for researchers of life sciences

The total Internet of Things (IoT) connected devices is projected to be around 25 to 75 billion units worldwide according to several claims (Holst, 2021; Horwitz, 2019) and each person will own 15 connected devices by 2030 (Heslop, 2019). In this context and never-ending pandemic situation, we propose a framework that enables remotely controlled and integrated smart lab services called “Smart Lab Bubble” for researchers especially in the commercial agriculture field, as in Fig. 1.

Here, labs are supposed to be interconnected in real-time and around the clock through communication networks to share equipment, data & information, and human resources. Here, the already existing smart city concept[1] would be adopted in interconnecting existing labs into a Smart Lab Bubble empowered with IoT capabilities. Further, it would be automated with a robotic and virtual experimentation environment when the lab is out of human presence. Each Smart Lab Bubble could be developed in line with the relevant stream of subject areas along with a set of policy directives. For example, Smart Lab Bubble could be designed based on a specific subject area such as Chemistry, Physics, Botany, and Biotechnology or using existing lab and equipment space in the country as appropriate. Further, these bubbles may be interconnected with each other to form an extended lab space or lab complex (Smart Big Bubble).

2.2. How Does the Internet of Things (IoT) benefit researchers, research business, and other stakeholders in the research business?

IoT is extremely useful in streamlining common working processes as sensors and actuators worked by the principles of IoT would be ably spawned anywhere to make multiple network links between every work step even in very remote places. IoT devices with sensors could be used to keep research equipment running at peak efficiency and would detect issues in the equipment before they have a negative impact on critical research and researchers. This would save the work and time lost by researchers and the costs of larger repairs leading to well-managed predictive maintenance (Coleman, Damodaran, Chandramouli, & Deuel, 2017). Further, IoT is a good avenue to integrate cloud computing into existing ubiquitous physical networks of different scales (Park, 2018) which are supposed to be established in the “Smart Lab Bubble”. Due to the huge amount of communications between interconnected devices, an enormous amount of data is generated through IoT resulting a large data sets referred to as Big Data (Tyagi & Kumar, 2020). When these big data are well managed through studies of digital humanities, they become intelligent information for better decision making on managing research performance to be practiced in the research culture formed by the “Smart Lab Bubble”.

2.3. Satellite links for increased remote connectivity

Satellite links could be used as appropriate and as per necessitates in these smart lab bubbles for increased overall IoT network performance (Petrovic et al., 2020). There are over 4,000 operational satellites found in geostationary, molniya, elliptical, and low earth orbits as of January 2022 to make communication links throughout the earth’s surface and beyond (Union of Concerned Scientists, 2022) and could be used more or less on the internet applications anywhere. Satellite communications have a huge impact on remote communications as they could be made available at places where cables can’t reach. This makes it a good solution in a pandemic situation as well as when remote labs are deprived of broadband connections and in need of high availability of internet services, especially for time-critical applications. In addition, satellites

[1] A smart city is a concept that encompasses many dimensions such as smart city governance, smart living, smart mobility, smart environment and etc. to public service. Similar type of dimensions are also expected to be practised in the Smart Lab Bubble.

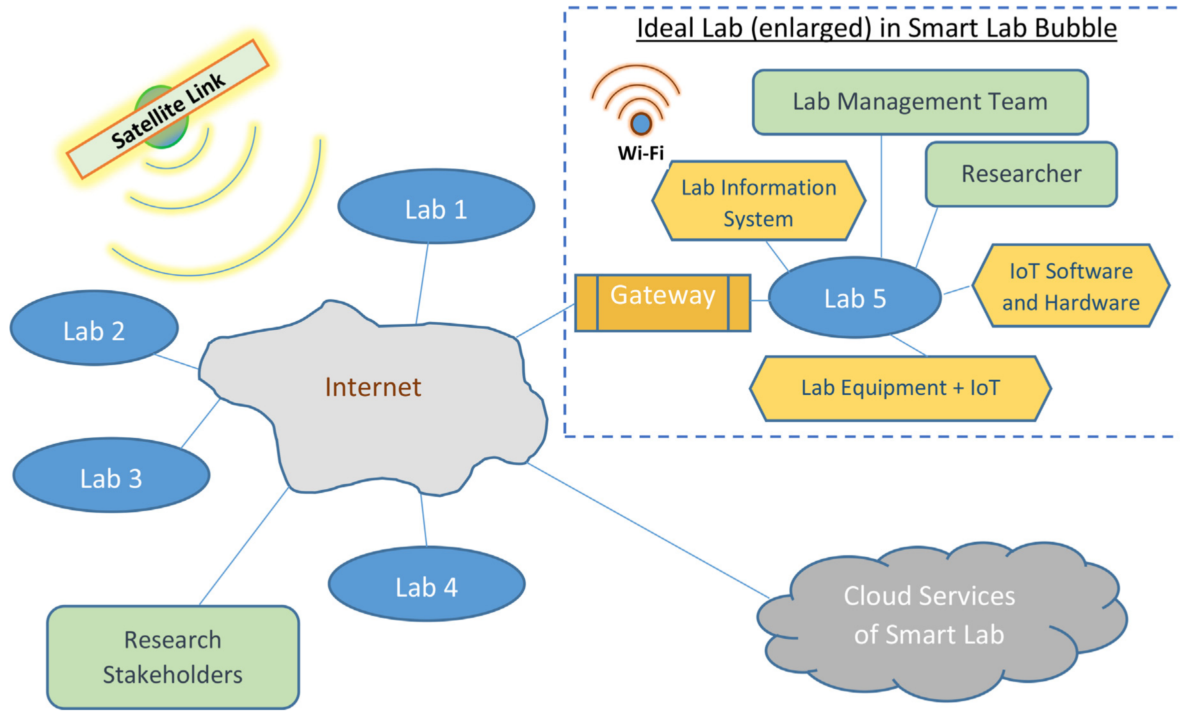

Fig. 1. Conceptual model of the Smart Lab Bubble (Five labs worked on commercial agriculture research are interconnected into one bubble)

could be used abundantly for one-way and two-way data transmissions through near-ground environmental monitoring equipment (weather stations and radiosondes) and two-way telemetry and telecontrol equipment respectively (Sweeting, 2018) in data collection strategies that are critically required for lab work of agriculture-related researches, especially in pandemic situations.

2.4. How Smart Lab Bubble will work with IoT

IoT devices in laboratories come in different types to enable a remotely controlled lab environment without human interventions or with minimum human interventions. Modern-day IoT devices in the lab could perform various lab tasks such as environment monitoring by sending alerts when the environment is out of specifications, collecting data and metadata on equipment such as incubators, balances, and pH meters for regulatory compliance, optimizing the processes by intelligent data management through data analytics using informatics systems like Electronic Lab Notebooks (ELN), Laboratory Information Management Systems (LIMS), Chromatography Data Systems (CDS), and Laboratory Execution Systems (LES) (Kranjc, 2021). ELN and LIMS are automated systems that replace traditional paper lab notebook and sample analysis processes respectively and they could interchange information and request additional work processes from systems like CDS and LES to create data-intensive applications more interconnected and sophisticated with additional capacities like metadata processings. According to our opinion, all of these capacities are being evolved with a speed that has not been anticipated before to create more unifying, overarching solutions that pave way for a proposed system like “Smart Lab Bubble”.

An IoT-enabled Smart Lab Bubble will use all devices including automated devices, such as collaborative robots or pipetting robots connected to the cloud or local server that can be controlled by the researcher externally and accessed from anywhere with an internet connection (Ryding, 2020). An administrative control panel with additional sensors in a central location could be used through the internet to facilitate the researcher to conduct their experiments in a more productive integrated manner, without unnecessary obstructions or error messages.

Researchers who are going to amplify DNA/ RNA samples of plant material may want to get assurance of the working condition of a PCR machine before extracting the relevant plant material into those pipetting robots. Smart Lab Bubble would help the researchers to track the location of the most suitable PCR machine available, monitor its health, and request necessary maintenance services in advance at the planning stage of the research. In addition, a device connected to the Smart Lab Bubble is supposed to have more extended life than a device in a normal lab through proactive steps and procedures, which could be provided by maintenance analytics established in the Smart Lab Bubble.

If equipment fails, researchers can search for another similar equipment in real-time, conduct that part of their research in another space, and transfer back with results to the original place as required.

These bubbles permit scientists to physically present in any of the labs that are easily accessible to them to do their research and at the same time use facilities at any other lab in the working bubble or any other bubble in the big bubble.

In addition, such an integrated system will overcome barriers in the form of compliance issues or simply a lack of communication between devices and researchers. It further enhances smart energy management and supports circular economy concepts of an ideal research lab.

However, we could also anticipate some issues in implementing such IoTs enable systems and could present one such scenario as follows. There would be an obvious issue in these connected environments when interfacing with instruments from different origins in the “Smart Lab Bubble” as those instruments may come with incompatible proprietary formats for data storing and data interchange (Noura, Atiquzzaman, & Gaedke, 2019). Nevertheless, we think that the advent of more sophisticated capabilities in the field of digital humanities would be useful in sorting out these problems by recommending the most suitable unified formats for interchanging data through intelligent policy formulations that could be achieved using literature, especially in the current context and research data mining without being bias on any proprietary options.

2.5. How Smart Lab Bubble would help remotely isolated researchers in the commercial agriculture field

Smart Lab Bubble provides so many facilities for researchers to conduct experiments in the commercial agriculture field. Further, it eliminates inherent weaknesses of the traditional research environment and facilitates researchers to be connected to the research work any time anywhere.

2.5.1. Virtual experimentation environment

Virtual experimentation simulations are supposed to be adequate for some experimental designs and trials to be prepared before the actual experiment itself. This will reduce the time that scientists need to be physically present in the actual experiment environment as he is well prepared beforehand for the actual experiment (Destino & Petrovic, 2021). In addition, this could be used to train and teach experimental groups remotely with the same level of hands-on experience (Corter et al., 2007) to conduct an experiment with reduced resources and waste when involved in the actual experiment. Some parts or whole experiments may be handover to the automation setup of the lab to reduce the overall time that may be required if the experiment is conducted solely in physical presence.

2.5.2. Prevention of data loss

The commercial agriculture research has streams of data coming at different stages from start to end of multiple research processes, and the frequency of analyzing these data is usually intensified at the end stage of the experiment. However, the researcher may be too selective on what to record in his limited presence in a lab in the new normal. This may result in data breaches (Layton & Watters, 2014), exfiltration (Ullah et al., 2018), or unwanted destruction of sensitive data associated with experimental steps such as sampling and calibrations in commercial agriculture research. Smart Lab Bubble will automate the data collection and thus will eliminate data loss. Further, it will improve the accuracy and standards of the data associated especially with live materials of agriculture experiments through the controlled environment provided by machine intelligence and diversified backups.

2.5.3. Smooth workflow with zero failure rate

IoT-enabling system solves connectivity issues between equipment better than any other system to maximize the research potential of a lab and the researcher. The IoT-enabled devices will connect all different elements of the laboratory from an automated micropipette to PCR machines to maintain the smooth workflow of the experiment. Then, machine output can be directly streamed into a digital format, saving the scientist valuable time and effort along with removing the susceptibility to human error (Chubb, 2020; Lilly & Strateos, 2020). Failure rate especially in reproducing manually performed experiments and data reporting has increased due to unexpected difficulties faced by researchers in this COVID-19 period. When a lab is interconnected and equipped with IoT devices, it is enabled with a fast, accurate, user-friendly, and a less number of human-machine interactions. Records of the research are always in connected data flow and updated in real-time in a traceable manner through tracker application software. For example, an IoT-enabled smart electronic pipette will always feed pipetting data to the tracker software, which will manage these real-time data to detect errors and facilitate decision support in pipette handling. Therefore, experiments are executed easier, quicker, and with greater precision. Moreover, a high degree of reproducibility would be observed while data is documented more accurately and research is more accessible to different parties.

2.5.4. Accurate monitoring of research processes

The sensors could be used to monitor vital stats in plants and animals, recommend nutrient plans for the growth of plants and animals, order prescriptions, etc. These monitoring mechanisms would call researchers' attention as required when the status is changed with respect to malnutrition, the spreading of diseases, etc of the living systems. Within plant or animal houses, IoT will be used to enable robots to perform remedial actions, while a researcher in a virtual place will perform administrative services. With added machine learning and AI technology, these actions could be streamlined and improved for best performance. In this way, it connects every tool in the laboratory, creating a truly smart, productive environment where machines can predict experiment outcomes and support more contextual decision-making using real-time data for research.

Some extant research argues that the performance of remotely managed systems may decrease synchronous communication that has normally been facilitated by human-sensitive in-person communication (Yang et al., 2022). However, it is expected that the performance management capacities of the proposed "Smart Lab Bubble" environment would provide alternative strategies and opportunities that were not anticipated before in such remotely managed systems to solve the issues that have been evolved into a new pattern in research in the context of commercial agriculture development. (Daum, 2021; Miller, 2021).

2.6. New strategical positions in Smart Lab Bubble: the force of non-technology sciences

It is expected that new strategical positions would be created in Smart Lab Bubble with the involvement of the non-technology sciences as follows.

2.6.1. Interventions of digital humanities

When research in commercial agriculture is conducted, scientific literature has an important role to make that research impactful one to its recipients i.e. people. Scientific literature contributes in two folds as references (research findings) for future research and scientific knowledge for literacy purposes. This literature as a core subject of humanities can be converted to value-added literature through digital interventions to form a new kind of digital humanities. These components of digital humanities would be resiliently achieved and useful in a new research culture facilitated in the "Smart Lab Bubble" where the institutional flexibility of a research institute thrives within a conducive environment of "Research for Society" (Abeysiriwardana, Jayasinghe-Mudalige, & Seneviratne, 2022) through real-time resource sharing, adoption of shared policies, knowledge sharing and avoiding unnecessary resource acquisitions and research duplications to produce optimum research outputs. Further, digital humanities would facilitate gradually expanding research literature along with its metadata to be included under one research culture paving the way for producing a broad set of tools, processes, and functions, especially as AI applications. This includes software tools for critical annotations (Mészáros & Kiss, 2018), opinion mining on lexicons using deep learning-based natural language processing (NLP) (Zhang et al., 2022), and image analyzing software of computer vision (Alexandre, Saint-Raymond, & Venturini, 2021) to help with research practices.

The proposed "Smart Lab Bubble" is a venue for incorporating digital humanities into a research culture where agriculture research would be conducted to make them more sustainable in their practice. Research protocols, research arguments, research schedules with resource allocations, and research literature converted to digitized (remediated) and born-digital materials would make a sustainable research practice enriched with the combinations of the methodologies from traditional humanities disciplines (such as rhetoric, history, philosophy, linguistics, literature, art, archaeology, music, and cultural studies) through new digital interventions (Crymble, 2021). These knowledge and materials enabled with new digital interventions provided by computing power (such as hypertext, hypermedia, information retrieval, data visualization, image processing, data mining, text mining, digital mapping, etc.) will live the communication and smooth workflow of research practice towards innovative commercial agriculture in the

"Smart Lab Bubble" environment. This would be supposed to hoist digital humanities to a new height in software studies, platform studies, and critical code studies enabling smooth implementation of the research environment worked out in the "Smart Lab Bubble". In addition fields like new media studies, information science, and cultural analytics (Salah, Manovich, Salah, & Chow, 2013; Acker & Clement, 2019; Tomaselli & Tomaselli, 2021) enabled through the digital humanities will contribute to the sustainability of integration of other technologies such as IoT, Robotics and Artificial Intelligence in the "Smart Lab Bubble". However, automated studies within Smart Lab Bubble may be needed to analyze heavy transactions between these elements to form new theories in digital humanities which in turn would nurture the healthy communication between humans and machines including computers (Peng & Zhou, 2022). We would introduce the terms digital humanities preparedness and digital humanities resilience within the concept of the "Smart Lab Bubble". We argue that these terms could be easily put into practice through this kind of interconnected real-time digital environment as opportunities for digital interventions are supposed to mushroom in the "Smart Lab Bubble" environment. Digital humanities preparedness refers to the ability of researchers and society to seize opportunities emerging from digital humanities. Digital humanities resilience would enable new techno-humanity disruptions in innovation capacity and digital literacy to be easily adopted in the digital humanity space.

Responsible research and innovation are expected to be expanded to their maximum within the "Smart Lab Bubble" environment with the continuous feedback extracted in real-time from the interactions between the society and the scientists. In this exercise of maintaining the sustainability of research business in an innovative commercial agriculture context, Corporate Social Responsibility (CSR), Corporate Sustainability, and Business Ethics play a vital role that goes beyond profits, growth, competitive advantage, and market shares to reach societal objectives such as prosperity, well-being, and sustainability (Martinuzzi, Blok, Brem, Stahl, & Schonherr, 2018; Dreyer, von Heimburg, Goldberg, & Schofield, 2020). As resource sharing is importantly intensified for research development and optimum research duplications (only permitted research duplications are encouraged) are exercised in inter-connected laboratories of "Smart Lab Bubble", the tension between individual interests and other stakeholders or the natural environment is suppressed sufficiently to ensure corporate sustainability in the research environment (Starik & Kanashiro, 2013; Whiteman, Walker, & Perego, 2013; Martinuzzi & Krumay, 2013). This further makes a tradeoff between commercial interests and social expectations of the responsible research developments that might be facilitated through policy options provided based on the evidence articulated by some scholarships of digital humanities.

2.6.2. *A new cultural position*

The tension between researchers and the farmer society is going to be relieved psychologically by opening up new human-technology interactions well managed in the connected network of Smart Lab Bubble. Here the trade-off between threats and opportunities for the farmer, researcher, environment, and the society as a whole is reached in developing the innovative and sustainable research culture. Further, a new form of interest in non-technology sciences such as social sciences, humanities, and management is expected to be added up to the quality of research output given by the technology sciences such as botany, zoology, chemistry, and physics.

While all technology-based sciences are supposed to participate corporately in developing commercial agriculture research, its success becomes more poignant on how well subjects of humanities such as communication, ethics and standards, human culture, scientific literature, philosophy, history, and art are reflective of the whole research process and research culture practiced by the researchers towards the well-being of the society. The non-technology sciences like humanities will produce new cultural positions, movements, perspectives, and modes of reflexivity in the conducive environment of integrated lab complexes enabling new human-technology research culture to be well consumed by the researchers with ease of practicing it. These new shapes of activities include new artistic and intellectual movements, new disciplines, research methodologies, and philosophical systems, new styles of behavior, actionable insights, and intellectual trends in the context of commercial agriculture research development that will not otherwise be materialized only with technology sciences. Therefore, it is very important to conduct proactive and productive collaborations on the interrelationship among technology, society, culture in general, and research culture to make Smart Lab Bubble reaches its maximum potential in executing a cooperative research culture. This newly formed culture is supposed to guide innovative commercial agriculture development by easing the burden of researchers' woes in the COVID-19 pandemic.

Non-technology sciences like Humanities are vehicles for guiding policymakers towards enabling the following strategies in the lab bubble.

- Make innovation a natural habit of the researchers.
- Determine the specific behaviors to be encouraged or avoided in the smart lab bubble.
- Best research practices nurtured with cultural values will make innovation an everyday habit for researchers.

To make researchers effective and efficient in researching in the lab bubble, their soft skills and productive personality capacities are required to be developed beyond a pure scientific-minded or scientific-behaved person. Therefore, the monitoring system established in the lab bubble would acquire more metadata concerning human values and respective psychological behaviors through non-technology science studies. The results of these studies would identify and reveal important cultural changes that are required to be incorporated immediately into the integrated network research culture to cultivate creative innovation talents with humanistic insight and develop professional managers with communication leadership and entrepreneurship. Therefore, it is more than a scientific endeavor and supports inoculating values of the new research culture properly and sufficiently in the proposed system.

As the success of the implementation of the smart lab bubble is revolved around its core functions such as the creativity of researchers as well as administrators in the sphere of ideas and communications, it is required to draw them closer to the art that uses new human-technology communications facilitated by artificial intelligence capabilities such as natural language processing, machine learning, etc. This enables new forms of manifestos, critical and journalistic writings, the organization of public events (concerts, readings, discussions), new journals, and articles made based on research findings and associated research practices intelligently exposed by the analytics of the lab bubble environment. They will create a new cultural movement, incorporating artistic and social components for researchers to use effectively in producing their research innovatively for the development of commercial agriculture in the process of impactful research development as depicted in Fig. 2.

3. Discussion

It is simply, the amount and quality of the agriculture products and services that research should focus on to improve. In the new normal, these amounts and quality should be achieved with less time and low or scarce inputs that have been aggravated by the COVID-19 pandemic. Therefore, all the stakeholders of the economy should be aware of the current performance of commercial agriculture in the pandemic locked down and any trend that may need to be reversed with possible technological interventions like the Smart Lab Bubble. (Galanakis, Rizou, Aldawoud, Ucak, & Rowan, 2021; UNESCAP-SSWA, 2020; OECD, 2020; Kurth, Walker, & Subei, 2020). Thus, Smart Lab Bubble influences the complex interplay of technology and humankind to form a better re-

Fig. 2. Techno-Society in action towards impactful research in the Smart Lab Bubble

search culture in the development of innovative commercial agriculture by fully respecting the universal rights of a researcher.

It is imperative to introduce remote work practices suitable for local conditions after understanding the differences and shape of the impact of the pandemic lockdown on the researcher to make that impact not negatively affect the research activity. The conducive environment created by the Smart Lab Bubble would make researcher feels that the remote work has created extra time and avenues to conduct their research work leisurely. Here, special precautions should be taken to keep human resource policies intact with the procedures of the system of the Smart Lab Bubble where the balance of the assessment and the safe side of new skills and capabilities is ensured. This could be achieved through strategies like up-skilling workers amid increasing automation while causing a change of attitude of the researcher towards the need of the country and world instead of gaining academic credit or personal interest alone.

However, the technology part of the Smart Lab Bubble alone may not contribute to the success of research implementation for commercial agriculture development. Performance management along with relevant policy interventions are required to guide research culture live in the proposed "Smart Lab Bubble" for achieving maximum impact out of the system.

Therefore, while following the proposed framework, a sufficient amount of focus should be directed on the performance of research institutes and researchers who work towards the success of commercial agriculture within the proposed "Smart Lab Bubble"nullM.

As a lab bubble consists of many interconnected labs, monitoring and allocation of resources could be done effectively and efficiently for many types of commercial agriculture research simultaneously with comparatively less effort from human interventions. This would further ensure all resources are optimally used at any time without or minimum idle time of resources in the smart lab. The policy changes introduced here would induce more resource sharing to be used in research work rather than researchers opting for dedicated equipment for their research work. This would also motivate researchers to avoid unnecessary acquiring of duplicate resources as they can easily reach any of the labs in the bubble in quick time for their optimum equipment needs.

3.1. Regulatory and policy environment in Smart Lab Bubble

Thus, the Smart lab bubble proposed in this paper is supposed to enable regulatory and policy environment on performance areas mentioned in Fig. 3 for the mass adoption of research networks towards research development on innovative commercial agriculture. These six core policies and one linked policy will further facilitate the optimum use of resources available in the scarce in the event of the COVID-19 pandemic. It would further stimulate co-developing research agendas in a transformative change to include commercial agriculture research as a major component of the research profile of the research institutes.

Table 1 shown below contains relevant policy interventions supposed to enact performance highlights of the Smart Lab Bubble to overcome the limitations of traditional research systems effectively and efficiently.

3.1.1. Real-time interactive online platform for promoting research findings

This would facilitate more transactions and trades to induce competitive remote practice in research work for both researcher and consumer. Further, it would create and enhance a network of partnerships that facilitate research and collaboration to strengthen mutual learning (Tamtik, 2012; Roux, Nel, Cundill, O'farrell, & Fabricius, 2017; Nieto & Santamaría, 2007) for research work development for innovative commercial agriculture.

3.1.2. Study the possibility of using virtual reality and augmented reality in remote collaboration

Virtual reality and augmented reality would be instrumental in guiding research work continuously within time constraints and schedules. It would allow principal researchers to provide inputs in simulations (Yu et al., 2010) to other researchers who are supposed to be local, unspecialized third parties in isolated areas while the principal researcher is locked down due to pandemics situations.

3.1.3. Use of automated systems such as intelligent environment control systems remotely handled via IoT and Drone technologies

Best-of-breed IoT platforms seamlessly connect a wide range of assets and deliver real-time performance data which supports real-time decision-making to prevent maintenance issues before they become maintenance problems (PTC, 2020). Ex: These technologies integrated more with precision agriculture would give decision supportive data for performance management of research in commercial agriculture.

3.1.4. Digital innovation to strengthen the lab system

The use of specialized apps in commercial agriculture research may provide a consistent experience across devices and would enable one source of information management for the performance management teams of the research institutes. Ex: Work Management Software integrated with performance management tools in Remote Workforces Environment.

3.1.5. Collaborative scenario planning supported by digital capabilities

To exercise an extreme form of social distancing while at work and make it not complicated for group work in research towards commercial agriculture development; a new form of work schedules should be

Fig. 3. Performance Interventions Empowered in Smart Lab Bubble

Table 1
Policy intervention required for strengthening the performance of the research on commercial agriculture

No.	Policy intervention	Area of performance
1	Many research facilities integrated into the real-time online platform	Real-time interactive online platform
2	Facilitate user-friendly remote team works for research collaborations towards commercial agriculture development	Virtual and augmented reality in remote collaboration
3	Encourage the use of remote devices to access field works in commercial agriculture.	Intelligent systems handled via IoT/ Drone technology
4	Research activities are supported through easy-to-use simple apps that could be used anywhere on any device.	Digital innovation to strengthen the lab system
5	Integrated research action plan for innovative commercial agriculture facilitated by information coming through the cloud of the Smart Lab Bubble.	Collaborative scenario planning
6	Every research action is accountable to a KPI developed for promoting commercial agriculture research in Smart Lab Bubble	KPIs are innovatively geared toward digital accountability
7	Linked policy: Good practices in information communication and technology (ICT) for sustainable use of the Smart Lab Bubble	Security of the lab work and its resources

prepared and guidelines must be developed on how those research activities should be carried out safely with the aid of real-time data mining supported by frontier technology interventions.

Collaborative scenario planning is done through digital capabilities enhanced by streaming data from new types of sensors, e-marketing platforms, food traceability systems, remote sensing, earth observation services, and social media. Advanced analytic tools and artificial intelligence techniques would use such data to improve the core processes of research institutes for creating uninterrupted supply chains at a rapid pace (Joglekar & Phadnis, 2020).

3.1.6. Key Performance Indicators (KPIs) innovatively geared by digital accountability

One of the main concerns of any system implementation is its performance and how could measure evaluate and monitor the performance of that system as there is no way that the performance measurement could be ignored or regressed in any situation even for a temporary period (Knight, 2020). Challenge is the keeping performance high in research work at research institutes in all of those circumstances when legacy metrics may be misleading and unhelpful for assessing remote performance (Schrage, 2020). Hence, monitoring agricultural research performance, using performance indicators, needs to receive urgent and increasing attention in order to tackle the funding, time, and location constraints that are imposed on research during the pandemic (Walker, Brewster, Fontinha, & Haak-Saheem, 2020). The question is how we should measure performance in such a situation and what policy changes are required to enable such performance monitoring and evaluation.

When innovation drives the engine of research, Key Performance Indicators (KPIs) innovatively geared by digital accountability and giving due acknowledgment and respect to distinctions between work and home life will play a major role in the performance measurement of research institutes works towards commercial agriculture in light of this pandemic period and maybe a good option in future as well. As researchers are dispersed and distanced, using KPIs associated with individuals rather than with the team, plays an effective and efficient role in performance management and results in more transparency for research performance. Research institutes may introduce or renovate if not exist, their data-driven dashboards to inspire people and project teams in a better way and promote positive outcomes. They are supposed to automatically capture and analyze, and explicitly communicate, their high-performance criteria to generate real-time analytic insights (Schrage, 2020). Personalized KPIs could be developed into an app to give a real-time pulse of the present situation of the performance and would act as a blood pressure meter of a researcher in a particular institute. This would create a friendly performance mentor for the researchers to guide their work towards common goals of success in commercial agriculture by flagging targets of zero hunger in 2030 even in a pandemic situation.

3.1.7. Linked policy to secure smart lab bubble - security for the lab work and its resources

IoT devices are always connected and easily able to communicate with each other around the clock. It has cameras and alarming systems that will be activated and communicate with lab owners, researchers, security persons, etc., if an unknown thing or process intervenes with its scheduled activities. Further, if necessary, the entire lab system will be locked down by backing up the storage to the secured cloud, while deleting the data from the local system (Olena, 2018). Research in commercial agriculture uses many toxic chemicals that can harm if inappropriately or accidentally used. Machines are thought to be safer than humans when chemicals are assigned to be handled in conducting research. Machines are quick to respond to accidents and are free from emotions so they can handle the situation more safely and instantly. This would further alarm researchers to evacuate from the concerned site on time and make them out of the danger immediately through the quick decision-making by the machine intelligence.

3.2. A techno-society for a good research culture

It is essential to make the technology-oriented research culture a part and parcel of the overall culture of the society as depicted in Fig. 4 to produce impactful research on commercial agriculture since such research practices are required to be accepted by the society for its successful implementation, in the field by the farmer community, and at the end of the supply chain by the consumer community. When research is conducted in the Smart Lab Bubble through technology interventions, so many factors concerning the science of humanity contribute in different perspectives to shape this researcher-society relationship into a stronger one. Thus, all actors, sciences, and processes are integrated into one force by forming a techno-society in the Smart Lab Bubble and acting on the newly positioned research culture that works for tireless innovations in commercial agriculture development.

Research culture needs to blend with the society to achieve its full potential towards the national goals of the country towards sustainable commercial agriculture development. The strategy of using humanities to cultivate a culture that values ethics and trust will facilitate researcher more interaction with the society that uses research outputs. Automated machine learning results come through artificial intelligence applications on aspects of this newly formed culture inside this integrated lab bubble would result in a plethora of knowledge that is worthwhile to understand for future remote communication practices. For example, it will be useful in suggesting new strategies on how to communicate research findings to society without the physical presence of a scientific community.

Change of behaviors of researchers is always expected in the ever-changing flexibility requirements of a research culture and so it is required to set behavioral goals from time to time. This creates unique research culture between technology and humans with respect to research development toward innovative commercial agriculture. The lab bubble facilitates a continuous chain of simulations of human activities toward research development in commercial agriculture. This has never been tested in view of human response to technology manipulations of live research activities. Therefore, it is required to study researcher responses to research simulations to better understand how the technology manipulations work optimally in such remotely managed systems with a special focus on important concerns like cyber security. Therefore, the cyber security culture is one such aspect that should be grown in this integrated network to harness maximum benefits out of this newly formed cultural position. A study on human behavior in response to cyber-attacks, and measuring what researchers do when they manage research remotely would improve the cyber security culture in the connected lab complex.

3.3. Much needed cooperative role of scientific scholars and humanities scholars

Research development is a product of research culture that requires the art of building new intellectual communities, new paradigms of thinking, and modes of communication with the participation of consumer society in the research product development process. Therefore, it is essential to make cooperation between scientific scholars and humanities scholars to identify what is essentially needed from research development. This would enhance the well-being of the society that links and interacts with a technologically savvy system like Smart Lab Bubble to make this integrated network survive without any technology debit.

In this COVID-19 period, researcher-society interactions are forced to migrate from cognitive, affective, and neoliberal capitalism to computational, surveillance, necro-capitalism, and anarcho-capitalism (White & Williams, 2014; Tornberg & Uitermark, 2021). Thus, the smart lab bubble becomes a researching conducive environment that is well-managed and nurtured by the wisdom of scientific scholars and humanities scholars where researchers can respond to such consequences with a positive attitude and thrive on it in collaborative efforts.

To implement this kind of system, government interventions such as deploying AI for its citizens, are highly needed. However, it can be seen even in more small-scale projects, such interventions are not sufficiently deployed by the governments, especially in developing countries. The challenges faced by such highly technological and cost-intensive integrated networks include the underinvestment in areas such as AI, Space Technology, Robotics, etc. by the government and the private sector in the corporation. Impaired vision and inadequate digital capacity and adaptability of the Governments, slow adoption of fast-growing AI-like technologies, and the promotion of the same for its citizens hinder the burgeoning of highly sophisticated but robust network systems like “Smart Lab Bubble” in the research infrastructure.

Therefore, governments should formulate national AI strategies and AI policy frameworks integrated with other frontier technologies while prioritizing the adoption of AI-like technologies in the key sectors such as research developments in the commercial agriculture field while keeping a balance between the research ecosystem and regulatory bodies. Governments can also boost private sector investment in AI-like technologies by providing basic infrastructures such as safe and secure

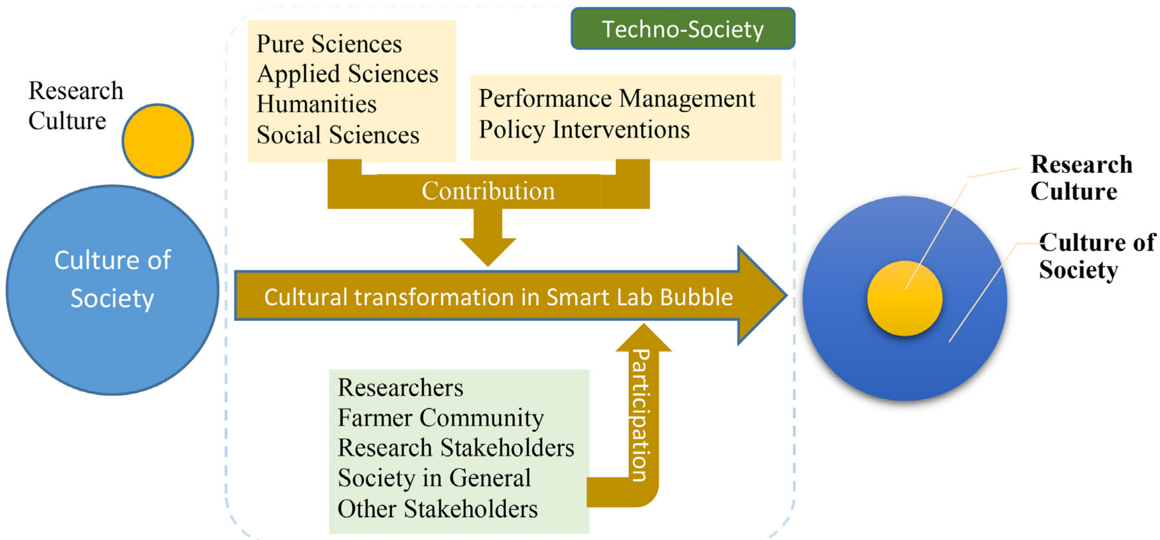

Fig. 4. Research culture becomes part of the culture of the society with the interventions of Techno-Society

cyberspace for implementing such AI-enabled lab complexes as proposed in this paper.

4. Conclusion

As depicted in the proposed framework earlier, the Smart Lab Bubble is formed by a connected network of remotely enabled labs having common rules, regulations, and properties that are integrated into a unique entity. This connected network is supposed to provide required laboratory services for researchers to conduct commercial agriculture research without time or service restrictions through a centralized management system. Within this framework, unique performance drives that could be blended with the key performance drives of the commercial agriculture research are expected to motivate innovative changes in the commercial agriculture industry. In this conducive environment, the innovative processes inherently fuelled by digital pulses are supposed to discover, create and develop ideas, refine them into useful forms, and use them to earn profits, increase efficiency, and/or reduce costs in commercial agriculture research even in a locked-down situation (Morris, 2020). Further, it will induce, promote and facilitate cross-research cultures by breaking disciplinary silos when commercial agriculture research is developed in collaboration with different sciences including social sciences and humanities.

The proposed framework is expected to provoke thoughts of leaders of research institutes in commercial agriculture to carefully scrutinize the landscape of emerging technologies and understand the opportunities of strategically leveraging innovation existing in such systems to make alternative communication networks and transform how their research is involved with long-term sustainable economic and social impacts to match with human satisfaction. This will make a better workforce willingness to be established for a new culture of innovative research practice through better human capital management in the research community of commercial agriculture development. In other words, they must put more weight on process-focused innovation instead of product-focused innovation or, as it is better known, business model innovation (BMI) in relation to resource management of research development in commercial agriculture to trade off risk and increase the return of research in this pandemic situation (Hasija, 2020). Here, more studies on these newly created cultural positions through non-technology sciences like arts and humanities will give more insights on aspects such as how to blur the distinction between reality and virtuality in a period like COVID-19.

This is an exciting time full of unanticipated and disconcerting lines of development, but everyone knows that it is not always easy to change and match everything in the new normal. It is high time to leverage digital technology to create new research values out of the streamlined performance of commercial agriculture research. Therefore, strategy changes and policy interventions in an innovative way as we depicted in the “Smart Lab Bubble” framework in the form of digital transformation are supposed to be in the cards of research leaders to gain access to the level of digitally mature research organization for the success of commercial agriculture research in the face of seemingly never-ending locked down.

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The authors have no relevant financial or non-financial interests to disclose.

Author contribution

We would like to present the Authors’ contributions as follows: author 1 contribute to the conception/ design and draft the work and author 2 and author 3 contribute by revising it. As Corresponding Author, I confirm that the manuscript has been read and approved for submission by all the named authors.

Conflict of Interest

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