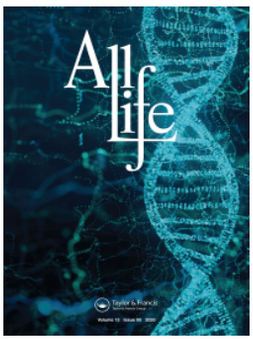

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Probing into the concept of 'research for society' to utilize as a strategy to synergize flexibility of a research institute working on eco-friendly commercial agriculture

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ABSTRACT

Research and Development work on Commercial Agriculture (CA) has not sufficiently been taken into account of those transformations occurring in the country's socio-economic and political environment, especially in the lens of decision-making and adoption of eco-friendly technologies in CA. It has been debated for a long time that well-set strategic policies and guidelines incorporated and agreed upon by all stakeholders into a model possess a vast potential to facilitate such decision-making towards the establishment of an eco-friendly CA. In the light of that, an illustrative model was built of which the logical paths were characterized by the variables stand for Key Performance Drives (KPD) to exhibit the state of societal acceptance of the research outputs on the concept of 'Research for Society' within the realm of functional flexibility of research institutes. The outputs and outcomes from such an exploratory analysis would facilitate research institutes working on CA to systematically adopt the 'best-fit KPDs' in research development and researches to be conceived from societal roots. Further, it would establish the true connections and dependencies between research, social awareness of research needs, and flexibility of research institutes to enhance the performance of the sector, through collected data on Key Performance Indicators (KPI).

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Commercial agriculture; eco-friendly agriculture; social awareness; organization flexibility; KPI

Introduction

Commercial agriculture and sustainable development goal (SDG) 2 – Zero Hunger by 2030

The contribution from Commercial Agriculture (CA) in the journey of subsistence agriculture to large-scale production agriculture at the forces of globalization and market integration could play a major role in achieving the Sustainable Development Goal (SDG) 2 – Zero Hunger by 2030 (Bhavani and 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).

Commercial agriculture practice of Sri Lanka in the socio-economic context

Commercial Agriculture is one of the major economic strengths of the Sri Lankan economy since it has become a pet subject and being continuously advanced under societal and political anticipations from the greatest period in the history of irrigation and agriculture of King Parakramabahu (Fernando 1980). The total cultivated land (excluding home gardening) in Sri Lanka is around 2 million hectares and three-quarters of which are non-plantation food crops covering around 25 percent of the total land area of the country, according to the report (DoA 2019). Although around 26.5 percent of the total labor force is engaged in agriculture (DCS 2020b), the contribution of the agricultural sector to the Gross Domestic Product (GDP) is 7.3 percent in the first quarter of 2020

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(DCS 2020a). Around 30 percent of the whole population or 80% of the total labor force live in the rural sector, claiming 80 percent of the agriculture labor force easily fall into the category of low wages employees (DCS 2019). This boils down to the fact that the productivity of CA is far below the level expected by the economy of Sri Lanka and the causality lies behind this should be sufficiently explained for retrieving the possible forces that could contribute to the improvement of productivity (Suresh et al. 2021).

Managing research for productive commercial agriculture

Research could be identified as a major force in driving productivity in Commercial Agriculture. In this context, the contribution of research to elevate the productivity of CA could be ascertained in several basic perspectives such as improved agriculture production, reduced postharvest loss, etc. (Beddington 2010; Kitinoja et al. 2011) through research and technology innovation (Alauddin et al. 2021; Dorgan et al. 2021; Lampach et al. 2021).

Agriculture research development without having well-set and directed driving forces on its intended purposes will not achieve its targets and fulfill the expectations of agriculture growth. Thus, well manage agriculture research will improve performance providing unprecedented opportunities, across the entire agriculture product value chain amidst rapid advances and innovation at the global, regional, and national levels.

Managing the performance of research development is thus become a key agenda item of the research institute in this regard. A well-formed strategy to measure the performance of the research institute towards innovative research development will then provide timely decisions on research development and direct the research institute for its ultimate goals and then to its vision. Using Key Performance Drives (KPD) to measure the performance of research institutes in developing research towards CA could be considered as one of the best strategies provided in this regard. Key Performance Indicator (KPI) is the tool to measure KPD of a particular field of interest in view of Organizational Development towards achieving its objectives, goals, and finally its vision. Therefore, KPI is such a dynamic tool to explain the complexity of measured performance drives in simple terms to decision-makers. The literature survey that was done to expose such performance drives revealed that the most prominent four KPDs to be used within the Performance Management System (PMS) of a research institute towards CA development are Commercialization, Technology Transfer, Research Collaboration, and Research for Society (Abeysiriwardana and Jayasinghe-Mudalige 2021a).

A 'friendly' KPD that drives eco-friendliness in commercial agriculture

One of the researchers' intended purposes in writing this paper is to discuss how productivity in Commercial Agriculture can be achieved through research development while promoting elements of Eco-friendliness to be reflected within it. The fourth KPD – Research for Society identified in the above study is one of the foremost key performance drives discussed in the literature in the context of research practices of a research institute towards Eco-Friendly CA development.

Therefore, the researchers discuss here how Research for Society KPD can be used within the PMS of a research institute and two of the major elements of organization design as known as awareness and flexibility which are dynamically participating in achieving this particular performance drive. Here, a model is formulated to test and validate the effectiveness of these elements within research development for innovative CA. Further, the researchers use one of the most argued topics – application of fertilizer – in CA both in Sri Lanka and globally to elaborate the importance of this strategy used for managing the performance of research institutes within the context of eco-friendliness, sustainability, and productivity of CA.

Exploration of the research for society concept for development of sustainable commercial agriculture research

It is expected that those functionalities linked with the concept of research for the society acted as key performance drives that enhance the institutional capacity of a research institute to cope with certain inherent problems of research development as well as muddle through environmental issues such as climate change issues, global warming, issues of circular economy, etc.,

(Ionescu 2021a) when research institute plan, strategize, practiced and implement its researches towards CA. This would further guide research institutes towards various sustainability goals, such as reducing emissions and building social responsibility into research design as well.

This kind of research culture is expected to be facilitated by,

(1) Using societal-friendly and eco-friendly implementation mechanisms to develop research outputs for CA developments
(2) Selecting and developing CA research products that have more-or-less eco-friendly characteristics
(3) Addressing environmental issues while satisfying societal needs through research developments in relation to CA

Sustainable organizational performance to implement environmentally friendly sustainable commercial agriculture

Research makes a contribution that is more valid to society when it is developed in an eco-friendly manner. Performance management of a research organization should be flexible enough to capture modern good environmental practices to its implementation mechanisms through modern technologies such as the Internet of Things (IoT) and Artificial Intelligence in smart manufacturing facilities (Suler et al. 2021) supported by data-driven decision making in the functions of product traceability, manufacturing maintenance, and process performance (Kovacova and Lazaroiu 2021).

Developing research products through a proper selection procedure that identify and understand the true connections and dependencies among research, social awareness of research needs, and flexibility of research institutes to enhance the performance of the sector towards eco-friendliness and reducing the carbon footprint of the research outputs would enable research institutes to act and plan their research agenda towards mitigating many environmental concerns such as climate change issues while giving generous research output the society. In this regard, it is important to identify and understand the relationships of organization flexibility, organizational trust, and organizational identity in view of corporate social responsibility as well in successful research development for sustainable CA.

A society concerned example: chemical fertilizer use in agriculture

Research development aims at addressing issues arising from different perspectives of fertilizer subject is a good example that could be used to demonstrate how research for society would work in sustainable research culture to shape innovative research towards CA development. The past few years have seen that chemical fertilizer (CF) gradually becomes one of the significant factors in the growth of the CA sector in developing countries like Sri Lanka due to many reasons (Mahaliyanaarachchi and Bandara 2010). This could be very well seen in rice production that alone contributes around 10 percent to the Gross National Income of the agriculture sector (CBSL 2020). In terms of agricultural inputs, the amount of chemical fertilizers imported to Sri Lanka in 2014 and 2017 was 487,700 and 761,800 metric tons respectively and it has been increased to 1,260,053 metric tons in 2020 (MoA 2021). According to these data, the annual increase in the import of chemical fertilizers has grown at a rate of around 20 percent. The amount of fertilizer applied in Sri Lanka per hectare of paddy fields is around 300 kg and yield is 4.6 Metric Ton (MT) when Australia takes yield around 10MT by applying only around 60–120 kg per hectare for its popular varieties (NSW 2018). However, the prices of food crops, including rice, have more than doubled during this period in Sri Lanka and domestic rice production or other food imports have not increased even at the increase of import or application of chemical fertilizers. On the other hand, the amount of foreign exchange spent on chemical fertilizers is approximately US $ 220–300 million in the recent past (MoA 2021). This shows that the effect made by fertilizer on society has not been taken adequately into the research lens to find, understand and address the productivity issues that distress society for some years.

Government – research institute – society in eco-friendly commercial agriculture

Meanwhile, the latest Sri Lankan government policy 'Vistas of Prosperity and Splendour', which has been mandated by the nearly 2/3rd majority of the voters at the 2018 Presidential Election, clearly has stated that Sri Lankan agriculture will promote and popularize organic agriculture during the next ten years (MOF 2020). Recently, a great deal of debate has arisen from both the scientific and public community about the

government's policy decision with short notice at the mid-of year 2021 to make CA free of CF and replace it with organic fertilizer (OF), but not without a kind of boosting programs like 'Eco-friendly Fertilizer Subsidy Program'. National Committee on Organic Agriculture lay out the objectives of this government initiative as identifying research needs and prioritizing them in organic agriculture to improve the production of cleaner foods; improving the quality of landscapes which includes soils, water, biota, and aesthetics; minimum impact on the environment; economically viable and acceptable to society (SLCARP 2021). According to the authors' opinion, this objective is supposed to be achieved in midst of two possible impediments namely that farmers are not sufficiently ready to accept it while research institutes are not sufficiently ready to produce what is required by such initiative.

The two main arguments put forward by the opposing group are that a reduction in output will lead to a major economic and social catastrophe (consumption, production, people involved) and declination of farmers' incomes will result in economic hardship and extreme poverty for the vast majority of the population. Without proper counter-arguments and lacking visibility of firm commitment of research institutions with dedicated researches (Rahmann et al. 2017) to cope with the situation, these arguments are apt to be rooted in the wisdom of a society.

In popularity of CF in farmer community and boost up it with subsidies given by government (Weerahewa et al. 2018), research institutes in Sri Lanka also have focused their research work more on development of advanced CF, application, and improvement of CF or research linked to CF (Nagahawatta 2021), rather than on developing any alternatives to it despite looming threats such as soil degradation and human diseases like Chronic Kidney Disease of Uncertain etiology (cKDU), cardiovascular diseases, cancer and blue baby syndrome (Jayasumana et al. 2015; Kulasooriya 2021). One reason may be that research institutes may not be systematically aware of societal and political changes of the country while organizational flexibility of the research institutes is not sufficient for catering to sudden societal and political requirement changes (Medialdea et al. 2018; de Nardis 2020). Even in this turmoil background, the Sri Lankan government keep a tight leash on its stance of implementing organic-only agriculture policy in the fields of agriculture despite the considerable resistance from all corners of concerns which would only be justified by the years to come and the success of alternative technologies and applications like Bio-Film Bio-Fertilizer (BFBF). Since BFBF has about 20 years long history from its research conception to emerging to the surface as a commercialized product and, be one of few successful commercialized agriculture applications currently in the fertilizer field (Pérez-Giménez et al. 2009; Seneviratne et al. 2011; Silva et al. 2014), the researchers take it as an example wherever appropriate to explain the performance drive – Research for Society – in Sri Lankan context.

How can research institutes contribute to research for society?

Considering all of these facts in the domain of research implementation and base on the knowledge generated through the conflicts of interests in fertilizer application in CA, two arguments were proposed to explain the research gap that pave the way in formulating the research question of this paper.

(1) Flexibility and social aware research of research organizations are of diminutive use when those two are not practiced sufficiently and simultaneously in the research institute
(2) Acceptable research in the socio-economic environment could only be successfully achieved through a bottom-up approach where research starts from society, is enriched by society, consulted by society, and awarded to the society by the scientific community to be tested and validated by the society.

Based on the above two arguments, the researchers formulate the research question as follows:

> What is the role of social awareness and flexibility in a research institute and how those two elements of concern could be used to mediate the realignment of all communities including the researcher and the farmer to societally accepted research for innovative Commercial Agriculture development?

Methodology

To identify the actual research needs of the society especially when the research intervention is sought to develop CA, the research institute should be on alert for its stakeholder's needs and the environment that those stakeholders act on. Further, research institutes

should be ready to accept the rapid change requests in that dynamic environment with readily available adaptation strategies to absorb it into the research practice with an optimum resource allocation. All of these should be integrated, monitored, and evaluated for further improvements and adjustments. Thus, social awareness and flexibility integrated with the right size and right manner will play their role as good tools of performance enhancers in a properly managed PMS to make this 'Research for Society' concept worthwhile to be practiced in dynamic research culture.

Researchers (May et al. 2021) have identified the importance of the mediation effect of organizational trust and organizational identity in view of corporate social responsibility. However, the concern of this paper would be more focused on understanding and identifying the moderating effects of functional flexibility of research institutes in view of sustaining corporate social responsibility among researchers, society, and other relevant stakeholders to maintain environmental integrity in research practices of the modern era.

Adopting the research for society in PMS of a research institute

Therefore, the 'Research for Society' concept is required to be strategized in research culture within organization expectations as well as should go beyond the boundaries of organization design to be positioned in a common research culture adopted by all research organizations that work towards the development of CA research for the well-being of the society. To this end, a concrete framework consisting of a model that could be tested and validated by any research institute and formulating policy options, guidelines, and procedures based on that model is expected to be effective and efficient in smooth research implementation towards sustainable and eco-friendly commercial agriculture research. For this, the following procedures are proposed and discussed to come out with a good model that interlinks the capabilities of research awareness and the flexibility of the research institute with the 'Research for Society' concept to establish it in the research culture acceptable to any research institutes that work on CA development.

The researchers would define social awareness in the context of research for CA development by referring to general descriptions of 'social awareness' in the literature (Perrini and Vurro 2006; Subedi et al. 2009) as follows.

> The capability to understand and respond in an appropriate way to a certain social issue arisen probably due to lack of research involved in the context of Commercial Agriculture development and, the ability to understand and properly communicate with people from different backgrounds and cultures associated with Commercial Agriculture for social change

For this purpose, an illustrative model was developed that could be used to test the validity and reliability of variables of concerns about functional flexibility and social awareness of research conduct of the research institute towards performance drive 'Research for Society' which is supposed to measure with its companion compounded KPI.

There were five key aspects of social awareness, seven key aspects of functional flexibility, and seven performance aspects for 'Research for Society' key performance drive/ composite KPI in a research organization to be considered simultaneously in implementing environmental friendly sustainable CA development (see Tables 1–3 respectively). The six latent variables (LV) were identified and proposed to be used in association with six hypotheses/ relationships (H) descriptions to test the validity and reliability of the proposed model.

An evaluation model to capture 'research for society'

The evaluation model proposed in Figure 1 will assess the functional flexibility and social awareness of research institutes in the context of organizational, societal, and environmental directives that would collectively form a compound performance drive – **'Research for Society'** – by promoting research towards CA development. In the model, certain relationships associated with Social Awareness and Functional Flexibility of a research institute were hypothesized for possible effects such as moderation effects, etc. for research performance towards eco-friendly CA accepted to society in general.

Social awareness could be highlighted concerning research development towards innovative CA development in the following instances with justifications for using them as mentioned in Table 1:

It is proposed that the latent variable SAW has a significant effect on RFS. Therefore, SAW is expected to be measured through CCP, SID, NPA, SIA, and SIS

Table 1. Model variables in social awareness, their relationships, and justifications.

	Variable	Type	Relationship	Justification
Social Awareness (SAW)		LV	**H1:** SAW has a significant effect on RFS	**Refer to the text of this manuscript**
1	Collaborative community participation (CCP)	LV	**H2:** CCP has a significant effect on SAW	Research is accepted only its stakeholders are satisfied with its outputs. This could be achieved through collaborative efforts of all stakeholder participation.
2	Social issues discovered (SID)	manifest	SID contributes SAW	More issues discovered will provide a good insight into what is required by the research.
3	National priorities analyzed (NPA)	manifest	NPA contributes SAW	National priorities are people's mandate, so they will provide good insight into research development.
4	Social issues analyzed (SIA)	manifest	SIA contributes SAW	Analyzing an issue produce data that could be converted into decision-support information.
5	Social issues solved (SIS)	manifest	SIS contributes SAW	Issues solved by research make research more sustainable as an industry.

Latent Variable (LV); Hypotheses (H)

Table 2. Model variables in functional flexibility, their relationships, and justifications.

	Variable	Type	Relationship	Justification
Functional flexibility of research institute (FLX)		LV	**H3:** FLX supports RFS (through social awareness) **H4:** FLX has a significant effect on RFS	**Refer to the text of this manuscript**
1	Process innovations (PIN)	manifest	PIN contributes FLX	Process innovations are needed to cater ever-changing needs of the agricultural society.
2	Continuous value additions to existing researches (CVA)	manifest	CVA contributes FLX	Here research output is continuously improved over time with more research on original research
3	Change of Resource (Human/ Machine) (COR)	manifest	COR contributes FLX	Adjusting and transferring of resources will affect the research output to reach its maximum
4	Technology adoption (TAD)	manifest	TAD contributes FLX	Quick and reliable outputs are a function of the technology adoption
5	Workforce willingness in adaption and evolution (WFW)	LV	**H5:** WFW has a significant effect on FLX	The ambition and emotional stability of a more diverse workforce exert stronger effects on adaptive performance. The research community has the upper hand in inheriting these characteristics naturally.
6	Extra hours worked (EHW)	manifest	EHW contributes FLX	Researchers willingly engage extra hours in work to complete research projects because they see the intrinsic value and delight in the challenge of those research projects.
7	Extra work done (EWD)	manifest	EWD contributes FLX	Researchers willingly engage in extra research work to see new developments because they see the extra recognition that they will have from it.

Latent Variable (LV); Hypotheses (H)

Table 3. Model variables in research for society, their relationships, and justifications.

	Variable	Type	Relationship	Justification
Research for society (RFS)		LV	**KPD/ KPI** has linked with **H3 and H4** in Table 2	**Refer to the text of this manuscript**
1	How many research works on social issues (either identified through institute interventions or requested by external interventions)? (ROS)	manifest	ROS contributes RFS	Integration of all inputs against outputs of research conduct will provide good insight into what will be the next right research for innovative and sustainable Commercial Agriculture.
2	How many researches are recommended/ accepted by society?/ Social satisfaction (SSA)	LV	**H6:** SSA has a significant effect on RFS	
3	How many researches are there to mitigate the complexity of a social problem? (ROC)	manifest	ROC contributes RFS	
4	How many researches shows its adaptability to change the request of society? (RAS)	manifest	RAS contributes RFS	
5	How much easy research output to be used in society? (ERE)	manifest	ERE contributes RFS	
6	How many researches meet quality criteria? (RMQ)	manifest	RMQ contributes RFS	
7	How many researches meet budget/ cost criteria? (RMC)	manifest	RMC contributes RFS	

Latent Variable (LV); Hypotheses (H)

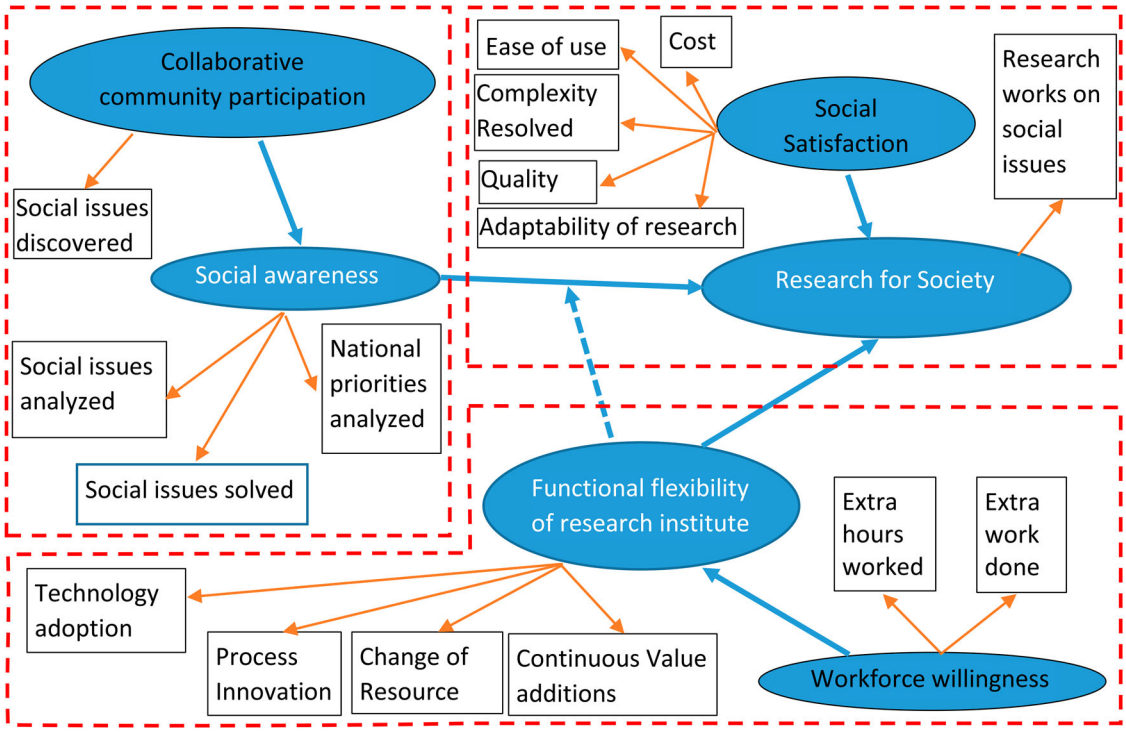

Figure 1. A conceptual model to be used in identifying, testing, and validating the complex structure of performance drives towards 'Research for Society' KPI.

along with the H2 hypothesis and relevant relationships as depicted in Figure 1. Some manifest and latent variables may be differed at/during/after the testing and validation period subjected to the implementation requirements of those variables in the research practice of the research institutes.

Against this backdrop, a well thought and managed research institute has a major role to play by identifying what are the functional weaknesses that stop them from producing what customers – in this instance society in agriculture development – expected from it. The researchers postulate the following reasons act behind this matter of urgency:

(1) Some institutes take on projects that are beyond their functional capabilities – this makes the research work fails in the mid of implementation.
(2) Institutes have structural and process weaknesses/issues that hold them back.
(3) Lack of Innovation support agenda in the research institute – rapidly converts inventions to innovations by making small changes enabling proper technologies to be adopted according to changing requirements of customers.

The 2nd and 3rd reasons could be considered as derivatives of the functional flexibility of the research institutes. Therefore, the researchers argue that the functional flexibility of a research institute has the most prominent part of all types of flexibilities of a research institute that could influence the outcome of its research products towards environmental friendly as well as innovative CA development.

Although functional flexibility is not comprehensively defined in the literature (De La Lastra et al. 2014), it is one of the important organizational design concerns (Valverde et al. 2000; Kelliher and Riley 2003) for many organizations and has become a key issue discussed in the Covid pandemic (Elias 2021). Functional flexibility refers to an organization's ability to re-engineer its business processes to match changing workloads, technology, and customer demands (Singh and Acharya 2013; Micevski et al. 2016). In order to become functionally flexible, the organization is expected to arm with competent human resources and technology adoption to change its business tasks regularly (Cappelli and Neumark 2004). Functional flexibility thus contributes to the organization's goals and, should be measured and monitored using key

performance drives associated with it for better decision making on it.

Following areas of performance drives as mentioned in Table 2 could be identified as important factors that affect the functional flexibility of the research institute associated with social acceptance of the research. The justifications for using such variables are mentioned in the justification column of Table 2.

It is proposed that the latent variable WFW has a significant effect on FLX while FLX has a significant effect on RFS. Therefore, WFW is expected to be measured through EHW and EWD while FLX is measured through PIN, CVA, COR, and TAD along with relevant relationships as depicted in Figure 1. Some manifest and latent variables may be differed at/during/after the testing and validation period subjected to the implementation requirements of those variables in the research practice of the research institutes.

The researchers argue that flexibility and social awareness for research development of research organizations are of diminutive use when those two are not practiced sufficiently and simultaneously in the research institute. This is because the capacity of the research institute to capture social changes into research outputs with rapid changes of socio-economic context is well depended on and smoothly facilitated by the willingness of the research institute to adjust its resources and processes as required towards that end. Therefore, it is essential to assess the flexibility of a research institute regularly along with its readiness of addressing the needs of the agriculture society to achieve relevant objectives and performance targets and at the same time compare their performance with that of other research institutes from the CA field. However, the researchers see the insufficient visibility of this compounded performance drive and would like to state that it may be due to a lack of attempt on measuring and monitoring its performance in the context of the organizational design of the research institute. A kind of policy implementation as proposed by the Sri Lankan government to change from CF to OF would be in vain if performance measurement of research and development institute is not getting such important performance drive into a strategical consideration within organization flexibility to cater research needs required for such implementations. Thus, the functional flexibility of the research and development institutes is very important in implementing government policy in due course with respect to CA (Momaya et al. 2017).

Although the theory on how flexible an organization should be to achieve socially accepted research for CA development shows some complexity, it must be measured with good understanding and much simplicity of its intended outcomes to make it part of all stakeholders of the research institute. Therefore, the researchers propose to integrate social aspects along with cohort flexibility aspects of research development into one PMS consisting of KPIs representing performance drive 'Research for Society'. The following KPIs are demarcated to structure the compound 'Research for Society' KPI (see Table 3). The justification for using such variables is mentioned in the justification column of Table 3.

The latent variable SSA has a significant effect on RFS. Therefore, SSA is expected to be measured through ROC, RAS, ERE, RMQ, and RMC while ROS is directly measured to find out its contribution to the RFS along with relevant relationships as depicted in Figure 1. Some manifest and latent variables may be differed at/during/after the testing and validation period subjected to the implementation requirements of those variables in the research practice of the research institutes.

Further, the researchers propose to test the model's applicability on research institutes work on CA research in Sri Lanka using a methodology consisting of the following two principal phases:

> Phase I – To identify Key Performance Drives that are responsible for societal acceptance of the research outputs integrated with the performance of functional flexibility of research institutes to measure and monitor such performance towards CA development in Sri Lanka.
>
> Phase II – Applying a suitable method in quantifying each key performance area possibly latent variables and alternative options, and for relating those elements to the overall goal of socially accepted research performance. Then using a suitable multivariate analysis method such as partial least squares – structural equation modeling (PLS-SEM) (Cepeda-Carrion et al. 2019; Mendez-Picazoa et al. 2021) to assess the social awareness (Figueroa-García et al. 2018), the performance of functional flexibility of a research institute (Lee and Yoo 2019), and at the same time, its moderation effects (Sarstedt et al. 2014) on socially accepted research performance based on the KPDs identified in the previous phase.

Discussion and implications: dynamic research culture

Research for Society has been identified as one of the four most concerned KPDs of research institutes of research development towards innovative CA according to the study of (Abeysiriwardana and Jayasinghe-Mudalige 2021a). Social awareness and the flexibility of a research institute are potential performance drives that could be used to help Research for Society KPD to achieve its maximum potential and get different shapes on how they are practiced in research institutes. A model was built using these three concepts/KPDs with appropriate variables and causal relationships to measure its effectiveness in research development. PLS-SEM is proposed as one of the good multivariate analysis methods to test and validate the model. Once the model is validated, the research institute is expected to follow that model along with some guidelines and policy options to achieve maximum research output using well-managed resources of the research institute towards CA development.

The model present in this research paper identifies key elements of concerns such as collaborative community participation, social issues discovered, national priorities analyzed, social issues analyzed and social issues solved to facilitate research awareness of research institutes. To enable flexibility of the research institute towards research for society, it recommends following performance drives known as process innovations, continuous value additions to existing researches, change of resource (Human/Machine), technology adoption, and workforce willingness in adaption and evolution. When they are interlinked and practiced simultaneously through policy options, rules, and guidelines, they are expected to mediate the realignment of all communities including the researcher and the farmer to produce societally accepted research for innovative CA development. In addition, they will promote the following three behaviors in the research culture towards sustainable CA development.

I. Looking Beyond Stakeholder Expectations

There is some extra pressure to meet the needs of stakeholders rather than considering them as customers and investors resulting in many research institutes to feel it as a burden on part of their administration (Hunsaker et al. 2021). If research institutes could be meaningfully integrating researchers, research business partners, agriculture communities, grassroots community organizations, etc. (Sharp and Smith 2003) into their strategies, it would produce universally accepted research. This capacity will also make agriculture society live within CA development and feel more comfortable within the healthy relationship of the research institute while research institute sustainability is ensured within the CA field.

II. Build Extra Relationships with Stakeholders at the Bounds of Research for Society

On the lines of discussions made by several other researchers on the concepts of social awareness and flexibility of a research institute in isolation for their success in research development (Kelley 2009; Lukovics et al. 2019), this paper proposes that those two concepts practiced in an integrated manner that would go an extra step forward and act as a highly sophisticated enabler in implementing environmental friendly CA research development. These factors will not be in the lens of decision making of a research institute if they are not identified as performance drives, logically connected, measured properly and, then reported to the research management in time through established PMS.

III. Smooth and timely transfer of research knowledge along with research outputs

Research development is successful and would be optimally used in the concerned domain when its ownership and identity are shared by all its stakeholders and implemented with a community of practice (CoP) approach (Stanca et al. 2022). Here, the involvement of middle-level knowledge facilitators such as science graduates, agriculture instructors and community actors to transfer researchers' intention along with the research product to the users of that research product in the society could be considered as a well-thought strategy implemented through the proposed model in view of smooth knowledge transferring from highly scientific community to a less-scientific community. This will make effective use of that research output for the intended purpose in CA development through building a shared identity and collective intelligence over the research product lifecycle. Thus, it is expected to solve access issues, communication issues,

and issues on sharing best practices between field and lab, timely and smoothly.

Here, the success of implementing this model further depends on the policy options and guidelines. Therefore, some policy options are proposed to be adopted along with the proposed model to make successful research development towards innovative and sustainable CA.

Policy directives for adopting 'research for society' in research institute

The research output becomes part and parcel and owned by the agriculture society is one of the important aspects in impactful research success. The following ways and methods are proposed to be fully facilitated in the organization design of the research institute through guidelines and policy directives when 'Research for Society' is implemented as KPD and measured using its representative compound KPI to get the maximum benefit of such a conducive environment created by the above KPD for successful research development towards innovative CA.

I. Horizontal and vertical transfer of research through 'Research for Society' in a PMS:

Working towards societal sensitive research practice depends on the mechanism used by the research institute to transfer its research output to society. A linear transfer of research innovation using a top-down approach where an extension agent handover the technology to the farmer society alone may not be strategically very successful as societal acceptance of the research product much depends on societal factors themselves such as peer recommendations, agriculture dealers in the society, social media promotions, field evaluations by farmer society itself, etc. Measuring 'Research for Society' will provide good directives to help decision-making on much-needed research for the time.

II. Facilitating innovations to come from ground level

Some important innovations may emanate from the farmer community and only be easily identified and improved if the researcher community closely works with them. The KPI Research for Society will good facilitator in this regard.

III. Facilitate organization design to quickly adapt for opportunities and be competitive in the research field

BFBF research team at the National Institute of Fundamental Studies (NIFS) quickly saw the opportunity in the government organic fertilizer program even at its initial stages. The research team identified the potential flexibility imbibed in their research that is very responsive to the requirements of the farmer community and government policy change because of the team's close follow-up with the farmer community. The research team made quick amendments to their focus on fertilizer strategy by researching how BFBF could be coupled with organic fertilizer instead of chemical fertilizer. Thus, their success of competitiveness in this field was determined by the social awareness and the strategized flexibility in their research conduct that has been practiced for some time along with their field experience.

IV. Social awareness and flexibility as smart performance drives in Agriculture 4.0

The researchers would like to mention a few policy directives that could be associated with the Social awareness and flexibility of research institutes in the context of Agriculture 4.0 to make research performance towards CA more sustainable in eco-friendly agriculture. Innovation in new and emerging technologies for CA could be used as a major strategy to conserve resources while producing more forever-rising demands of a growing population (Klerkxa and Rose 2020). Here, research focused on gene-edited crops, drones, robotics, and artificial intelligence hold promise – so long as these are not seen as a panacea (Daum 2021; Miller 2021), but rather as solutions for farmers burning needs by assessing their capabilities from the viewpoint of farmer community. Following is a clear example in the Sri Lankan context, that social awareness could be critically assessed in well-managed research performance. Drone technology developed by local research institutes like Arthur C. Clarke Institute for Modern Technologies (ACCIMT) could be critically discussed in the research domain for its possible collation with BFBF application in the field since BFBF is a liquid fertilizer in a bottle and remote practices are welcome by farmer community especially in a period like Covid pandemic.

It is proposed to implement Collective Awareness Platforms geared by Information and Communications Technology (ICT) systems (Kappas et al. 2019) within the performance management systems of the research institute. These systems will be equipped with open online social media, distributed knowledge creation, and artificial intelligence decision support systems which stand on big data platforms to leverage the 'network effect'. These systems in turn will create awareness of problems and possible solutions that request collective efforts of researchers and farmers, enabling new forms of social innovation to reshape research development more towards societal expectations with eco-friendly characteristics.

Further, the performance of research development especially in automated production systems coupled with corporate environmental performance towards sustainable CA should be measured and monitored through the best set of integrated KPIs to guide the research agenda for developing innovative research products within the limits of environmental concerns such as emissions of Greenhouse gases, water consumption, waste production, etc (Coatney and Poliak 2020; Cunningham 2021).

A method to avoid misconceptions and pitfalls in selecting 'right' research

Once fully strategized the 'Research for Society' in organization design of a research institute, KPI associated with it may provide corrective measures that have not been visible before to be adopted in research administration. One such instance is when public research institutes base their decisions on the misconception that they are well informed about farmers' priorities, field conditions, and resources – which is often not the case and could not be comprehended without having proper evaluation and management strategies. Farmer society can learn effectively, especially if given some support from a well-established source. Transmission learnings from farmer to the farmer are limited when farmers are not properly placed in an interconnected society. The initial stages of introducing BFBF to the farmer community in early 2010–15 made havoc in the farmer community as much needed technical input was not given to farmers by experts in that field when distributing the fertilizer by the commercial partner of the research. This ultimately led to the misconception that the BFBF was making the soil worse among the farmer community. Then the expert team with the principal researcher went to the field and worked with the farmer community practicing the fertilizer application which ultimately resulted in the massive success of the product among the farmer community according to the memory recalled from the 3rd author of this manuscript. Therefore, data collected on Research for Society KPI will provide concrete evidence and guidance on what instances that researcher community could strategically and directly involve with the farmer community at the field level to make new researcher-farmer relationships facilitating transmission learning successfully in technology transfer.

Future directions

The proposed model is expected to be useful in understanding and identifying different factors that affect the degree of awareness in the research culture and the flexibility of the research institute to cope with the change requests along with possible relationships that bridge them smoothly to have multiple effects on performance drives of the research development on innovative CA.

Research institutes can use structured or semi-structured interviews as an effective and feasible research method to collect primary data of its research practices to be used in testing and evaluating the proposed model to estimate complex cause–effect relationships with latent variables, etc.

In addition, every research institutes usually have some kind of secondary (or archival) data regarding its research practices as almost every piece of researches is evaluated at different stages by different evaluation bodies. This makes research institutes in possession of such data and information in testing and evaluating the proposed model with PLS-SEM to explore and adopt real-world causal relationships in performance management towards successful CA research development (Avkiran and Ringle 2018). Further, as the iterative approach of PLS-SEM is nicely worked with limited information (Hair et al. 2014), research institutes can evaluate this model even with limited data and information available in some research institutes that are immature with respect to the data management of the research implementation. This would make the research institute easily adopts the best fit model of an implementation strategy for research

development towards CA development even at the early stage of development of its research agenda.

It should be further confirmed and explored the various perspectives of the importance of flexibility of research institutes simultaneously with social awareness within organization design in implementing and improving the Research for Society performance drive towards CA development with more empirical studies with different variables and causal relationships that could affect its research strategy. The behavior of the research culture in the organization design in view of promoting green research culture is one such initiative required to be studied further for promoting eco-friendly research culture among researchers, society, and other relevant research partners (Ionescu 2021b).

The research institute should be aware that according to their vision and mandate, the perspectives incorporated into 'Research for Society' KPI may require slight to moderate adjustments when it is measured and used as a decision support tool in its management. The confidence built-in research institutes with results of such studies and methodologies developed in a structural manner for implementing good PMS will give additive support to manage the research performance competitively towards that end (Abeysiriwardana and Jayasinghe-Mudalige 2021b).

Conclusions

Society and the environment is one integrated unit where all components including climate change have been woven into one web to withstand, balance, and satisfy the requirements of all its stakeholders. Ground-level persons such as farmers and extension workers formed a society that closely deals with the environment to provide good feedback on the needs of sustainable research that society needs. However, most researchers are not sufficiently aware that the disruptive effects on the environment caused by agricultural technology are due to the reason that it was not conceived from a bottom-up approach. In this context, the 'Research for Society' is a very important performance drive of a research institute that requires the dynamics of the flexibility of the research institute to make it blossom into fully fledge institutional capacity in the context of environmentally friendly CA development.

Further, the researchers' study and the experience here intimate that the lack of studies to understand the true connection and dependencies between research, social awareness of research needs, and flexibility of research institute in implementing the key performance drive – 'Research for Society', hinders the true capacity of reaping the benefits of environmentally friendly agriculture practices.

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