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Perspective Paper

An Index for Key Performance Indicators (KPIs): A Lens to Probe the Performance Drivers of Research in Commercial Agriculture

Prabath Chaminda Abeysiriwardana[a] ✉,
Udith K. Jayasinghe-Mudalige[b]

[a]*Research and Innovation Section, Ministry of Education, Sri Lanka*

[b]*Department of Agribusiness Management, Wayamba University of Sri Lanka, Sri Lanka*

Abstract

Research work carried out in any institution could be meaningfully administered, and the outputs generated rendered more rewarding for its key stakeholders, if a set of critical success factors (CSFs) are outlined ex-ante. When CSFs are neither clearly identified nor practised in a vital sector such as commercial agriculture, difficulties arise with timely monitoring and evaluation, and tallying the achievements with intended Sustainable Development Goals (SDGs) – particularly the goal of 'zero hunger'. This article proposes a Key Performance Index (KPI index) that takes into account CSFs that would aid in evaluating the success of research linked with commercial agriculture development. How such an index is used to facilitate monitoring of scarce resource utilisation and internal processes of research institutes, and thereby support evidence-based decision-making to sustain a conducive research culture is explored with a special focus on underutilised performance drivers (e.g., societal development and environmental sustainability) in line with agriculture research.

Keywords: Commercial Agriculture, Research Institutes, Performance Management, KPI, KPI Index

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✉ abeysiriwardana@yahoo.com   https://orcid.org/0000-0003-0300-2020

Introduction

Research institutes play a major role in commercial agriculture by introducing products and services that improve agricultural output in terms of both quality and quantity (Figueiredo, 2016). Research that finds practical solutions to burning issues and brings about social benefits to achieve the socio-economic growth of a nation act as an enabler in this regard (Kueffer et al., 2012; Kundu et al., 2020). It is imperative to examine whether research institutes have truly focused on this mission through their research agenda. The focus of a research institute could be rightly directed by measuring its performance against critical success factors (CSF) (Parmenter, 2015) that would contribute to achieving the goals of effective research (Razzak, 2022) for the commercial agriculture sector. Key Performance Indicator (KPI) is a tool that could be well utilised to measure the performance of a research institute that works toward productive commercial agriculture (Park et al., 2006; Samsonowa et al., 2009).

In this context, many research institutes, organisations, administrative bodies, etc. of developed countries use diverse KPIs with different intentions to manage the performance of research. For example, the dedicated evaluation and planning unit for science and technology of Korea, KISTEP (Korea Institute of S&T Evaluation and Planning) has a mission of raising the effectiveness of research and development (R&D) investment by enhancing science and technology (S&T) planning and evaluation. Korea is said to have a good strategic investment plan supported by the government and one core strategy under it is “strengthen the strategy research” (Centre for International Cooperation Policy - Korea Institute of S&T Evaluation and Planning [CICP-KISTEP], 2021) which warrants many KPIs to be called to manage its performance.

Although these techniques and tools are available to measure the performance of research institutes and have been in use for quite a long period, they have not been put into a structure and practiced effectively to measure the most sensitive aspects of research success in commercial agriculture such as social responsibility and environment-friendliness of agriculture research along with its economic sustainability. This could be due to a lack of guidelines, policies, and well-defined techniques and tools integrated into a proper performance management system. Especially in developing countries like Sri Lanka, the situation is further worsened with the insufficient commitment to initiating, planning, and monitoring such a system and inadequate investment in R&D to maintain such a system continuously (Chae, 2009). When a developing country like South Korea has nearly 5%, while

Japan and Germany go beyond 3% R&D investment as % of GDP, a developing country like Sri Lanka has only less than 0.5% R&D investment in the year 2018 according to the world bank database (The World Bank Group, 2022). Even in conditions like low investment, research in commercial agriculture can be expected to provide a huge impact on the economy of a developing country like Sri Lanka, if the performance of the research process in this sector is carefully managed.

Sri Lanka has fertile tropical land with immense potential for the cultivation of a variety of crops that can facilitate the transition from subsistence agriculture to commercial agriculture. Although agriculture is an important and impactful sector of the Sri Lankan economy, issues such as low productivity, less profitability, and natural disasters such as the COVID 19 pandemic hamper the growth of this sector (Roshana & Hassan, 2020; Thibbotuwawa & Hirimuthugodage, 2015). In the first quarter of 2020, the share of agriculture in Sri Lanka's Gross Domestic Product (GDP) was around 7.3%, although the sector provides livelihood and security to around 30% of the population (Department of Census and Statistics [DCS], 2020). These statistics indicate that this sector is important for achieving the United Nations' sustainable development goal (SDG 2) of zero hunger (United Nations World Food Programme, 2017) since the livelihood of around one-third of the population depends on that sector; however, its contribution to the GDP is very low. Therefore, the necessity of improving productivity is important for the socio-economic growth of Sri Lanka. We argue that improving productivity could be supported by research that is managed with a special focus on critical areas vulnerable to underperformance. In this context, developing KPIs into a robust tool for performance management could create a strategic change in the development plan of a research institute.

Although KPIs are abundantly used in research institutes, it should be checked whether the right set of KPIs associated with critical success factors is used in the context of research and development (Abeysiriwardana & Jayasinghe-Mudalige, 2021). Do those KPIs measure the right performance that is useful for decision-making in developing commercial agriculture? Are traditional and frequently used KPIs in research institutes challenging enough in the present context of competitive and networked research business? Do they capture the research requirements of the society for maintaining the resilience and sustainability of food systems in the modern environmental context (Amato-Lourenço et al., 2021) in evaluating the performance of research contribution to the commercial agriculture sector? Is a sufficient area of concern covered by the available set of KPIs, and if not, which set of KPIs could be useful in achieving effective performance measurements of research works of research institutes towards the success of commercial agriculture covering all aspects of sustainability? Does the evaluation strategy of the research institute have disconnected KPIs that would not give synergised effect on performance management? These are some concerns regarding KPIs in this sector.

Given this, the main objective of this perspective paper is to develop a KPI index combining the most relevant and important KPIs that drive the performance of a research institute toward commercial agriculture development. For example, the proposed KPI index is equipped with attributes that could emphasise a new set of core strategies that have gained much attention in recent years to make research more sustainable in its existence. “Research for society and community” is one such area of performance that could enhance the research contributions to greater quality of life by focusing on society-friendly characteristics of commercial agriculture such as corporate social responsibility and corporate environmental responsibility (el Ghoul et al., 2016; Withisuphakorn & Jiraporn, 2015). Thus, the proposed KPIs would direct and evaluate research aimed at making businesses contribute to society's well-being without compromising its economic sustainability even in the context of competitive profit earnings.

In this paper, the proposed KPI index founded on composite KPIs[1] is assessed for its effectiveness by comparing its outcome against the outcome of individual KPIs. In this index, some specific aspects of research, such as commercialisation and competitiveness are expected to pave the way forward for performance improvement of research institutes for helping to improve the commercial agriculture sector. Further, the sustainability concerns addressed by the research process are captured by indicators related to socially responsible and environment-sensitive approaches such as the circular economy and carbon footprint concepts merged into research outputs. All of these key areas of concern are expected to be reflected and highlighted by the proposed KPI index. The two ways of using KPIs - as individual indicators or as a compositely made index form – are presented in this paper and demonstrated using a hypothetical set of values to understand its application in performance measurement of research toward sustainable commercial agriculture development.

The paper begins with a theoretical framework outlining the attributes and relationships between indicators, performance indicators, and KPIs in line with measuring the performance of research. This is followed by a description of the data

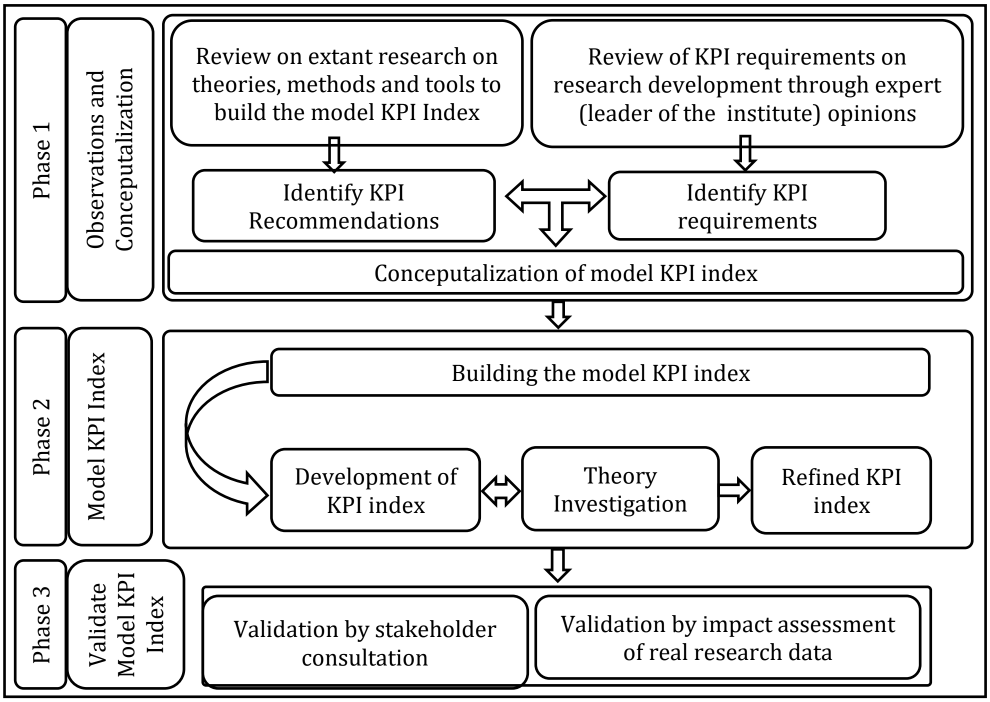
[1]In its simple form, a composite KPI is an indicator that aggregates multiple KPIs of having common interest to form a single KPI to represent and manage that wide area of interest.

collected and analysed in the development of the KPI index. Finally, the adjustments and extensions that could be introduced to make the KPI index more reliable and efficient in diverse research environments would be discussed. The flexibility of the proposed KPI index in adopting such complex characteristics of the research process into its structure would be thus elaborated.

Theoretical Framework: Developing KPIs into a Robust Tool for Performance Management

The whole process of developing a model KPI index and elevating it into a matured decision-making tool is explicated in Figure 1 to provide a clear idea about how it should be developed for a research institute with the participation of many stakeholders.

Figure 1: A Framework for Converting Individual KPIs into KPI Index to Measure Research Performance



Source: Based on the design research methodology (DRM) explained by (Blessing & Chakrabarti, 2009) and (Sassanelli & Terzi, 2022)

In this paper, some steps of the framework of developing the KPI index have not been completed as they have to be developed with the participation of research institutes according to their individual business needs and therefore out of the scope of this perspective paper. Further, Phase three - empirical validation of this index - needs to be done by future researchers. The presented design research methodology (DRM) framework is expected to provide a necessary guideline in completing the unfinished steps of building this model index into a fully-fledged KPI index.

Phase 1: Initiation of Model KPI-Index by Observations and Conceptualisation

The KPIs of an organisation should be ideally derived from the specific set of organisational goals and objectives that reflect CSFs of the business success of the research institute. The model KPI index developed in this paper is a generic model that aims to fit a broad but critical set of objectives that can be considered as success makers of research institutions on commercial agriculture.

Although KPI or its derivatives are not expected to be simple, the more it becomes simple more it becomes usable, flexible, and sustainable in organisational culture (Abeysiriwardana, Jayasinghe-Mudalige, & Seneviratne, 2022; Bai & Sarkis, 2014; Gamme & Johansson, 2014). KPI Index proposed here is essentially made simple as it should be understood by all layers of employees in the hierarchy of the organisation to enable its transparency in the decision-making process of the research institute. The index is also easily decomposable to let it easily be understood at its atom level in line with the performance of an institute.

The index was systematically built on the basis that only the most-wanted KPIs were selected from a pool of available KPIs pertaining to research in the commercial agriculture sector. First, a prominent set of 22 non-financial and 11 financial indicators that could be used in ideal research institutes to evaluate their performance in commercial agriculture was identified in Table 1.

The indicators in Table 1 are only an indication of the best possible set of KPIs of a research institute to increase the productivity of research in the commercial agriculture sector. Any of these indicators may also become a KPI without any change to their structure and behaviour according to the business strategy of an organisation and thus would represent a CSF of an organisation's visionary performance. How they were selected in the present exercise of constructing a model KPI index is justified and explained in Table 2. However, when they are used practically in a research institute, only the KPIs that work well with institute goals and vision should be selected under a proper evaluation method such as SWOT (strengths, weaknesses, opportunities, and threats) analysis, expert judgment, analysis of historical data of the

Table 1: Indicators for Measuring the Performance of Research in Commercial Agriculture Development

	Non-financial indicators	Code	Financial indicators	Code
1	Number of research publications indexed in SCI/ international research awards/ grants	BR1	Total expenditure	RE1
2	Number of research publications in other indexed journals/ national research awards/ grants	BR2	Cost of a scientific publication	RE2
3	Number of research publications in non-indexed journals/ other research awards/ grants	BR3	Cost to manage and maintain a patent	RE3
4	Number of patents	CR1	Expenditure on purchase equipment	RE4
5	Number of technology transfer activities	CR2	Expenditure on maintenance of equipment	RE5
6	Number of commercialisations	CR3	Expenditure on chemicals and consumables	RE6
7	Number of collaborative projects	RC1	Revenue generated by patents, licenses	RR1
8	Number of joint publications with different institute contribution	RC2	Revenue generated by technology transfer activities	RR2
9	Number of days other institutes use this institute equipment	RC3	Revenue generated by commercialisation and spin-off	RR3
10	Number of equipment purchased	RA1	Technical service revenue	RR4
11	Number of researchers	RA2	Consultancy service revenue	RR5
12	National and community issues solved	RS1		
13	Students completing a degree programme	RS2		
14	Students enrolled in a degree programme	RS3		
15	Teacher-hours of professional development	RS4		
16	Continuously maintain laboratory accreditation	RS5		
17	Science and Technology popularisation programmes	RS6		
18	Science and Technology popularization publications	RS7		
19	Number of technical services provided	RS8		
20	Number of consultancy services provided	RS9		
21	The total value of proposals/ awards/ grants produced	RS10		
22	Number of proposals/ awards/ grants produced	RS11		

Note: The above KPIs are based on a synthesis of ideas expressed in the literature, some key papers of which are presented in Table 2 research institute, predictive analytics, etc along with considering their relevancy for improvement of the concerned sector, if any.

Table 2: Justification for Selection of Indicators for Proposed Model KPI Index

No. of the indicator in Table 1	Justification and references for selecting the indicator
1. All financial and non-financial indicators	The survey report of 100 Main Science & Technology Indicators of Korea (2021-September) highlights the selected indicators (KISTEP, 2021).
2. All financial and non-financial indicators	The main categories of indicators in the work on scientometrics and bibliometrics of the Organisation for Economic Co-operation and Development (OECD) highlight the selected indicators (Organisation for Economic Cooperation and Development [OECD], 2022).
3. 7-9 (Non-financial indicators)	Research mobilisation would increase scientific productivity (Amador et al., 2018; Sandstrom, 2009).
4. 1-6, 10, 11, 13-15 (Non-financial indicators)	The core set of STI indicators relevant to the “S and T System”, “Firms”, “Government” and “Environment” categories highlights the importance of the selected indicators (United Nations Conference on Trade and Development [UNCTAD], 2010).
5. 1-7, 10-12, 16-20 (Non-financial indicators)	A document on the research impact pathway by the Australian Research Council (ARC) highlights the importance of the selected indicators (Australian Research Council [ARC], 2019).
6. 21-22 (Non-financial indicators)	Indicators relating to grants could be used to measure and increase scientific performance (Gyorffy et al., 2020).
7. All financial indicators	Financial indicators become good KPIs when they are mostly sought by external parties to get an idea about institutes' research success (Ishaq Bhatti et al., 2014).

Indicators selected for developing the index are derived from the indicators identified in the literature. The selected indicators get into the selection based on the frequency and emphasis that they have on potential subjects of importance to the development of the commercial agricultural sector (Abeysiriwardana & Jayasinghe-Mudalige, 2022a; Geisler, 1994; Katz, 2000; Kolar et al., 2018; Kolar et al., 2020; Morrar, 2018). However, the indicator set mentioned in Table 1 is not supposed to be exclusive, final, or comprehensive. Instead, they represent a common but versatile set of indicators to represent most of the performance drivers that could be used for making critical decisions on the success of the research process.

Phase 2: Developing a Model KPI Index

In this phase, the model index is developed classifying the indicators identified in Phase One into KPIs in two stages.

The 22 non-financial indicators presented in Table 1 were used to propose 14 KPIs for research institutes that work on research to develop the commercial agriculture sector (see Table 3). These 14 KPIs were designated as 1st stage KPIs as they represent research actions, functions, and strategies that are frequently mentioned in the research agenda/ plan/ policy of a research institute, cover many performance measures, and are specifically mentioned in some of the seven pillars of Global Innovation Index (GII) (World Intellectual Property Organisation [WIPO], 2021); however, it may not be a comprehensive list as research performance management covers many complex business strategies that are unique to individual research institutes. These 14 KPIs can also be considered general influential drivers of research performance in terms of the development of the commercial agriculture sector as a science, technology, and innovation-based sector (Ministry of Education, Culture, Sports, Science and Technology [MEXT], 2022; Old Dominion University [ODU], 2018). To narrow down the performance drivers of research, those 14 KPIs were grouped into 7 major criteria through the facts and thoughts mentioned in the literature (Abeysiriwardana & Jayasinghe-Mudalige, 2022a; Agostino et al., 2012; Meek & Lee, 2005) and their relevance to the subjects mentioned in the 2nd stage KPIs. Therefore, in effect, we propose 2nd stage KPIs as CSFs of research institutes that work on commercial agriculture development. However, this classification is subjective to the vision of its maker (e.g., the leader of a research institute); much depends on the business strategies of a research institute. Therefore, in adopting them it is better to have them validated by an expert panel appointed by the relevant research authority.

The number of KPIs selected to represent the CSFs of research institutes mentioned in this perspective paper was in line with the upper and lower limits of the optimum number of KPIs that is advised by the well-known practitioners of KPIs; Kaplan and Norton: up to 25 (Kaplan & Norton, 1996); Warren: less than 15 (Warren, 2011); Parmenter: about 10 (Parmenter, 2015); Hope and Fraser: less than 10 (Hope & Fraser, 2003). Based on these guidelines, seven (7) success areas relevant to performance management/ measurements of a research institute toward commercial agriculture (CA) development are proposed and designated as 2nd Stage or ultimate KPIs for a research institute. These 2nd Stage KPIs that are expected to reflect CSFs of a research institute are corporate KPIs derived from outcome-based 1st Stage KPIs.

These 2nd Stage KPIs are expected to be considered as performance drivers that could be utilised in changing the institute's strategies for future improvements in research. How 1st Stage KPIs are combined to form 2nd Stage KPIs are depicted in Table 3.

Table 3: First Stage KPI Statements Classified under the Criteria and Proposed Second Stage KPI

1st Stage KPI (KPI on the outcome)	Proposed 2nd stage KPI	Code
1. Basic research contribution (BR1+ BR2 + BR3)	Basic research contribution	BR
2. Commercialisation success (CR1+ CR3) 3. Technology transfer success (CR2)	Commercial research contribution	CR
4. Collaborative research (RC1+ RC2) 5. Resource sharing (RC3)	Research culture development	RC
6. Number of equipment obtained (RA1) 7. Number of researchers employed (RA2)	Research assets	RA
8. Research proposal/ Awards output (RS10+ RS11) 9. Science and Technology popularisation (RS6+ RS7) 10. National and community reach and empowerment (RS1+ RS2+ RS3+ RS4) 11. Consultancy and technical services (RS5+RS8+RS9)	Research for society and community (with avenues to be adjusted with variable focus on environmental sustainability)	RS
12. Non-IP-related research revenue (RR4+ RR5) 13. Intellectual Property related research revenue (RR1+ RR2+ RR3)	Research Revenue	RR
14. Expenditure on research (RE1+ RE2+ RE3+ RE4+ RE5+ RE6)	Research Expenditure	RE

The KPI index is developed using 2nd Stage KPIs. The 2nd Stage KPIs are combined to form the proposed corporate KPI index and are expected to predict the impact of research on commercial agriculture development in the long run.

The performance of a particular area of concern i.e. Percentage Performance (PP) as a function of variables, Achieved Progress (AP), Baseline performance (BP), and Target Progress (TP) in relation to the effectiveness of research work by research institutes towards commercial agriculture is calculated using the formula in Equation 1:

$$PP = \frac{AP - BP}{TP - BP} \times 100 \qquad (1)$$

A 100% achievement indicates that the research institute achieves its performance as expected at the start of its research agenda and it has achieved its intended goals 100% at the end of the research process. The above formula calculates the PP of any performance area using data obtained through any indicator or KPI. The following conditions were enforced to make limits on Equation 1.

- The minimum and the maximum values allowed for the formula are 0 – 100 respectively.
- 0 or (-) values means the research institute has no progress towards its specific targets/ goals
- 100 or 100+ values mean the research institute has progressed well towards its specific targets/ goals.

In this paper, the KPI index is developed using only non-financial 2nd Stage KPIs. The financial KPIs are not in the model KPI index in the perspective paper to reduce complexity. Further, they play a different role compared to non-financial KPIs in research performance management and supporting a research institute's vision and mission toward innovative commercial agriculture development. In addition, the use of financial KPIs with non-financial KPIs simultaneously in measuring the performance of an institute can be debatable due to many reasons mentioned in the extant research (Ittner, 2000). That does not mean that they could not be incorporated into the same KPI index; however, it would require thorough investigation on the part of the research institute and future research on the subject as well.

Index Development

The KPI index is developed as follows:

The KPI index exemplified in this perspective paper is developed using the 2nd Stage KPIs, BR, CR, RC, RA, and RS as they cover research institute contributions and capacity achieved during a particular year with respect to non-financial critical success factors. These KPIs represent intellectual capital and innovative organisational culture – the two most important aspects of a research institute that may need to be evaluated at present (Chartered Global Management Accountant, 2012; Kotane & Kuzmina-Merlino, 2012; Parmenter, 2015).

The 2nd Stage KPIs are calculated using Equation 1 assigned to each of Equations 2 to 6 as follows. (Note: In this example, in the formulas in Equations 2 to 6, an arbitrary weightage is assigned to each indicator in Table 1 according to our judgment and experience regarding the contribution of each (in general) to the development of commercial agriculture.) The term 'Max (…)' is used to denote the maximum value that can be achieved at a particular instance of calculation.

Max (KPI_BR) = BR1*0.6 + BR2*0.3 + BR3*0.1 = 100 (2)

Extended version of Equation (2) by assigning Equation (1) to Equation (2):

Max (KPI_BR) = (AP_BR1 – BP_BR1)/ (TP_BR1 – BP_BR1)*100*0.6 + (AP_BR2 – BP_BR2)/ (TP_BR2 – BP_BR2)*100*0.3 + (AP_BR3 – BP_BR3)/ (TP_BR3 – BP_BR3)*100*0.1 = 100

Max (KPI_CR) = CR1*0.4 + CR2*0.3 + CR3*0.3 = 100 (3)

Extended version of Equation (3) by assigning Equation (1) to Equation (3):

Max (KPI_CR) = (AP_CR1 – BP_CR1)/ (TP_CR1 – BP_CR1)*100*0.4 +(AP_CR2 – BP_CR2)/ (TP_CR2 – BP_CR2)*100*0.3 + (AP_CR3 – BP_CR3)/ (TP_CR3 – BP_CR3)*100*0.3 = 100

Max (KPI_RC) = RC1*0.5 + RC2*0.4 + RC3*0.1 = 100 (4)

Extended version of Equation (4) by assigning Equation (1) to Equation (4):

Max (KPI_RC) = (AP_RC1 – BP_ RC1)/ (TP_ RC1 – BP_ RC1)*100*0.5 + (AP_ RC2 – BP_ RC2)/ (TP_ RC2 – BP_ RC2)*100*0.4 + (AP_ RC3 – BP_ RC3)/ (TP_ RC3 – BP_ RC3)*100*0.1 = 100

Max (KPI_RA) = RA1*0.5 + RA2*0.5 = 100 (5)

Extended version of Equation (5) by assigning Equation (1) to Equation (5):

Max (KPI_RA) = (AP_RA1 – BP_ RA1)/ (TP_ RA1 – BP_ RA1)*100*0.5 + (AP_ RA2 – BP_ RA2)/ (TP_ RA2 – BP_ RA2)*100*0.5 = 100

Max (KPI_RS) = RS1*0.2 + RS2*0.1 + RS3*0.1 + RS4*0.1 + RS5*0.1 + RS6*0.05 + RS7*0.05 + RS8*0.1 + RS9*0.1 + RS10*0.05 + RS11*0.05 = 100 (6)

Extended version of Equation (6) by assigning Equation (1) to Equation (6):

Max (KPI_RS) = (AP_RS1 – BP_ RS1)/ (TP_ RS1 – BP_ RS1)*100*0.2 +
(AP_ RS2 – BP_ RS2)/ (TP_ RS2 – BP_ RS2)*100*0.1 +
(AP_ RS3 – BP_ RS3)/ (TP_ RS3 – BP_ RS3)*100*0.1 +
(AP_ RS4 – BP_ RS4)/ (TP_ RS4 – BP_ RS4)*100*0.1 +
(AP_ RS5 – BP_ RS5)/ (TP_ RS5 – BP_ RS5)*100*0.1 +
(AP_ RS6 – BP_ RS6)/ (TP_ RS6 – BP_ RS6)*100*0.05 +
(AP_ RS7 – BP_ RS7)/ (TP_ RS7 – BP_ RS7)*100*0.05 +
(AP_ RS8 – BP_ RS8)/ (TP_ RS8 – BP_ RS8)*100*0.1 +
(AP_ RS9 – BP_ RS9)/ (TP_ RS9 – BP_ RS9)*100*0.1 +
(AP_ RS10 – BP_ RS10)/ (TP_ RS10 – BP_ RS10)*100*0.05 +
(AP_ RS11 – BP_ RS11)/ (TP_ RS11 – BP_ RS11)*100*0.05 = 100

Finally, the KPI_Index is calculated as follows on a scale of 0 – 100, using the formula depicted in Equation 7:

$$KPI\ index = \sum_{x=0}^{n} K^x W^x \qquad (7)$$

where K^x = PP of xth 2nd stage KPI, W^x = weightage of xth 2nd stage KPI, and $\sum_{x=0}^{n} W^x = 1$

In using this formula, first, the weightage of each KPI on the KPI index is determined based on the importance of that KPI to the research contribution to the development of the commercial agriculture sector. In practice, weightage should be validated by an expert panel or following statistical procedures like Pearson correlation ratios, Bayesian Gaussian processes, optimisation procedures, etc (Becker et al., 2017). In addition, the influence of a particular KPI should also be assessed by the individual research institute according to its CSFs' influence on the business strategy of that research institute. For example, a research institute that is conducting basic research may assign a higher weightage value to BR to make its business strategy more aligned with its mandate while an applied research institute would prefer the highest weightage value to CR. We argue that, in general, the KPIs influence research success with the lowest influence by RC and RA and the highest influence by CR because the commercial agriculture sector may depend more on applied research for its success in the economy. However, we agree that this may not be a valid argument for the success of all research institutes that work in the commercial agriculture sector.

We provide an example below (see Equation 8). To make this example simple, in calculating the KPI index, a set of arbitrary values are assigned as weightage (similar to the weights assigned to each indicator), according to the argument presented above, based on our judgment and experience.

$$\text{Max (KPI index)} = KPI\_BR*0.2 + KPI\_CR*0.4 + KPI\_RC*0.1 + KPI\_RA*0.1 + KPI\_RS*0.2 = 100 \quad (8)$$

The minimum and maximum values allowed at each stage of calculation are 0 – 100 respectively

Model KPI Index in Practice

Data were simulated for three fictitious institutes as an example to demonstrate how to calculate and interpret this model KPI index.

An Example Using Simulated Data

Data for 3 fictitious research institutes for the 22 non-financial indicators were generated by random numbering (see Table 4).

Table 4: Baseline Data Value, Target Data Value and Achieved Data Value of Three Fictitious Research Institutes

Indicator Code	Institute 1			Institute 2			Institute 3		
	Baseline	Target	Achieved	Baseline	Target	Achieved	Baseline	Target	Achieved
BR1	6	12	11	8	16	16	2	4	2
BR2	3	6	6	4	8	7	10	20	16
BR3	5	10	7	5	10	5	7	14	11
CR1	3	6	6	2	4	4	6	12	7
CR2	9	18	18	5	10	10	6	12	6
CR3	2	4	3	3	6	6	5	10	7
RC1	3	6	6	2	4	2	5	10	10
RC2	5	10	7	4	8	4	2	4	2
RC3	21	42	40	26	52	26	17	34	28
RA1	2	4	2	3	6	4	3	6	6
RA2	19	38	24	16	32	31	9	18	9

Indicator Code	Institute 1			Institute 2			Institute 3		
	Baseline	Target	Achieved	Baseline	Target	Achieved	Baseline	Target	Achieved
RS1	4	8	8	3	6	6	2	4	3
RS2	2	4	4	2	4	3	3	6	3
RS3	5	10	8	4	8	8	3	6	6
RS4	53	106	106	49	98	56	53	106	88
RS5	2	4	2	5	10	10	2	4	2
RS6	9	18	10	6	12	11	7	14	11
RS7	10	20	12	2	4	2	2	4	2
RS8	7	14	12	3	6	6	7	14	7
RS9	3	6	6	2	4	3	5	10	6
RS10	5	10	9	4	8	4	2	4	4
RS11	3	6	6	2	4	2	5	10	8

Each indicator has a baseline data value, target data value, and achieved data value per institute for the particular year. In the example, baseline data value and achieved data value are generated through random numbering (since this is a hypothetical example) and the target data value is set by multiplying the baseline data value by factor 2 (as the target is practically higher than the baseline value, the next integer value of 1, i.e. 2 was used multiplying baseline value by 2 to uniformly increase the target values compared to baseline values in this simulated example).

Table 5: Indicator Values and Second Stage KPI Values for the Three Example Research Institutes

Indicator Code	KPI Code	Institute 1		Institute 2		Institute 3	
		Indicator value	2nd Stage KPI value	Indicator value	2nd Stage KPI value	Indicator value	2nd Stage KPI value
BR1		83		100		0	
BR2	BR	100	84	75	83	60	24
BR3		40		0		57	

Indicator Code	KPI Code	Institute 1 Indicator value	Institute 1 2nd Stage KPI value	Institute 2 Indicator value	Institute 2 2nd Stage KPI value	Institute 3 Indicator value	Institute 3 2nd Stage KPI value
CR1	CR	100	85	100	100	17	19
CR2		100		100		0	
CR3		50		100		40	
RC1	RC	100	75	0	0	100	56
RC2		40		0		0	
RC3		90		0		65	
RA1	RA	0	13	33	64	100	50
RA2		26		94		0	
RS1	RS	100	74	100	66	50	39
RS2		100		50		0	
RS3		60		100		100	
RS4		100		14		66	
RS5		0		100		0	
RS6		11		83		57	
RS7		20		0		0	
RS8		71		100		0	
RS9		100		50		20	
RS10		80		0		100	
RS11		100		0		60	

The values of the 22 non-financial indicators for each institute were calculated using the formula in Equations 1 by feeding respective data values in Table 4. These are presented in the "Indicator value" column of Table 5. The respective formulas in Equations 2-6 were fed with relevant indicator values multiplied by relevant weightage to obtain each 2nd Stage KPI value of each institute presented in the "2nd Stage KPI value" column of Table 5. Then 2nd Stage KPI values were combined to form the KPI index for each institute (see Table 6) using the formula in Equation 8.

Finalising the model KPI index

The KPI index proposed here captures five non-financial performance drives of a research institute. A 100-point Likert Scale, ranging from 'extremely unfavourable in achieving the CSF/ Goal' (0) to 'extremely favourable in achieving the CSF/ Goal'

(+100), was constructed considering fifty (50) as the neutral point. In this perspective paper, performance achievement was categorised into three categories based on quartiles of the scale. If any research institute wants to use more than three categories, they may use percentiles or any other form of categorisation as per their requirements. Mean scores above 75 were considered as Achieving Targets, mean scores below 50 were considered as Not Achieving Targets, and Mean scores between 50 – 75 were considered as Marginal Performance, based on their location in the quartiles. Marginal performance is expected to be achieved when highly weighted KPIs of a research institute have not performed well for a research institute even though other low weightage KPIs have better performance values. Research institutes may consider 'Marginal Performance' as acceptable performance as per their institutional capacities and requirements, which are subjects beyond the discussion of this perspective paper. KPI Indices of all three institutes that were calculated by using the formula in Equation 8 and the above 2nd Stage KPI values are given in Table 6 along with the respective categorical performance achievement of each institute.

Table 6: Categorisation of Performance According to KPI-Index

	Institute 1	**Institute 2**	**Institute 3**
KPI_Index	74	76	31
Category of Performance	Marginal Performance	Achieving Target	Not Achieving Targets

The observations of calculated 2nd Stage KPI values of three research institutes are summarised in Table 7.

Table 7: Summary of Performance Based on Second Stage KPI Values of Research Institutes

Institute	**2nd Stage KPI values**					**Average 2nd Stage KPI value**
	Highest	**2nd Highest**	**3rd Highest**	**4th Highest**	**Lowest**	
Institute 1	CR=85	BR=84	RC = 75	RS=74	RA=13	67
Institute 2	CR=100	BR=83	RS=66	RA=64	RC=0	55
Institute 3	RC=56	RA=50	RS=39	BR=24	CR=19	41

When average 2nd Stage KPI values are taken, no institute seems to achieve the targets according to the category of performance mentioned in Table 6. However, weighted 2nd Stage KPI values put into a KPI index shows that Institute 2 was achieving targets and Institute 1 had a marginal performance. It indicates that average 2nd Stage KPI values put into an index would not provide a good indication of achieving targets as average 2nd Stage KPI values (Commercialisation, Research Collaboration, Research for Society aspects, and even Basic Research aspects) are not weighted on their importance to the performance improvement or business strategy of a research institute. In other words, when a non-critical indicator becomes extremely low or high in performance, the average indicator value in an index depends highly on that low or high value and gives a distorted impression about the overall performance by overshadowing the performance of the critical success factors.

Explaining this further using the example, even though RC is 0, Institute 2 is achieving its target according to the KPI index which seems to be due to having high CR (100) and BR (83) values. However, with a high BR(84) value along with comparatively higher other 2nd Stage KPI values, Institute 1 is only just close to achieving targets. Therefore, this example demonstrates that the index reflects a research institute’s performance in relation to the largest contributor to the institute's success, which in this case is “Commercial research contribution” (with the highest assigned weightage (0.4) on its importance to the research business success) rather than the contribution of comparatively low weightage CSFs like “Basic research contribution” (BR), Research assets (RA), etc. The reflection of the importance of different CSFs on the KPI index is further supported by the results of Institute 3. Institute 3, despite having a marginal performance for two 2nd stage KPIs (RC (56) and RA (50)) could not achieve overall marginal performance because of their low importance (captured through low weight); the underperformance of the more important KPIs CR (19) and BR (24) have dragged the overall performance index to a value much lower than the minimum marginal performance (KPI = 31).

“Research for Society” in the context of performance management

As noted at the beginning of this paper, a highlight of the proposed model KPI index is its increased focus on ‘Research for Society’. The commercial agriculture sector is expected to be armed with better innovations to increase its contribution to the economy of a country through well-focused research outputs that satisfy different stakeholders' expectations. This can be achieved through managing and streamlining the performance of research with many strategies such as integrated performance management systems that are mentioned in research (see e.g., Abeysiriwardana and Jayasinghe-Mudalige,- (2022b), and such strategies could be captured in the evaluations by the KPI index proposed in this perspective paper. Furthermore, a sector-specific performance evaluation of research can help make an integrated research contribution from scattered research institutes that work on commercial agriculture and make agriculture research move in one direction of productivity with social benefits highlighted within the sector.

In this context, the KPI index constructed here can be discussed in two different scenarios.

1. KPI index that has a "Research for Society" component in a more general context
2. KPI index that has a more complex "Research for Society" component for special requirements such as the circular economy and environmental sustainability.

KPI index that has a "Research for Society" component in a more general context

Every research institute claims that its research contributes immensely to societal well-being. Their justification in this regard comes through KPIs such as the ones mentioned in Table 1 and Table 3 under the research for society (RS) category. We propose that these are still too general and lack real insights to guide research institutes to produce more benefits for society out of their research process. As discussed earlier and explained below, a multidisciplinary focus on developing KPIs can be expected to provide better KPIs for research in the commercial agriculture sector. When a KPI index, based on the model proposed in this paper, is developed comprising variables focused on aspects such as environmental sustainability, social responsibility, and user-friendliness that align better with the "Research for Society" KPI, along with a high weightage assigned to that KPI, the KPI index can be expected to enable managing and guiding research in the direction of social acceptance without failures in sustainability (Abeysiriwardana, Jayasinghe-Mudalige, & Seneviratne, 2022). Such a KPI index will facilitate the collection of reliable data on such research processes to support decisions and policies for fostering new research interventions for the commercial agriculture sector to achieve UN's SDGs, especially SDG 2: Zero Hunger.

Adapting the "Research for Society" Component of the KPI to Suit Special Requirements Such as the Circular Economy or Environmental Sustainability

Some research institutes with matured performance management systems such as fully integrated and artificial-intelligence (AI)-driven, have very complex CSFs taken into consideration when they make decisions on research direction towards their mission and vision (Abeysiriwardana, Jayasinghe-Mudalige, Kodituwakku et al., 2022). Their strategy in implementing research is different when it comes to environment-concerned matters especially in the commercial agriculture field due to various reasons such as when the scope of research directly concerns environmental issues. For example, applied research that works on innovations for agriculture may consume a lot of resources and produce by-products such as waste that directly influence the dynamics of the environment. As these by-products of research may affect the productivity of the research in many aspects such as societal rejection of such research due to lack of corporate social responsibility in the research process, their effect needs to be measured through a performance driver to control such effects of the research processes. Further, in such a performance management strategy, research on commercial agriculture is expected to provide insights on gaps and opportunities identified through environment research, climate change research, etc., and is expected to be well-positioned to assist such global challenges by incorporating them into the research agenda of a research institute. In view of this, to satisfy the multidisciplinary requirements expected from the modern research culture, environmental KPIs could be considered a good candidate (Zarzycka & Krasodomska, 2021) to be integrated with some broader KPIs of research to form composite KPIs that could be used to measure the "Research for Society" performance drive.

The KPI index proposed here has a "Research for Society" component that can be easily adjusted to incorporate such aspects and also with the ability to assign more weightage to such aspects. It could be easily introduced the required criteria into the KPI index either by dropping or adding a 2nd stage KPI and adjusting the weightage values with new components to match the mandate of the research institute. Therefore, this simple but versatile KPI index has been provided with easily adjustable components that could be adapted to capture even the much-veiled performance enhancers of research institutes that are devoted to complex performance drives such as contributions to the circular economy and environmental sustainability in commercial agriculture development.

Conclusion

In this paper, a KPI index was developed by combining non-financial KPIs into one composite indicator for the commercial agriculture development sector, and assessing its effectiveness against when individual KPIs or non-weighted KPIs are used, by utilising an example of three hypothetical research institutes. For organisational achievements to become more than the sum of its part achievements derived from objectives, the correct set of indicators should be grouped and combined to form new critical success factors and should be measured to make them ideal performance drivers for the research institutes. In this context, this paper attempt to explain a corporate KPI index that can be useful to identify the performance of commercialisation aspects along with other critical success factors of research institutes for improved commercial agriculture research. Furthermore, it exemplified better use of composite KPIs and how such KPIs adjusted with relative weightage of their importance (according to CSFs of a research institute) can support better decision-making in research rather than when individual indicators are used for that purpose. Therefore, the proposed model KPI index is technically robust enough to be resiliently adopted in research sectors other than commercial agriculture, with minimum or no change.

The presented index is a ‘model KPI- index’ and the indicators are recommended to be validated for their usefulness for a given research institute by an expert panel with some assistance from analytics on existing/ simulated data before being used in the research institute. Further, if a research institute mandate does not cover any of the stated KPIs, then before calculating the index, those indicators should be removed and the weightage of other remaining indicators should be adjusted as appropriate.

It is expected that the more the structure of the KPI index is unaltered across research institutes when in use, the validity of comparing research institutes' performance will also be comparatively high for crafting corporate research institute strategies for commercial agriculture development. However, the KPI index proposed here can accommodate any number of complex KPIs easily into its equations without many changes to its original structure. Thus, it is expected to facilitate the incorporation of many complex composite KPIs such as socio-political values and good practices of environmental sustainability easily into its structure, leading to a better decision makings process in an agile research infrastructure framework for the development of the commercial agriculture sector.

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