Online Teaching Quality Management in higher vocational Colleges and under the Background of Regular Epidemic Prevention and Control

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Abstract

The purpose of this research were to describe the current status of online teaching quality management in colleges and universities during regular epidemic prevention and control. Data were collected from 968 students in Nanchang Engineering college, Jiangxi Province, China, through questionnaires and interviews for quantitative and qualitative analyses.

The results of this research showed that as lack of innovation in management concept, lack of professional online teaching platform and difficulties in the implement of student management system, online teaching were facing four dilemmas now. According to the existing problems and causes, this research put forward the promotion strategies of online teaching quality management in colleges and universities.

Keywords: Online Teaching, Quality Management, Higher Vocational College

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Introduction

In 2020, the sudden outbreak of Covid-19 forced the nation to be at home, disrupting our original rhythm of life. At the same time, the original teaching order of more than 2,700 general colleges and universities in China was disrupted, resulting in more than 30 million college students not being able to return to school as scheduled. The Chinese Ministry of Education has launched an initiative entitled Disrupted Classes, Undisputed Learning to provide flexible online learning to hundreds of millions of students from their homes (Huang, et al., 2020). Universities have proposed teaching programs and strategies to combat the epidemic, and actively carried out online live teaching, online homework, online defense, and other distance learning activities to ensure that the negative impact of the epidemic on university teaching is minimized.This large-scale online teaching activity is an unprecedented challenge for universities in terms of teaching methods and quality. The most significant effect due to the Covid-19 outbreak on education was the loss of classroom learning activities as usual (Liguori & Winkler, 2020; Lynch, 2020; Zhang, Wang, & Yang, 2020). There are many differences appeared between online teaching and traditional teaching mode, such as the teaching environment is changed from centralized teaching in a classroom to independent teaching at home; the interpersonal object is changed from multiple co existences with teachers and students to single coexistence with family members; the management mode is changed from “other discipline” to “self-discipline”, from “face-to face” management to “voice-to-voice” and “call-to-action” management, from “familiar management mode” to “exploratory management mode”; from the field supply of learning resources to online resources. At the same time, online teaching in colleges and universities puts forward high requirements on teachers’ and students’ network signals, computer and cell phones and other terminal devices, and requires teachers and students to master online teaching operation methods and skills. Facing all these challenges, it is urgent to explore a new management mode of online teaching.Teaching in higher education is a high- cost, sequential and regular talent training activity, and the training opportunity is often only once. Once the quality of teaching deviates, it will change the original training plan and be detached from what the public needs. Covid-19 has revealed emerging vulnerabilities in education systems around the world. It is now clear that society needs flexible and resilient education systems as we

face unpredictable futures (Ali, 2020). Online teaching in colleges and universities, online is the way, teaching is the essence. To ensure the quality of teaching, the only way to improve the quality of online teaching is to follow the law of teaching management, make effective use of information-based teaching resources and technical means, and establish a more systematic, scientific and efficient comprehensive quality management system with the management goal of improving the teaching effect and improving the quality of talent training.

Concepts and Theories Related to Online teaching

Concept of Online teaching

Online teaching is a kind of teaching activity, and its elements contain: students, teachers, teaching support staff, teaching managers, technical support staff, transaction office staff, terminal equipment, curriculum, teaching environment, and so on (Liu, & Zhang, 2016). The most basic elements are students, teachers, internet, and online courses. Students are developmental people with thinking activity and language communication, abstract ability and learning instinct; teachers are developers of online courses, transmitters of knowledge and evaluators of assessment; the internet has the function of sending and receiving courses; courses are teaching contents, which constitute relevant contents for interdependent, co-developing, indispensable and inseparable relationship among online teaching elements, and it is the interconnection of the four basic elements of online teaching that drives the generation of online teaching system. The quality management of online teaching in colleges and universities should be carried out around the online teaching elements. Online teaching uses information technology to promote the development of diversity in teaching and learning, focuses on teachers' internet operation ability, overcomes the imbalance of teaching resources allocation, breaks the limitations of classrooms, changes teaching contents and teaching methods, and changes the sense of bondage for teachers to supervise students, so as to achieve the teaching goal of innovating talent cultivation and improving the teaching quality in colleges and universities. Online learning activity. Online teaching is a kind of learning activity, which is its most basic nature. It is different from other educational activities of human society and also different from other internet activities.

Compared with the traditional teaching, online teaching has the following important characteristics.

Openness: The traditional teaching method is closed and the course is only available to students on campus. Online teaching courses break the dilemma of not being able to share knowledge in university teaching, and more students can participate in it.

Convenience: The traditional teaching scenario is that teachers teach knowledge in a closed classroom. Online teaching mode breaks the space-time solid plate in traditional teaching, time becomes much freer, and the physical space become much more personalized.

Repeatability: Traditional teaching classes have a fixed teaching schedule, teaching content is difficult to repeat, learning content is not easy to save. Online teaching courses can be saved for playback, review and consolidation at any time, so that knowledge is ingrained into the learner's knowledge system.

Autonomy: Traditional teaching is mainly managed by the head teacher. Online teaching has a relaxed learning atmosphere and is mainly self-managed, with more emphasis on optimizing students' independent thinking and self-restraint.

Personalization: Each learner has individual differences and has different abilities in terms of experience and knowledge reserves and problem-solving abilities. Personalized development is the needs of today's society and also is one of the goals and tasks of online teaching in colleges and universities.

Concepts and Theories Related to quality management

Concept of quality management

Total quality management theory was first cited systematically in the United States, after the total quality management theory achieved a certain degree of success in Emile Durkheim's social view business management in the United States, other countries have followed one by one, and the total quality management theory has been introduced into different enterprises with the target. In the continuous development of TQM theory, according to the latest research, its meaning is defined as "a management approach to achieve long-term success of an organization with quality as the center, with the participation of all employees as the foundation, to satisfy customers and benefit all members of the organization and society" (Liu, 2005). Total Quality Management is a management concept and approach to control and manage in advance and in a comprehensive manner. Its distinctive feature is "total", and

"total" summarizes three levels of characteristics. That is, the horizontal scope of the object involved in the management is comprehensive; vertically speaking, the scope of management is all-round; management involves the whole process. The basic method of total quality management is: one process, four stages and eight steps (Gong, 2003).

One process, which looks at management as a process. The management organization is required to complete various stages of work within the mission time. Four stages, based on the theoretical basis of the management process, American researcher Deming applied it to total quality management and summarized the PDCA cycle, which is also known as the "Deming Cycle". Eight steps, in order to solve and improve quality problems, the four stages in the PDCA cycle can also be specifically divided into eight steps. Planning phase: analyze the current state of management and identify the existing quality problems; conduct attribution analysis of quality problems; weight the factors affecting quality; propose an implementation plan for each factor affecting quality results and produce the plan. Implementation phase: execute the per-defined plan and implement the strategies. Inspection phase: check the specific implementation status of the planned plan. Processing phase: stage evaluation is conducted to develop strengths and improve weaknesses; quality factors that remain to be addressed are proposed and transferred to the next cycle.

Principles of online teaching quality management in colleges and universities

The online teaching quality of colleges and universities is reflected in the comprehensive quality of the students involved in teaching activities from a macro and long-term perspective. We should establish the comprehensive quality concept of coordinated development of knowledge ability, innovation ability and information learning ability and the quality concept that students trained by colleges and universities can adapt to the diversified development of society (Sallis, 1992). The online teaching quality management in colleges and universities is the teaching quality management in which all departments and all members of the university participate together. The principle of all-membership is to focus on human needs, fully mobilize the enthusiasm and creativity of teachers, students and teaching assistants to participate in online teaching management, so that all members have a sense of mission for teaching quality, and teaching managers call on all members to participate in online teaching quality management from many aspects. Online teaching quality management and evaluation in colleges and universities is the inspection and supervision of each process of online teaching implementation, rather than, and not with the management of a certain stage of the traditional

model. The comprehensive quality management system should monitor and regulate the whole process of teaching, so that the preparation process of measures can be monitored in advance, the implementation process can be monitored in the middle of the process, and the rectification process can be monitored afterwards. Online teaching quality is affected by the application of information-based teaching, quality of teachers and students, online teaching objectives and teaching process management, teaching platform and other factors, so teaching quality is the result of the interaction of a system with multiple elements. Therefore, the design of online teaching quality management system must follow the principle of systemic. The online teaching quality management system is designed by using scientific ideas and methods to clarify the accurate weights of each evaluation index and to guide teachers, students and managers to clearly understand the online teaching quality improvement strategy.

Context of a higher vocational college

Higher vocational colleges refer to higher vocational colleges. Higher vocational colleges include higher vocational colleges and higher technical colleges, which is the higher stage of vocational and technical education. Higher vocational education is divided into regular colleges and adult colleges and universities through the national unified entrance examination to admit new students.

In accordance with the spirit of the Higher Education Law of the People's Republic of China and the relevant documents of The State Council, higher vocational education is administered by the provincial people's governments. Under the guidance of the State's macro-policies, the provincial government, based on the actual needs of the economic and social development of the region and combined with the overall situation such as enrollment capacity and employment status, determines the annual enrollment plan, enrollment methods, professional Settings, charging standards and household registration management, issues academic certificates, guides graduates to find employment, and determines the subsidy standard for per student educational expenses. At the same time, it has the responsibility to ensure the quality of education, standardize the order of running schools and improve the conditions of running schools.

Higher vocational education admits new students through a unified national entrance examination. Divided into two categories:

Ordinary universities. It is usually held in June each year. The object of application is mainly the fresh ordinary high school graduates, and the fresh secondary school graduates, vocational high school graduates, technical school graduates (collectively referred to as "three school students") and previous high school graduates can also apply. Among them, "three school students" take the "32 2" method for examination. In addition, schools that hold 5-year higher vocational education can accept fresh junior high school graduates to apply for the entrance examination, which is the same as that of ordinary secondary schools, and is determined by the local administrative department. High school for adults. It is usually held on the first weekend of October each year. Among them, the applicants for higher vocational education include in-service personnel, previous high school graduates and fresh secondary school graduates, vocational high school graduates and technical school graduates, using the "32" method of examination. In December, the province unified admission, the next spring enrollment. It shall be submitted to the provincial administrative department of education for examination and approval. Professional caliber can be wide or narrow, both wide and narrow. The Ministry of Education has formulated the Guide for the Specialty setting of Higher vocational colleges to guide the specialty setting of higher vocational colleges. Graduates have the ability to work directly. At the same time, many schools implement vocational skills assessment and appraisal for students according to the relevant vocational skills assessment standards of the labor and social security departments, so that students can obtain the corresponding academic certificate and vocational qualification certificate at the same time when they graduate.

Thoughts on online quality management of higher vocational colleges under epidemic situation

Thoughts on online quality management of higher vocational colleges under epidemic situation Good online teaching in higher vocational colleges should have the following skills:

Effective knowledge transfer from teachers to students is a crucial aspect of the teaching and learning process. This transfer encompasses various elements such as lesson planning, teaching materials, and learning management techniques. However, in today's dynamic educational landscape, both classroom and online learning environments present unique challenges. Online teaching leverages technology as the primary medium for knowledge transfer and thought exchange. Unlike traditional face-to-face interactions, virtual teaching requires educators to be proficient in utilizing diverse platforms that best suit their teaching

methods. A teacher's adeptness in navigating these technological tools ensures a seamless and convenient knowledge-sharing experience. To achieve this, educators need to be well-versed in the initial usage and understanding of such technologies. Gaining proficiency in basic troubleshooting and addressing internet connectivity issues also contributes to the smoothness of the teaching process.

Moreover, Teaching must be well-informed about copyright laws and intellectual property rights to responsibly use and share information and content. Respecting copyright ensures that the materials used for teaching are legally sourced and attributed, promoting an ethical learning environment. Equipping students with technology skills is equally crucial. Teachers should incorporate technology-related topics in their curriculum, enabling students to not only understand but also effectively utilize various tools and platforms. Fostering students' problem-solving abilities in managing technological challenges during the learning process empowers them to navigate and adapt to different learning environments successfully.

Ultimately, by honing their technology skills, educators can overcome the challenges posed by diverse teaching environments. This, in turn, creates a more seamless and productive teaching and learning experience for both teachers and students alike. With a strong foundation in technology integration and understanding copyright regulations, educators can ensure that knowledge transfer occurs efficiently and effectively, leading to enhanced academic achievements and enriched learning experiences.

2. Encouraging self-learning skills through the integration of online teaching can greatly benefit students' academic development. The key lies in prioritizing content comprehension. By gauging students' understanding, teachers can identify areas where students face difficulties, thereby customizing their teaching approach accordingly. In this context, a shift has occurred, moving from traditional post-class questioning to a proactive approach where students engage with the content before class through a technique known as "Flipped Classroom." The process begins with students reading the assigned content in advance. This not only prepares them for the upcoming class but also highlights any uncertainties they may have. As they encounter doubts or questions while reading, they are encouraged to note them down. These points of confusion serve as valuable feedback for the teacher, enabling them to craft a more targeted and focused teaching plan. The "Flipped Classroom" model entails flipping the conventional sequence of learning activities. Instead of the teacher disseminating information during class time, the primary delivery of content occurs through pre-recorded lectures or other online

resources accessible to students before the class session. As students have already familiarized themselves with the content, the in-class time shifts towards interactive discussions, problem-solving activities, and one-on-one clarifications. During these in-class sessions, teachers address the questions and uncertainties raised by the students. By doing so, educators can ensure that the learning experience caters to the specific needs of their students, making it more engaging and effective. Furthermore, this approach nurtures students' self-learning skills, as they are encouraged to take responsibility for their learning journey. It promotes active participation, critical thinking, and independent problem-solving. Students become more invested in their education, and their confidence grows as they see their inquiries being valued and addressed by the teacher.

In conclusion, integrating online teaching with a focus on content comprehension and utilizing the "Flipped Classroom" model is a powerful way to foster self-learning skills among students. By encouraging pre-class engagement with the content and proactively addressing doubts during in-class sessions, teachers can create a more personalized and impactful learning experience. This approach empowers students to take ownership of their education, equipping them with essential skills for lifelong learning.

Conclusion

Online education during the epidemic has promoted the reform of China's education concept to a certain extent. Higher vocational colleges must realize that a complete and systematic system is the basis of online education management. Higher quality, personalized, equal and mutual assistance online course design is the core of online education management, and building a multi-party cooperative school education certification system is the guarantee of long-term development. At the same time, we realize that advocating online education management in higher vocational colleges is not an alternative to traditional education. On the contrary, traditional education is still fundamental and mainstream. Higher vocational colleges should constantly seek to complement and combine traditional education and online education. Higher vocational colleges should do a good job in online education management, and formulate norms, systems and advanced rules is the core. It is very important for each higher vocational college to study and use big data and information technology to provide you with accurate management plans for the interaction of students and teachers, taking into account the freedom of online learning and ensuring the

standardization of higher vocational college management. Promote the collaboration of various departments and service units in the school to manage online education activities in a systematic and comprehensive way. Higher vocational colleges must break the original campus siege, go out to communicate and cooperate with all parties in society, integrate multi-advantage resources, and continue to upgrade the online education service system of higher vocational colleges. Provide more accurate personalized service. Find multiple values and develop multiple commercialization paths. The development, research and management of online education no longer rely solely on government support, but should seek multiple forces, grasp the flexibility and lifetime of online education, and establish a good endogenous incentive mechanism. So that vocational colleges can have a good and perfect education management system whether during the epidemic or in the offline management state.

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The Impacts of Hospital Logistics Strategies on Performance

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Abstract

This study explores the levels of hospital logistics strategies (i.e. policy and management, central procurement, warehouse management, inventory management, transportation and distribution, as well as information and technology management) and hospital logistics performance (i.e. cost, time, reliability, and safety), and then investigates the effects of logistics strategies on logistics performance. Descriptive statistics and multiple regression analyses were employed to analyze the data from 97 large hospitals in Thailand. The results demonstrated that warehouse management had the highest logistics strategy score, while policy and management received the lowest score. For logistics performance, Thai hospitals performed best in reliability and worst in cost, respectively. Every logistics strategy significantly affected overall performance. Transportation and distribution, as well as information and technology management significantly affected most performance.

Keywords: Logistics Strategy, Logistics Performance, Hospital, Healthcare

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Introduction

Healthcare operations, services and performance have received attentions from many researchers (Feibert and Jacobsen, 2019), (Chang et al., 2019), (Giovanis et al., 2018), (Simons et al., 2017), (Poksinska et al., 2016). Competition in healthcare services and costs are high. Highest costs for healthcare are personnel expense and cost of medical supply, respectively (Mustaffa and Potter, 2009), (Feibert et al., 2019). Healthcare logistics has been developed to improve performance and satisfy customers. Contrasting general business activities, healthcare logistics focuses on patient's safety. Cost is the secondary goal. The key factors of hospital logistics for performance improvement are, for example, procurement, inventory and warehouse management, and distribution of medicine and medical supply.

The government of Thailand has a policy to drive Thailand to an international health center under the campaign "Healthcare Capital of the World" (Department of Health Service Support, 2020). Hospital logistics in Thailand is new and should be improved to enhance logistics performance. Therefore, this research aims to examine the levels of logistics strategies and performance and to study the impacts of logistics strategies on the logistics performance of large hospitals in Thailand.

Literature Review

Logistics strategies have been developed to plan, support, and control the flow of various activities from the beginning to the end in order to meet customer requirements (Langley, 2012). Researchers propose logistics strategies such as policy and management, central procurement, warehouse management, inventory management, transportation and distribution, as well as information and technology management. Policy and management involve operational planning and performance control to set the efficiency of the flow, storage of goods, services, and related information from upstream and downstream to meet customer requirements (La Londe and Masters, 1994). Centralized procurement in healthcare affects the level of public healthcare services (Ferraresi et al., 2021). Warehouse management is the activities including receiving, storing, and delivering goods (Utami et al., 2020). Inventory management is referred to activities relevant to planning and controlling inventories at an appropriate level (Oluwaseyi et al., 2017).

Transportation and distribution in healthcare businesses concern the movement of medicines, medical supplies and medical devices relating to health services (Moons et al., 2019). Information and technology management include planning, collecting, storing, and forwarding data and information to the users (Liao, 2005).

From comprehensive literature review, logistics strategies have an influence on performance. Policy and management can satisfy customers in terms of cost, time, reliability, and security (Langley, 2012), (Ferraresi et al., 2021), (Munson and Hu, 2010). Central procurement affects the cost and time (Athipratchayasakul, 2004). (Kłodawski et al., 2017). Warehouses and inventory management have impacts on cost, time, reliability, and safety (Moons et al., 2019), (Carrus et al., 2015), Vanichchinchai and Apirakkhit (2018) advised that a suitable warehouse location can reduce transportation costs, increase responsiveness and enhance competitiveness. Transportation and distribution have effects on cost, time, and reliability (Feibert and Jacobsen, 2019), (Rossetti et al., 2012). Information and technology management influence cost, time, reliability and safety (Kritchanchai et al., 2018).

In this research, the following hypotheses were established to explore the relationships between logistics strategies and logistics performance of hospitals in Thailand.

H1: Logistics strategies have significant positive impacts on overall logistics performance.

H2: Logistics strategies have significant positive impacts on cost.

H3: Logistics strategies have significant positive impacts on time.

H4: Logistics strategies have significant positive impacts on reliability.

H5: Logistics strategies have significant positive impacts on safety.

Research Methodology

Measurement instruments for hospital logistics strategies were developed from Szymonik (2012) and Syahrir et al. (2018). Research of Kritchanchai et al. (2018) was applied to develop hospital logistics performance measures. Six hospital logistics strategies in this study comprised: policy and management, central procurement, warehouse management, inventory management, transportation and distribution, as well as information and technology management. Each strategy contained five measurement items. Hospital logistics performance in this research was composed of four dimensions: cost, time, reliability, and safety. Each dimension consisted of 5 items. A seven-point Likert scale from 1 (strongly disagree.) to 7 (strongly agree.) was used for assessment. The institutional review board of the university

approved the survey instrument to assure compliance with international guidelines for human research protection.

Hospital logistics is still new in Thailand. Implementation of modern healthcare logistics practices such as central procurement, inventory and warehouse management, transportation network and information technology need significant resources. Generally, many small hospitals especially governmental hospitals lack of resources to invest for modern management systems including healthcare logistics. Then, they may have insufficient logistics maturity levels and are inappropriate samples for this study. As a result, this research concentrated on the large hospital with more than 200 beds. The questionnaires were sent to large hospitals across Thailand via post and e- mail. The respondents were logistics executives of hospitals. 97 valid questionnaires were returned. The sample profiles were shown in Table 1. PASQ statistics 18 was utilized for data analysis.

Table 1: Sample Profiles

Profile	Count	%
Respondent		
Director, deputy director, assistant to director	32	32.99%
Department head	28	28.87%
Others	37	38.14%
Total	97	100.00%
Hospital type		
Governmental (under Ministry of Public Health)	23	23.71%
Governmental (others)	30	30.93%
Private	44	45.36%
Total	97	100.00%
Hospital size		
200 – 599 beds	80	82.47%
600 – 999 beds	10	10.31%
> 1,000 beds	7	7.22%
Total	97	100.00%

Result and Discussion

Table 2 showed level of logistics strategy and performance of sample hospitals. Overall logistics strategy score was 5.95.

The highest and the lowest logistics strategy scores were warehouse management (6.40) and policy and management (4.83) respectively. This implied that Thai hospitals more emphasized physical tangible logistics activities e.g. warehouse management, procurement, inventory management and transportation. Soft policy and management factor received insufficient attention according to Vanichchinchai (2021b). Although intangible policy and management at higher strategic level are difficult to observe and measure, they are key and leading factors to drive efficient and sustainable operational activities at lower level. Thus, Thai hospitals should give more importance to logistics policy and management though providing more commitment and resources such as budget, workforce and time. Such policy and management should be communicated to relevant internal and external logistics stakeholders, too.

The overall logistics performance score was 5.94 and was almost equal to overall logistics strategy (5.95). Reliability had the highest score (6.19), while cost had the lowest score (5.61). This is because the nature of humanitarian or healthcare businesses, which more focuses on safety related activities and less emphasizes cost. However, hospital logistics cost still should be improved without expenses of patient safety. For example, the concepts of lean, which is an operational supply chain management tool/technique (Vanichchinchai, 2019), can be introduced to eliminate wastes or unnecessary activities, leading to lower transaction cost and time with higher safety and quality in healthcare logistics. Accordingly, in Thai hospitals, Vanichchinchai (2021d) advised that the lean had significant positive effects on all service quality performance (i.e. reliability, assurance, tangibility, empathy and responsiveness).

Table 2: Level of Logistics Strategy and Performance

Factor	Mean	S.D.
Hospital logistics strategy		
Overall logistics strategy	5.95	0.89
Policy and management	4.83	1.46
Central procurement	6.34	0.70
Warehouse management	6.40	0.83
Inventory management	6.11	1.23
Transportation and distribution	6.06	0.96
Information and technology management	5.93	1.07
Logistics performance		
Overall logistics performance	5.94	0.97
Cost	5.61	1.30
Time	5.80	1.14
Reliability	6.19	0.83
Safety	6.15	0.88

Cronbach' s alpha coefficients of independent and dependent dimensions ranged between 0.88 and 0.97 confirming the reliability of the measurement instruments. Multiple regression analyses were applied to test the hypotheses as shown in Table 3.

Table 3: Multiple Regression Analysis

Factor	Overall performance			Cost			Time			Reliability			Safety		
	β	t	Sig.	**β**	t	Sig.	**β**	t	Sig.	**β**	t	Sig.	**β**	t	Sig.
A	0.095	5.230	0.000*	0.239	4.531	0.000*	0.176	3.502	0.001*	-0.060	-1.899	0.061	0.031	0.775	0.441
B	0.110	3.071	0.003*	0.132	1.280	0.204	-0.043	-0.436	0.664	0.294	4.761	0.000*	0.029	0.372	0.711
C	-0.186	-3.523	0.001*	-0.238	-1.751	0.083	-0.084	-0.645	0.521	0.221	2.690	0.009*	0.195	1.848	0.068
D	0.066	2.226	0.029*	0.094	1.160	0.249	0.062	0.796	0.428	0.092	1.906	0.060	-0.142	-2.282	0.025*
E	0.440	14.727	0.000*	0.564	6.733	0.000*	0.702	8.799	0.000*	0.128	2.568	0.012*	0.227	3.544	0.001*
F	0.431	14.165	0.000*	0.443	5.040	0.000*	0.246	2.938	0.004*	0.339	6.162	0.000*	0.515	7.289	0.000*
F		565.189			120.571			100.683			138.551			85.611	
Sig.		0.000*			0.000*			0.000*			0.000*			0.000*	
R^2		0.976			0.889			0.870			0.904			0.851	
Adjusted R^2		0.974			0.882			0.862			0.898			0.841	

As shown in Table 3, H1 was supported. All logistics strategies had significant positive impacts on overall logistics performance. This is because these hospital logistics strategies are key factors for logistics performance improvement according to Syahrir et al. (2018). In detail, policy and management, transportation and distribution, and information and technology management significantly affected logistics cost. H2 was accepted. Moons et al. (2019) revealed that transportation was important for delivering medical supplies. In addition, they recommended that hospitals needed a well-defined supply chain policy to align internal logistics processes and control costs. Wang et al. (2018) reported that healthcare information technology had a positive relationship with return on assets and productivity in hospitals. Regarding H3, policy and management, transportation and distribution, and information and technology management had significant effects on time. In order to track products in healthcare services, the connections of people, documents, and things were required. Moons et al. (2019) found that inventory management, data, and technology management should be emphasized to improve healthcare logistics performance. Logistics management should focus on reducing healthcare service time, while maintaining quality (Supeekit et al., 2016). For H4, it was found that information and technology management, central procurement, warehouse management, as well as transportation and distribution had significant impacts on reliability. Ferraresi et al. (2021) advised that the central procurement system increases the efficiency of anti-corruption in public procurement. Kłodawski et al. (2017) revealed that organizing logistics activities improved the cost and reliability of warehousing. Information and technology management, transportation and distribution, as well as inventory management strategies influenced safety. H5 was accepted. Kritchanchai et al. (2018) stated that healthcare logistics must focus on inventory management, data, and technology management to ensure the accuracy and reliability of the information as well as the safety of the patient. Moons et al. (2019) reported that logistics was important for safety, availability, and supply ability.

Conclusion

This research investigated the links between healthcare logistics strategies and performance in Thai hospitals. It revealed that physical logistics strategies (e.g. warehouse management) were strengths, while intangible logistics policy and management were weakness. Therefore, Thai hospitals should give special attentions on soft factors (e.g. policy, commitment, human resource) for efficient and sustainable operational logistics activities, too. Thai hospitals performed well in safety related performance (e.g. reliability, safety). It was recommended that contemporary productivity improvement tools/techniques such as lean should be applied to enhance cost and time performance. Table 4 summarized the effects of hospital logistics strategies on performance. This research found that every healthcare logistics strategy had significant effects on hospital logistics performance. Transportation and distribution, as well as information and technology management significantly affected overall performance and every performance dimension. Accordingly, Kritchanchai et al. (2018) found that information and technology management was a vital strategy to improve the efficiency of healthcare logistics. Reliability was affected by most strategies. As a result, it is recommended that Thai hospitals should improve logistics strategies especially transportation and distribution, and information and technology to enhance performance.

This study collected data from large hospitals only. The applications of logistics strategies and their effects on performance in smaller hospitals should be further researched. Different healthcare units have different practices and performance (Vanichchinchai , 2021a). Thus, the influences of hospital characteristics (e.g. size, care capability) on these relationships should be further investigated. In addition, hospital services are high-contact services, which practices and performance may vary by care providers perceptions and abilities (Vanichchinchai, 2021b), (Vanichchinchai , 2021c). Therefore, the roles of human factors (e.g. care provider satisfaction) on logistics strategies and performance should be explored in future research.

Table 4: Summary of the effects of hospital logistics strategies on performance

Factor	Overall performance	Cost	Time	Reliability	Safety	Total
A	*	*	*			3
B	*			*		2
C	*			*		2
D	*				*	2
E	*	*	*	*	*	5
F	*	*	*	*	*	5
Total	**6**	**3**	**3**	**4**	**3**	**19**

Note: A = policy and management; B = central procurement; C = warehouse management; D = inventory management; E = transportation and distribution; F = information and technology management.

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A Study of Green Logistics Management in Rice Cultivation of Thai Farmers for Sustainability Case Study: Farmers in SAKON NAKHON Province

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Abstract

Thailand has been experiencing agrochemical-based commercial rice production for several decades (Kerdnoi et al., 2014). Such practice is against the national direction - sustainable development goals (SDGs). Therefore, this study observed green logistics (GL) management of rice cultivation processes among Thai farmers in Sakon Nakhon Province, Thailand. Currently, limited studies have investigated this issue. The data was collected from twenty farmers from May 21 – June 20, 2023, using semi-structured in-depth interviews and direct observation methods. The collected data was then analyzed by mainly content analysis method. A purposive sampling strategy was adopted to select interviewees who could provide multiple-round interviews and observations. Only one farmer out of twenty did not adopt any GL practices. Other selectively adopted techniques that suited them and used chemical substances and bio-farming. Current problems identified were farmers' health, rice storage methods, environmental issues, and insufficient GL knowledge among elderly farmers. Many beneficial practices were also found, such as (i) using Trichoderma to suppress the growth of plant pathogenic microorganisms and regulate the rate of plant growth and (ii) breeding and development of seed stock for organic rice. The future study could strengthen the weaknesses above and expand the research scope covering other units in the rice supply chain, embrace farmers of all ages, and encourage government

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agencies to provide more significant support to farmers. The practical training program must include GL content and give more importance to organic farming.

Keywords: Green Logistics, Sustainable Development Goals (SDGs), Rice Cultivation, Green Logistics Strategies

Introduction

"Rice" is a significant economic crop in Thailand and is the staple grain of Thai cuisine. According to the Thai Rice Exporters Association of the year 2022, Thailand is one of the leading rice exporters, with a volume of 3,507,020 tons or 60,932.3 million baht in the first half of 2022. These volumes increased by more than 40% compared to 2021 (Thai Rice Exporters Association, 2022). Still, the problems of farmers' welfare remain unchanged (Kongtip et al., 2018; Titapiwatanakun, 2012).

Pesticide intoxication is one of the significant public health problems in Thailand, and the number of cases regarding the toxic effects of substances usually increases during the growing season of many crops in the rainy season (Tawatsin, 2015). Chemical farming resulted in increasing health problems among farmers (and their families' health) and consumers and concerns about husbandry (e.g., soil degradation and animal welfare) (Pornpratansombat et al., 2011). In addition, most chemical fertilizers, pesticides, gasoline, etc., are not domestic inputs but are imported inputs. Kongtip et al. (2018) collected information on the work activities and conditions of 424 Thai farmers representing five farm types: rice, vegetable, flower, rice/vegetable, and flower/vegetable. Their results were:

"Rice farmers were found to have the highest prevalence of allergies, nasal congestion, wheezing, and acute symptoms after pesticide use, while flower farmers had the lowest prevalence of these health outcomes. Rice farmers reported the highest prevalence of hazardous working conditions, including high noise levels, working on slippery surfaces, sitting or standing on a vibrating machine, spills of chemicals/pesticides, and sharp injuries. (Kongtip et al., 2018, p. 167)"

The above unsustainable manners have significantly impacted humans and the environment, receiving significant attention from all sectors. Organic farming and sustainable agriculture concepts were considered and applied in Thailand. Yanakittkul and Aungvaravong (2020) mentioned that substituting current practices with organic farming is an appropriate solution to these human and environmental problems. This meets the global agenda – Sustainable Development Goals (SDGs), which balances a need for economic, social, and environmental (WCED, 1992). SDGs are the only way to deliver a healthy environment to the next generations. Regarding hazardous working conditions pointed out by Kongtip et al. (2018), the United Nations (2023) mission is to integrate Occupational Safety Health and Risk

Management into daily operations, ensuring that it becomes a natural part of operations' culture, enhancing management and staff cooperation to achieve long-term results. Both unsustainable farming and farmers' poor working conditions are thus critical research opportunities in Thailand.

We preliminary observed rice cultivation processes and their supply chain in Sakon Nakhon Province. The study was undertaken on March 25 and April 25, 2022, and later presented at UTCC (6th UTCC National Conference). As part of a pilot study, this research found that chemical-based farming is a common practice applied across Sakon Nakhon. These hazardous substances are directly harmful to the health of farmers, consumers, and nearby communities. Other unsustainable practices in logistics activities were found, such as poor planning on seed selection, stock management of rice, and delivery. Results obtained from the pilot study above are highly consistent with Kongtip et al. (2018) and Pornpratansombat et al. (2011).

The study of Green Logistics highlights issues that directly impact farmer's health, poor rice storage methods, and environmental impacts. Most issues are compounded by a lack of understanding of GL, particularly amongst the older community. However, reviewing literature found that limited studies in Thailand have provided suitable GL practices to the farmers.

The main objective of this paper is to identify and explore the effects of implementing GL practices for Thai farmers. Addressing Green Logistics (GL) and applying the principles of GL to achieve sustainability could minimize eco-impacts in rice cultivation and promote SDGs, which is our primary objective.

Literature Review

Green Logistics and Its Components

Logistics, as a part of supply chain management, typically includes inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third-party logistics service providers (CSCMP, 2022). Since logistics supports the movements of products, finance, human, and information, it supports business growth of all sizes, increase the efficiency of organization operations, and involves our daily activities (Beamon, 1999). In farming, from the pilot study, logistics activities started from (i)

planning of cultivation, (ii) sourcing of rice grain, fertilizers, machine, etc., (iii) stocking of grain, (iv) cultivation, (v) harvesting and packaging, (vi) distribution (transportation), and (vii) reverse-logistics. However, growing logistics produces a sizeable environmental impact (Aronsson & Brodin, 2006; Sbihi & Eglese, 2010). For example, transportation consumes many fossil fuels, producing high carbon emissions, PM2.5, and noise pollution. Another example is the use of chemical fertilizers that impact the health of farmers and consumers.

Green logistics (GL) is a new discipline that emerged in the last 30-35 years and aims at coping with environmental impacts from logistics activities (Rodrigue et al., 2001). Several authors have given definitions of GL as:

Saroha (2014): *"Efforts to measure and minimize the environmental impact of logistics activities, these activities include a proactive design for disassembly."*

Sibihi & Eglese (2007): *"Producing and distributing goods sustainably, taking account of environmental and social factors."* Therefore, GL measures the environmental impact of different distribution strategies, reducing energy usage in logistics activities, reducing waste, and managing its treatment.

GL provides both eco-benefits and financial benefits (e.g., cost reduction through minimization of resources and waste) and social benefits such as increasing public image (Beamon, 1999; McKinnon & Kreie, 2010; Saroha, 2014). Practitioners must first understand the environmental problems and their impacts and purposes to formulate the best environmental strategies to address the problems (Seroka-Stolka, 2014). This is mainly consistent with the ISO 14001 concept.

The introduction of SDGs in Our Shared Future – 1987 raised growing attention from policymakers, practitioners (both public and private sectors), and academia. Although academic progress is evident, many practitioners have struggled to implement GL. There are four factors affecting GL – company, customers, politics, and society, according to Seroka-Stolka (2014). McKinnon et al. (2015, p.5) stated, "Green logistics is a relatively young but rapidly evolving subject." Research areas suggested by previous authors include small organizations, developing nations using qualitative research methods, and other sectors apart from manufacturing and logistics service providers (Feng et al., 2022; Tseng et al., 2019). Syahruddin and Kalchschmidt (2012) argue that few contributions are available for GSCM/GL in the agricultural sector.

Green Logistics in Sustainable Agriculture

Sustainable agriculture was summarized by Rigby & Cáceres (2001) as follows: integrated pest management, integrated crop management, low-input agriculture, low-input sustainable agriculture, biodynamic farming, and organic farming. Organic farming is a branch of sustainable agriculture. According to Scofield (1986), organic farming emphasizes the concept of 'wholeness,' implying the "systematic connexion or coordination of parts in one whole." Still, the above concept is highly subjective; therefore, we selected other sources for the definition. Lampkin (1994) stated that organic farming is "to create integrated, humane, environmentally and economically sustainable production systems, which maximize reliance on farm-derived renewable resources and the management of ecological and biological processes and interactions, to provide acceptable levels of the crop, livestock, and human nutrition, protection from pests and disease, and an appropriate return to the human and other resources."

Comparing agriculture to supply chain management, Scofield's definition of " wholeness" and "coordination" would be similar to the supply chain that coordinates and integrates all units in the same supply chain. Green supply chain (GSC) is, therefore, difficult to achieve in reality, also in the early stage of organic farming in Thailand. However, the concept of Lampkin that maximizes reliance on a farm refers to the operations in a single farm, which is similar to the concept of GL. Therefore, this study highly adopted the concept of Lampkin through this study.

Nisbet et al. (2005) believe that sustainable agriculture practices in the agricultural supply chain help minimize the environmental impact and provide public reassurance through countermeasures both in and off the chains. Jöhr (2004) suggested increasing environmental awareness, sharing knowledge, tracing, and monitoring practices to encourage sustainable agriculture. Syahruddin & Kalchschmidt (2012) reviewed 80 papers that summarized GL measurements for agriculture as providing healthier and safer products, preserving nature and biodiversity, land use change, minimizing the overuse of water, using renewable energy, more significant economic impacts, and the advancement of sensing, information, automation, and control technologies.

Green Logistics in Rice Cultivations in Thailand

Organic farming re-emerged in Thailand in the early 1980s after the health and environmental effects of improper use and heavy reliance on agrochemicals began manifesting themselves (Pornpratansombat et al., 2011). Past studies observed organic farming, such as Pornpratansombat et al. (2011), Yanakittkul & Aungvaravong (2020), and Suwanmaneepong et al. (2020).

In the Northeast of Thailand, Pornpratansombat et al. (2011) attempted to answer why a more significant proportion of farmers do not adopt organic agriculture. They answered that the essential factors in adopting organic farming were positively significant, including water accessibility, farm-gate price, and attitude to conventional production problems. Yanakittkul and Aungvaravong (2020) needed more support from government agencies, especially for smallholder farmers. They stated that the policy should encourage farmers to join the organic group and support the group regarding water sources, machinery for preparation and harvesting, and low-interest funding. In Chachoengsao Province, Suwanmaneepong et al. (2020) found that information or knowledge that impacts farmers' attitudes toward environmental concerns was the most important reason for adopting organic rice farming. Their results are consistent with the study of Singthongchai (2018). Singthongchai reported that knowledgeable farmers changed the old production system that used chemicals to organic agriculture through the process and various factors, resulting in a model called the "Upstream Model," which will be used as a guideline in this study.

Some studies focused on the development of GL for Sustainability, and Chua-Insoon et al. (2020) reported that farmers, who are essential variables, also need support from organizations or related agencies. GL's development will also help develop and promote sustainability in other areas. Success will lead to sustainability. The main problem was injury, ranging from mild to severe illness, disability, or death, caused by contact with animals, microorganisms, dust, plants, materials, chemicals, driving tractors, and tools used in agriculture. (Setthithum et al., 2013). This problem was from using chemical fertilizers. Dr.Sudarat Chaichalerm (2013) reported that the behavior of farmers during the preliminary screening of sick farmers showed most of them to have abnormal symptoms. It was found that they had been contaminated with these related chemicals. To reduce the contamination of rice when in storage, Srijuan and Thongkamsamut (2016) have focused on how good paddy grains must be stored within a barn in weather-appropriate conditions for construction. There is the idea of improving the barn wall granary rice used in construction using zinc clay to plaster over the galvanized wall. It combines the construction of the materials of the past with the materials of the present. It will help maintain the quality of the rice grains as well.

Regarding fertilizer selection, Yenpoka et al. (2019) found that more than 96.67% of farmers decided to buy chemical fertilizers to help increase rice production. Organic fertilizer is rare, and their production is more complex than chemical fertilizer. In our pilot study, we found both non-chemical and chemical-free farming. They were driven by their attitudes, rice

productivity, production costs, market demand, problems, and obstacles. Rueanchan (2021) stated that these factors are commonly considered among farmers and researchers.

The Analyses of Current Studies

This section presented the results of reviewing the literature regarding green logistics of rice cultivation. These are the keywords used for searching in the central database of Thailand (Thaijo - https://www.tci-thaijo.org/). The results were as follows (see Table 1).

(i) Using 'green logistics, rice' in English found five results; only three articles were relevant,

(ii) Using 'green logistics, rice' in the Thai language found no result, and,

(iii) Using 'green supply chain, rice' in English found four results but redundant with (i) 2 results; so, it can be used only in two articles.

We also searched the above keywords in Google Scholar, which found similar results as in Thaijo. Therefore, there were only five articles for the analysis.

In Thailand, GL was highly studied in, e.g., automobiles, tourism, agriculture, etc. However, in the rice cultivation sector, GL needs more study, as presented in Table 1. Previous studies observed GL as follows. 1. Saengsathien and Namchimplee (2022) observed GL of rice transportation. This is not relevant to rice cultivation. 2. Panmanee et al. (2018) found the best GL practices, such as using NGV and LPG gas. However, their effectiveness can be questioned since they have not tried these practices. In addition, according to CSCMP (2022), these logistics activities were not observed: (i) procurement, (ii) planning of production, and (iii) reverse logistics. So, these cannot provide a complete view of GL. 3. Julsawat et al. (2021) observed ways to reduce the cost of the rice mill, not farmers. Therefore, this study needs to identify a straightforward GL practice for farmers. 4. Chidchob et al. (2019) focused on 'driver' or 'pressure' to go green. They found eight drivers (e.g., rules and regulations, customer pressure). Again, best practices have yet to be identified. Dechanubeksa et al. (2020) estimated GSCM knowledge of entrepreneurs and GSCM impacts on marketing performance.

Reviewing extant literature found these issues. One, holistic GL activities from cultivation planning and rice seed procurement/sourcing to delivery to customers and reverse logistics were nearly absent—best GL practices needed to be demonstrated. Therefore, a clear picture of GL processes and the solutions for unsustainable farming still need to be discovered. This increased difficulty in identifying problems and potential solutions for Thai farmers to meet SDGs. Another is that past authors did not use qualitative methods, so in-depth data is lacking.

Interestingly, these research gaps were quite similar to the studies of Feng et al. (2022) and Tseng et al. (2019).

Table 1: Review of Existing Literature

Author	Topic	Research Method
1. Saengsathien and Namchimplee (2022)	Green point-to-point logistics at Kalasin: A case study of rice transportation	Mathematical model for routing
2. Panmanee et al (2018)	Alternative Logistics Systems for Enhancing Competitiveness of Rice in Chiang Mai, Chiang Rai and Phayao Provinces	-The participatory action research (PAR) and the analytical hierarchy process (AHP) analysis - Focus on cultivation to delivery
3. Julsawat et al (2021)	The Cost Reduction of The Rice Mill by Using Green Logistics and Supply Chain	In-depth interview with nine rice mills
4. Chidchob et al (2019)	Green supply chain management of processing packed rice entrepreneurs in Thailand	Survey-questionnaire 80 Processing packed rice entrepreneur.
5. Dechanubeksa et al (2020)	Green Management on Marketing Performance of Organic Rice Community Enterprise in Maha Sarakham	Survey-questionnaire 169 entrepreneurs of organic rice community enterprise

Research Methods

The central objective of this study is **to observe green logistics management in rice cultivation of Thai farmers for a sustainability case study: farmers in Sakon Nakhon province.**

We selected Sakon Nakhon province because of the following reasons. This research was first conducted as a pilot study in Sakon Nakhon, the home city of one researcher, during COVID-19, which limited access to other provinces. One of the authors, a farmer, found the same problems as indicated by the pilot study: (i) farmers used high chemical substances, and (ii) had poor GL performance. Farmers continued chemical farming without understanding the

effects and better solutions. When discussing these issues on June 6, 2023, with officers in the Office of Provincial Agriculture, Sakon Nakhon, they stated that this problem **was commonly found across Thailand.** They further said, *"For Sakon Nakhon, our office still insufficiently educated farmers because of a limited budget. Therefore, many farmers know only chemical farming methods. GL concept is new for us. Please explore this topic realistically and share knowledge with us."* In short, the findings from studying farmers in Sakon Nakhon can be generalized, as stated by the officers.

We used the qualitative research method, which was adopted since this area has a limited understanding and in-depth information is needed to uproot the problem (Miles & Huberman, 1994; Yin, 2009). We observed logistics activities of farming aimed to search for problems and identified effective solutions consistent with Seroka-Stolka (2014). Semi-structured in-depth interviews and direct observation were crucial data collection methods (see Appendix A). The questions used in the data collection process were developed from the literature, pilot study, and feedback from the UTCC conference (see the questions below). The collected data were analyzed by content analysis focusing only on the field's critical messages (Stemler, 2001). This study's twenty potential respondents were specific volunteers from 257,349 registered farmers in Sakon Nakhon Province. They were selected with the support of the Office of Provincial Agriculture Sakon Nakhon and the Office of Agriculture, which know this area the best. We found that the farmers in Sakon Nakhon province have similar guidelines and procedures. We used criteria to determine the number of volunteers by adhering to the principles of the nature of population (Nature of Population), consistent with Chancharoen (2005). Study on determining samples with little difference or similarity, then a small sample can be used. We have determined the criteria for selecting qualifications: 1) having a domicile in the pilot area to serve as a model for farmers in Sakon Nakhon Province. 2) farming in Sakon Nakhon Province even though it is their own rice field and rent space for farming. 3) provider. The information must cooperate in participating in research activities. 4) the information provider must be between 18 years of age and over and have experience and skills in farming. Hence, the purposeful random sampling strategy selected only farmers who could support this research with multiple rounds of interviews and observations. Therefore, they could be either organic, chemical, or farmers who used both methods. Multiple rounds of data collection were undertaken to increase research validity and reliability. The data collection took place between May 21 and June 20, 2023.

In the early stage of applying green practices in farming, the establishment should be placed in a single organization. This aligns with the organic farming concept of Lampkin (1994) and the GL concept of Dey et al (2011). Dey et al. stated that when the GL practices are firmly implemented, this can be coordinated with others in the supply chain. The pilot study taken in the year 2022 also confirmed this fact. Therefore, we have decided to focus on GL rather than GSCM.

Interview Questions

1. Do farmers know about green logistics and environmental management? (Adapted from research by Tsenga et al., 2018)

2. Do farmers follow the standards or processes of rice farming? (Adapted from research by Thanonkaew, 2016)

3. What are the effects of using chemicals in rice cultivation on the environment, health, and others? (Adapted from the research of Isuwan and Chobtang, 2020 and Setthetham et al., 2013)

4. Have farmers applied the organic farming method? If yes, what are the farming processes (from plant planning to product distribution and reverse logistics) (Adapted from research by Chuea-Insoong et al., 2021; An et al., 2021).

5. Are these farmers aware of the adverse environmental effects on the rice growing process? If yes, what are the guidelines for practice? (Adapted from the research of Li et al., 2022)

6. What are the success factors in farming? (Adapted from research Chochunya et al., 2021)

The Analyses of Results and Discussions

Holistic of Green Logistics in Thai Farming

This section provides a holistic view of logistics operations in rice cultivation (see Figure 1). The process starts with the manure or compost added to the rice field, and the farmers plow their fields before planting. Later, farmers select varieties of rice plants. They often change types of grain every 2-3 years to prevent rice contamination and ensure good yields. Farmers use vehicles (e.g., truck, tractor, and combine harvesters) to support their transportation and farming in all stages. These vehicles can either be purchased, leased, or

rented. Later, the rice grains were soaked in water for approximately two days, and then the grain was packed in a sack for two nights. After this, the processed grains can be sown in the prepared field. Some farmers use cover crops that add organic matter to the soil to enrich soil fertility. Such crops were such as Sunn hemp (Por Thueng) and legumes. After planting them, farmers only plow a little to avoid damaging the topsoil.

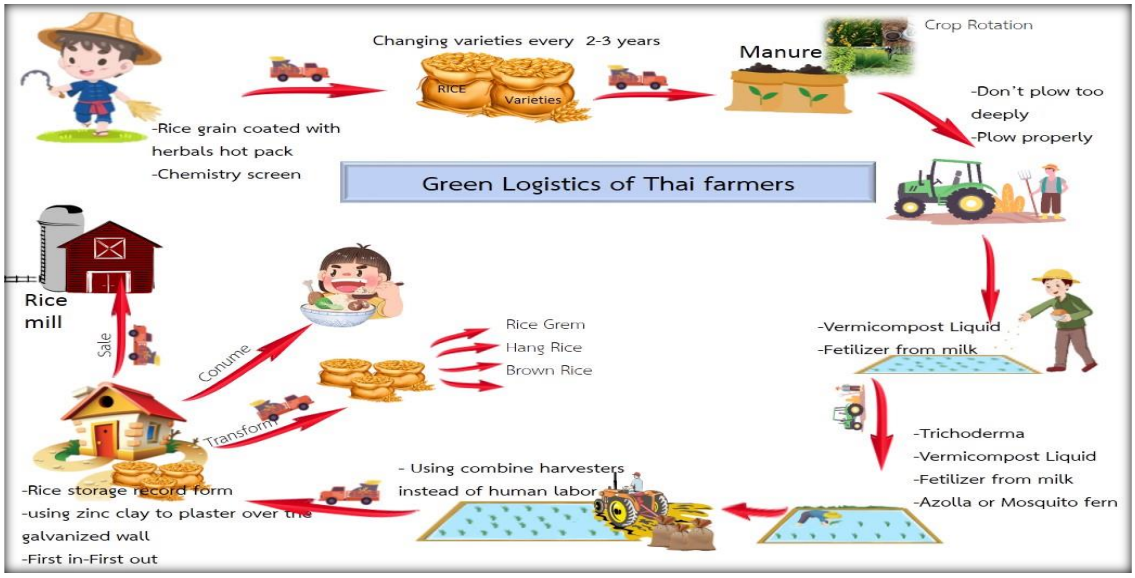

Figure 1: Holistic of Green Logistics in Thai Farming

Source: by Authors.

Furthermore, farmers set the exact schedule and rounds of plowing to reduce the energy consumption of the tractor. Farmers mix vermicompost liquid with milk hormones to prepare the rice grain for growing efficiently to spray the grain. We can also spread these two components on the field before planting. Later, farmers often use Trichoderma, vermicompost liquid, fertilizer, milk hormones, and Azolla to speed up the rice leaf germination. This concentrated liquid must be diluted before use in the field. Farmers often use human labor available in that area during harvest season and tractors for harvesting instead of solely using humans because of higher costs. Farmers transported their grains to the same destinations to save cost and fuel. The harvested grains are packed in the sack and brought to the storage room/area. They often record their rice in stock by using the concept "Oldest to Newest" or FIFO (first in - first out) (see Appendix B). This minimizes the wastage of rice.

Regarding the storage place, farmers are often concerned that the place should have good ventilation to minimize heat and moisture. Both of them can cause the rice to spoil

faster. The rice grain can be managed by three methods: (i) own consumption, (ii) selling the leftovers to the rice mills, and (iii) transforming rice grain into many products such as hung rice and directly distributing to consumers.

Green Logistics for Farmer's Health

We found that health problems were commonly found among respondents. The problems include body aches and pains, which can be relieved by massage, taking medicines, and using rice grain-coated herbal hot packs. This solution is consistent with Phataranit (2013). We found two respondents developing their grain-coated herbal hot packs, which will be them soon. However, the problems with chemical substances were unknown or unrealized among respondents. It is in line with previous studies such as Pornpratansombat et al. (2011), Yaruang and Sukonthasarn (2016), Jaikan et al. (2019), Yanakittkul & Aungvaravong (2020) and Suwanmaneepong et al. (2020). All farmers have never been chemically screened. They have a primary health checkup according to the symptoms of illness, e.g., dizziness, allergic reactions, rashes from soaking in water that has chemicals, and difficulty breathing from inhaling chemicals. Yaruang and Sukonthasarn (2016) undertook a blood test for chemicals among farmers. These researchers found that more than 50% of those who took blood tests had chemicals in their blood that could affect their long-term health conditions. The most common effects of exposure to these chemicals were eye irritation, respiratory symptoms, sore throat, and nasal irritation. The best way to prevent this is to reduce the use of chemicals, not smoke during spraying, not eat or drink water, shower immediately after spraying pesticides, and keep chemicals in separate storage areas (Jaikan et al., 2019).

Another problem was cancer from using chemicals. Many studies found that those who used to work in agriculture were more at risk than those who had never worked in agriculture. Lerro et al. (2020) studied the use of Dicamba herbicides in US agriculture and found that Dicamba is associated with cancer.

Environmentally-friendly rice storage

This research found that 75% of farmers store their rice in barns. Srijuan and Thongkamsamut (2016) proposed a guideline for using materials that exist in nature, such as Peia soil (ancient clay used to build walls in the past). Using Peia soil to insulate the barn walls effectively reduced heat transfer and prevented moisture better than other materials. We also found that 25% of farmers store rice at home for the inconvenience. This practice resulted in

the mixing of old rice and new rice. Since rice has its lifetime, segregating old and new rice should be done. To solve the problem, we proposed guidelines and developed a record form for effectively storing rice (see Appendix C). The guidelines and form were distributed to all respondents. We found that only 11 farmers used the form because it helps to know the current volumes of rice in stock and discharged. Nine farmers did not use the form because they needed more rice. When applying the FIFO system, Butphrom et al. (2018) FIFO reduces the cost of storing products and mistakes in data.

Green Logistics in rice cultivation for sustainability

The study found that only 30% of farmers have sustainable knowledge. This problem requires more significant support from the government, consistent with Singthongchai (2018), Yanakittkul & Aungvaravong (2020), and Suwanmaneepong et al. (2020). Farmers who can apply the principles of GL for rice cultivation were such as young farmers trained at the Sakon Nakhon Provincial Agriculture Office. The office has a Smart Farmer project for farmers over 45 years old, with each district organizing a training course each year for 10 cases (farmers). The government allocated a budget for the study trips to organic farming. The network should be expanded to increase learning, exchange experiences, and gather best GL practices for farmers. The network saves government and farmer's costs (Klomthongcharoen, 2017; Yanakittkul & Aungvaravong, 2020). Effective GL practices from respondents can be summarized as follows (see also Appendix D).

- Manure: The most commonly used manures are made from cow dung. The manure gradually releases nutrients to the rice plants throughout rice growth. It contributes to improved soil structure and water infiltration. Farmers should use the manure in the correct volume, at the right time, and with a suitable method (WanidaWattanapayapkul, 2015). The current cost of buying dried manure is 35 baht per sack (20 kilograms). Farmers often use two sacks of manure per 1 Rai.

- Vermicompost Liquid: Commonly, farmers raise earthworms in trays or basins that have drainage holes. The bedding materials for earthworms are a mixture of manure and soil. Farmers feed their earthworms with vegetable scraps or weeds, raise them indoors, and need frequent watering. After feeding the earthworm for 40-45 days, it is ready to produce the vermicompost liquid. The liquid is mixed with molasses and water and is fermented for about 15 days. Before use, the fermented liquid must be diluted – 1- liter vermicompost liquid with 20 liters of water. Then, the diluted liquid is sprayed on the field after plowing. Saichon

Sukyanakij et al. (2021) reported that using vermicompost liquid resulted in higher soil organic matter, Nitrogen, and Phosphorus. Our study confirms a higher crop yield when using vermicompost instead of chemical fertilizer. This practice is cost-saving (about 150-200 Baht) since farmers only invest in feeding equipment and molasse, while earthworms can be obtained from natural sources.

- Azolla: These are processes of raising Azolla: 1) prepare the pond by digging it for about 30- 40 centimeters deep, 2) bed the pond with a plastic sheet, 3) add manure and soil into the pond, 4) fill the pond with water, 5) add Azolla in the pond, and 6) after 15-21 days of rooting, we can move the Azolla for propagation or use in the field. This plant is also a good nitrogen source for rice cultivation and effectively kills weeds. The cost of raising Azolla is about 1000 Baht.

- Trichoderma: This fungus is effective in controlling plant diseases, preventing fungi, resistance to pathogens, and promoting plant growth. (Kaewchai, 2012). Trichoderma costs 5 kilograms per 350 baht. 1 kg of Trichoderma powder is mixed with 100 liters of water per 1 Rai. Spreading diluted Trichoderma on the field accelerated the tillering stage of rice and rice growth. Interestingly, most farmers still do not know about Trichoderma. Therefore, agricultural agencies should disseminate this valuable information to farmers.

- Cultivation: Before planting rice, farmers should grow cover crops such as legumes and Pothueng to restore the soil's physical, chemical, biological, and organic properties. This practice improves the structure of the soil; therefore, rice will grow better (Chuenjit Kaewkanya, 2011). The cost of using Pothueng was as follows: 1) Pothueng seed is 35 baht per kilogram (1 Rai uses 3-5 kilograms), 2) plowing for planting is 300 baht/1 Rai. 3) harvesting requires manual labor costs of 300-600 baht/1 Rai, and 4) other expenses are 100 baht/1 Rai. Therefore, the average total cost is 775 to 1100 baht/1 Rai. The average maximum yield of Pothueng is 120 kilograms, which can sell at an average of 25 baht per kilogram. Therefore, farmers earn about 2,000-3,000 baht per Rai. However, farmers should be concerned that growing Pothueng often takes 120-130 days. In addition, other factors can impact the cultivation, such as soil fertility and irrigation.

- Milk hormones: The procedures for making milk hormone are as follows: 1) mixes spoiled milk (100 kg) with molasses (1 kg), bio-fermented (200 ml), and one teaspoon of yeast, 2) stores mixed liquid in a black tank with a lid and leave it for one month, 3) After that, mixes 10 ml of milk hormone with 20 liters of water and spray onto the soil for plowing. The hormone accelerates rice germination and growth of rice. Costs of making hormones include

spoiled milk (100 kilograms per 300 baht), molasses (1 kilogram per 15 baht), yeast (1 kilogram per 200 baht), bio extract (85 baht per liter), and a black tank with a lid (300 baht). Therefore, the average cost of making milk hormones is about 900 baht (References to the price from the equipment agricultural materials store in Sakon Nakhon Province).

Obstacles to changing to organic agriculture in rice cultivation

The results indicated that farmers' beliefs, insufficient knowledge, and adoption costs were significant barriers to adopting agriculture. This is consistent with previous studies such as Jöhr (2004), Yanakittkul & Aungvaravong (2020), Suwanmaneepong et al. (2020), and Singthongchai (2018). Most farmers believe that organic agriculture has a higher cost than chemical farming. However, if the farmers have organic knowledge, they can adopt a cost-saving practice that reduces total cost, increases crop yield and revenue, raises soil fertility in the long term, and promotes health. Chochanya et al. (2021) reported that the competency of Thai farmers who were successful in farming had three main aspects, including the knowledge of organic farming, integrated farming, and new theory agriculture, which can be developed in good practice. This study asserted the gaps between the knowledge and practices of farmers. Therefore, government agencies and other institutions, such as universities, should encourage farmers to become members of organic farming networks. Farmers who are members of agricultural cooperatives will understand the importance of organic agriculture and become one of those successful farmers. This is because many best practices/practitioners, training, and support will encourage farmers to develop more organic practices (Somsrisai & Poungngamchuen, 2009).

Another significant barrier is that Thailand still needs more communication explaining the adverse results of chemical farming practices. The government agencies did not undertake farmers' blood tests and physical checks to identify the outcomes of chemical usage. Wanudom (2018) reported that conflicts between the government sector and those involved in agrochemical policy cause communication delays and policy problems that go against state practice and government sector-provided information that deliberately distorts the truth. Therefore, the government sector must have clear communication rights and pay more attention to the policy to support reducing the use of chemicals in agriculture. To do this, the organic farming network can support this communication. Local government authorities such as district health promotion hospitals, subdistrict administrative organizations, and village headmen are responsible for promoting sustainable health according to the national direction.

If communications are well cooperated, the community or farmers will recognize and comply with the policy to effectively reduce the use of chemicals in agriculture (Wanudom, 2022).

Green Logistics practices in rice cultivation for sustainability.

Table 2: Cost and CO2 emissions of GL practices in rice growing process

GL practices	Cost	Emissions CO_2	Benefits
1. Keep rice varieties.	-		- Reduce costs
2. Buy rice varieties from other sources	650 baht/25 kg.		- Prevents mixing of rice varieties
3. Buffalo plows the field	-		- Reduce costs
4. Tractor	300-400 baht/1 rai		- Save time
5. Manure	35 baht/1 sack/30 kg.		- Increase minerals in the soil
6. Vermicompost Liquid	165 baht	632.45 kg. CO_2 /rai or 2.01 kg. CO_2 /Paddy 1 kg.	- Increase organic matter in the soil
7. Azolla	1,000 baht/rai		- Increase nitrogen - Get rid of weeds
8. Trichoderma	350 baht/5 kg.		- Accelerate tillering - Accelerate growth
9. Milk hormones	900 baht		- Accelerate tillering
10. Cultivation	775 baht/1 rai		- Restoring deteriorated soil - increase income
11. Human labor (harvesting rice, planting)	300-400 baht/1 rai (2 people/rai/1 day)		- Save fuel - Can make use of rice straw
12. Transportation	10-15 km./ 1 liter/31.94 baht		- Save time

The table shows the costs and CO_2 emissions of the GL practices in the rice cultivation process for the cost of rice varieties, a reference from the Sakon Nakhon Rice Seed Center. Labor wages Tractor wages Production of various organic fertilizers, including manure, vermicompost, Azolla, fresh milk hormones, and Trichoderma fungi. Based on information from volunteers and agricultural equipment stores in Sakon Nakhon Province. For the price of petrol, refer to information from PTT Public Company Limited (information as of August 17, 2023). The fuel

consumption rate of cars is based on information from CHOBROD Co., Ltd. (2023). CO2 emissions based on research articles of the Climate Change Science Institute (CAA) (2020).

Conclusions

This research observed green logistics management in rice cultivation of Thai farmers in Sakon Nakhon Province. This topic received attention among scholars, particularly organic issues. The GL focuses were from planting planning to delivery and reverse logistics, in which limited studies have observed this. In addition, the study area - Sakon Nakhon Province differs from others in terms of purpose, content scope, population, and relevant factors. The data was collected from twenty farmers from May 21 to June 20, 2023, using semi-structured, in-depth interviews and direct observation.

The results of the current problems were identified. Firstly, farmers' health problems range from regular pains to an accumulation of harmful chemicals in their bodies, which can cause cancer. Secondly, the rice storage method uses Peia soil (clay used to build walls) to improve air ventilation and retain rice quality effectively. New rice was often mixed with old rice, in which FIFO practices should be adopted to extend the rice's lifespan. Thirdly, many farmers often solely use chemical fertilizers or simultaneously use organic fertilizers to maximize crop yield. Several best practices were identified by respondents: using manure, Vermicompost Liquid, raising Azolla, rotating crops, using Trichoderma, and using milk hormones. This increases the quality of rice production, minimizing costs and generating more significant income than chemical farming. Lastly, farmers demonstrated insufficient environmental knowledge, particularly elderly farmers. Knowledge regarding both environment and organic farming should be given to farmers.

The government should organize training programs for farmers, using departments such as the Provincial Agricultural Office, District Agriculture Office, and Bank for Agriculture and Agricultural. The practical training program must include (i) the negative impacts of chemical farming, (ii) physical health checks, (iii) the organic farming methods, and (iv) logistics activities and GL. The program can be supported by local hospitals and organic farming networks in Thailand (Soroslikhit et al., 2008). We have offered this training program to officials in Provincial Agriculture Sakon Nakhon. They strongly agree that the next training should include GL content and give more importance to organic farming to farmers.

Zhu et al. (2012) reported that the government can also play a role by encouraging, through incentives or demonstration projects, the promotion of core supply chain enterprises. This study can provide implications for the agricultural sector and government authorities in other provinces and countries. The government should provide training in agriculture to embrace not only young farmers but also farmers of all ages, such as extract training programs and organic farming training programs to help all farmers learn and apply the knowledge to develop their careers. Farmers still need health care for themselves and to be aware of the effects of using chemicals in farming. So, perception of potential health problems is essential for them. The government should communicate with farmers to expedite policy formulation to support farmers' medical checkups by coordinating with community memorial hospitals and resolving policy to urgently reduce the use of chemicals to reduce the risk of cancer among farmers. Agricultural offices visit the area to provide knowledge for farmers. Personnel of the Bank for Agriculture and Agricultural Cooperatives should release information for farmers who are members of the Bank to make farmers aware of their health. So, government agencies and universities should take greater responsibility to promote national Sustainable Development Goals (SDGs).

Limitations of Research and Future Study

The scope of this study is limited only to rice farmers in Sakon Nakhon province. Therefore, the general views of the rice supply chain, farmers across Thailand, and other crops must be included. Future studies should expand this scope, covering all units in the supply chain. Integrated research teams for these disciplines are needed, including agriculture, medicine, business, and supply chain.

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A Study of Green Logistics Management in Rice Cultivation of Thai Farmers for Sustainability Case Study: Farmers in SAKON NAKHON Province

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Abstract

Thailand has been experiencing agrochemical-based commercial rice production for several decades (Kerdnoi et al., 2014). Such practice is against the national direction - sustainable development goals (SDGs). Therefore, this study observed green logistics (GL) management of rice cultivation processes among Thai farmers in Sakon Nakhon Province, Thailand. Currently, limited studies have investigated this issue. The data was collected from twenty farmers from May 21 – June 20, 2023, using semi-structured in-depth interviews and direct observation methods. The collected data was then analyzed by mainly content analysis method. A purposive sampling strategy was adopted to select interviewees who could provide multiple-round interviews and observations. Only one farmer out of twenty did not adopt any GL practices. Other selectively adopted techniques that suited them and used chemical substances and bio-farming. Current problems identified were farmers' health, rice storage methods, environmental issues, and insufficient GL knowledge among elderly farmers. Many beneficial practices were also found, such as (i) using Trichoderma to suppress the growth of plant pathogenic microorganisms and regulate the rate of plant growth and (ii) breeding and development of seed stock for organic rice. The future study could strengthen the weaknesses above and expand the research scope covering other units in the rice supply chain, embrace farmers of all ages, and encourage government

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agencies to provide more significant support to farmers. The practical training program must include GL content and give more importance to organic farming.

Keywords: Green Logistics, Sustainable Development Goals (SDGs), Rice Cultivation, Green Logistics Strategies

Introduction

"Rice" is a significant economic crop in Thailand and is the staple grain of Thai cuisine. According to the Thai Rice Exporters Association of the year 2022, Thailand is one of the leading rice exporters, with a volume of 3,507,020 tons or 60,932.3 million baht in the first half of 2022. These volumes increased by more than 40% compared to 2021 (Thai Rice Exporters Association, 2022). Still, the problems of farmers' welfare remain unchanged (Kongtip et al., 2018; Titapiwatanakun, 2012).

Pesticide intoxication is one of the significant public health problems in Thailand, and the number of cases regarding the toxic effects of substances usually increases during the growing season of many crops in the rainy season (Tawatsin, 2015). Chemical farming resulted in increasing health problems among farmers (and their families' health) and consumers and concerns about husbandry (e.g., soil degradation and animal welfare) (Pornpratansombat et al., 2011). In addition, most chemical fertilizers, pesticides, gasoline, etc., are not domestic inputs but are imported inputs. Kongtip et al. (2018) collected information on the work activities and conditions of 424 Thai farmers representing five farm types: rice, vegetable, flower, rice/vegetable, and flower/vegetable. Their results were:

"Rice farmers were found to have the highest prevalence of allergies, nasal congestion, wheezing, and acute symptoms after pesticide use, while flower farmers had the lowest prevalence of these health outcomes. Rice farmers reported the highest prevalence of hazardous working conditions, including high noise levels, working on slippery surfaces, sitting or standing on a vibrating machine, spills of chemicals/pesticides, and sharp injuries. (Kongtip et al., 2018, p. 167)"

The above unsustainable manners have significantly impacted humans and the environment, receiving significant attention from all sectors. Organic farming and sustainable agriculture concepts were considered and applied in Thailand. Yanakittkul and Aungvaravong (2020) mentioned that substituting current practices with organic farming is an appropriate solution to these human and environmental problems. This meets the global agenda – Sustainable Development Goals (SDGs), which balances a need for economic, social, and environmental (WCED, 1992). SDGs are the only way to deliver a healthy environment to the next generations. Regarding hazardous working conditions pointed out by Kongtip et al. (2018), the United Nations (2023) mission is to integrate Occupational Safety Health and Risk

Management into daily operations, ensuring that it becomes a natural part of operations' culture, enhancing management and staff cooperation to achieve long-term results. Both unsustainable farming and farmers' poor working conditions are thus critical research opportunities in Thailand.

We preliminary observed rice cultivation processes and their supply chain in Sakon Nakhon Province. The study was undertaken on March 25 and April 25, 2022, and later presented at UTCC (6th UTCC National Conference). As part of a pilot study, this research found that chemical-based farming is a common practice applied across Sakon Nakhon. These hazardous substances are directly harmful to the health of farmers, consumers, and nearby communities. Other unsustainable practices in logistics activities were found, such as poor planning on seed selection, stock management of rice, and delivery. Results obtained from the pilot study above are highly consistent with Kongtip et al. (2018) and Pornpratansombat et al. (2011).

The study of Green Logistics highlights issues that directly impact farmer's health, poor rice storage methods, and environmental impacts. Most issues are compounded by a lack of understanding of GL, particularly amongst the older community. However, reviewing literature found that limited studies in Thailand have provided suitable GL practices to the farmers.

The main objective of this paper is to identify and explore the effects of implementing GL practices for Thai farmers. Addressing Green Logistics (GL) and applying the principles of GL to achieve sustainability could minimize eco-impacts in rice cultivation and promote SDGs, which is our primary objective.

Literature Review

Green Logistics and Its Components

Logistics, as a part of supply chain management, typically includes inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third-party logistics service providers (CSCMP, 2022). Since logistics supports the movements of products, finance, human, and information, it supports business growth of all sizes, increase the efficiency of organization operations, and involves our daily activities (Beamon, 1999). In farming, from the pilot study, logistics activities started from (i)

planning of cultivation, (ii) sourcing of rice grain, fertilizers, machine, etc., (iii) stocking of grain, (iv) cultivation, (v) harvesting and packaging, (vi) distribution (transportation), and (vii) reverse-logistics. However, growing logistics produces a sizeable environmental impact (Aronsson & Brodin, 2006; Sbihi & Eglese, 2010). For example, transportation consumes many fossil fuels, producing high carbon emissions, PM2.5, and noise pollution. Another example is the use of chemical fertilizers that impact the health of farmers and consumers.

Green logistics (GL) is a new discipline that emerged in the last 30-35 years and aims at coping with environmental impacts from logistics activities (Rodrigue et al., 2001). Several authors have given definitions of GL as:

Saroha (2014): *"Efforts to measure and minimize the environmental impact of logistics activities, these activities include a proactive design for disassembly."*

Sibihi & Eglese (2007): *"Producing and distributing goods sustainably, taking account of environmental and social factors."* Therefore, GL measures the environmental impact of different distribution strategies, reducing energy usage in logistics activities, reducing waste, and managing its treatment.

GL provides both eco-benefits and financial benefits (e.g., cost reduction through minimization of resources and waste) and social benefits such as increasing public image (Beamon, 1999; McKinnon & Kreie, 2010; Saroha, 2014). Practitioners must first understand the environmental problems and their impacts and purposes to formulate the best environmental strategies to address the problems (Seroka-Stolka, 2014). This is mainly consistent with the ISO 14001 concept.

The introduction of SDGs in Our Shared Future – 1987 raised growing attention from policymakers, practitioners (both public and private sectors), and academia. Although academic progress is evident, many practitioners have struggled to implement GL. There are four factors affecting GL – company, customers, politics, and society, according to Seroka-Stolka (2014). McKinnon et al. (2015, p.5) stated, "Green logistics is a relatively young but rapidly evolving subject." Research areas suggested by previous authors include small organizations, developing nations using qualitative research methods, and other sectors apart from manufacturing and logistics service providers (Feng et al., 2022; Tseng et al., 2019). Syahruddin and Kalchschmidt (2012) argue that few contributions are available for GSCM/GL in the agricultural sector.

Green Logistics in Sustainable Agriculture

Sustainable agriculture was summarized by Rigby & Cáceres (2001) as follows: integrated pest management, integrated crop management, low-input agriculture, low-input sustainable agriculture, biodynamic farming, and organic farming. Organic farming is a branch of sustainable agriculture. According to Scofield (1986), organic farming emphasizes the concept of 'wholeness,' implying the "systematic connexion or coordination of parts in one whole." Still, the above concept is highly subjective; therefore, we selected other sources for the definition. Lampkin (1994) stated that organic farming is "to create integrated, humane, environmentally and economically sustainable production systems, which maximize reliance on farm-derived renewable resources and the management of ecological and biological processes and interactions, to provide acceptable levels of the crop, livestock, and human nutrition, protection from pests and disease, and an appropriate return to the human and other resources."

Comparing agriculture to supply chain management, Scofield's definition of " wholeness" and "coordination" would be similar to the supply chain that coordinates and integrates all units in the same supply chain. Green supply chain (GSC) is, therefore, difficult to achieve in reality, also in the early stage of organic farming in Thailand. However, the concept of Lampkin that maximizes reliance on a farm refers to the operations in a single farm, which is similar to the concept of GL. Therefore, this study highly adopted the concept of Lampkin through this study.

Nisbet et al. (2005) believe that sustainable agriculture practices in the agricultural supply chain help minimize the environmental impact and provide public reassurance through countermeasures both in and off the chains. Jöhr (2004) suggested increasing environmental awareness, sharing knowledge, tracing, and monitoring practices to encourage sustainable agriculture. Syahruddin & Kalchschmidt (2012) reviewed 80 papers that summarized GL measurements for agriculture as providing healthier and safer products, preserving nature and biodiversity, land use change, minimizing the overuse of water, using renewable energy, more significant economic impacts, and the advancement of sensing, information, automation, and control technologies.

Green Logistics in Rice Cultivations in Thailand

Organic farming re-emerged in Thailand in the early 1980s after the health and environmental effects of improper use and heavy reliance on agrochemicals began manifesting themselves (Pornpratansombat et al., 2011). Past studies observed organic farming, such as Pornpratansombat et al. (2011), Yanakittkul & Aungvaravong (2020), and Suwanmaneepong et al. (2020).

In the Northeast of Thailand, Pornpratansombat et al. (2011) attempted to answer why a more significant proportion of farmers do not adopt organic agriculture. They answered that the essential factors in adopting organic farming were positively significant, including water accessibility, farm-gate price, and attitude to conventional production problems. Yanakittkul and Aungvaravong (2020) needed more support from government agencies, especially for smallholder farmers. They stated that the policy should encourage farmers to join the organic group and support the group regarding water sources, machinery for preparation and harvesting, and low-interest funding. In Chachoengsao Province, Suwanmaneepong et al. (2020) found that information or knowledge that impacts farmers' attitudes toward environmental concerns was the most important reason for adopting organic rice farming. Their results are consistent with the study of Singthongchai (2018). Singthongchai reported that knowledgeable farmers changed the old production system that used chemicals to organic agriculture through the process and various factors, resulting in a model called the "Upstream Model," which will be used as a guideline in this study.

Some studies focused on the development of GL for Sustainability, and Chua-Insoon et al. (2020) reported that farmers, who are essential variables, also need support from organizations or related agencies. GL's development will also help develop and promote sustainability in other areas. Success will lead to sustainability. The main problem was injury, ranging from mild to severe illness, disability, or death, caused by contact with animals, microorganisms, dust, plants, materials, chemicals, driving tractors, and tools used in agriculture. (Setthithum et al., 2013). This problem was from using chemical fertilizers. Dr. Sudarat Chaichalerm (2013) reported that the behavior of farmers during the preliminary screening of sick farmers showed most of them to have abnormal symptoms. It was found that they had been contaminated with these related chemicals. To reduce the contamination of rice when in storage, Srijuan and Thongkamsamut (2016) have focused on how good paddy grains must be stored within a barn in weather-appropriate conditions for construction. There is the idea of improving the barn wall granary rice used in construction using zinc clay to plaster over the galvanized wall. It combines the construction of the materials of the past with the materials of the present. It will help maintain the quality of the rice grains as well.

Regarding fertilizer selection, Yenpoka et al. (2019) found that more than 96.67% of farmers decided to buy chemical fertilizers to help increase rice production. Organic fertilizer is rare, and their production is more complex than chemical fertilizer. In our pilot study, we found both non-chemical and chemical-free farming. They were driven by their attitudes, rice

productivity, production costs, market demand, problems, and obstacles. Rueanchan (2021) stated that these factors are commonly considered among farmers and researchers.

The Analyses of Current Studies

This section presented the results of reviewing the literature regarding green logistics of rice cultivation. These are the keywords used for searching in the central database of Thailand (Thaijo - https://www.tci-thaijo.org/). The results were as follows (see Table 1).

(i) Using 'green logistics, rice' in English found five results; only three articles were relevant,

(ii) Using 'green logistics, rice' in the Thai language found no result, and,

(iii) Using 'green supply chain, rice' in English found four results but redundant with (i) 2 results; so, it can be used only in two articles.

We also searched the above keywords in Google Scholar, which found similar results as in Thaijo. Therefore, there were only five articles for the analysis.

In Thailand, GL was highly studied in, e.g., automobiles, tourism, agriculture, etc. However, in the rice cultivation sector, GL needs more study, as presented in Table 1. Previous studies observed GL as follows. 1. Saengsathien and Namchimplee (2022) observed GL of rice transportation. This is not relevant to rice cultivation. 2. Panmanee et al. (2018) found the best GL practices, such as using NGV and LPG gas. However, their effectiveness can be questioned since they have not tried these practices. In addition, according to CSCMP (2022), these logistics activities were not observed: (i) procurement, (ii) planning of production, and (iii) reverse logistics. So, these cannot provide a complete view of GL. 3. Julsawat et al. (2021) observed ways to reduce the cost of the rice mill, not farmers. Therefore, this study needs to identify a straightforward GL practice for farmers. 4. Chidchob et al. (2019) focused on 'driver' or 'pressure' to go green. They found eight drivers (e.g., rules and regulations, customer pressure). Again, best practices have yet to be identified. Dechanubeksa et al. (2020) estimated GSCM knowledge of entrepreneurs and GSCM impacts on marketing performance.

Reviewing extant literature found these issues. One, holistic GL activities from cultivation planning and rice seed procurement/sourcing to delivery to customers and reverse logistics were nearly absent—best GL practices needed to be demonstrated. Therefore, a clear picture of GL processes and the solutions for unsustainable farming still need to be discovered. This increased difficulty in identifying problems and potential solutions for Thai farmers to meet SDGs. Another is that past authors did not use qualitative methods, so in-depth data is lacking.

Interestingly, these research gaps were quite similar to the studies of Feng et al. (2022) and Tseng et al. (2019).

Table 1: Review of Existing Literature

Author	Topic	Research Method
1. Saengsathien and Namchimplee (2022)	Green point-to-point logistics at Kalasin: A case study of rice transportation	Mathematical model for routing
2. Panmanee et al (2018)	Alternative Logistics Systems for Enhancing Competitiveness of Rice in Chiang Mai, Chiang Rai and Phayao Provinces	-The participatory action research (PAR) and the analytical hierarchy process (AHP) analysis - Focus on cultivation to delivery
3. Julsawat et al (2021)	The Cost Reduction of The Rice Mill by Using Green Logistics and Supply Chain	In-depth interview with nine rice mills
4. Chidchob et al (2019)	Green supply chain management of processing packed rice entrepreneurs in Thailand	Survey-questionnaire 80 Processing packed rice entrepreneur.
5. Dechanubeksa et al (2020)	Green Management on Marketing Performance of Organic Rice Community Enterprise in Maha Sarakham	Survey-questionnaire 169 entrepreneurs of organic rice community enterprise

Research Methods

The central objective of this study is **to observe green logistics management in rice cultivation of Thai farmers for a sustainability case study: farmers in Sakon Nakhon province.**

We selected Sakon Nakhon province because of the following reasons. This research was first conducted as a pilot study in Sakon Nakhon, the home city of one researcher, during COVID-19, which limited access to other provinces. One of the authors, a farmer, found the same problems as indicated by the pilot study: (i) farmers used high chemical substances, and (ii) had poor GL performance. Farmers continued chemical farming without understanding the

effects and better solutions. When discussing these issues on June 6, 2023, with officers in the Office of Provincial Agriculture, Sakon Nakhon, they stated that this problem **was commonly found across Thailand.** They further said, *"For Sakon Nakhon, our office still insufficiently educated farmers because of a limited budget. Therefore, many farmers know only chemical farming methods. GL concept is new for us. Please explore this topic realistically and share knowledge with us."* In short, the findings from studying farmers in Sakon Nakhon can be generalized, as stated by the officers.

We used the qualitative research method, which was adopted since this area has a limited understanding and in-depth information is needed to uproot the problem (Miles & Huberman, 1994; Yin, 2009). We observed logistics activities of farming aimed to search for problems and identified effective solutions consistent with Seroka-Stolka (2014). Semi-structured in-depth interviews and direct observation were crucial data collection methods (see Appendix A). The questions used in the data collection process were developed from the literature, pilot study, and feedback from the UTCC conference (see the questions below). The collected data were analyzed by content analysis focusing only on the field's critical messages (Stemler, 2001). This study's twenty potential respondents were specific volunteers from 257,349 registered farmers in Sakon Nakhon Province. They were selected with the support of the Office of Provincial Agriculture Sakon Nakhon and the Office of Agriculture, which know this area the best. We found that the farmers in Sakon Nakhon province have similar guidelines and procedures. We used criteria to determine the number of volunteers by adhering to the principles of the nature of population (Nature of Population), consistent with Chancharoen (2005). Study on determining samples with little difference or similarity, then a small sample can be used. We have determined the criteria for selecting qualifications: 1) having a domicile in the pilot area to serve as a model for farmers in Sakon Nakhon Province. 2) farming in Sakon Nakhon Province even though it is their own rice field and rent space for farming. 3) provider. The information must cooperate in participating in research activities. 4) the information provider must be between 18 years of age and over and have experience and skills in farming. Hence, the purposeful random sampling strategy selected only farmers who could support this research with multiple rounds of interviews and observations. Therefore, they could be either organic, chemical, or farmers who used both methods. Multiple rounds of data collection were undertaken to increase research validity and reliability. The data collection took place between May 21 and June 20, 2023.

In the early stage of applying green practices in farming, the establishment should be placed in a single organization. This aligns with the organic farming concept of Lampkin (1994) and the GL concept of Dey et al (2011). Dey et al. stated that when the GL practices are firmly implemented, this can be coordinated with others in the supply chain. The pilot study taken in the year 2022 also confirmed this fact. Therefore, we have decided to focus on GL rather than GSCM.

Interview Questions

1. Do farmers know about green logistics and environmental management? (Adapted from research by Tsenga et al., 2018)

2. Do farmers follow the standards or processes of rice farming? (Adapted from research by Thanonkaew, 2016)

3. What are the effects of using chemicals in rice cultivation on the environment, health, and others? (Adapted from the research of Isuwan and Chobtang, 2020 and Setthetham et al., 2013)

4. Have farmers applied the organic farming method? If yes, what are the farming processes (from plant planning to product distribution and reverse logistics) (Adapted from research by Chuea-Insoong et al., 2021; An et al., 2021).

5. Are these farmers aware of the adverse environmental effects on the rice growing process? If yes, what are the guidelines for practice? (Adapted from the research of Li et al., 2022)

6. What are the success factors in farming? (Adapted from research Chochunya et al., 2021)

The Analyses of Results and Discussions

Holistic of Green Logistics in Thai Farming

This section provides a holistic view of logistics operations in rice cultivation (see Figure 1). The process starts with the manure or compost added to the rice field, and the farmers plow their fields before planting. Later, farmers select varieties of rice plants. They often change types of grain every 2-3 years to prevent rice contamination and ensure good yields. Farmers use vehicles (e.g., truck, tractor, and combine harvesters) to support their transportation and farming in all stages. These vehicles can either be purchased, leased, or

rented. Later, the rice grains were soaked in water for approximately two days, and then the grain was packed in a sack for two nights. After this, the processed grains can be sown in the prepared field. Some farmers use cover crops that add organic matter to the soil to enrich soil fertility. Such crops were such as Sunn hemp (Por Thueng) and legumes. After planting them, farmers only plow a little to avoid damaging the topsoil.

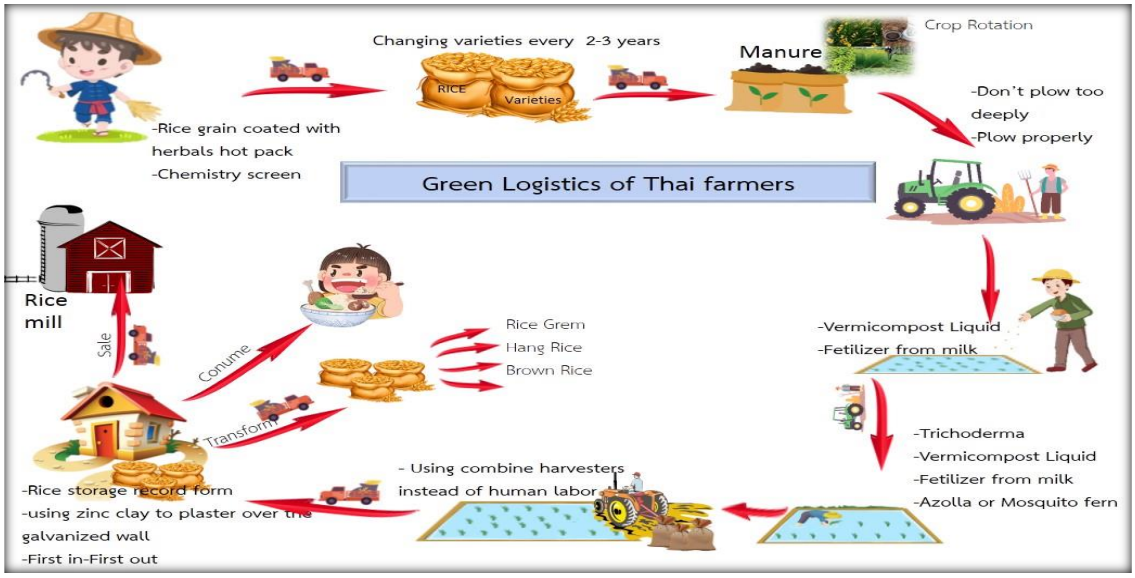

Figure 1: Holistic of Green Logistics in Thai Farming

Source: by Authors.

Furthermore, farmers set the exact schedule and rounds of plowing to reduce the energy consumption of the tractor. Farmers mix vermicompost liquid with milk hormones to prepare the rice grain for growing efficiently to spray the grain. We can also spread these two components on the field before planting. Later, farmers often use Trichoderma, vermicompost liquid, fertilizer, milk hormones, and Azolla to speed up the rice leaf germination. This concentrated liquid must be diluted before use in the field. Farmers often use human labor available in that area during harvest season and tractors for harvesting instead of solely using humans because of higher costs. Farmers transported their grains to the same destinations to save cost and fuel. The harvested grains are packed in the sack and brought to the storage room/area. They often record their rice in stock by using the concept "Oldest to Newest" or FIFO (first in - first out) (see Appendix B). This minimizes the wastage of rice.

Regarding the storage place, farmers are often concerned that the place should have good ventilation to minimize heat and moisture. Both of them can cause the rice to spoil

faster. The rice grain can be managed by three methods: (i) own consumption, (ii) selling the leftovers to the rice mills, and (iii) transforming rice grain into many products such as hung rice and directly distributing to consumers.

Green Logistics for Farmer's Health

We found that health problems were commonly found among respondents. The problems include body aches and pains, which can be relieved by massage, taking medicines, and using rice grain-coated herbal hot packs. This solution is consistent with Phataranit (2013). We found two respondents developing their grain-coated herbal hot packs, which will be them soon. However, the problems with chemical substances were unknown or unrealized among respondents. It is in line with previous studies such as Pornpratansombat et al. (2011), Yaruang and Sukonthasarn (2016), Jaikan et al. (2019), Yanakittkul & Aungvaravong (2020) and Suwanmaneepong et al. (2020). All farmers have never been chemically screened. They have a primary health checkup according to the symptoms of illness, e.g., dizziness, allergic reactions, rashes from soaking in water that has chemicals, and difficulty breathing from inhaling chemicals. Yaruang and Sukonthasarn (2016) undertook a blood test for chemicals among farmers. These researchers found that more than 50% of those who took blood tests had chemicals in their blood that could affect their long-term health conditions. The most common effects of exposure to these chemicals were eye irritation, respiratory symptoms, sore throat, and nasal irritation. The best way to prevent this is to reduce the use of chemicals, not smoke during spraying, not eat or drink water, shower immediately after spraying pesticides, and keep chemicals in separate storage areas (Jaikan et al., 2019).

Another problem was cancer from using chemicals. Many studies found that those who used to work in agriculture were more at risk than those who had never worked in agriculture. Lerro et al. (2020) studied the use of Dicamba herbicides in US agriculture and found that Dicamba is associated with cancer.

Environmentally-friendly rice storage

This research found that 75% of farmers store their rice in barns. Srijuan and Thongkamsamut (2016) proposed a guideline for using materials that exist in nature, such as Peia soil (ancient clay used to build walls in the past). Using Peia soil to insulate the barn walls effectively reduced heat transfer and prevented moisture better than other materials. We also found that 25% of farmers store rice at home for the inconvenience. This practice

resulted in the mixing of old rice and new rice. Since rice has its lifetime, segregating old and new rice should be done. To solve the problem, we proposed guidelines and developed a record form for effectively storing rice (see Appendix C). The guidelines and form were distributed to all respondents. We found that only 11 farmers used the form because it helps to know the current volumes of rice in stock and discharged. Nine farmers did not use the form because they needed more rice. When applying the FIFO system, Butphrom et al. (2018) FIFO reduces the cost of storing products and mistakes in data.

Green Logistics in rice cultivation for sustainability

The study found that only 30% of farmers have sustainable knowledge. This problem requires more significant support from the government, consistent with Singthongchai (2018), Yanakittkul & Aungvaravong (2020), and Suwanmaneepong et al. (2020). Farmers who can apply the principles of GL for rice cultivation were such as young farmers trained at the Sakon Nakhon Provincial Agriculture Office. The office has a Smart Farmer project for farmers over 45 years old, with each district organizing a training course each year for 10 cases (farmers). The government allocated a budget for the study trips to organic farming. The network should be expanded to increase learning, exchange experiences, and gather best GL practices for farmers. The network saves government and farmer's costs (Klomthongcharoen, 2017; Yanakittkul & Aungvaravong, 2020). Effective GL practices from respondents can be summarized as follows (see also Appendix D).

- **Manure:** The most commonly used manures are made from cow dung. The manure gradually releases nutrients to the rice plants throughout rice growth. It contributes to improved soil structure and water infiltration. Farmers should use the manure in the correct volume, at the right time, and with a suitable method (WanidaWattanapayapkul, 2015). The current cost of buying dried manure is 35 baht per sack (20 kilograms). Farmers often use two sacks of manure per 1 Rai.

- **Vermicompost Liquid:** Commonly, farmers raise earthworms in trays or basins that have drainage holes. The bedding materials for earthworms are a mixture of manure and soil. Farmers feed their earthworms with vegetable scraps or weeds, raise them indoors, and need frequent watering. After feeding the earthworm for 40-45 days, it is ready to produce the vermicompost liquid. The liquid is mixed with molasses and water and is fermented for about 15 days. Before use, the fermented liquid must be diluted – 1- liter vermicompost liquid with 20 liters of water. Then, the diluted liquid is sprayed on the field after plowing. Saichon

Sukyanakij et al. (2021) reported that using vermicompost liquid resulted in higher soil organic matter, Nitrogen, and Phosphorus. Our study confirms a higher crop yield when using vermicompost instead of chemical fertilizer. This practice is cost-saving (about 150-200 Baht) since farmers only invest in feeding equipment and molasse, while earthworms can be obtained from natural sources.

- **Azolla:** These are processes of raising Azolla: 1) prepare the pond by digging it for about 30- 40 centimeters deep, 2) bed the pond with a plastic sheet, 3) add manure and soil into the pond, 4) fill the pond with water, 5) add Azolla in the pond, and 6) after 15-21 days of rooting, we can move the Azolla for propagation or use in the field. This plant is also a good nitrogen source for rice cultivation and effectively kills weeds. The cost of raising Azolla is about 1000 Baht.

- **Trichoderma:** This fungus is effective in controlling plant diseases, preventing fungi, resistance to pathogens, and promoting plant growth. (Kaewchai, 2012). Trichoderma costs 5 kilograms per 350 baht. 1 kg of Trichoderma powder is mixed with 100 liters of water per 1 Rai. Spreading diluted Trichoderma on the field accelerated the tillering stage of rice and rice growth. Interestingly, most farmers still do not know about Trichoderma. Therefore, agricultural agencies should disseminate this valuable information to farmers.

- **Cultivation:** Before planting rice, farmers should grow cover crops such as legumes and Pothueng to restore the soil's physical, chemical, biological, and organic properties. This practice improves the structure of the soil; therefore, rice will grow better (Chuenjit Kaewkanya, 2011). The cost of using Pothueng was as follows: 1) Pothueng seed is 35 baht per kilogram (1 Rai uses 3-5 kilograms), 2) plowing for planting is 300 baht/1 Rai. 3) harvesting requires manual labor costs of 300-600 baht/1 Rai, and 4) other expenses are 100 baht/1 Rai. Therefore, the average total cost is 775 to 1100 baht/1 Rai. The average maximum yield of Pothueng is 120 kilograms, which can sell at an average of 25 baht per kilogram. Therefore, farmers earn about 2,000-3,000 baht per Rai. However, farmers should be concerned that growing Pothueng often takes 120-130 days. In addition, other factors can impact the cultivation, such as soil fertility and irrigation.

- **Milk hormones:** The procedures for making milk hormone are as follows: 1) mixes spoiled milk (100 kg) with molasses (1 kg), bio-fermented (200 ml), and one teaspoon of yeast, 2) stores mixed liquid in a black tank with a lid and leave it for one month, 3) After that, mixes 10 ml of milk hormone with 20 liters of water and spray onto the soil for plowing. The hormone accelerates rice germination and growth of rice. Costs of making hormones include

spoiled milk (100 kilograms per 300 baht), molasses (1 kilogram per 15 baht), yeast (1 kilogram per 200 baht), bio extract (85 baht per liter), and a black tank with a lid (300 baht). Therefore, the average cost of making milk hormones is about 900 baht (References to the price from the equipment agricultural materials store in Sakon Nakhon Province).

Obstacles to changing to organic agriculture in rice cultivation

The results indicated that farmers' beliefs, insufficient knowledge, and adoption costs were significant barriers to adopting agriculture. This is consistent with previous studies such as Jöhr (2004), Yanakittkul & Aungvaravong (2020), Suwanmaneepong et al. (2020), and Singthongchai (2018). Most farmers believe that organic agriculture has a higher cost than chemical farming. However, if the farmers have organic knowledge, they can adopt a cost-saving practice that reduces total cost, increases crop yield and revenue, raises soil fertility in the long term, and promotes health. Chochanya et al. (2021) reported that the competency of Thai farmers who were successful in farming had three main aspects, including the knowledge of organic farming, integrated farming, and new theory agriculture, which can be developed in good practice. This study asserted the gaps between the knowledge and practices of farmers. Therefore, government agencies and other institutions, such as universities, should encourage farmers to become members of organic farming networks. Farmers who are members of agricultural cooperatives will understand the importance of organic agriculture and become one of those successful farmers. This is because many best practices/ practitioners, training, and support will encourage farmers to develop more organic practices (Somsrisai & Poungngamchuen, 2009).

Another significant barrier is that Thailand still needs more communication explaining the adverse results of chemical farming practices. The government agencies did not undertake farmers' blood tests and physical checks to identify the outcomes of chemical usage. Wanudom (2018) reported that conflicts between the government sector and those involved in agrochemical policy cause communication delays and policy problems that go against state practice and government sector- provided information that deliberately distorts the truth. Therefore, the government sector must have clear communication rights and pay more attention to the policy to support reducing the use of chemicals in agriculture. To do this, the organic farming network can support this communication. Local government authorities such as district health promotion hospitals, subdistrict administrative organizations, and village headmen are responsible for promoting sustainable health according to the national direction.

If communications are well cooperated, the community or farmers will recognize and comply with the policy to effectively reduce the use of chemicals in agriculture (Wanudom, 2022).

Green Logistics practices in rice cultivation for sustainability.

Table 2: Cost and CO2 emissions of GL practices in rice growing process

GL practices	Cost	Emissions CO_2	Benefits
1. Keep rice varieties.	-		- Reduce costs
2. Buy rice varieties from other sources	650 baht/25 kg.		- Prevents mixing of rice varieties
3. Buffalo plows the field	-		- Reduce costs
4. Tractor	300-400 baht/1 rai		- Save time
5. Manure	35 baht/1 sack/30 kg.		- Increase minerals in the soil
6. Vermicompost Liquid	165 baht	632.45 kg. CO_2 /rai or 2.01 kg. CO_2 /Paddy 1 kg.	- Increase organic matter in the soil
7. Azolla	1,000 baht/rai		- Increase nitrogen - Get rid of weeds
8. Trichoderma	350 baht/5 kg.		- Accelerate tillering - Accelerate growth
9. Milk hormones	900 baht		- Accelerate tillering
10. Cultivation	775 baht/1 rai		- Restoring deteriorated soil - increase income
11. Human labor (harvesting rice, planting)	300-400 baht/1 rai (2 people/rai/1 day)		- Save fuel - Can make use of rice straw
12. Transportation	10-15 km./ 1 liter/31.94 baht		- Save time

The table shows the costs and CO_2 emissions of the GL practices in the rice cultivation process for the cost of rice varieties, a reference from the Sakon Nakhon Rice Seed Center. Labor wages Tractor wages Production of various organic fertilizers, including manure, vermicompost, Azolla, fresh milk hormones, and Trichoderma fungi. Based on information from volunteers and agricultural equipment stores in Sakon Nakhon Province. For the price of petrol, refer to information from PTT Public Company Limited (information as of August 17, 2023). The fuel

consumption rate of cars is based on information from CHOBROD Co., Ltd. (2023). CO2 emissions based on research articles of the Climate Change Science Institute (CAA) (2020).

Conclusions

This research observed green logistics management in rice cultivation of Thai farmers in Sakon Nakhon Province. This topic received attention among scholars, particularly organic issues. The GL focuses were from planting planning to delivery and reverse logistics, in which limited studies have observed this. In addition, the study area - Sakon Nakhon Province differs from others in terms of purpose, content scope, population, and relevant factors. The data was collected from twenty farmers from May 21 to June 20, 2023, using semi-structured, in-depth interviews and direct observation.

The results of the current problems were identified. Firstly, farmers' health problems range from regular pains to an accumulation of harmful chemicals in their bodies, which can cause cancer. Secondly, the rice storage method uses Peia soil (clay used to build walls) to improve air ventilation and retain rice quality effectively. New rice was often mixed with old rice, in which FIFO practices should be adopted to extend the rice's lifespan. Thirdly, many farmers often solely use chemical fertilizers or simultaneously use organic fertilizers to maximize crop yield. Several best practices were identified by respondents: using manure, Vermicompost Liquid, raising Azolla, rotating crops, using Trichoderma, and using milk hormones. This increases the quality of rice production, minimizing costs and generating more significant income than chemical farming. Lastly, farmers demonstrated insufficient environmental knowledge, particularly elderly farmers. Knowledge regarding both environment and organic farming should be given to farmers.

The government should organize training programs for farmers, using departments such as the Provincial Agricultural Office, District Agriculture Office, and Bank for Agriculture and Agricultural. The practical training program must include (i) the negative impacts of chemical farming, (ii) physical health checks, (iii) the organic farming methods, and (iv) logistics activities and GL. The program can be supported by local hospitals and organic farming networks in Thailand (Soroslikhit et al., 2008). We have offered this training program to officials in Provincial Agriculture Sakon Nakhon. They strongly agree that the next training should include GL content and give more importance to organic farming to farmers.

Zhu et al. (2012) reported that the government can also play a role by encouraging, through incentives or demonstration projects, the promotion of core supply chain enterprises. This study can provide implications for the agricultural sector and government authorities in other provinces and countries. The government should provide training in agriculture to embrace not only young farmers but also farmers of all ages, such as extract training programs and organic farming training programs to help all farmers learn and apply the knowledge to develop their careers. Farmers still need health care for themselves and to be aware of the effects of using chemicals in farming. So, perception of potential health problems is essential for them. The government should communicate with farmers to expedite policy formulation to support farmers' medical checkups by coordinating with community memorial hospitals and resolving policy to urgently reduce the use of chemicals to reduce the risk of cancer among farmers. Agricultural offices visit the area to provide knowledge for farmers. Personnel of the Bank for Agriculture and Agricultural Cooperatives should release information for farmers who are members of the Bank to make farmers aware of their health. So, government agencies and universities should take greater responsibility to promote national Sustainable Development Goals (SDGs).

Limitations of Research and Future Study

The scope of this study is limited only to rice farmers in Sakon Nakhon province. Therefore, the general views of the rice supply chain, farmers across Thailand, and other crops must be included. Future studies should expand this scope, covering all units in the supply chain. Integrated research teams for these disciplines are needed, including agriculture, medicine, business, and supply chain.

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Appendix A: Observation Form

Observation Form
Code of Record.....Date.....
Period Time.....Place.....
Events and Behaviors.....
Advices.....

Appendix B: Record of Rice Storage

Record of Rice Storage				
Date	Type of Rice	Import	Export	Note

Appendix C: Results of Rice Storage Record

Record of Rice Storage			
NO.	Used	No Used	Reason
1	-	√	A small amount of rice.
2	-	√	A small amount of rice.
3	√	-	Systematic storage of rice.
4	-	√	A small amount of rice.
5	-	√	A small amount of rice.
6	-	√	A small amount of rice.
7	-	√	A small amount of rice.
8	√	-	Systematic storage of rice.
9	√	-	Systematic storage of rice.
10	√	-	Systematic storage of rice.
11	-	√	A small amount of rice.
12	√	-	Systematic storage of rice.
13	√	-	Systematic storage of rice.
14	√	-	Systematic storage of rice.
15	√	-	Systematic storage of rice.
16	√	-	Systematic storage of rice.

Record of Rice Storage			
NO.	Used	No Used	Reason
17	√	-	Systematic storage of rice.
18	√	-	Systematic storage of rice.
19	-	√	A small amount of rice.
20	-	√	A small amount of rice.
Total	11	9	

Appendix D: Practical Guideline of Green Logistics

Practical Guideline of Green Logistics							
NO.	Manure	Vermicompost Liquid	Azolla	Trichoderma	Cultivation of cover crops	Fertilizer milk hormones	Others
1	√	√	-	-	-	-	√
2	√	√	-	-	-	-	√
3	√	-	-	√	-	-	√
4	√	-	-	-	-	-	-
5	√	-	-	-	-	-	-
6	√	-	-	-	-	-	-
7	√	-	-	-	-	-	-
8	√	-	-	-	√	-	√
9	√	-	-	-	√	-	√
10	√	-	-	-	√	-	√
11	√	-	-	-	-	-	√
12	√	-	-	-	-	-	√
13	-	-	-	-	-	-	-
14	√	-	-	-	-	-	√
15	√	-	-	-	-	√	-
16	√	-	-	-	-	-	√
17	√	√	√	-	-	-	√
18	√	-	-	-	-	-	√
19	√	-	-	-	-	-	√
20	√	-	-	-	-	-	√
Total	17	3	1	1	4	1	16