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The influencing factors developing PDCA model to achieve sustainability of area-based infrastructure project evaluation (AIPE)

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Abstract

The critical of area-based infrastructure projects evaluation (AIPE) concerns lack of appropriate tools and efficient key indicators to evaluate throughout the process. So, the projects cannot respond to the needs or necessities of the people in area according to the specified goals and sustainability. This study aims to analyse the influence factors of AIPE by a modified Plan-Do-Check-Act (PDCA) process to gain project sustainability. The study employed both quantitative and qualitative methods. The in-depth semi-structured interview was established at the beginning of a reliable pilot case study. The questionnaire used for data collection was mailed to representatives across Thailand. The findings showed that the influencing factors can be divided into four groups: (1) 'Plan' process which consisted of two factors that are 'implementation plan and good governance' (IPGG) and 'action plan and stakeholder cooperation' (APSC), (2) 'Do' process which involved 'budget provision and public support' (BPPS) and 'organisation administration and management tool' (OAMT), (3) 'Check' process which contained 'area participation and leader competency' (APLC), and (4) 'Act' process which included 'research development and knowledge management' (RDKM). The project developers, managers, administrators, researchers, operators, and related stakeholders can develop effective PDCA process for the successful and sustainability AIPE within boundaries specified.

Keywords Area-based development · Infrastructure development · PDCA process · Sustainable development · Governance · Stakeholder cooperation

1 Introduction

An area-based infrastructure project is necessary to drive spatial sustainable development because it can respond to the basic needs, relevant to the improvement of lives and well-being in the area (RIDF, 2021; RDPB, 2023). Therefore, project implementation requires the integration of administration and project management, policy and plan, nature and environment, geosocial, finance and budget, and information and knowledge. These aspects can affect area-based development efficiently and sustainably (United Nations, 2018; Aksorn & Phansri, 2022; Aksorn & Charoenngam, 2015, 2016; Zeng et al., 2015; Shen et al., 2011;

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Evans, 2009; Wong et al., 2008). The corporate social responsibility (CSR) could contribute to sustainability of projects and positive responses in both ethical and economic aspects (Bevan & Yung, 2015; Lim & Loosemore, 2017). Thus, area-based infrastructure development (ABID) is essential at the local, regional, and national levels.

The key objectives of ABID concern creating economic stability, social development, and production process support without causing any impact on the environment (Ali et al., 2016; Shen et al., 2011; United Nations, 2015; Zeng et al., 2015). For developing countries where people have a variety of occupations and lifestyles, there are several types of area-based infrastructures needed to be developed in the area to support their lifestyles. ABID is the development of basic physical systems built to serve a community or region. The examples of these community or regional services are a healthcare centre or hospital, educational support or a school, transportation, electricity, water and sanitation, and telecommunication sectors (African Development Bank (AfDB), 2019). In Thailand, government agencies develop area-based infrastructure projects as public projects. Most developments are transportation networks, communication systems, electricity and energy, educational and medical institutions, soil and water management support for agricultural activities, occupation promotion, and environmental conservation, all of which influence sustainable development (RIDF, 2022; RDPB, 2022; Bakker et al., 2018; Leungbootnak & Charoenngam, 2007).

Infrastructure projects face the challenges regarding area-based development often because they lack financial resource, performance capabilities, enough investment in infrastructure, and proper management of infrastructure to achieve sustainability (Dahiya & Das, 2019; Smoke, 2019). One major issue of ABID is the deterioration of the structure caused by ageing, natural deterioration and poor-quality design (Ansar et al., 2016; Barthorpe, 2010; Flyvbjerg et al., 2009; Panenka et al., 2020; Silva & Guevara, 2022). The other problems area-based infrastructure faces are the lack of accurate maintenance planning, maintenance budget, real and ongoing reporting on the condition of the infrastructure (Eedlenbruch et al., 2009; Frow et al., 2010; Vishnu & Padgett, 2020). As a result, the condition of area-based infrastructure deteriorates rapidly due to the lack of integrated systematic managing, integration to other systems connection, and coordination between administrators responsible for that infrastructure system (Aksorn & Phansri, 2022; Dahiya & Das, 2019; Krajangsri & Pongpeng, 2019; Smoke, 2019). Consequently, the implement of the area-based infrastructure cannot respond to the needs or necessities of the people in the area according to the specified objectives (Tao et al., 2020; Vishnu & Padgett, 2020; Wen et al., 2020). The development of sustainability assessment and the reporting tools for infrastructure is also crucial because they function to inform on progress towards reaching sustainability goals (Siew et al., 2016).

Aksorn and Phansri (2022) identified the influencing factors on area-based infrastructure project sustainability. The study addressed water resources infrastructure development in local conditions. The results identified the factors in four groups and they proposed developed models for area-based infrastructure project sustainability. The models were also tiered according to the expectation of sustainability of ABID outcomes. The study can be beneficial for decision-makers and developers to effectively plan for sustainability of ABID within certain specified area conditions. However, how the application of effective management tool that could achieve a sustainable goal in practice needs a further study. Also, the proper key indicators guideline needs more exploring for evaluating AIPE. For these reasons, this study explored the influencing factors, identified key indicators, and conducted the life cycle management tool applying PDCA process to evaluate the sustainability of ABID. This study applied both qualitative and quantitative methods to accomplish the objectives. The qualitative process was established at the beginning by applying a pilot case study with an in-depth interview to validate content. The quantitative process using questionnaires to collect data was implemented and the questionnaires were delivered to local government's agencies in public sectors across Thailand. Their responsibility is to implement public infrastructure projects in their respective local areas. The integration of PDCA process as a management tool was to evaluate the projects on sustainability patterns in local areas. Moreover, project administrators, developers, managers, and related stakeholders in local administrative organisations in Thailand have been familiar with the PDCA process. The expected outcomes for this research could contribute to project developers, managers, administrators, researchers, and operators that can implement the effective PDCA management tool for the sustainability of AIPE.

2 Literature review

2.1 Sustainability of area-based infrastructure project

Area-based infrastructure projects refer to the basic physical systems to serve local communities such as water supply and sanitation system, road and transportation service, school and education service, and electricity sectors (African Development Bank, 2019). The ABID challenges to drive infrastructure sustainable development in local, regional, and national levels (RIDF, 2021; Aksorn & Phansri, 2022; RDPB, 2023). The process of ABID starts with setting the vision and strategic objectives. Then, the development of the strategic targets and development strategies take place. The strategic and action plans are also implemented to serve the ABID (Department of Public Works and Town & Country Planning (DPT), 2022). The infrastructure project development plays a critical role in the development of economy, society, and environment at local, regional, and national levels and requires a body of knowledge to systematically manage various aspects of the project success (RDPB, 2022; Project Management Institute (PMI), 2021; Zeng et al., 2015). The development of area-based infrastructure projects is essential to sustainable development (Bevan & Yung, 2015; Doloi, 2012; Evans, 2009; Lazar & Chithra, 2021; Lim & Loosemore, 2017; Vries & Peterson, 2009; Xia et al., 2018).

Area-based infrastructure projects implement to response the community sustainable development. The projects must integrate a great deal of knowledge and be executed step by step from the planning, design, implementation, inspection, monitoring, and evaluation stages (RIDF, 2022; RDPB, 2022; PMI, 2021). It is important for area-based infrastructure project development to comply with community development plans. The participation of the community is necessary because the development pattern is often involved in multiple dimensions, including economy, society, culture, natural resources, environment, technology, people, geosocial, business operations, good governance, morality, networking, and global changes (Aksorn & Charoenngam, 2015, 2016; Meadowcroft et al., 2005).

AIBD involves various aspects in area conditions: road, transportation system, electrical system, irrigation system, public property, export and import market, watershed development, and warehouse. The infrastructure also includes the physical support of flood protection and drainage, schools, hospitals, education, energy, communications, processed agriculture, and local industries and handicrafts (Leungbootnak & Charoenngam, 2007). Infrastructure project management has the objective of planning, organising, monitoring, controlling, and reporting all issues of the projects and motivating all stakeholders to reach the goals of the development. The management of a project is a structured process of regulation based on the method of plan, do, check, and act (PDCA) model. The PDCA method is one of the effective tools to manage the project (PMI, 2021). This method already includes all stages necessary for planning, implementing, controlling, monitoring, and improving the existing work as the quality control and continuous improvement. This study integrated PDCA process as management tool to achieve successful and effective sustainability of AIPE.

Aksorn and Charoenngam (2015) studied local development project sustainability. The research combined qualitative and quantitative methods together. The study explored the impacts of factors that had an influence on area-based infrastructure for sustainable development (AISD). The results showed six dimensions affecting the AISD. These concerns policy and plan, natural resources and environment, budget and finance, knowledge and information, management and administration, and facility and infrastructure. The study suggested the aspects of management and information to have highly significant influence on the sustainability of local infrastructure development.

Aksorn and Charoenngam (2016 and 2017) studied the sustainability of community infrastructure project development. This study aims to explore how sustainability factors affect community infrastructure development. The results revealed that there are 12 sustainability factors and four stages. The initial stage consists of three factors: response to local problems and needs, consideration of strengths and weaknesses of the community, and leadership competency. The design and development stage concerns two factors: integration of top-down policy and bottom-up requirements, and budget provision. The implementation stage involves three factors expertise agency support, infrastructure system support, and project management tools application. The evaluation stage includes four factors: area-based research application, integration of economy, society, environment and culture, centre for information and knowledge for increasing agricultural productivity, and internships training skills and developing expertise in various fields.

From Aarseth et al. (2017), the study explored the sustainability of project patterns on the topics of project management and sustainable production. The analysis disclosed in the project sustainability research and articles. The study identified the strategies to support sustainability goals both from the viewpoints of the project organisation and the host organisation. The study defined eight different strategies that are (1) the setting of strategic and tactical sustainability goals, (2) the development sustainable supplier practices, (3) the emphasis of sustainability in project design, (4) the inclusion of sustainability-promoting actors in project organisation, (5) the development of sustainability competencies, (6) the sustainability-emphasis in project portfolio management, (7) the setting of sustainability policies, and (8) the influence on sustainability of project practices. The findings were confirmed by an illustrative empirical case in Norway on the delivery of seawater-based heating infrastructure. These sustainability strategies can serve as a tool to improved sustainability for project developers, managers, and institutions regulating projects (Aksorn & Phansri, 2022).

The Royal Initiative Discovery Foundation (RIDF, 2022) has studied an integrated area-based development model to assess the sustainability according to the royal initiatives covering three areas, namely fiscal report, wisdom report, and project financing report. These three areas have been followed up, evaluated, and reported since the beginning of project development. However, further study on factors affecting the project evaluation and key indicators of area-based project development should be carried out of. The key indicator for success of evaluating area-based infrastructure project development needed to be investigated includes finding a relation between these two variables. The results can be a guideline for sustainable area-based infrastructure project development.

However, literature on an effective life cycle management process for sustainability of ABID is scarce (Aksorn & Phansri, 2022). Consequently, this study aims to investigate the influencing factors and key indicators of AIPE. This also analysed the relation to the purpose of the sustainability model and developed effective life cycle management tool of AIPE. This study combined both 'Sustainable Development Goals' (SDGs) and 'Sufficiency Economy Philosophy' (SEP) (RDPB, 2022; United Nations, 2015). The application of the SDGs concept is usually for balancing sustainable development for national and international levels as global goals. The creativity, technology, knowhow, and financial resources from all of society are necessary to achieve the SDGs in every context (United Nations, 2015). Meanwhile, SEP has been implemented to drive sustainable development in local and regional areas. The concept gives emphasis to the middle path as an overriding principle for appropriate conduct starting from the level of families to communities (RDPB, 2022). The PDCA model is also integrated to gain an effectively successful project evaluation (PMI, 2021). The challenge for this research is how to integrate three concepts to drive sustainable infrastructure development at local, regional, and national levels. This study aims to integrate three concepts that can fulfil the sustainability of infrastructure project management at local, regional, and national levels. Consequently, the reviews also combined infrastructure sustainability management in terms of social, economy, socio-economic, geosocial, cultural, and environmental concerns. These results could be a guideline for applying the sustainability of AIPE to achieve efficiency and gain benefits in the regional and national areas.

2.2 Sustainability project evaluation

Sustainable project evaluation is how project delivery and support processes are planned, monitored, and controlled, with consideration of the economic, environmental, and social aspects of the life cycle of the project's resources, processes, deliverables, and effects, meant for realising benefits for stakeholders and performed in a fair, transparent, and ethical way with participation from stakeholders (Silvius & Schipper, 2014). Achieving sustainability is becoming progressively more essential for determining the overall accomplishment of infrastructure projects (Yuan, 2017).

Evaluation refers to the follow-up or the systematic process of collecting and analysing data to determine the performance, worth, value, or the product of that process (American Evaluation Association, 2014; PMI, 2021). The evaluation of the project performance could set standards of high-performance projects and detect any inefficiencies for future improvement (Cao & Hoffman, 2011; Farris et al., 2006). Previous studies on evaluating project performance employed various methods which are based on various sets of factors and criteria for evaluation that have an impact on the project performance (PMI, 2021). The evaluation tools depend on related conditions such as actors, money, and time available. For example, the evaluation of relative performance efficiency of the finished projects, data envelopment analysis (DEA) has been an effective tool that incorporates multiple input and output variables that influence the performance of projects (Xu & Yeh, 2014; Cao & Hoffman, 2011; Eilat et al., 2006; Farris et al., 2006; Vitner et al., 2006).

Project evaluation also functions in accordance with the goal setting, implementation deciding, problems solving, changing or resolving to make a project valuable. Project evaluation is an assessment that the project is conducted in accordance with the intended objectives, within the specified resources and timeframe. Project evaluation also considers the consistency and achievement of the objectives, efficiency, effectiveness, and impact (PMI, 2021). In addition, project evaluation is an evaluation that encompasses both process and impact evaluations. It includes the important factor, implementation of the plan, and the project-caused changes or expansion in accordance with the objectives (Rossi et al., 2004).

He et al. (2019) evaluated and analysed the relationships between megaproject social responsibility, innovation, and project performance in megaproject. The research methodology applied the procedure of development of questionnaire survey, sample selection, data collection, and data analysis. The authors' results demonstrated that social responsibility of megaproject has a significant and positive effect on performance of projects, and this relationship is partly facilitated by innovation. The findings could contribute to the other studies having found inconsistent outcomes on the direct and indirect effects of social responsibility and performance of organisations/projects. Megaproject managers can enhance sustainability and project performance by emphasising innovation and social responsibility.

Kaku et al. (2023) evaluated the relationship between satisfaction and participation of stakeholders in the process of environmental impact assessment (EIA) through public–private and infrastructure projects. The data collection employed interviews with stakeholders, questionnaires, reports, and consultations. The authors show that most stakeholders (55%) did not get involved in the EIA decision-making process. The local communities and NGOs had a little influence despite their great interest in the EIA process, which justified their inadequate public participation in the stages concerning EIA. The satisfaction of stakeholders can grow by the influence of adequate information and involvement in the EIA. The study recommended getting the stakeholders involved from the earliest stages of the EIA process and providing information and knowledge regarding relating to the project development. Also, the stability of the environment is an inevitable requirement of sustainable development, and previous studies have confirmed that economy and technological innovation have a positive enabling effect on the environment (Liu et al., 2023).

The area-based economy is a proposition that can contribute to social change and a path towards sustainability (Nogueira et al., 2023). Considering problems regarding the environment in relation to the economy and society, the sustainable infrastructure has been developed from assessment frameworks to ensure balanced environmental, social, and economic consequences of infrastructure projects. Infrastructure has long functioning periods, multifaceted supply chains, and important impacts on communities (Chan et al., 2022). Economic development, technological innovation, and environmental mechanism are the main driving forces for the area-based development (Liu et al., 2023).

The empirical previous studies related to project and infrastructure management have explored sustainability factors and evaluated different aspects that are environmental (Ali & Khalilzadeh, 2023; Garg et al., 2023; Kaku et al., 2023), economic (Stanitsas & Kirytopoulos, 2023), and social (Baba et al., 2021; Maddaloni & Sabini, 2022).

From the reviews, what are influencing management factors and key indicators for evaluating the sustainability of ABID has yet to be explored and so does how to effectively apply the management tool throughout the life cycle process to manage the area-based infrastructure projects. To sum up, this study has the objectives to:

(1) Analyse the influencing factors and key indicators of AIPE.

(2) Recommend the management guideline for evaluating ABID.

Figure 1 shows the conceptual framework. The total 89 items include both independent and dependent variables as shown in Table 1.

3 Research methodology

A step-by-step procedure was set up to accomplish the objectives, which was employed for selecting a set of influencing factors and key indicators for AIPE. The methodological details of the research can be summarised as follows.

(1) At the beginning, from literature review, project documents and the first discussion of a selected case study, the 89 influencing factors, and key indicators of AIPE were identified. These combined both theoretical and practical in terms of preliminary factors (see Table 1).
(2) Then, five well-qualified cooperative experts, who (1) work as project managers or developers, (2) have at least 15 years of experience in area-based infrastructure project, (3) were willing to participate in carrying out research, took part in determining the content validity of influencing factors and indicators. Some identifying required items with needed amendments, which had been scrutinised, were excluded, others revised—to receive maintenance or improvement. From this step, the seven factors were removed. The experts provided their opinions on only 82 selected influencing factors and keys indicator (see Table 1). They also recommended adjusting some indicators that had already been revised in Table 1.

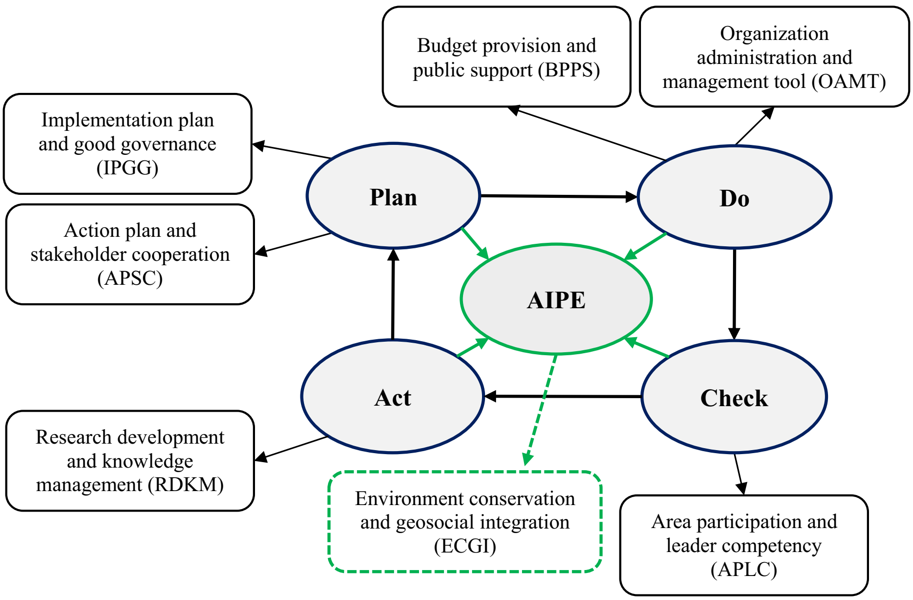

Fig. 1 Research conceptual framework

Table 1 The content validated and coding of influencing factors for AIPE

No	Influencing factors	Coding
1	Corporate executives have experience in evaluating projects (Chan & Chan, 2004; Toor & Ogunlana, 2008)	X01
2	Person in charge of the project has the knowledge and ability to assess the project (Banihashemi et al., 2017; Jha & Iyer, 2006)	X02
3	Project managers understand area-based problems (Brillo & Simondac-Peria, 2021)	X03
4	Staffs have the knowledge and ability to assess projects (Banihashemi et al., 2017; Mahamid, 2014)	X04
5	The project designer has knowledge and the ability to evaluate projects (Banihashemi et al., 2017; Mahamid, 2014; Yang & Wei, 2010)	X05
6	A clear assignment of responsibilities to those involved project (Jha & Iyer, 2006; Toor & Ogunlana, 2008)	X06
7	Stakeholders continue to be involved with the project (Chan & Chan, 2004; Xue et al, 2018)	X07
8	People in the area cooperated with the project (Chan & Chan, 2004; Jha & Iyer, 2006; Mancini & Marek, 2004; Toor & Ogunlana, 2008; Xue et al, 2018)	X08
9	Participation of people in the project area (Banihashemi et al., 2017; Mancini & Marek, 2004; Xue et al, 2018)	X09
10	Community leaders have abilities to plan and administrative the project (Chan & Chan, 2004; Jha & Iyer, 2006; Mancini & Marek, 2004; Sun et al., 2020)	X10
11	Community leaders have knowledge and understanding the area (Jha & Iyer, 2006)	X11
12	People involved in the project have coordination skills (Banihashemi et al., 2017; Chan & Chan, 2004)	X12
13	Community project leaders have the ability to coordinate with the area (Mancini & Marek, 2004)	X13
14	Consideration the suitability of the project location (Banihashemi et al., 2017)	X14
15	Implementation of the project according to appropriate standards (Toor & Ogunlana, 2008; PMI, 2021; Park & Kwon, 2011)	X15
16	There are requirements and master plans for project implementation (Banihashemi et al., 2017; Toor & Ogunlana, 2008)	X16
17	Clear objectives and purposes (Banihashemi et al., 2017; Jha & Iyer, 2006; Xue et al, 2018; Yang & Wei, 2010)	X17
18	The project responds to national or area strategies (Xue et al, 2018)	X18
19	Integration with many sectors (Chan & Chan, 2004)	X19
20	Identification potential risks or problems (Banihashemi et al., 2017)	X20
21	Supporting funded by the state or central government (Banihashemi et al., 2017; Chan & Chan, 2004)	X21
22	Assignment match with the knowledge and competence of the responsible person (Toor & Ogunlana, 2008; Kokkaew & Rudjanakanoknad, 2017)	X22

Table 1 (continued)

No	Influencing factors	Coding
23	Application of programs and technology in project operations (Azizi et al., 2020; Chan & Chan, 2004; Toor & Ogunlana, 2008; Vishnu & Padgett, 2020)	X23
24	A systematic coordination process of employees within the organisation (Jha & Iyer, 2006; Toor & Ogunlana, 2008; Xue et al, 2018; Kokkaew & Rudjanakanoknad, 2017)	X24
25	The project is coordinated between organisations and localities (Jha & Iyer, 2006; Toor & Ogunlana, 2008)	X25
26	An effective communication system within the project (Banihashemi et al., 2017; Jha & Iyer, 2006; Mahamid, 2014; Toor & Ogunlana, 2008; Yang & Wei, 2010)	X26
27	The project supports the creation of added value for local businesses (Chan & Chan, 2004; Xue et al, 2018)	X27
28	Machines supports in project (Toor & Ogunlana, 2008; Xue et al, 2018)	X28
29	Bringing local wisdom to the project (Raymond et al., 2010; Tuğaç, 2022)	X29
30	Research support in the area (Joseph et al., 2008; Lee et al., 2009)	X30
31	Review of the work process from government agency (Banihashemi et al., 2017; Chan & Chan, 2004)	X31
32	Project meetings are held regularly (Jha & Iyer, 2006)	X32
33	Locally available resources (Banihashemi et al., 2017; Jha & Iyer, 2006; Mahamid, 2014; Toor & Ogunlana, 2008; Xue et al, 2018)	X33
34	The economic conditions are favourable to the project implementation (Banihashemi et al., 2017; Chan & Chan, 2004; Toor & Ogunlana, 2008)	X34
35	The political condition does not obstruct the project (Chan & Chan, 2004; Toor & Ogunlana, 2008; Banihashemi et al., 2017)	X35
36	The project is continuously monitored (Banihashemi et al., 2017; Jha & Iyer, 2006)	X36
37	The assessment of staff in the project (Xue et al, 2018; Kokkaew & Rudjanakanoknad, 2017)	X37
38	The satisfaction of people who use the project (Xue et al, 2018)	X38
39	Public listening opinion in area (Kaku et al., 2023; Mancini & Marek, 2004)	X39
40	Financial stability of project contractor (Banihashemi et al., 2017; Toor & Ogunlana, 2008)	X40
41	Transparency of project bidding (Banihashemi et al., 2017; Chan & Chan, 2004; Mahamid, 2014; Toor & Ogunlana, 2008)	X41
42	Gathering relevant information of project (Toor & Ogunlana, 2008; Yang & Wei, 2010; Mahamid, 2014; Okakpu et al., 2020)	X42
43	Weather variability (Jha & Iyer, 2006; Mahamid, 2014; Toor & Ogunlana, 2008; Yang & Wei, 2010)	X43
44	People in area understand the objectives of the project (Aksorn & Charoenngam, 2015)	X44

Table 1 (continued)

No	Influencing factors	Coding
45	Staff are trained on the job regularly (Yang & Wei, 2010)	X45
46	Maintenance of the infrastructure that supports the project (Vishnu & Padgett, 2020; Xue et al, 2018)	X46
47	Plan for reducing the use of resources (Tao et al., 2020; Xue et al, 2018)	X47
48	The project is managed with good governance (Xue et al, 2018; Ouyang et al., 2022)	X48
49	The project has a quality guarantee plan (Banihashemi et al., 2017; Chan & Chan, 2004)	X49
50	The project has guidelines for dispute resolution (Banihashemi et al., 2017)	X50
51	Knowledge training or improve the skills of staff (Jha & Iyer, 2006; Kokkaew & Rudjanakanoknad, 2017)	X51
52	Training to provide knowledge or develop advanced skills for executives (Jha & Iyer, 2006)	X52
53	Setting up a centre for training and knowledge in the area (Xue et al, 2018; Peskircioglu, 2008)	X53
54	People in the area understand the objectives of the project (Mancini & Marek, 2004)	X54
55	Employee training on regular tasks (Yang & Wei, 2010)	X55
56	There is ongoing maintenance of the infrastructure (Vishnu & Padgett, 2020; Xue et al, 2018)	X56
57	The project uses resources efficiently and reducing the use of resources (Tao et al., 2020; Xue et al, 2018)	X57
58	The project has a quality guarantee (Banihashemi et al., 2017; Chan & Chan, 2004)	No
59	The project has guidelines for dispute resolution (Banihashemi et al., 2017)	No
60	The project takes into account the safety of the area (Çıdık & Phillips, 2021; Xue et al, 2018)	X58
61	Knowledge training or improve the skills of staff (Jha & Iyer, 2006; Kokkaew & Rudjanakanoknad, 2017)	No
62	Training to provide knowledge or develop advanced skills for executives (Jha & Iyer, 2006)	No
63	Setting up a centre for training and knowledge in the area (Aksorn & Charoenngam, 2015; Brent & Labuschagne, 2007; Ferguson et al., 2010; Xue et al, 2018)	No
64	The project responds to local problems and needs (Aksorn & Charoenngam, 2015; Brillo & Simondac-Peria, 2021)	X59
65	Integration between central policy and community needs (Lin et al., 2010; Price et al., 2011)	X60
66	The project has an analysis of strengths, weaknesses, opportunities, and threats (Nasuchon & Chareles, 2010; Terrados et al., 2007)	X61
67	Research and development that can be applied in practice (Joseph et al., 2008; Lee et al., 2009)	X62
68	The information obtained is sufficient to design and implement the project (Razali & Juanil, 2011)	X63
69	Internship, skills training, and development of expertise in various fields (Collins, 2008)	X64

Table 1 (continued)

No	Influencing factors	Coding
70	The community has a role and participation in the decision-making process (Baba et al., 2021; Dimitriou & Field, 2019; Fleeger & Becker, 2008)	X65
71	Community development plan and action plan (Fleeger & Becker, 2008; Busscher et al., 2015; RIDF, 2020; DPT, 2022)	X66
72	The community cooperates and helps to work together very well (RDPB, 2022)	X67
73	Government agencies play a role in supporting the implementation of the project (Hosny et al., 2021; Lei & Herder, 2011; Peterson et al., 2010; Yung & Chan, 2012)	X68
74	Sources of funding for project initiation or support the budget (Kamara et al., 2008; Nguyen et al., 2021; Vries & Peterson, 2009; Wen et al., 2005)	X69
75	Budget allocation for ongoing operations or repairs (Eedlenbruch et al., 2009; Frow et al., 2010)	X70
76	Reliable of implementation project agency (Hong et al., 2012; Aksorn & Charoenngam, 2017; Engebø et al., 2022)	X71
77	Administration and management systems implement as tools for project management (Park & Kwon, 2011; Gardoni & Murphy, 2020; Brooks et al., 2021; PMI, 2021)	X72
78	Encourage the establishment of community financial institutions (George & Prabhu, 2003)	X73
79	Technology transfer to the area (Brent & Labuschagne, 2007; Martinsions et al., 1996)	X74
80	Network development and cooperation with external communities (Campo et al., 2009)	X75
81	Networking with government agencies educational institution or private (Barrutia, et al., 2007; RIDF, 2022)	X76
82	Maintaining a good relationship between project participants and the community (Kaku et al., 2023; Perez, 2009)	X77
83	The project integrates economic, social, environmental, and cultural aspects together (Berges-Alvarez et al., 2022; Bevan & Yung, 2015; Doloi, 2012; Elshaboury & Marzouk, 2020; Gardoni & Murphy, 2020; Lazar & Chithra, 2021; Lim & Loosemore, 2017; Xia et al., 2018)	X78
84	Consideration of geosocial in the area (Ghomashchi, 2012)	X79
85	Implementation of the project taking into account environmental conservation (Chester & Allenby, 2021; Coller et al., 2021; Tiwari & Thakur, 2020; Zhang et al., 2022)	X80
86	Project process that does not poison the environment (Çıdık & Phillips, 2021; Coller et al., 2021; Kock & Gemunde, 2019; Tiwari & Thakur, 2020)	X81
87	Conservation of forests and watersheds (Koch-Ørva et al., 2019)	X82

Table 1 (continued)

No	Influencing factors	Coding
88	Standard operation process (Brooks et al., 2021; Park & Kwon, 2011)	No
89	Receive financial support from non-governmental or foreign agencies (Hosny et al., 2021; Peterson et al., 2010)	No

X01,… = validated factor (82 factors). No = not validated factor (7 factors)

(3) Next, a five-point Likert scale-based draft questionnaire was developed with categories ranging from 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The draft questionnaire comprised of three parts: relevant background information of interviewees (including age, gender, position, education, and professional experience), questions on significant factors affecting of AIPE in practice, and comments and suggestions on questionnaire content.
(4) After that, the improved questionnaires were revised from draft questionnaire based on comments from the experts who work as project developers, project managers, practitioners, and researchers in area-based conditions.
(5) Then, to determine the reliability of improved questionnaire, the experimental projects of area-based Royal Development Project (RDP), founded by His Late Majesty King Bhumibol Adulyadej of Thailand to support area-based activities and careers of local people, in Udon Thani and Kalasin Provinces, Thailand, were chosen due to their success (RDPB, 2022). The data were gathered from the areas and the project managers, developers, researchers, and practitioners confirmed the practical use.
(6) Next, the revised questionnaires were delivered to target populations nationwide. Also, the online questionnaire was sent and distributed to relevant stakeholders including project developers, project managers, practitioners, researchers, and on-site project staff, who serve the Local Administrative Organisations (LAOs) across Thailand.
(7) Finally, the data analysis of the items in the completed questionnaire was conducted to guarantee that items were meeting satisfaction regarding their reliability, validity, efficiency, and interpreted the results descriptively.

4 Data collection

Most infrastructure projects with high significant impacts on area-based development in Thailand involve transportation system, water resource, and other related issues (RIDF, 2022; RDPB, 2022; Aksorn & Charoenngam, 2016, 2015). The local government agencies have a duty to develop public infrastructure projects in their respective local area. There are 7,850 Local Administrative Organisations (LAOs) taking full responsibility for area-based infrastructure project development—Subdistrict Administrative Organisations (SAO), Provincial Administrative Organisations (PAO), Subdistrict Municipalities (SM), City Municipalities (CM), and Town Municipalities (TM). All these organisations are worth coping very well with studying all target population for the expected outcome (Department of Local Administration, 2022).

A total of 3,000 hard copies of questionnaires were distributed to target respondents: policy makers, project developers, project managers, specialists, inspectors, researchers, and technicians. Also, the online questionnaire was posted to all target respondents who work at the Local Administrative Organisations (LAOs). For this research, approximately 73,110 respondents from 7850 LAOs have been working directly with related local infrastructure projects for many decades. Therefore, those became the best representatives suitably put in the right place of the procedure.

5 Data analysis and results

The 590 returned of complete questionnaire were used for the analysis of data by using the version-28 SPSS. To ensure this analysis would give valid results, it follows five main steps (Comrey & Lee, 1992):

(1) The identification of the variables
(2) The computation of a correlation matrix for the variables
(3) The extraction of the unrotated factors to see whether the chosen model fits the data
(4) The rotation of the factors to make them more interpretable
(5) The interpretation and labelling of the rotated factors
(6) The development of the regression model and relationship.

The analysis found that 62.25% of all respondents are from Subdistrict Administrative Organisations (SAOs), 76.78% are technicians, 61.20% graduated a bachelor's degree, 51.53% are male, the average years of working experience are 13.03, and the average years of age are 42.21. All the details are presented in Table 2.

Table 2 Profile of the respondents ($n=590$)

Respondents' profile	Number	Percentage
Organisations		
Subdistrict administrative organisation	424	65.74
Provincial administrative organisation	9	1.40
Subdistrict municipality	172	26.67
City municipality	36	5.58
Town municipality	3	0.47
Positions		
Policy maker	31	4.81
Manager	45	6.98
Specialist	7	1.09
Inspector	30	4.65
Researcher	40	6.20
Technician	492	76.28
Educations		
Undergraduate	96	14.88
Bachelor	404	62.64
Master	141	21.86
Doctoral	4	0.62
Sex		
Male	304	51.53
Female	286	48.47
Work's experience (years) mean =	13.03	std = 9.337
Age (years) mean =	42.21	std = 9.528

Table 3 KMO measure and Bartlett's test

Kaiser–Meyer–Olkin measure of sampling adequacy	0.985	
Bartlett's test of sphericity	Approx. Chi-square	52700.742
	Df	3321
	Sig	0.000

Table 4 Partial correlation matrix

Item	X40	X41	X42	X43	X44	X45	X46	X47	X48	X49	X50
X40	1.000	.559	.631	.380	.603	.518	.611	.574	.599	.612	.542
X41	.559	1.000	.720	**.258**	.628	.525	.577	.460	.717	.660	.468
X42	.631	.720	1.000	.310	.731	.639	.720	.608	.694	.654	.618
X43	.380	**.258**	.310	1.000	.301	.476	.368	.457	.348	**.288**	.359
X44	.603	.628	.731	.301	1.000	.608	.675	.590	.671	.640	.570
X45	.518	.525	.639	.476	.608	1.000	.711	.692	.626	.580	.531
X46	.611	.577	.720	.368	.675	.711	1.000	.675	.672	.655	.572
X47	.574	.460	.608	.457	.590	.692	.675	1.000	.622	.547	.587
X48	.599	.717	.694	.348	.671	.626	.672	.622	1.000	.772	.602
X49	.612	.660	.654	**.288**	.640	.580	.655	.547	.772	1.000	.655
X50	.542	.468	.618	.359	.570	.531	.572	.587	.602	.655	1.000

Correlation is significant at the 0.01 level (2-tailed)

The bold was shown the correlations value that less than 0.30, that is variable X43 need to be removed

5.1 Validity and reliability test

This study applied both Bartlett's test of sphericity and the Kaiser–Meyer–Olkin (KMO). The latter was used to evaluate sampling adequacy and measure if the partial correlations among variables are 0.985 larger than 0.70. The former was for checking if the correlation matrix is an identity matrix, indicating that the significant level of 0.000 less than 0.05 is acceptable as shown in Table 3 (Pett et al., 2003). Also, the calculation of the Cronbach's alpha in Table 5 took place to assess how dependable the questionnaire is. Such results above 0.70 indicate the reliability of the questionnaire (Nunnally & Berstein, 1994).

The multicollinearity testing and correlation matrix were analysed as shown in Table 4. According to Pett et al. (2003), the correlation matrix is closely examined for item consistency and to confirm which item is too highly ($r \geq 0.80$) or not sufficiently correlated ($r \leq 0.30$). The highly correlated items caused problems with multicollinearity—one or more of them might be abandoned. If any were not correlated enough, there would not be much share common variance, which would make it not sufficiently qualified for further study. According to Nunnally and Berstein (1994), the standard in statistic of p value was set to less than 0.05, which means the confidence level of 95% is used. From the calculation, correlations were found higher than 0.30 and less than 0.80, which were so sufficient that multicollinearity did not occur. The only X43 variable has correlation of less than 0.3 that needs to be removed.

Table 5 The result of rotated component (variables)

Item	Factor loading	Factors	Cronbach's alpha		% of variance explained	% Cumulative of variance
X59	0.729	Implementation Plan and Good Governance (IPGG)	0.982	**0.990**	20.703	**71.331**
X49	0.701					
X58	0.697					
X41	0.696					
X48	0.677					
X60	0.670					
X66	0.656					
X38	0.653					
X44	0.638					
X39	0.632					
X65	0.632					
X67	0.626					
X42	0.615					
X54	0.612					
X68	0.598					
X71	0.591					
X57	0.578					
X56	0.567					
X63	0.563					
X36	0.552					
X81	0.539					
X46	0.526					
X50	0.501					
X40	0.481					

Table 5 (continued)

Item	Factor loading	Factors	Cronbach's alpha	% of variance explained	% Cumulative of variance
X72	0.469				
X24	0.468				
X31	0.459				
X70	0.447				
X26	0.435				
X30	0.791	Research development and knowledge management (RDKM)	0.974	17.158	
X53	0.758				
X62	0.731				
X74	0.725				
X55	0.719				
X45	0.690				
X29	0.684				
X64	0.665				
X73	0.641				
X52	0.617				
X76	0.615				
X51	0.584				
X47	0.582				
X75	0.558				
X61	0.549				
X32	0.549				
X33	0.547				
X37	0.509				
X23	0.452				

Table 5 (continued)

Item	Factor loading	Factors	Cronbach's alpha	% of variance explained	% Cumulative of variance
X34	0.451				
X27	0.437				
X20	0.437				
X16	0.594	Action plan and stakeholder cooperation (APSC)	0.945	7.587	
X17	0.568				
X15	0.565				
X18	0.564				
X14	0.515				
X07	0.475				
X25	0.454				
X22	0.441				
X19	0.433				
X02	0.770	Organisation administration and management tool (OAMT)	0.911	7.530	
X01	0.721				
X04	0.669				
X05	0.652				
X03	0.646				
X06	0.511				
X09	0.687	Area participation and leader competency (APLC)	0.918	6.550	
X08	0.658				
X10	0.632				
X11	0.593				
X12	0.512				
X13	0.505				

Table 5 (continued)

Item	Factor loading	Factors	Cronbach's alpha	% of variance explained	% Cumulative of variance
X79	0.589	Environment conservation and geosocial integration (ECGI)	0.938	6.430	
X77	0.584				
X78	0.582				
X80	0.536				
X82	0.506				
X21	0.504	Budget provision and public support (BPPS)	0.785	5.373	
X28	0.474				
X69	0.464				
X35	0.411				

Extraction method: principal component analysis

Rotation method: varimax with Kaiser normalisation

The bold was shown the correlations value that less than 0.30, that is variable X43 need to be removed

5.2 Exploratory factor analysis (EFA)

The calculation of the exploratory factor analysis (EFA) with varimax rotation was shown in Table 5 to determine the underlying factor structure and set causing variables of influencing factors adopted in the AIPE. From result, they were classified into six group factors: (1) implementation plan and resource availability, (IPRA) (2) action plan and stakeholder cooperation (APSC), (3) budget provision and public support (BPPS), (4) organisation administration and management tool (OAMT), (5) area participation and leader competency (APLC), and (6) research development and knowledge management (RDKM). The total calculation of cumulative variance can be explained in 74.00%.

After that, careful consideration to analyse the influencing factors of AIPE by modified PDCA (Plan-Do-Check-Act) model was established. This was to explore the relation of variables by applying regression analysis. There are four processes in the PDCA model: (1) 'Plan' process consisting of two factors that are 'implementation plan and good governance' (IPGG) and 'action plan and stakeholder cooperation' (APSC), (2) 'Do' process involving 'budget provision and public support' (BPPS) and 'organisation administration and management tool' (OAMT) factors, (3) 'Check' process containing 'area participation and leader competency' (APLC) factor, and (4) 'Act' process including 'research development and knowledge management' (RDKM) factor.

5.3 Effect of influencing factors on AIPE

From the analysis, the results show that some $\beta > 0$. Also, because the p value is so small (less than 0.001), it can be concluded that influencing factors have a direct influence on AIPE. Figure 2 could be evidence to support the significance and influence factors on AIPE. The finding shows that the AIPE is influenced by the four PDCA processes: (1) 'Plan' process which consisted of two factors that are IPGG and APSC, $\beta = 0.779$, $t = 11.499$, and $p \leq 0.01$, (2) 'Do' process which involves BPPS and OAMT, $\beta = -0.111$, $t = -2.060$, and $p \leq 0.05$, 3) 'Check' process which contains of APLC, $\beta = -0.094$, $t = -2.198$, and $p \leq 0.05$, and 4) 'Act' process which includes RDKM, $\beta = 0.396$, $t = 9.340$, and $p \leq 0.01$. These four modes collectively explain the AIPE ($R^2 = 0.740$, $F = 415.882$, and $p \leq 0.05$). From the results, only two processes that are 'Plan and Act' have the positive effect and the 'Plan' process has the largest effect of influencing factors of AIPE. The result also showed that there are remarkably high correlations between 'Plan' and 'Do', and 'Check' and 'Act' as shown in Table 6 and Fig. 2.

6 Findings and discussion

The study was conducted to identify the life cycle management factors and explore key indicators applying PDCA process to guideline for evaluating the area-based infrastructure project. These categories built with the questionnaire and stats were used for structure findings. The findings are detailed below.

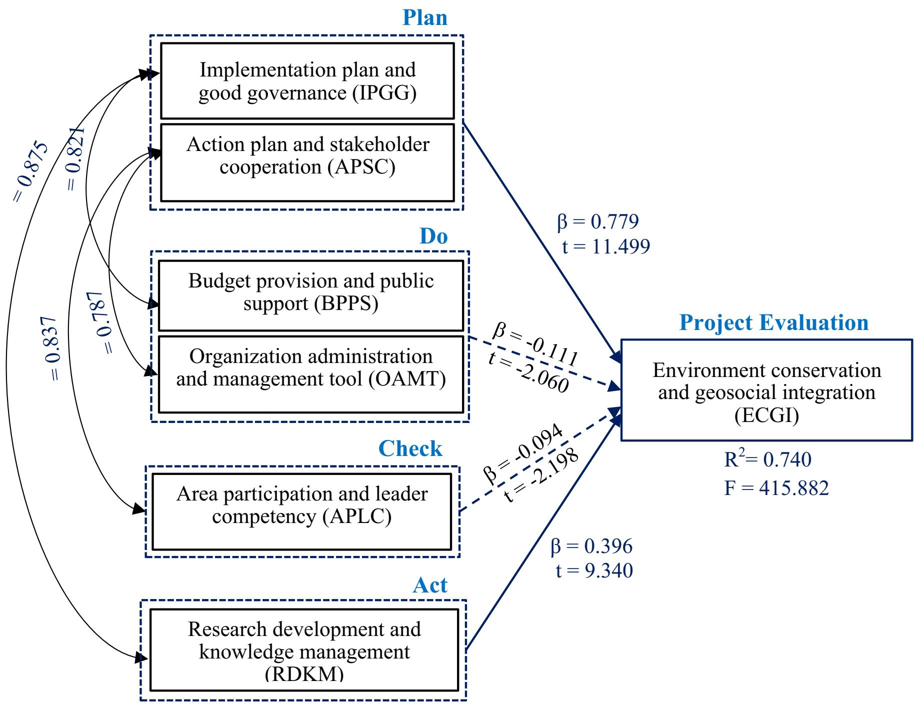

Fig. 2 The relationship of keys indicator and AIPE

6.1 Plan process

This process consists of two factors.

6.1.1 Implementation plan and good governance (IPGG)

This factor concerning 'implementation plan and good governance' gets 29 items. Among this group, 'the project responds to local problems and needs' receives the highest loading factor (LF) 0.729. The others significant cope with the quality guarantee plan, the safety of area, transparency of project bidding, integration between central policy and community needs, and good governance. From empirical research, the area-based project development must respond to the area-based problems and local people needs (Aksorn & Charoenngam, 2015; Brillo & Simondac-Peria, 2021). Moreover, there is considerable influence among 'good corporate governance on the planning function', 'coordination function', 'organisational culture', 'firm performance', and 'firm sustainability' (Wendry et al., 2023). Also, the confidence or trust in one another of project managers and participants could exhibit the benefits of a healthy relationship (Jabareen & Carmon, 2010). Trust network among project participants has more influence on project success than trust between the contractor and project owner (Li et al., 2020). The trusting relationship could realise and ensure the sustainability development (RIDF, 2022). From previous evident research, the many plans could effectively manage the successful infrastructure project (PMI, 2021). For example,

Table 6 Coefficients analysis

Model		Unstandardised coefficients		Standardised coefficients	t	Sig	Correlations			Collinearity statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.129	.109		1.183	.037					
	PLAN	.779	.068	.648	11.499	.000	.836	.429	.243	.140	7.132
	DO	−.111	.054	−.096	−2.060	.040	.738	−.085	−.043	.206	4.860
	CHECK	−.094	.043	−.084	−2.198	.028	.673	−.091	−.046	.302	3.310
	ACT	.396	.042	.400	9.340	.000	.814	.360	.197	.242	4.127

Dependent variable: ECGI

the quality control plan could drive reliability, safety, availability, and costs (Baron, et al., 2023). The life cycle management plan is applied in the design, prediction, assessment, and optimal management of life cycle performance, reliability, safety, and risk of civil structures and infrastructure (Chen et al., 2022). In addition, project life cycle analysis and risk informed are decision tools to advance management of public investments in performance assurance and risk mitigation of infrastructure projects (Ellingwood & Lee, 2016). All effective plans, appropriate policies, and suitable strategies are employed to solve the unsustainable figures (Park & Kwon, 2011). The projects sustainability fulfils the good governance and social responsibility in terms of ethics and economy (Bevan & Yung, 2015; Lim & Loosemore, 2017).

6.1.2 Action plan and stakeholder cooperation (APSC)

This factor, namely 'action plan and stakeholder cooperation', comprises nine items. For this group, the 'there are requirements and master plans for project implementation' gets the highest LF 0.504. The others include clear objectives and purposes, implementation of the project according to appropriate standards, the project responds to national or area strategies, and consideration the suitability of the project location. From research evidence, the policy-based decision model for restoration action planning could support disaster mitigation of interdependent infrastructure systems under uncertainty (Sun et al., 2021). The optimal maintenance plan should be executed on infrastructures with long service-life to ensure the required quality of service, for fear of their deterioration processes (Ter Berg et al., 2019). In the action plan, the implementation and evaluation stages of area-based infrastructure projects require knowledge in many fields; for example, economy, society, environment, culture, and social landscape (Caspeele et al., 2020). Moreover, the poor cooperation between some stakeholders and lack of the governance arrangement has become the cause of the lack of smooth communication, emergence of conflict, narrow conception, and lack of mutual understanding (Woldesenbet & Kebede, 2021). Also, the cooperation of people in area and geosocial understanding are all important drives that make spatial development successful and sustainable (Chen et al., 2022). The approaches of collaboration and networking can support local governments, provide knowledge, keep resources, and the best practices (Barrutia et al., 2007).

6.2 Do process

This process includes two factors.

6.2.1 Budget provision and public support (BPPS)

This factor relates 'budget provision and public support' comprises four items. The 'supporting funded by the state or central government' gains the highest LF 0.504. The others consist of machine support in a project, internship skills training and development of expertise in various fields, and the political condition does not obstruct the project. Although most of the local administrations' revenue comes from taxes, loans, properties, and enterprises, they still require the financial provision and support from subsidies of the central government for infrastructure development (RIDF, 2022). The recent research presents the multi-infrastructure asset management that needs to be addressed for evaluating and managing infrastructure development in an integrated way and obstacles for doing need to be identified (Daulat et al., 2022). The analysis of life cycle costing serves as a tool for decision support for budget of infrastructure structures (Nishijima & Faber, 2009). Life cycle costing (LCC) approaches can handle uncertainty in the underlying financial variables of cash flows, rates of interest, timing of cash flows, and duration of LCC analysis (Sun & Carmichael, 2018). Moreover, the budget allocation aims to optimise how budgets are allocated to maintain the operation of the infrastructure structures (Nishijima & Faber, 2009). Participation and information from the local representatives in the selection stage leads to the more effective budget provision and support for project implementation (Eedlenbruch et al., 2009). The rework during a construction process due to design changes, errors, and omission are the main sources of overruns in projects (Love et al., 2014). In addition, proper project management can render support and budget sufficient in unexpected occurrences to achieve sustainable development (Eedlenbruch et al., 2009). The insufficiency in budget keeps local functions from happening and limits the implementation of programs and projects (RDPB, 2022).

6.2.2 Organisation administration and management tool (OAMT)

This factor is 'organisation administration and management tool' has six items. The 'person in charge of the project has the knowledge and ability to assess the project' obtains the highest LF 0.770. The others involve 'corporate executives have experience in evaluating projects', 'staffs have the knowledge and ability to assess projects', 'the project designer has knowledge and the ability to evaluate projects', and 'project managers understand area-based problems. From empirical research, an application of a project management tool is essential in implementation by driving the managers and staff members in the projects to handle all tasks successfully (Kumar & Markeset, 2006). The tool of management with holistic perspective integrated also must be inspected on issues regarding socio-economic, environment, and area-based culture (Nasuchon & Chareles, 2010). Bringing practical resolution by using management tools to proceed project with success and sustainability requires integration of strategic holistic management, planning, and multidisciplinary knowledge (Carlson & Cohen, 2018). The management and design of infrastructure systems require making assumptions and decisions about constantly changing aspects of the project over the project's lifetime (Silva & Guevara, 2022). Also, the systematic inspection-based treatment can provide an effective tool for sustainability of management of infrastructure (Sheils et al., 2010).

6.3 Check process

6.3.1 Area participation and leader competency (APLC)

This factor concerning 'area participation and leader competency' consists of six items. The 'participation of people in the project area' carries the highest LF 0.687. The related items concern 'people in the area cooperated with the project', 'community leaders have abilities to plan and administrative the project', 'community leaders have knowledge and understanding the area', and 'people involved in the project have coordination skills. One empirical study shows that more public participation has been implemented in public projects to aid the smooth execution at the micro level and, at the macro level, to foster collaborative governance (Xie et al., 2017). The public participation and hearing approach are increasingly employed to prevent infrastructure project delays caused by public objections

(Manowong & Ogunlana, 2008). Public participation is an important concern of environmental impact assessment (EIA) because it is crucial in building a sustainable environment (Ye et al., 2023). Also, the participants in a project, especially an owner and a contractor, have an important influence in promoting project success (Li et al., 2020). The lack or loss of collaboration between project partners is seen as a major professional issue in the execution of a project in the construction sector. However, trust, commitment, and reliability enable collaboration in construction projects (Deep et al., 2021; Faris et al., 2022). Moreover, there are strong indications of public infrastructure development to suggest that these project management leader competencies affect the success of project (Rwelamila, 2007). Competency-based performance management is created from the key competencies underlying superior levels of performance with composure and team leadership being the most influencing effect (Dainty et al., 2004). However, leadership competency may lead and motivate that in its diverse guises as good leadership operating through power-sharing and power-amassing which is acceptable (Liu & Fang, 2006).

6.4 Act process

6.4.1 Research development and knowledge management (RDKM)

This factor relating to 'research development and knowledge management' includes 22 items. The 'research support in the area' gets the highest LF 0.791. The others concern 'setting up a centre for training and knowledge in the area', 'training to provide knowledge or develop advanced skills for executives', 'employee training on regular tasks', 'staff are trained on the job regularly', and 'bringing local wisdom to the project'. The knowledge management (KM) related to knowledge asset processes and the planning and control of activities is particularly significant for fulfilling organisational objectives and gaining competitive advantage (Terzieva, 2014). KM in project is developed from the concept 'to think better about practice' to one of 'supporting people to act better in practice' that a practice-based view is presented as being applicable to construction where practitioners compose action from experience (Boyd, 2013). KM is in fact a critical element of successful process integration (Fugate et al., 2009). KM is also promoted as an important and necessary factor for survival of organisation and maintenance of competitive strength. Transferring implementation of knowledge management to other projects is crucial for how successfully a project is implemented and managed (Pereira et al., 2021). Many information sources could be compliance, unity, and reasonability for defining problems and effect (Barish & Knoblock, 2008; Boutin et al., 2009). The empirical evidence suggests that the area-based research development in infrastructure engineering and management has been used for spotting and estimating the impact of events or procedures on the process of construction in an area (Leicht et al., 2010). The qualitative research methods of using observational studies can lead to answers to 'what' phenomena arose, especially when the public participates in a process, and insights into 'why' the phenomena happened.

6.5 Key indicators of AIPE

6.5.1 Environment conservation and geosocial integration (ECGI)

This factor 'environment conservation and geosocial integration' that concerns key indicators of AIPE consists of five items. The 'consideration of geosocial in the area' earns the highest LF (0.589). The others involve ‘maintaining a good relationship between project participants and the community’, ‘the project integrates economic’, ‘social’, ‘environmental and cultural aspects together’, ‘implementation of the project taking into account environmental conservation’, and ‘conservation of forests and watershed’. From empirical research, the impact on environment becomes a vital concern in selecting the appropriate construction or rehabilitation method for infrastructure projects (Zayed et al., 2011). The environmental impact protection of infrastructure needs the appropriate plan at the planning phase to provide what the society needs, including balancing different factors such as cost and time (Larsen et al., 2022). Also, economic and technological innovation have a positive enabling effect on the environmentally sustainable development (Liu et al., 2023). Furthermore, the area-based economy can encourage social transformation and a way to sustainability. (Nogueira et al., 2023). Previous studies found that the ethical and economic aspects of social responsibility can be fulfilled with the area-based project sustainability (Bevan & Yung, 2015; Lim & Loosemore, 2017). However, infrastructure has a central role in raising people’s standard of living and contributing to economic growth (Chan et al., 2022).

The decision at the planning phase of infrastructure projects aims to provide the best way of meeting people’s needs, balancing cost, and managing time and environmental impact (Larsen et al., 2022). Also, designing resource-efficient projects is an important approach to minimise the use of raw material and the impact on the environment. However, the direct maintenance cost is only a small part when compared to the social cost and environmental impacts (Peng et al., 2022). The sustainability criteria are sharp chiefly on cutting energy consumption and improving waste recovery. Designing buildings that are resource-efficient is an important approach to lower use of raw material and mitigate environmental impacts (Vares et al., 2020). In addition, the flexibility of project management is necessary in making decisions when facing different causes of uncertainty and in avoiding information asymmetry between the parties to improve environmental maintenance decisions (Lozano & Silva, 2019). Geosocial integration also provides the foundation of AIPE for social and industrial upgrade and transformation (Han et al., 2021). Different regions have a variety of patterns of development and structures of economy where geosocial integration organisations are critical to form differential Organisational Geosocial Network (OGN) structures (Zhao et al., 2022).

In short, the AIPE refers to how project delivery is planned, implemented, monitored, and controlled, with consideration of the economic, social, and environmental aspects for focusing benefits for all stakeholders (Silvius & Schipper, 2014). AIPE also considers the follow-up of systematic process, the achievement and consistency of the objectives, effectiveness, efficiency, and impact to achieve the sustainability ultimate goals (Rossi et al., 2004). The PDCA process that has been familiarised to administrative organisations could be applied as a management tool to evaluate projects on sustainability patterns in different local areas in Thailand (RDPB, 2022). This result showed a positive effect of conducting the PDCA process to evaluate the sustainability of AIPE.

7 Conclusions

The PDCA can be applied as an effective management tool throughout the life cycle to gain project success and drive project sustainability (Aksorn & Phansri, 2022; Altaf et al., 2022; Wang, 2021; Altaf et al., 2022; PMI, 2021). To sum up, the influential factors and key indicators of AIPE have been explored and could proceed steadily. The results could fulfil the objectives of this study which are identified as six groups in PDCA process:

(1) 'Plan' process consists of two factors that are 'implementation plan and good governance' (IPGG) with 29 items and 'action plan and stakeholder cooperation' (APSC) with nine items. The critical items for IPGG are the project responds to local problems and needs, coping with the quality guarantee plan, the safety of area, transparency of project bidding, integration between central policy and community needs, and good governance. In addition, the significant items of SPSC are requirements and master plans for project implementation, clear objectives and purposes, implementation of the project according to appropriate standards, the project responds to national or area strategies, and consideration the suitability of the project location.
(2) 'Do' process involves 'budget provision and public support' (BPPS) with four items and 'organisation administration and management tool' (OAMT) with six items. The important items of BPPS are financially supported by the state or central government, machine supports in a project, internship skill training and development of expertise in various fields, and the political condition that does not obstruct the project. The major items of OAMT are that persons in charge of the project have the knowledge and ability to assess the project, corporate executives have experience in evaluating projects, staffers have the knowledge and ability to assess projects, the project designer has knowledge and the ability to evaluate projects, and 'project managers understand area-based problems.
(3) 'Check' process contains 'area participation and leader competency' (APLC) with six items. The critical items for this process are participation of people in the project area, people in the area cooperating with the project, community leaders having abilities to plan and administrative the project, community leaders having knowledge and understanding the area, and people involved in the project having coordination skills.
(4) The 'Act' process includes 'research development and knowledge management' (RDKM) with 22 items. The significant important items for this process are research support in the area, setting up a centre for training and knowledge in the area, training in knowledge or advanced skills for executives, employee training on regular tasks, a staff trained on the job regularly, and bringing local wisdom to the project.

There is an ongoing rise of awareness of their responsibility to ensure sustainability by executing project development strategies, policies, and action plants among governments in different countries which will contribute to sustainable development (Aarseth et al., 2017). The focus of setting sustainability policies strategy is the establishment of laws, regulations, norms, and guidelines that encourage sustainability of the infrastructure projects at the national level (Block & Paredis, 2013; Bossink, 2002; Chen & Chambers, 1999; Meech et al., 2006; Ross et al., 2010). Also, the central policy for infrastructure development usually guides the local and regional governments to effectively manage the area-based infrastructure project (Leungbootnak & Charoenngam, 2007). For this reason, the objectives of sustainability ABID should set up and put into local administrative strategies and action plans by following the central government policies (DPT, 2022; Aarseth et al., 2017). However, the actual implementation of the sustainability guidelines and visions in practice are the real challenges (Chen & Chambers, 1999; Ross et al., 2010). This study gives a guideline for the management of area-based infrastructure project sustainability. The AIPE plays a critical role in the development of society, economy, and environment at local, regional, and national levels and requires systematically managerial aspects to gain project success and drive sustainability (RDPB, 2022; Zeng et al., 2015).

The outcomes of this study provide the sustainability pattern and evaluate the performance of area-based infrastructure. The study could contribute to stakeholders of area-based infrastructure project development such as project developers, managers, administrators, researchers, and operators. They can develop the effective PDCA process within certain restrictions and boundaries of a specified area. However, the important limitation of the study which ought to be recognised is the data collection which were from the limited boundary, only from Thailand. Based on the limitations of this study, the comparison of different countries could beneficially contribute to the field of research on sustainability of AIPE worldwide. Although these indicators have been evaluated and commented, still, there is no indicator that can fit every situation or infrastructure. This would be important that even if those indicators have been assessed, every infrastructure should adopt and customise the use of these in area-based condition of respective countries.

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Data availability All data generated or analysed during this study are included in this published article.

Declarations

Conflict of interest All authors have no conflicts of interest.

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