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ORIGINAL PAPER

Converting knowledge into sustainability performance of freight villages

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Abstract Along with the globalization of industry and trade, the importance of freight villages (FVs) greatly grows due to the substantial benefits they can generate, such as supply chain management efficiency, intensive provision of logistics services, modal shift, regional economic growth and employment, lower energy consumption, and environmental consequences. Hence, the sustainability performance tends to become a strategic goal that FVs' operators and decision makers (e.g., transport agents, warehouse providers and freight forwarders, logistics operators, and FV management company) endeavor to achieve. However, due to the lack of a systematic approach toward FVs sustainable development, existing literature has not yet clearly defined what strategic direction should be followed to pursue such a goal. This article proposes a knowledge-related approach to promote sustainability performance of FVs. This article highlights sustainability as a strategic goal of FVs rooting in the evidences from academia and practical cases. In addition, it explains the principle of ensuring sustainability by FVs with twofold meanings. Meanwhile, it summarizes the sustainability dimensions in the context of FVs. After introducing the significances of knowledge assets and knowledge management (KM) approach to the sustainability drawing on the implications from sustainability balanced scorecard (SBSC), it analyses KM characteristics in logistics and FVs area. Then, how the general KM process (knowledge acquisition, sharing, and application) act on FVs sustainable development is clarified. In which, the sustainability-related stakeholders of FVs are identified. Finally, it proposes a roadmap of organizing KM for sustainability-oriented FVs considering the distinct features of KM in FVs context. To support the success of this roadmap, this article recognizes two key elements including human ability and stakeholders' involvement. Furthermore, a checklist for building FVs sustainability capability based on SBSC is provided, which is hopefully being a referring guidance for FVs' operators and decision makers.

Keywords Sustainability performance · Freight village · Knowledge · Knowledge management

1 Introduction

The importance of freight villages (FVs) greatly grows, due to the changing freight and logistics processes characterized by containerization, globalization, third-party logistics, and intermodal transportation. Facilitated by changes in freight and logistics processes, FV has emerged around the world as a new generation of intermodal logistics and distribution facilities, in response to the challenges posed by regional population and freight growth [1]; especially in some emerging countries, for example, Brazil, China, India, and Russia, huge trade volume depends on the containerization, but the transport cost of moving containers to or from seaports constitutes a large part of the total transport costs. Consequently, the "inland leg" is clearly a crucial part of the supply chain from the point of view of operational efficiency and total supply chain cost [2]. The idea of FV forms the backcloth of "inland leg" development and gains increasing concerns in such areas. Meanwhile, in some developed countries, like Germany,

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Italy, Holland, USA, and Japan, they still keep emphasis on FVs development due to the functionalities beyond reducing transport cost, for example, consolidated urban transportation, sustainable city logistics, and environmentally intermodal transportation.

A freight village (FV) is a cluster of quality industrial–intermodal–distribution–logistics buildings located within a secure perimeter where a range of support services are provided by every user. It enables a high degree of accessibility and transfers freight from one mode to another with generating less negative environmental impacts [3, 4]. FVs are thought to maximize efficiency, while minimizing externalities such as urban congestion and negative impacts on air quality [5, 6]. Nowadays, the "FV" concept is developed to offer basic services to various transport and logistics companies located within its site, as well as to external users. By which, enterprises can be faster and easier to realize logistics location (buy or rent), thus decreases transit times and improves quality [7]. Due to the intermodality feature, FVs are recommended as environmentally adapted solutions in supporting green logistics and supply chain management. It has been pointed out that FVs by nature care for the environment since they allow for less warehouse dispersion around the country, less adverse side effects of transport on the environment, including air and water pollution, noise, as well as reduction in pollution emissions of vehicle to the central cities. As important nodes in local logistics network, FVs are able to help achieving local community development objectives. Broadly speaking, such natures position FVs as a promising facilitator in developing sustainable transport and logistics industry. Responding to these functions, sustainability performance gradually becomes an important evaluation criterion concerning FVs.

However, there can be major obstacles between desiring and realizing sustainability of FVs. These challenges are both conceptual and practical. To manage the scope, the complexity and uncertainty of problems crossing three dimensions: economy, environment, and society; thus, it is important to take account of different types and sources of knowledge. Knowledge has been widely recognized and accepted as a strategic resource in the area of logistics. Knowledge-based resources include all the intellectual abilities and knowledge possessed by employees, as well as their ability to learn and acquire more knowledge. Thus, knowledge-related resources of FVs include what settled enterprises and other segments have mastered as well as their potential for adapting and acquiring new information. These resources are seen as being crucial for developing sustainable FVs in today's environment. Furthermore, in the knowledge economy, a key source of sustainability relies on the way to create, share, and utilize knowledge [8], which can be understood as a term "Knowledge Management" (KM). Sustainability issue of FVs becomes more and more dependent on KM execution, due to the needs such as sustainability awareness, stakeholders information exchanging, advanced especially environmental technology and conceptual guidance, professional education.

This article relies on the field of intangible assets (knowledge) and KM to help explore and understand what can be done to address the following concerns toward sustainability of FVs:

1. Clarifies the involvements of sustainability issues in the context of FVs;
2. Recognizes the need to integrate knowledge and KM approach in obtaining FVs sustainability;
3. Follows iterative processes of knowledge acquisition, sharing, utilization;
4. Structures a roadmap of organizing KM process,
5. Proposes the key element of successful roadmap using, and
6. Provides a checklist for building FVs sustainable development capability.

2 Sustainability in the context of FV

2.1 FV concept

2.1.1 FV definitions

FVs are very widely used in the process of trade and transport in all around the world. In international bibliography, the term "Freight Village" continues to be used interchangeably with the terms: "Platformes Multimodales/Logistiques" (France), "Interporti" (Italy), "Gueterverkehrszentren" (Germany), "Logistics Park/Logistics Center" (China), or even with the more general term "Dry Port".

FV is accepted in this article as the unified name describing a defined area within which all the activities relating to transport, logistics, and distribution of goods, both for national and international transit, are carried out by various operators [9]. United Nations Economic Commission for Europe (UNECE) defines it from the cluster perspective: geographical grouping of independent companies and bodies which are dealing with freight transport (e.g., freight forwarders, shippers, transport operators, and customs) and with accompanying services (e.g., storage, maintenance, and repair), including at least a terminal [10]. In most cases, FVs are intermodal terminals, which are the principal components of an intermodal transport chain, thereby constituting the nodes where the transshipments of goods from one mode to the other takes place. Due to the integration of various transport modes, transport and

logistics companies can take advantages of common infrastructure, equipment, and services, without proceeding to heavy and risky investments if they had to choose the "individual" use [11]. Apart from using public heavy and risky investments like intermodal, located companies can cut cost from such aspects: reducing marketing cost because of the clustering's conveniences and brand power for absorbing customers; reducing investments in infrastructures like warehouse and yard-crane by the co-construction with other FV members; joining co-purchasing of energy like electricity to get a cheaper price; reducing emptying truck journey through consolidated transportation with other allied FV members.

Figure 1 describes the basic functions in a FV, which are characterized by: (1) spatial concentration of independent logistics (e.g., transport, distribution, and warehousing) and commercial trade companies in an industrial estate; (2) intersection of two or more different transport modes, particularly road/rail by an intermodal terminal; (3) interface between local traffic and long-distance traffic; (4) logistics facilities and service stations are provided; and (5) the cooperation between settled companies improves the commercial and ecological efficiency. The cooperation is usually coordinated by an independent development and management company [12].

2.1.2 *Sustainability is a strategic goal of FVs*

In the initiation of FVs, the environmental and sustainability functionality is indeed a strategic goal expected by researchers and practitioners. To support this assertion, numerous evidences can be found.

When talking "sustainable logistics," FV concept is pointed out as one of the two discussions, the other one relates to the long-term innovation and visionary strategy [14].

According to the statement of Europlatforms [9], FV is naturally characterized by economical and sustainable functions: "optimize area utilization," "safeguards the environment (moving the heavy traffic concerned from residential areas to the Logistics Centre)," "optimization of the logistics chain, lorry utilization, warehouse utilization, manpower organization," "a decrease in the total transport costs, total industrial costs, personnel costs…"

One goal of the FV development is to relieve the roads from goods traffic and promote the use of environmentally friendly transport carriers such as rail and waterway [15]. Urban freight transport contributes to the economic functioning of a city, it also creates externalities, like congestion, noise, and hazardous situations [16]. The Organization for Economic Co-operation and Development (OECD) (2003) proposed that urban freight consolidation and distribution as one of the most important techniques for improving the sustainability of sites and urban [17]. Owing to the intermodality, urban transport route optimization and transport companies' collaboration, FVs provide the opportunities in the aspect of urban freight consolidation and distribution. Furthermore, Visser et al. [18] pointed out that the goals of FVs include the reduction in local pollution, traffic noise, and the consumption of urban space for transport infrastructure and the general improvement of the urban environment.

In addition, FVs can mitigate negative impacts (e.g., scenic nuisance and noise) and making the FVs more

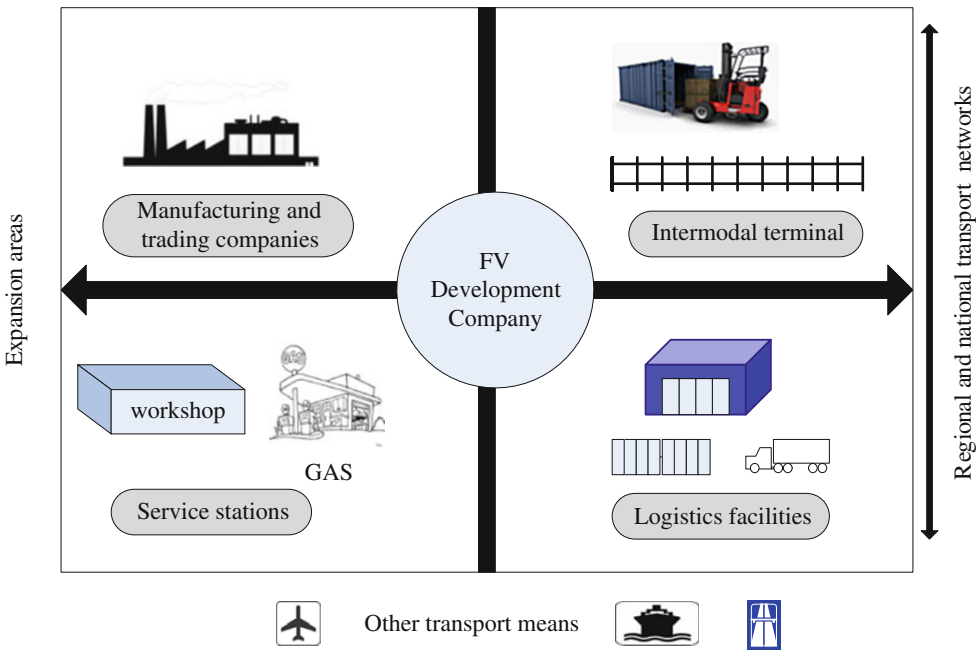

Fig. 1 Basic functions in a FV (Adapted from [13])

compatible with neighboring land uses. They are thought to maximize efficiency, while minimizing externalities such as urban congestion and negative impacts on air quality [19].

Wisetjindawat [20] explicitly gives the FVs' goals in the three aspects of sustainable development scheme:

- Environmental aspect: less emissions and noise, usage increase of better environmental transport modes (rail and inland water);
- Social aspect: better in terms of health and safety, less congestion, more efficient services;
- Economic aspect: reduction in the number of vehicle trips and vehicle kilometers, reduction in the unit cost, opportunities of revenue gain to avoid empty return truck.

Apart from the evidences provided by the literatures and reporting documents, this article discovers the reality in the following FV examples where sustainability is a strategic goal:

- FV Interporto Bologna (IT) project is the result of many public goals, for example, promoting intermodal rail transport to reduce heavy truck traffic in the city, improving urban goods distribution, and promoting environmentally sustainable economic development.
- FV Bremen (DE) was initiated by a desire to reduce heavy truck traffic and increase intermodality.
- The superior goal of FV Berlin-Brandenburg project (DE) is environmental- and urban compatible. It offers the transport industry an environmentally friendly and economical feasible solution for all supply and disposal tasks.
- Being a "freight city," Alliance Texas project (US) is a finest and special example of how industrial, commercial, institutional, and residential activities can be located in close proximity to one another without conflicts.
- Nodric Transport Centre (DK), Denmark relocated freight facilities out of cities to improve environment, safety, and support business.

2.2 Sustainability of FVs

2.2.1 Twofold meanings in FVs sustainability

Sustainability on a macro level embraces the integration of three basic principles, namely "environmental integrity," "social equity," and "economic propersity" [21]. The concept of sustainable development defined in Brundtland Report is often used when speaking in environmental terms, but it is more adequate with a broader interpretation in terms of a balanced (coevolutionary) industrial, social, ecological, and economic development [22]. As discussed above, the double nature indicates that FVs are inherently polluting entities, meanwhile they are an opportunity for the sustainability of the region. Consequently, this paper extends the sustainability in the context of FVs to twofold meanings beyond the sustainable development themselves, but also the sustainability they created.

(1) Private nature means FVs definitely are business units similar with general enterprises, therefore naturally they engaged in the trade of goods, services, or both to consumers by consuming certain resources [23]. Externalities in ecological environment and social community are inevitable, and "corporate responsibility" is thus increasingly becoming a theme in today's business development. Each FV usually starts out with its own set agenda; however, actually, lots of them exist simply to make money and ensure the logistical value: service (e.g., availability, performance, and reliability) and cost minimization. If FVs do not concerns lowers environmental impacts, it will be unpromising to sustain long-term competitive advantage with the improvement of eco-awareness. The logistics industry is a major source of CO_2 emissions, accounting for 13.1 % of global greenhouse gas emissions, according to the Intergovernmental Panel on Climate Change [24]. Concerning the operations of FVs, the transport threatens the ecological environment evidently. A significant and growing share of total CO_2 emissions and other harmful environmental impacts emanates from freight transports. Due to the status quo will result in an increase in congestion and pollution and will ultimately threaten the competitiveness of Europe's economy, the White Paper—European transport policy for 2010 (European Commission 2001) advises the European Union to focus on efficient transport to ensure EU's prosperity [25]. In this report, less congestion, fewer emissions, more employment, and more growth are explicitly raised [26]. It lists ten goals for a competitive and resource-efficient transport system in order to achieve the 60 % GHG emission reduction target, which are summarized in following three approaches [26]:

- Developing and deploying new and sustainable fuels and propulsion systems.
- Optimizing the performance of multimodal logistic chains, including by making greater use of more energy-efficient modes.
- Increasing the efficiency of transport and of infrastructure use with information systems and market-based incentives.

Being the intermodal infrastructure holders and primarily conducting intensive transport-related activities, to some extent, FVs are obligatory to carry out new forms of transport rules and implement efficient technologies. Effective ways involve using low-emission trucks,

reducing empty trips, sophisticated intermodal route planning, etc.

Despite the transport, FVs in connection to environmental aspects covers a variety of functional areas in distribution processing, such as eco-efficient unloading vehicle, green packaging, supervise waste disposal, and emission control. Following "3R" principles (reduce-reuse-recycle), located companies are required to incorporate the sustainability objectives into their daily activities.

(2) As the traffic nodes and logistics consolidation center, FVs play the important role in city logistics scheme. Given that, since 2007, more people live in cities than rural areas, new logistics concepts are needed to avoid congestion, pollution, low supply chain reliability, and growing cost [27].

Figure 2 simply depicts FVs functioning in sustainable city logistics. Supply chains are always more complex because of the localization of new worldwide production centers in the emerging countries. Traditionally, port and airport infrastructures allow commercial connections with these production centers; additionally, FVs are widely used in the more complex and articulated transport networked supply chain. As the important nodes connecting

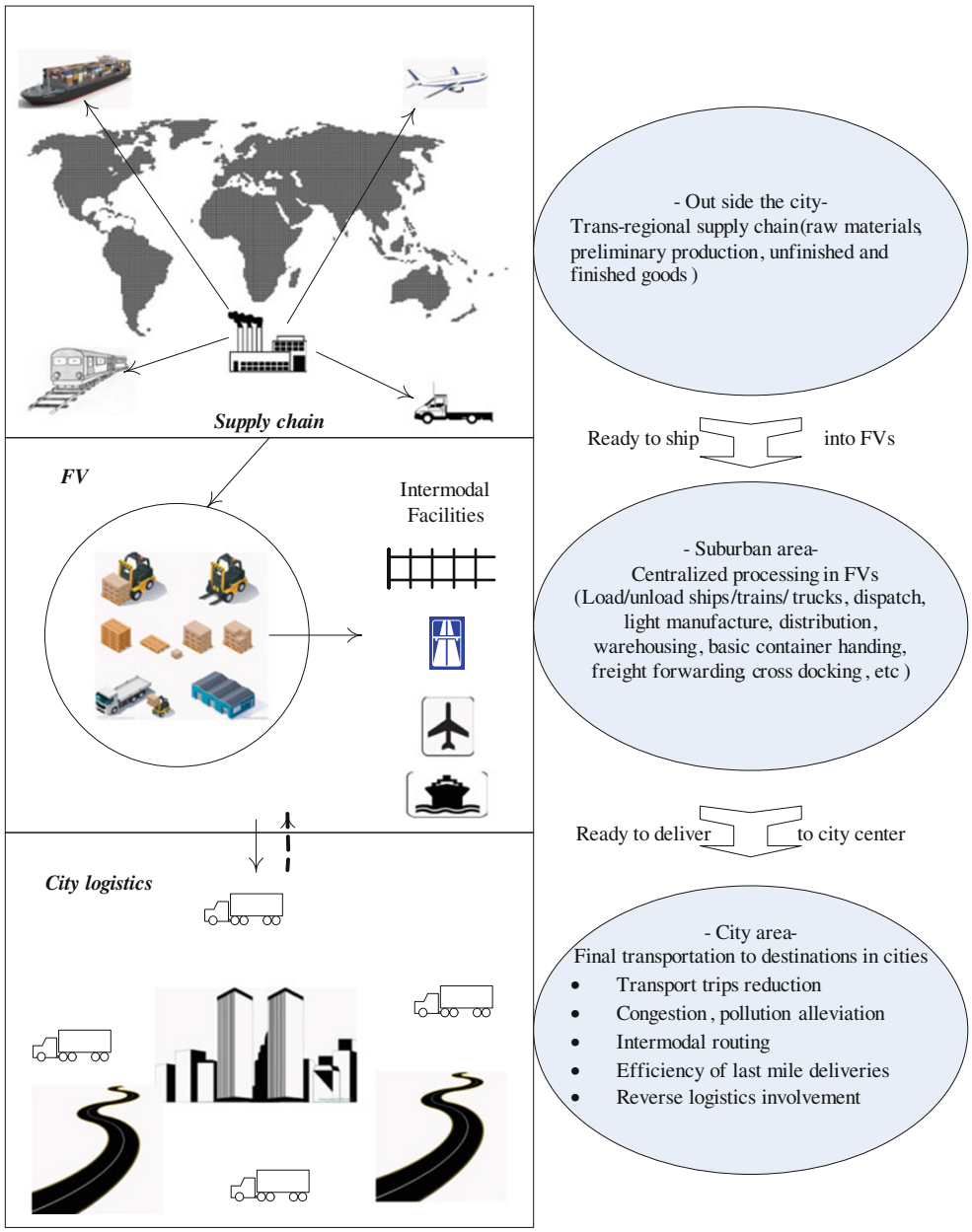

Fig. 2 FVs' greening functionality toward sustainable city logistics

transregional supply chains, FVs reduce transport processes within urban. Usually, FVs locate in remote area (suburban) to provide integrated logistics activities for the city delivery, which is a response to the uninterrupted city distribution and decongestion of urban traffic. Furthermore, because of the intermodality feature, FVs are recommended as environmentally adapted solutions in implementing green logistics and supply chain management. The combination of transport modes inside the FVs, particularly the use of environment-friendly modes, as train and ship, results in the reduction in CO_2 emissions by heavy vehicles [28]. In addition, FVs provide channels and places for reverse logistics, which is connected with environmental management issues due to it aims to the recovery of used products and materials with obvious environmental gains.

2.2.2 *A summary of FVs' contributions to the sustainability*

FV is a logistics phenomenon with broad economic, social, and environmental consequences. Under certain technical and regulatory conditions, FV has a major impact in reducing not only the economic cost of transport systems, but also the negative externalities that affect the population, thus contributing to sustainable development [29].

FV is able to combine the specific strengths of each mode at European and world level to offer their clients and, consequently, society at large the best service in terms of efficiency, price, and environmental impact in the broadest sense (economic, ecological, energy, etc.) [26]. To be more precise, Fig. 3 describes FV as a pivotal element contributing to the three dimensions of sustainability.

3 Knowledge-related approach to sustainability

3.1 Knowledge asset, KM, and sustainability performance

Knowledge is defined as a justified belief that increases an entity's capacity for effective action [30, 31]. It has been a crucial asset related to but distinct from tangible assets, monetary assets, and the traditional accounting concept of intangible assets [32]. Hence, nowadays, knowledge asset is widely recognized as a resource that plays a pivotal role in value creation of organizations, as well as companies' competitiveness foundation in knowledge-based view of the firm in strategic management.

The rationales for investing in KM for sustainable development purpose are listed as follows [33]:

- Filling the knowledge gaps that inhibit policy development toward sustainability;
- Generating recommendations that will fast track innovation for sustainability;
- Resolving current frustrations with inadequate or inappropriate policy development and implementation;
- Learning from each other across sectors and regions about best practices,

This article proposes the KM approach is effective for realizing sustainability performance with the conceptual tool of sustainability balanced scorecard (SBSC). SBSC is evolved from the traditional balanced scorecard (BSC). BSC is designed by Kaplan and Norton is as follows: learning-and-growth perspective (priorities to create a climate that supports organizational change, innovation, and growth), internal/business process perspective (strategic

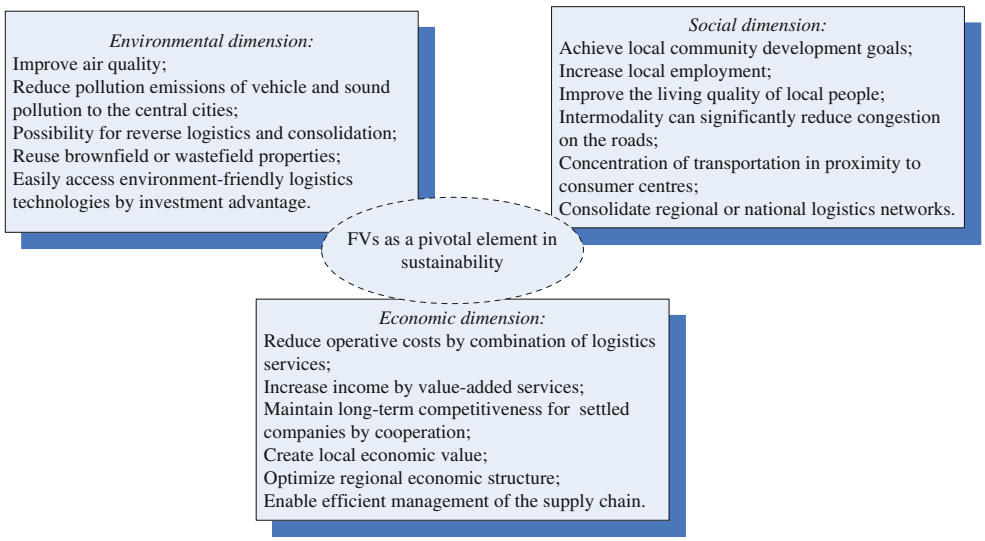

Fig. 3 FVs' contributions within three dimensions of sustainability

priorities for various business processes, which create customer and shareholder satisfaction), customer perspective (strategy for creating value and differentiation from the perspective of customer), and finally financial perspective (strategy for growth, profitability, and risk viewed from the perspective of the shareholder); in financial perspective financial objectives, similar to traditional systems of management and accounting are of importance [34].

Carl Ulrich Gminder and Thomas Bieker discussed how the tool of the BSC can be used for the management of sustainability in general and corporate social responsibility (CSR) in particular [35]. Integrating sustainability into BSC not only exist in the literatures, but also in practice field. Some companies like Lunds Energi, Novartis, Novo Nordisk, and Shell, they are documented to be using the BSC and carrying out environmental and social programs [36]. There are basically three possibilities to integrate environmental and social aspects in the BSC. First, environmental and social aspects can be integrated in the existing four standard perspectives. Second, an additional perspective can be added to take environmental and social aspects into account. Third, a specific environmental and/or social scorecard can be formulated [37]. This article recommends the SBSC frame as showed in Fig. 4. Four perspectives are "learning-and-growth perspective," "process perspective,, "stakeholder perspective," and "sustainability perspective."

The SBSC frame gives implications concerning the functions of knowledge and KM as well as how KM works to adapt sustainability performance improvement (See Fig. 5). Specially, the aspect of "learning and growth" is always the base for strategic routes, which refers to skills, information, experts, and technologies. Through KM

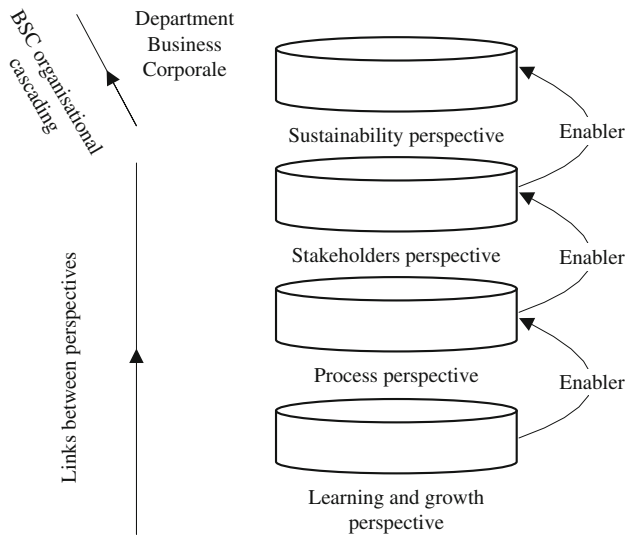

Fig. 4 Cascading sustainability balanced scorecard (Adapted from [38])

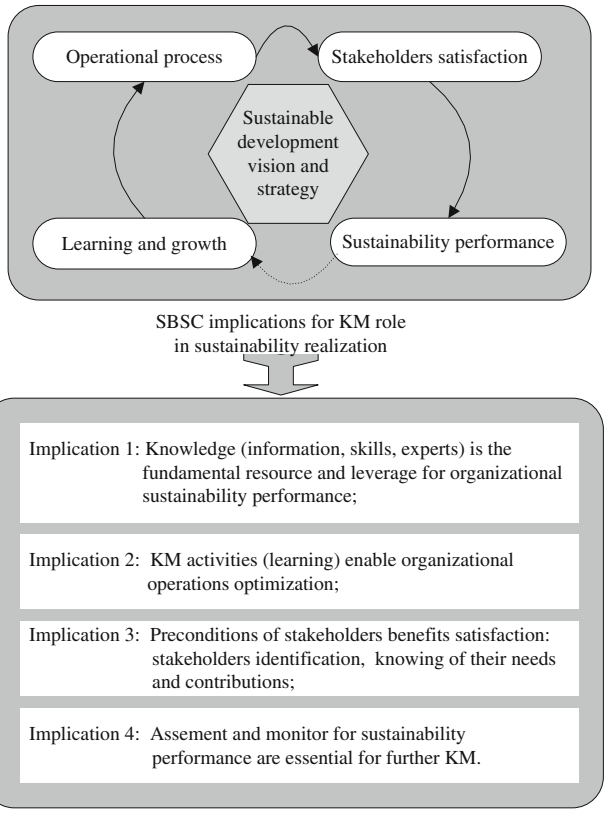

Fig. 5 SBSC implications for sustainability-oriented KM principles

actions, knowledge assets are possible to qualify and optimize organizational processes including the production process and service process. Indeed, stakeholder relationships are strengthened relying on the knowledge network with multiple stakeholders' engagement, and this is because that sustainable development is a complex and interactive issue depending on various sectors of the community. In addition, the evaluation of sustainability performance is a feedback and reflection for further KM implementation.

3.2 Discussing knowledge and KM in logistics and FV

The integration of knowledge-related topics (such as IT, learning, knowledge sharing, and knowledge acquisition) into the field of logistics and supply chain management are gradually recognized by people, though there is little discussion in FV aspect. Esper et al. have identified the following five dynamic capabilities that are all vital for the continuous development of the bundling of logistics processes and IT systems: managerial knowledge and presence, cross-functional teamwork, control, learning, supply chain relationships. They pointed out a range of logistics capabilities are recognized associated with customer focus, supply management, integration, measurement, and information exchange [39]. Elbert et al. [40] think that through

an exchange of knowledge and experience with other FV percipients and thereby an enhanced transfer of best practice solution in different areas of logistics, structures and process impulses changes in the FV.

As most researchers mentioned when defining FV: "a cluster of freight-related business," this of course brings FV concept into the view of industrial cluster. However, the following distinctions of FVs from general industrial clusters are proposed by this article:

- Double nature of FV: public node and commercial entity.
- Twofold meanings of sustainability.
- Depends largely on the facilities and infrastructure.
- Services-base for general industries.
- Governments and public sectors intervention.
- Critical role of information/knowledge for agile performance in logistics and supply chain.

Considering the above distinctions, two characteristics of KM in the context of FVs logistics and supply chain are identified.

Multi-levels of knowledge mapping Logistics has evolved from a mere activity of goods handling management to a strategic operation on which regions and countries can leverage to be competitive. Therefore, logistics development relates multi-levels of knowledge and knowledge holders. Considering FVs' double nature, multi-levels of knowledge mapping becomes one distinct characteristic of KM in FVs researches. (1) Policy knowledge, which refers to the top–down regulations and policies are managed at government level. (2) FV concept only exists for around 20 years, and logistics itself is a quite young and very dynamic field of knowledge and science. Scientific knowledge is urgently needed for cultivating qualified logisticians. (3) Innovative knowledge, which allows the enterprises located in FVs to lead in a way that clearly differentiates it from anybody else. (4) Externalities knowledge, the knowing about logistics activities impacts on global warming (increasing contribution of transport to CO_2 emissions), air, water and noise pollution, transport include congestion and traffic accidents. (5) Administrative knowledge used in conjunction with the support operations in a FV. (6) Operational knowledge, relating to the information chain with the process of transshipment unloading and control, storage, cargo handling, package, transportation in FV.

Collaborative KM in logistics and supply chain management Since the collaboration is the core of supply chain, logistics activities and supply chain naturally require information intensive and multi-cultured environments. Logistics and supply chain management emphasize the integration across organizations, so as to know about quality standards and procedures, database requirements of suppliers or customers, stock control procedures, and transportation information. The importance of business relationships in the supply chain is well established by collaborative KM. Moreover, collaborative KM can deal with the Bullwhip effect of supply chain by knowledge sharing. The bullwhip effect is near-hand term for a dynamical phenomenon in supply chains. The information in supply chain usually includes details on the nature of the goods, quality, health and origin certificates, safety and other handling instructions, destination, shipper, receiver, intended mode of hinterland transport, and required arrival date and time. Currently, such information is not regularly available to container terminals, or hinterland transport operators, until the very last moment [41]. In order to integrate trading partners, to streamline their objectives, and to achieve common goals of improving reliability and flexibility and waste minimization, collaboration-oriented KM particularly dominates in the logistics and supply chain management field [42]. FVs are parts of a larger freight flow network, but there are differences into which extent they collaborate with each other. Collaborative KM has a significant impact on supply chain learning and information dissemination across multiple segments along the logistics and supply chain in FVs.

4 KM process implementation toward sustainability performance of FVs

In line with the implications above, this section focuses on the KM implementation in FVs, which realizes the converting of knowledge into sustainability performance. KM strategy is not an option but a necessity for FV operators to establish, since the FV operators are able to obtain knowledge through both cooperative and competitive networks and the acquired knowledge facilitates the enhancement of logistics value and sustainability contribution to the community/region [43]. The framework of KM process enabling FVs sustainability is showed as Fig. 6. In which, KM process, FV activities, and FV sustainability performance are outlined. Synergy effects are the direct expressions of FVs sustainability, which are embedded at three layers:

- Synergy of firms within a FV. There are two major types of inter-firm relationships that both contribute to the success of clusters and emerge as a result of agglomeration: vertical and horizontal [1]. In this article, vertical relationships refer to the linkages between firms along the logistics service chain "receiving-processing-storing-commissioning-packing-dispatch–disposal." Besides, with the functional diversification expansion in FVs, another kind of units

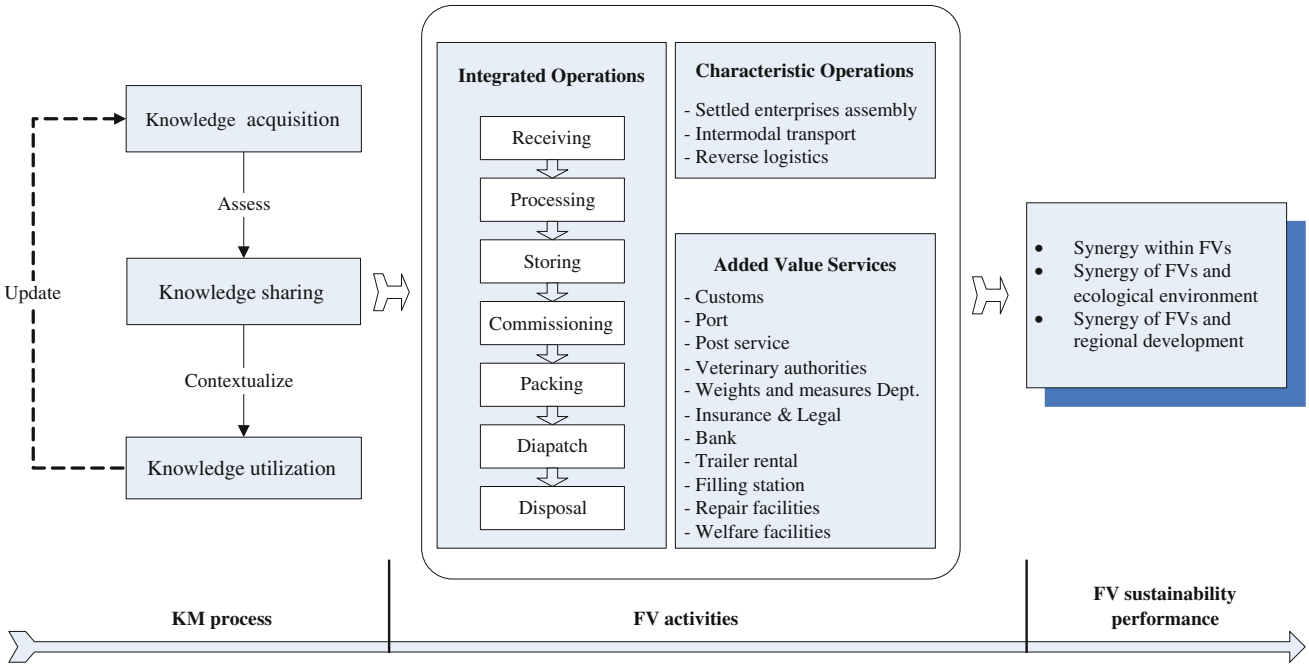

Fig. 6 Framework of KM process for driving FV sustainability performance

increasingly appears in FVs. They provide value-added services, such as customs, port, post-services, and veterinary authorities, and the vertical synergy of them highly complement FVs' attractiveness for private funding and customer preference. Meanwhile, horizontal relationships include those business agreements between firms that have "parallel" or cooperating positions in the logistics process or added value services. Horizontal synergy promisingly reduces "cut-throat competition" among "parallel" firms within a FV and thus improve the whole' capability.

FV Management Company functions as a communication platform for exchange of experiences for service structures and development [44].

Synergy of firms within a FV is probably strengthened by knowing the upstream and downstream divisions' conditions, also by collecting valuable information or skills about their suppliers, customers, cooperative partners and business, political environments.

- Synergy of FVs and ecological environment. Intermodal transport and reverse logistics are major enablers in this aspect. This requires a process or systems approach for execution and "a higher degree of skill and broader knowledge of the transportation/supply chain processes…information, equipment, and infrastructure" [45]. Due to the distributed nature of actors and information resources involved in intermodal transport, the need for efficient KM is imperative. Besides, in reverse logistics, KM integrates information from external and internal elements of the management process of the product returned, aids to allies in reverse logistics to make appropriate choices, supports the process, and manages partnerships [46].
- Synergy of FVs and regional development. FVs have become an important part of logistics industry in a region. Since the logistics costs-to-GDP ratio indicates the efficiency of regional development performance to a great extent, the synergy between FVs and regional development is gaining more and more attentions from governments and local authorities. Governments and local authorities have involved in the guiding, suggesting even controlling FVs' behaviors, therefore allowing the establishment of industry standards and avoidance of low-quality FV. They are responsible for the connecting and allocation of transportation resources (road, railway, waterway, and air), reserve of key strategic materials and emergency supplies, and promote the interactions between different FVs at the regional level. Meanwhile, in complying with the related regulations and laws, FVs tend to obtain policy supports and public financing as well as private financing.

To achieve the maximum synergy of FVs and regional development, FVs should be proactive in "understanding" the tendency of policies made by governments as well as making the operation situations and bottlenecks known to local authorities. Moreover, the governments and local authorities keep contact with FVs operations within their

jurisdiction. Consequently, they can have great access to knowledge from the practices of FVs, which potentially helps adjusting the regional logistics industry planning and other industries development strategies.

KM facilitates the synergy effects mentioned above. Many researchers use the terms knowledge and information interchangeably, emphasizing that there is not much practical utility in distinguishing knowledge from information in knowledge sharing research. We adopt this perspective by considering knowledge as information processed by individuals including ideas, facts, expertise, and judgments relevant for individual, team, and organizational performance. In this article, an integrated KM cycle is distilled consisting of three processes: (1) knowledge acquisition, (2) knowledge sharing and dissemination, and (3) knowledge utilization. Table 1 summarizes the three processes with their relevance to sustainable behaviors of FVs. The process of knowledge acquisition will bring the development and creation of insights, skills, and relationships. In the transition from knowledge acquisition to knowledge sharing, knowledge content is assessed. Knowledge sharing disseminates and makes available what is already known. Knowledge is then contextualized in order to be used ("utilization") [47].

4.1 Stakeholders identification of sustainability-oriented FVs

Sustainability, as the combination of economic, ecological, and social requirements, cannot be achieved unless all stakeholders are involved. Sustainable development can only be given real meaning and achieved through a multi-stakeholder approach [50]. Freeman defined stakeholders as "any group or individual who can affect or is affected by the achievement of the organization's objectives" [51]. Stakeholders, then, are much more than just "interested parties." They put something in ("contributions") and in return they get something out ("inducements").

Concerning the context of FVs, Kapros argued that although there are numerous stakeholders involved directly to the development of FVs, most of them can be grouped into five main categories: (1) owners or managers, (2) potential users, (3) other transport actors, (4) local authorities, (5) special interest groups [52].

This article identifies three scopes of stakeholders concerning a FV (See Fig. 7):

- Primary stakeholders. Individuals or organizations who directly operate or benefit from this FV, including investors, located companies, and FV Management Company/association.
- Correlative stakeholders. Individuals or organizations whom this FV interacts with to generate benefits in a broader meaning, consisting of suppliers, customers, public transport authorities, public terminals, other FVs, other FVs, industrial groups, inhabitants, and natural environment.
- Influential stakeholders. Individuals or organizations that influence FV operations in wide environments in terms of policy, financial, technology, professional guides, and social morality. The influential stakeholders probably are state government, local municipality, professional associations, financial supporters, fiscal offers, universities and research institutions, non-governmental organizations (NGOs).

Table 1 KM process and relevancies to FVs sustainable behaviors

Process	Main points	Relevancies to FVs sustainable activities
Knowledge acquisition	Identification and subsequent codification (or creation) of existing internal knowledge and know-how within the organization and/or external knowledge from the environment [47]	Making the knowledge visible in FVs
		Knowing status of logistics market and customer preferences
		Recognizing the value of new knowledge for lifting logistics services efficiency
		Tracking the regulations policies and regulations on transportation
		Learning experience of successful FVs cases
Knowledge sharing	Processes transferring, disseminating, and distributing knowledge order to make it available to those who need it [48]	Improving friendly competition and cooperation of enterprises within the same business unit in FVs
		Creating synergies of different parts in FVs
		Promoting positive interactions with other FVs and local authorizes
Knowledge application	Incorporating knowledge into an organization's products, services and practices to derive value from it [49]	Clean production process, reverse logistics
		Green packaging, warehousing, etc.
		Low-emission vehicles, environmental friendly intermodality and alternative fuels
		Technology-based service improvement
		Regulating FVs public behaviors

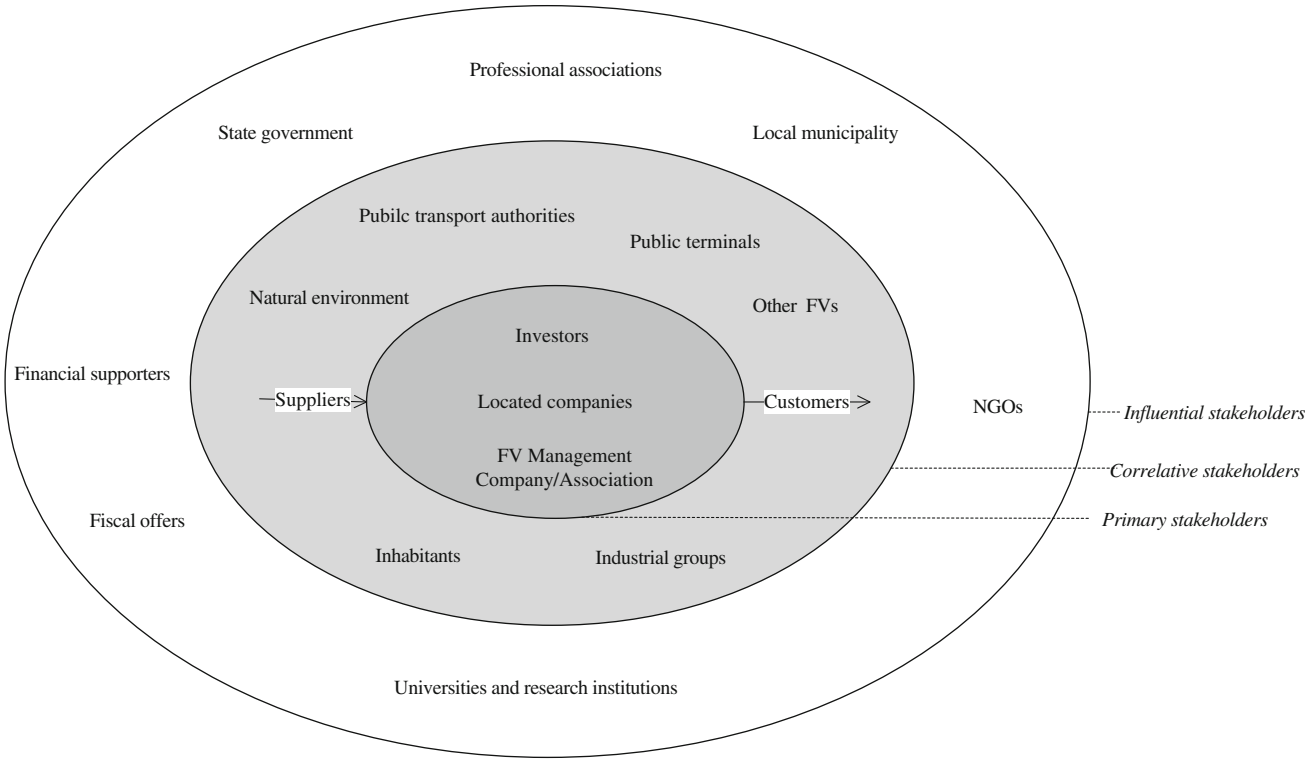

Fig. 7 A general stakeholder map for a sustainability-orientated FV

The characteristics of many environmental problems and social issues of FVs pose a real challenge to traditional scientific knowledge, because they cover (1) agglomeration and clustering issue, (2) inter-regional operation, and (3) interactions with the urban development scheme. In consequence, from the outset, the process of developing the Master plan aimed to link up players from industry, academia, government, and civil society on a broad basis and to overcome structures of thinking and working that are "set in stone" [53].

In response to these challenges, there is a considerable shift in management approaches to FVs sustainability performance, moving from management informed by reductionist ideas to a post-normal science associated with the erosion of boundaries between different forms of knowledge and rationality and the coupling of social and ecological systems [54]. This shift is reflected in concepts such as stakeholder involvement, knowledge networks, and greening education. Thus, in the context of FVs, knowledge/information-related activities toward sustainability are evidently supported by stakeholders' involvement.

4.2 Knowledge acquisition

Knowledge acquisition is "the process by which knowledge is obtained" [49]. This process is mainly reflected in identification and subsequent codification (or creation) of existing internal knowledge and/or external knowledge, and know-how within the organization. In this article, knowledge acquisition is defined as a process by which organizations (firms and other units) in FVs obtain new knowledge from their external environments (other organizations relevant to FVs and public environments). Acquired knowledge does not have to be newly created, only new to the FVs' existing "knowledge warehouse". The advantage of knowledge acquisition basically is the elicitation, collection, analysis, modeling, and validation of scattering knowledge in settled enterprises and complementary units in FVs, as well as the absorption of external knowledge; especially, the knowledge acquired from external environment is critical, and they usually are information about market demand and customer preferences, new knowledge generated by external commercial or research organization for lifting logistics services efficiency or the quality of other services, the regulations policies and regulations on transportation, best practice of successful FVs experience.

Table 2 summarizes the sources of knowledge which can be acquired and may be possible to become the knowledge assets for FVs. Four levels of knowledge assets are covered: environmental knowledge, human knowledge, structural knowledge, and relational knowledge. According to the four levels, the knowledge assets are detailed following their sub-levels, which point out the sources for knowledge acquisition.

4.3 Knowledge sharing

When knowledge is inventoried in the manner of acquisition, the next critical step is to present an assessment against selection criteria that will follow closely the organizational goals. Is this content valid? Is it new or better? that is, is it of sufficient value to the organization such that it should be added to the store of intellectual capital [47]?

Table 2 Sources of knowledge acquisition

Level	Sub-level	Content of knowledge assets
Environmental knowledge	Insights into business environment	Status quo of regional logistics market
		Transport policies tracking
		Potential customers identification
		Interaction with distribution intermediaries
		Trends of competitors(other FVs)
		Current commercial business models
	Interpretation of social, ecological environments	Sense of air pollution, noise, traffic accidents increase caused by fleet increase
		Understanding of low-carbon and sustainable economy
		Reorganization of FV functions in traffic congestions
Human knowledge	Organizational capital	FV objects definition and value orientation
		Cultural atmosphere
		Environmentally aware business models and technologies
		Ongoing formal and informal training
		Impediments
	Individual capital	Professional abilities on cost/time, reliability, flexibility
		Personal environmental awareness
		Employment base
		Adaptability and competency of their jobs
		Learning ability
		Innovation ability
Structural knowledge	Products and services	Dimensions of FVs standard services, advanced services, complete services, integrated services
		Intermodal transportation operations and simulation
		Experiences of waste logistics and reverse logistics
		Life cycle of products
		Green products innovation
	Business management	FV governance structure
		Regulatory structure
		KM ability
		Investment management capability
		Performance management capability, audit and review
	Supportive technology	Specialized IT software for operational management
		RFID, automatics, intelligence application level
		Information and communications technologies (ICT)
		Database maintenance skills
Relational knowledge	External stakeholder relationships	External stakeholders identification: customers, suppliers, government, community, special groups, other FVs
		Positioning stakeholders
		Interests and requirements acquisition
		Skills and experiences of building collaborative stakeholder relationships
	Internal stakeholder relationships	Stakeholders identification: board members, employees, management layer, shareholders, settled companies
		Knowing of requirements and dynamics
		Ability of establishing trust, loyalty, and communication among them

In the context of sustainability performance of FVs, the assessment takes "logistics efficiency & effectiveness," "economic benefits," "environmental protection," and "social contribution" into consideration. On the basis of assessment, knowledge of potential value toward FVs sustainability is added to the store of intellectual capital (knowledge assets).

Through the process knowledge acquisition, settled enterprises and complementary units in FVs hold knowledge they need, respectively. Then, knowledge sharing is the important part in the subject of KM, through which one unit is affected by the experience of another [55]. It is referred to as the processes transferring, disseminating, and distributing knowledge in order to make it available to those who need it. It provides task information and know-how to help others and to collaborate with others to solve problems, develop new ideas, or implement policies or procedures.

An efficient knowledge sharing approach is more important than ever in tightly coordinating the independent bodies (partners or companies) in a FV (or relevant to FV operations) and preventing the bullwhip effect. These independent bodies involve the enterprises and complementary entities within a FV, and external entities interacting with this FV within its influential regions, such as networking FVs, public traffic planners, external industries, universities, and research institutions. Knowledge sharing in FVs can be in the forms of: intra-enterprises species (within FV), inter-enterprises species (within FV), and between FVs and the external related entities. Successful knowledge sharing will increase the whole knowledge stock of FVs and at the same time, establish the "mutualistic symbiosis" of enterprises species in FVs, create synergies of different enterprises species in FVs, and promote positive interactions. These three forms of knowledge sharing are interrelated (See Fig. 8).

1. Intra-enterprises species knowledge sharing within FV. It refers to the knowledge sharing among the enterprises in the "peer group," and these "peer groups" are divided according to their services areas. In FVs, they usually relate loading/unloading, storage, freight forwarding, assembly and packaging, cross-docking, terminal operations, etc. Technical and customers' (or market) information becomes the core content of the knowledge sharing among them. The "cluster" characteristic requires the alliances of peer enterprises in FVs rather than fierce competitions. The technical performance of these enterprises species is essential for absorbing more customers to establish business relationships and reducing their own risks by consolidated shipments and consolidated warehouse. Furthermore, through knowledge sharing, it is likely to facilitate consensus on the logistics activities following sustainable development principles, for example, the purchase decision and utilization of eco-friendly forklifts, executive safety standards on storage and package/repackage of hazardous materials, clean distribution processing, optimization of multimodal transport routing, optimizing vehicle capacity utilization, reducing empty trips, sharing expertise, rapid cross-docking, establishment of staff development plan. In all, intra-enterprises species knowledge sharing is important both in its own right and because it is embedded in the context of inter-enterprises species (within FV) knowledge sharing.
2. On the basis of intra-enterprises species knowledge sharing within FV, the integration of inter-enterprises species knowledge sharing can be better for the whole FV's performance. Inter-enterprises species knowledge sharing in FVs means knowledge sharing among enterprise groups in different areas. Considering the service series offered by FVs, strengthening relationships among the different enterprises species or units are crucial. As mentioned above, nowadays, the integrated operations inside a FV form a logistics service chain which can be summarized as: "receiving-processing-storing-commissioning-packing-dispatch-disposal." Besides, the complementary bodies inside a FV (e.g., bank, customs offices, insurance and legal, post office, repair station, weights and measures Dept., and veterinary authorities.) offer supportive activities for conveniences and efficiency of logistics operations. Almost the whole procedure of goods circulation can be fulfilled by the provision of FVs. Therefore, successful knowledge sharing may smooth the logistics chain and enable the cohesive activities in FVs. Inter-enterprises species knowledge sharing within FV has the potential to enhance the whole FV's cohesiveness, thereby consolidating the position of FV in the regional logistics system, as well as better integrating itself into the context of knowledge sharing with external entities.
3. Knowledge sharing between FVs and the external related entities. Coupling effects are created by the interactions between FV and its external related entities. External related entities are described as linked FVs/Ports, public traffic agencies, regional industries, universities, and research institutes, etc. The specifications are listed as following:

    - With the expansion of logistics services in global market, FVs tend to cooperate with other FVs or ports to increase their market share, especially in a long transport chain covering multiple countries or continents. Usually, the logistics network is

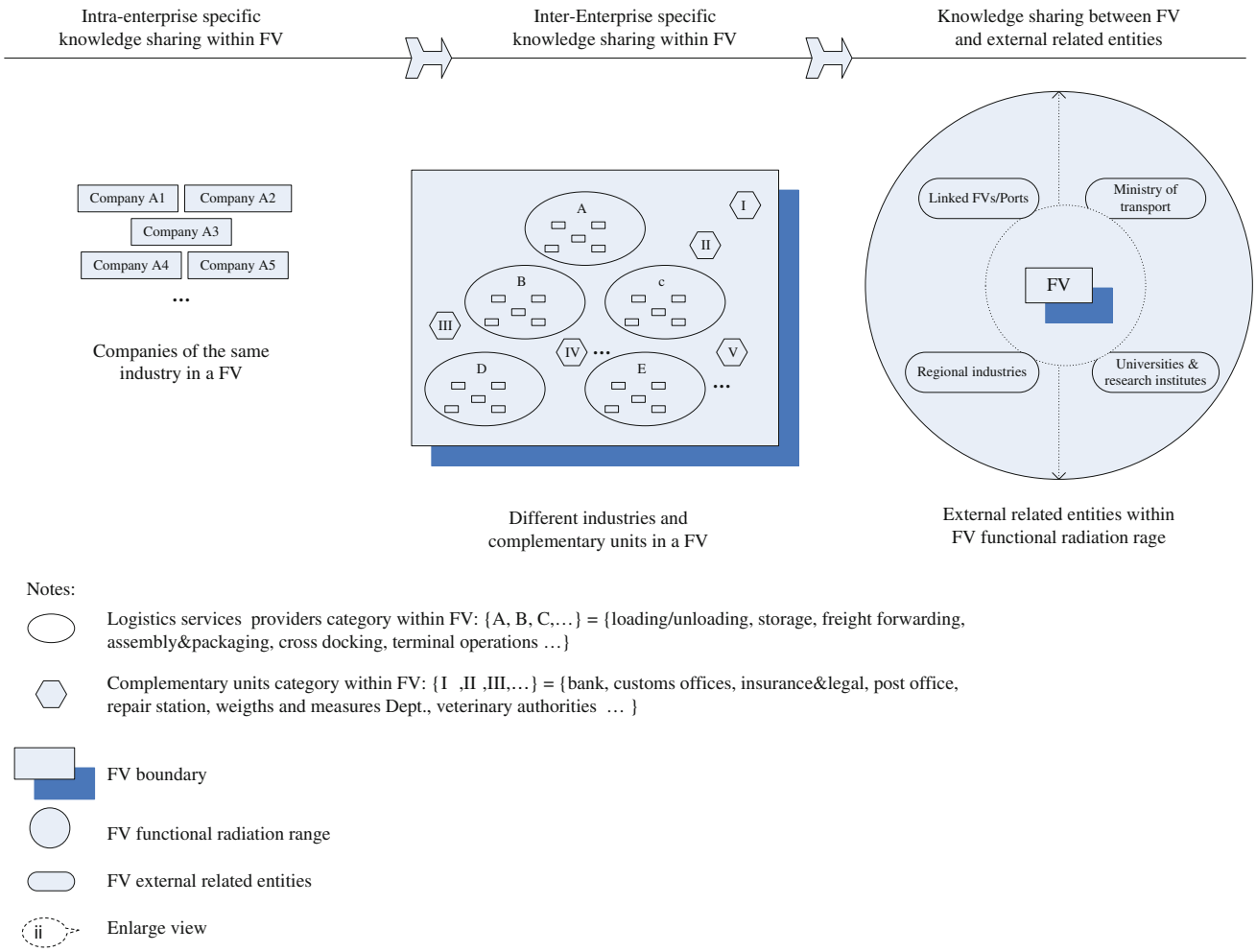

Fig. 8 Interrelated three contexts of FVs knowledge sharing

constituted by the nodes mainly in the form of FVs and ports, and these linked notes cooperate to execute transport tasks. Knowing about each other and trust among these liked notes ensure the entire freight distribution network is used as efficiently and effectively as possible. Figure 9 roughly describes the location of GVZ (Güterverkehrszentrum is FV) Bremen and its linked FVs/Ports. As one of the most successful examples of FVs in Europe, in a central spot among North Sea ports, GVZ Bremen claims an ideal geographical location. When JadeWeserPort opens, Bremen will be in the middle of the three major harbors in Bremerhaven, Wilhelmshaven, and Hamburg. On the way to North Sea, there are ports of Cuxhaven and Brunsbüttel located. GVZ Bremen distributes goods southwards to German cities like Osnabrück and Hannover. Encouraging knowledge sharing of these notes' processes to increase efficiency and quality of operations, thereby the significance of GVZ Bremen as a logistics hub can be expected to increase as drastically as the volume of the flow of commodities [56].

- The intermodal transport characterized FVs closely connect with the Ministry of transport (road, rail, waterway, and air). More and more countries or regions regard FVs as important content in logistics program. In response to this, government's investment in the national transport system is substantial. Effective knowledge sharing between FVs and Ministry of transport is crucial for establishing an efficient traffic network. It is encouraged to optimize communications between policymakers (Ministry of transport) and transport stakeholders (FVs, ports, etc.). In Germany, they realize that it is necessary to establish a permanent discussion group comprising representatives of the Federal Ministry of Transport, Building and Urban Development and, in particular, representatives from businesses and associations in the freight transport

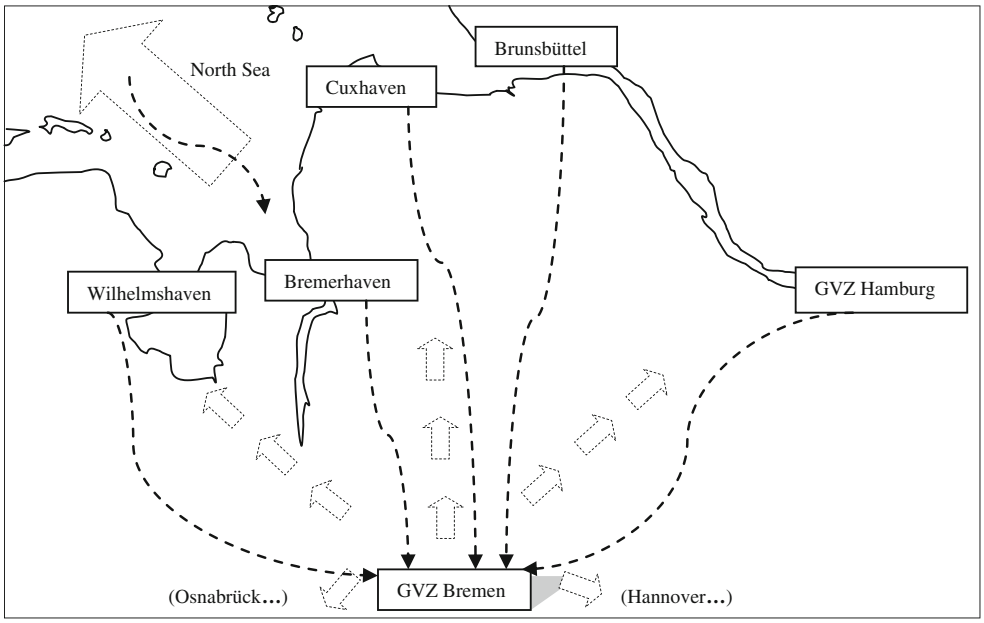

Fig. 9 Linked FVs/ports of GVZ Bremen

and logistics sector [57]. The combined transport is designed to enhance the overall system, relieve congestion on the roads and ensure more environmentally friendly transport operations. This intensified exchange of ideas and experience will enable the interactions between FVs and Ministry of transport.

- FV is widely considered by both practitioners and researchers a vital contributor to regional industries' prosperous. As a regional logistics service cluster, FV and its served industries are tightly bound up. Every industry, whether it is automotive, high tech, chemical industry, petroleum industry, food industry or other, has their own specific logistics requirements and needs. These are unique and often they differ from one industry to the other. In order to offer matched facilities and services items, FVs might constantly access these industries to find out the individual logistics needs and the transport requirements, thereby ensuring that all shipments reach their destination, on time and at cost. Similarly, companies in various industries can select appropriate FVs to take over their logistics tasks via knowing actual conditions. In addition, FVs tend to have extensive know-how of green supply chain management especially reverse logistics. FVs provide an advantageous condition to develop reverse logistics for the regional industries. In fact, the majority of companies solve the reverse logistics relying on third-party logistics enterprises, for example, SEARS Company outsources the returns management to the Genco Shipping & Trading Limited, GM Company (General Motors) deals with reverse logistics in cooperation with UPS, 3 M (Minnesota Mining and Manufacturing Corporation) Company outsources the reverse logistics to Genco and Gatx logistics enterprises etc. A completed reverse logistics process consists of sections such as returns acceptance, returns analysis, returns disassembly, and disposal of disassemble materials. The ultimate success of a reverse logistics will depend on its ability to participate in one or more successful organizations, as well as its ability to integrate the enterprise's complex network of reverse chains. In response to the trend of reverse logistics outsourcing by third-party logistics enterprises, FV will hopefully become a major executive part in reverse chains. A knowledge sharing approach is where knowledge is maintained at product level and is updated as the product moves across the various stages of its life cycle. This will enable decision support that handles the unique requirements of every product. Knowledge sharing also ensures that all individual involved in return processes to access it [46].
- Some industries, especially knowledge-intensive sectors, tend to enhance competitiveness through supplying technology and training specialized personnel, and they increasingly attempt to collaborate with universities/research institutes [58]. The capitalization of knowledge concerns the

transformation of knowledge into "social capital by academics, involving sectors of the university such as the departments of basic science, from this point on, relatively uninvolved with industry" [59]. In recent decades, federal, state, and local governments have created a variety of mechanisms to encourage knowledge-based economic development. One of the mechanisms is the collaboration between universities/research institutes and industries in the form of knowledge sharing. FVs reflect the strength and advantages of logistics industry in a region. Their advanced quality necessitates the close cooperation with universities/research institutes, with the purposes of efficient logistics technologies, new craft and environmental equipments, strategic information, and highly qualified staff. The knowledge sharing activities can be:

- University/research institutes and FVs exchange programs and student internships;
- Cooperative research projects, some of which involve government participation and the use of specialized facilities;
- Specialized programs designed by the university/research institutes for continuing education and training of professionals of FVs;
- University/research institutes help FVs to grasp strategies and concepts relating logistics, technical and organizations planning of logistics systems, supply chains and logistics network design, etc.;
- University/research institutes provide laboratory for modeling and simulation in logistics, traffic, and transportation;
- Improved approaches adapting the logistics development created by the joint efforts combing the theory and practice;
- Specialists from university/research institutes also hold positions in FVs, which can be a direct knowledge sharing way.

4.4 Knowledge utilization

Knowledge utilization is the process incorporating knowledge into an organization's products, services, and practices to derive value and achieve their visions. Figure 10 depicts the roadmap of knowledge utilization for achieving FVs' visions. FVs' visions are defined as: be a driver for alternative transport network configurations; social logistics cost reduction and efficiency enhancement; integrations with industries for current situations improvements.

Once knowledge is transferred to, or shared with others, it may be utilized through elaboration (the development of different interpretations), infusion (the identification of underlying issues), and thoroughness (the development of multiple understandings by different individuals or groups) in order to be helpful in facilitating innovation, collective learning, individual learning, and/or collaborative problem-solving [60]. These activities promoted upon the knowledge base represented by the learning-and-growth perspective of FVs, and they are embedded in FVs operational processes mainly in the form of products, services, and function. The function extensions in this article are referred to as the synergic contributions beyond FVs' typical activities, for example, facilitating industries development, regional economic increase, and community life improvement. Regarding FVs' operational processes, the knowledge utilizations toward sustainability usually focus on: clean production process, reverse logistics; green packaging, warehousing; low-emission vehicles, environmental friendly intermodality, and alternative fuels; technology-based service improvement; regulating FVs public behaviors. Knowledge utilization directly influences the quality and efficiency of FVs operational processes. Moreover, successful knowledge utilization is necessary to meet the goals and objectives of FVs with responses to knowledge about customers, environmental regulations, and social requirements. Good stakeholder relationships are possible to be established relying on these responses, due to the benefits of customers, ecological environment, and the society are the values utilization of FVs in a broad meaning. Sustainability performance is viewed to find the knowledge gap in FVs operations.

The knowledge utilization section makes a cycle combing the KM process with the FVs sustainability realization, which can be explained as SBSC-guided strategy route to sustainable development of FVs. The SBSC reflects the knowledge, skills, and systems that practitioners need (the learning-and-growth perspective) in order to innovate and build strategically adequate and efficient capabilities (operational process perspective) to satisfy customers, ecological environment and the society (stakeholders relationships perspective) and, eventually, will provide increased value for their sustainable development (sustainability perspective). The SBSC-guided strategy route should be able to assist FVs operators and decision makers and become a helpful and successful sustainable development management instrument integrating the optimal management of environmental resources and financial resources. The SBSC has a structure that seeks to maximize FVs' potentials, as well as gives managers an overview of the whole FV sustainability realization from the knowledge base and knowledge utilization. It helps in implementation, monitoring, and evaluation of FVs sustainable development strategy with KM approach, using financial and nonfinancial indicators [61] to achieve sustainability performance.

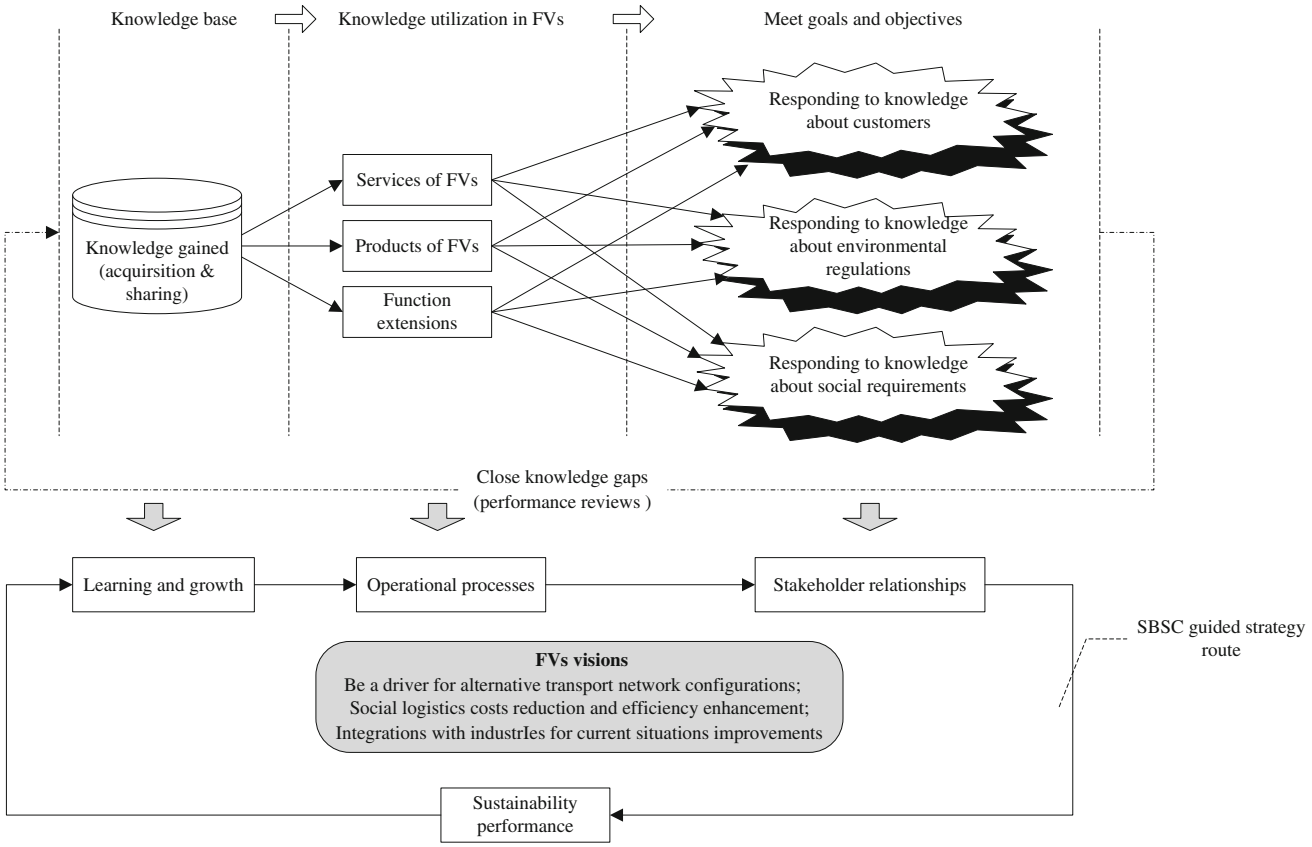

Fig. 10 Knowledge utilization in achieving FVs vision

5 Building FVs sustainability capability

5.1 Roadmap of organizing KM for sustainability-oriented FVs

Considering the distinct characteristics including "multi-levels knowledge mapping" and "collaborative KM" of KM in the context of logistics and FVs, a roadmap of organizing KM for building FVs' sustainability capability is illustrated in Fig. 11. A spectrum of KM layers is needed to span FV's physical district due to its double nature. The backbone of this roadmap basically consists of links "knowledge expansion," "knowledge processing," "knowledge gap discovery," which interact and are embedded within the SBSC-guided framework. FVs are able to obtain sustainable development capabilities with the support of KM crossing socioeconomic layer, functional layer as well as auditing layer, and they are interdependent with each other. Table 3 lists the details of three layers of KM approaches to sustainable development of FVs.

The knowledge expansion results from KM at socio-economic layer, it connects people to knowledge, which provide adequate source and social foundation for KM at the functional layer within FVs. The latter transforms knowledge into expected results in real operations of FVs. To replenish the knowledge from the socioeconomic perspective and reform knowledge processing at functional layer, an auditing layer of KM is proposed. We will analyze the three layers of organizing KM in the context of FVs in detail as following:

KM at socioeconomic layer KM at socioeconomic layer concerns the availability of knowledge being available to people. Thus, people who engage in logistics and FVs operations are able to gain access to knowledge in the form of logistics-related science, policies, diagnostic reports, education, and training program. "A knowledge age to follow" is emphasized, which becomes a precondition ensuring the sustained and sound development in logistics-related fields. At this layer, moreover, it is a shift to cognition toward that knowledge is a limiting resource rather than financial resource. Connecting knowledge to people requires the provided knowledge are framed and embedded in several other prominent social sectors, such as governments department, public transit agencies, and education institutions. This layer of KM enables the correction or creation of awareness such as greening logistics and supply chain, CSR (corporate social responsibility), and the formation of integrated logistic capability at industrial and social levels. Other

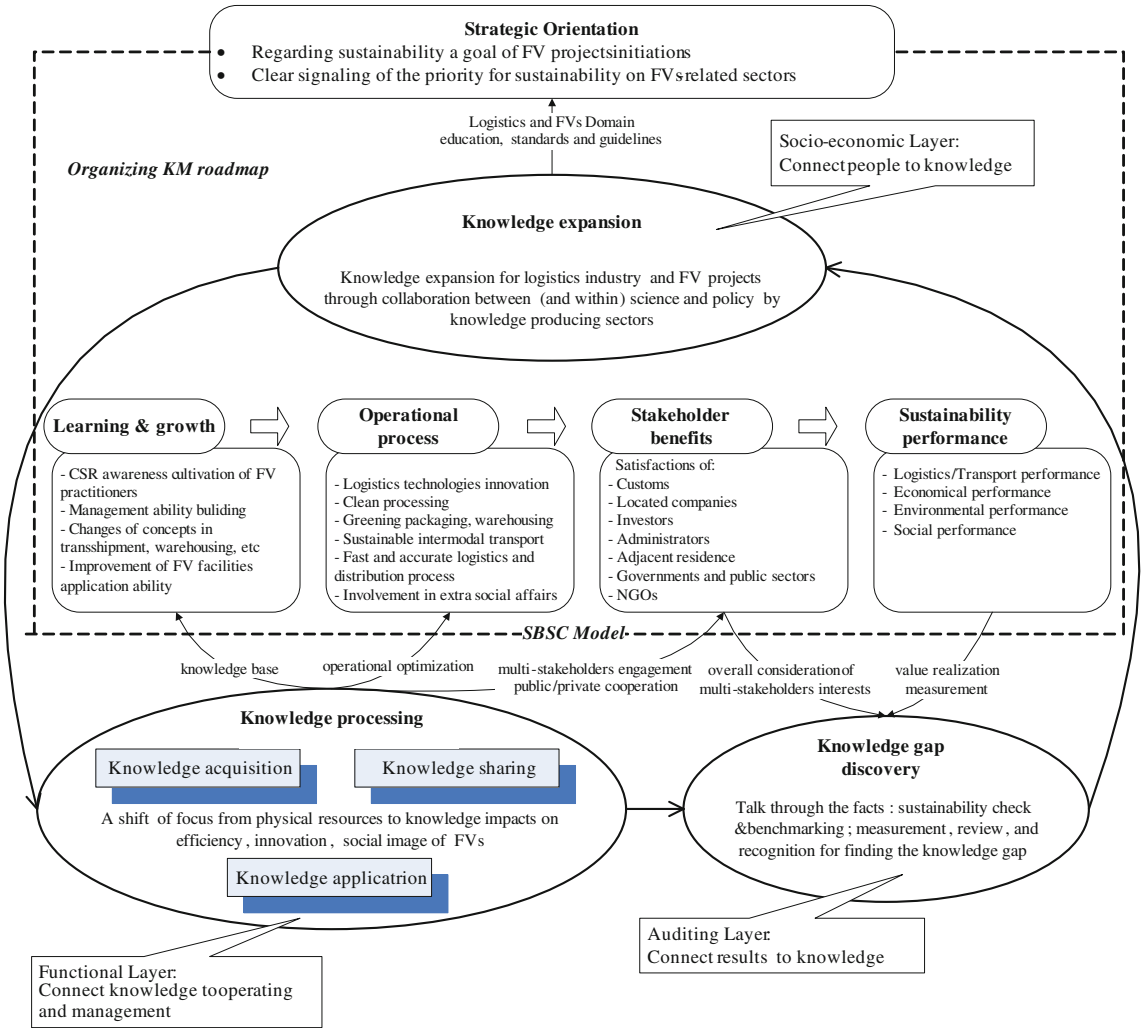

Fig. 11 A roadmap of organizing KM for building FVs' sustainability capability

activities include creating green awareness through media, setting up official eco-labelling systems, and encouraging greening execution in SMEs (small- and medium-sized enterprises) through various incentives, for example, tax exemption and service discounts.

KM at functional layer KM at functional layer refers to actions on FVs operations including the governance, operating, and organization culture with the support of knowledge processing. As in the resource-based view of business, it represents a shift of focus from physical resources to knowledge impacts on efficiency, innovation, social image of FVs. Knowledge processing (acquisition, sharing, and application) refines operations including receiving, storing, packing, dispatch, reverse logistics and transport network design, and waste management. The results of KM processing are mentioned:

- Providing knowledge base for FV practitioners' learning and growth, which consists of corporate social responsibility and greening mindset cultivation of FV practitioners; FV management ability adaption; updating concepts in transhipment, logistics and distribution, production, warehousing, etc.; the improvement of FV facilities application.
- Enabler of operational optimization, logistics technologies innovation (e.g., energy saving technologies, E-commerce, RFID technology, telematics, data acquisition technologies, optical scanning); clean processing; reusable packaging and eco-labelling, energy-efficient warehousing; secure handling of goods transport, especially in the areas of recycling and dangerous goods is an important end environmentally crucial task in logistics; holding knowledge and experience of available transport modes, referring which to deign sustainable intermodal transport solutions for long-distance transport task; exchanging information in logistics community usually comprising carriers, sellers, forwarders, terminal

Table 3 Three layers of KM and approaches to build FVs sustainability capability

Levels	Key points	Approaches
Socioeconomic level	Knowledge expansion Connect people to knowledge Precondition guarantee	Consolidation in science knowledge of logistics field, especially the incorporation of interdisciplinary knowledge (Environics, Engineering, Economics, Management, Informatics)
		Policies making in supporting ecological FVs (taxation-free and preferential conditions, franchise, disciplinary measures)
		Directives for sustainable traffic (e.g.,GHG emission standards, traffic safety laws),waste recycling, air and water pollution index
		Diagnostic report (e.g., European Commission Transport: white paper)
		Education and training of logistician for the society, tri-ability on theory, implementation and practice (Referring Fig. 12)
Functional layer	Knowledge processing (knowledge acquisition, sharing, application) Connect knowledge to operating and management process Execution guarantee	Creating learning culture in FVs and located enterprises
		Position competence training system of FV management, concerning environmental management principles and standard
		Direct contracts between the delivering companies and the end customers or receivers
		Application of green operations to improve an existing product or process (core processes, reverse logistics and network design, and waste management)
		Promoting cooperation among different carriers and facility service providers
		Vertical collaboration and horizontal collaboration to facilitate information and knowledge dissemination
Auditing layer	Knowledge gap discovery Connect results to the knowledge Continuity and sustainability guarantee	Tracking the record of data and performance, e.g., avoided CO_2 emissions between different alternative mode, CO_2 emission savings per ha marketed area, per employee, per enterprise, reduction potential in power consumption
		Publications about performance checking and measurement (e.g., Ranking of European FVs, Chinese FVs Investigation Report in 2006, 2008, 2012)
		Lessons learned and case study of productive FVs
		Identification of unrecognized optimization approaches
		Reflect the knowledge gap to knowledge producers

operators, customs, banks, warehouse operators, so as to facilitate fast and accurate logistics and distribution process; involving in extra social affairs (e.g., urban consolidation and distribution in densely populated cities, facilities support for agricultural logistics in some developing countries).

- Opportunities for the realization of multi-stakeholder satisfactions. Sustainability-oriented FVs pursue the balanced benefits among customs, located companies, investors, administrators, neighboring residence, governments and public sectors, NGOs. KM at the functional layer leads to realize satisfactions of them, since a multi-stakeholder satisfaction is decisive for FVs' sustainable development.

KM at auditing layer KM at auditing layer ensures the quality of results examining, which makes the results examining to talk through the facts. On the basis of authentic data and information collected by the approaches of questionnaires, face-to-face interviews, statistical documents, FVs specialists or managers try to measure, review, and recognize the FVs performance. Accordingly, the horizontal and vertical comparisons allow for discovering the knowledge gap on the way to sustainable development of FVs. KM at auditing level reveals the forming process of knowledge following the route "data-information-knowledge."

In practice, sustainability check and benchmarking have been applied in evaluating FVs performance. For example, in order to check the implementation performance of a FV's green strategy, "Siemens Mobility and Logistics Division of the Infrastructure & Cities Sector" collects the information on such aspects: energy consumption (How much and for what does your FV consume energy?), energy mix (Where does the energy for your FV comes from?), energy saving technologies (What kind of technologies do you already use?), energy saving strategy (Do you have a clear energy efficiency target and strategy?), energy saving practice (How is energy efficiency embedded into your daily operation?). According to the data and information analysis, the measurements on FV's green strategy are taken, which can be used as cases for learning, and in other words, it is experience which is a kind of knowledge [62]. Another example relating benchmarking

in the project initiated by Association of German FVs (DGG) relating the ranking of European FVs 2010, FVs from over 30 countries were included in the benchmarking process. This Benchmarking involves data and information collection from respondents, information processing, and knowledge (measurement results, case experiences, and hints) exposure. Through the information transfer, the results about ranking of European FVs in 2010 are generated in the form of explicit knowledge existing in documents or webpage, in which, "Interporto Verona ranks No.1, with 211 points, GVZ Bremen ranks No.2, with 211 points, GVZ Nürnber ranks No.3 with 205 points…(maximum performance score: 250 points)" [63].

5.2 Key elements

To support the success of this roadmap, two key elements for the above roadmap are identified as human ability and stakeholders' involvement.

5.2.1 Human ability

From the perspective of BSC or SBSC, a learning-and-growth metric means the employee metric. It is a framework for assessing employee satisfaction, productivity, and retention. Such a metric targets the learning-and-growth perspective of BSC that is and remains "the foundation for all strategy"[64]. In the era of knowledge-based economy, people—the only repository of knowledge -are the main resource. This key element concerns employee training and organizational cultural attitudes toward both individual and origination self-improvements. Two human groups are vital to FVs, logistics practitioners and FV management.

5.2.1.1 Human ability of logistics practitioners A logistician is a professional logistics practitioner. Due to the complex mix of logistics services involved in FVs, the increase in logisticians bringing becomes a fundamental element when executing strategies. Logistics is a very broad field comprising procurement, production, distribution and disposal activities, and a new trend in the industry which is the Fourth-party logistics—consulting companies offering logistics services. Logisticians are therefore required to be skilled in three aspects: theory, practice, and implementation. They are named strategic and theoretical logisticians, operative logisticians, and implementing logisticians. Figure 12 describes the tasks of logisticians, and relations and tensions between theory, implementation and practice in logistics. Prerequisites for a successful logistician are analytical thinking, openness about new ideas, creativity, and judgment. Operative logisticians need the ability to think practically. Prerequisites to success for an implementing logistician are constructive thinking, organizational competencies, and a profound knowledge of the possible solutions [65]. They support each other with offers of strategies and method, installations, experiences, and observations; the offers of recognitions and ideas, rules and regulations, return and use.

5.2.1.2 Human ability of FV management Currently, some successful FV cases evidence that the management supported by an independent company (FV Management

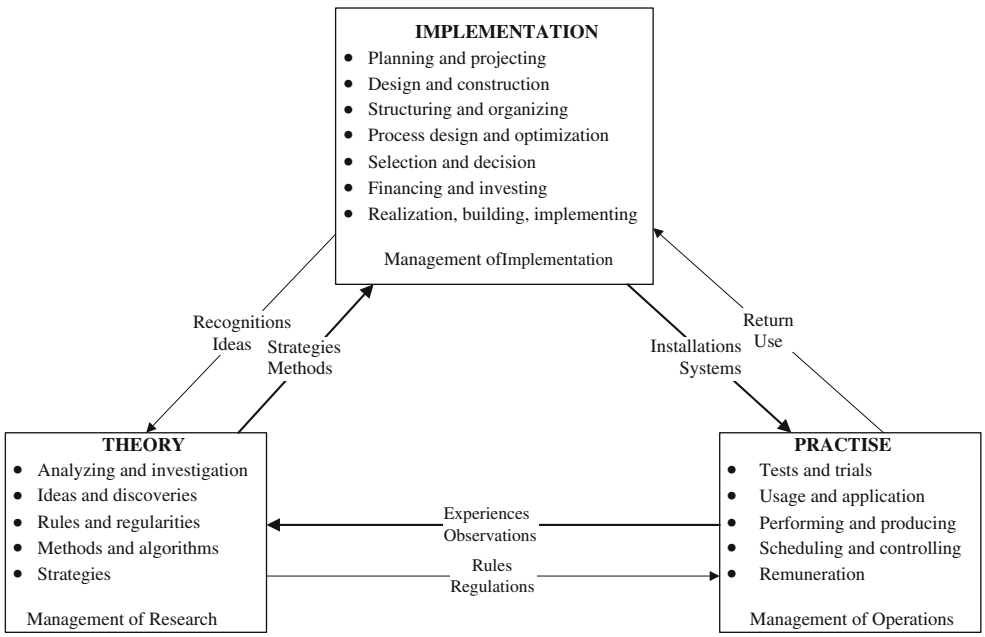

Fig. 12 Tasks of logisticians and relations and tensions between theory, implementation, and practice in logistics (Adapted from [65])

Company) is an effective approach to effective management tasks of FVs. In this research, the ability of FV management is considered a key element needing to be concerned and improved.

In brief, the benefits generated by the ability of FV-managing company comprises: First, recognizing synergy potentials and achieving cost advantages on behalf of the enterprises located through initiating and modernizing cooperation activities; second, as a service and communication platform, it coordinates the companies and institutions involved. Table 4 summaries two examples including Interporto Bologna and GVZ Bremen regarding their FV-managing companies' functions.

Implications from the two examples can be concluded as: FV Management Companies are not only concerned with the real estate aspect of FV (acquisition of new settlers/users), but also are responsible for a broad communication and cooperation activities. Owing to the cooperation promoted by the FV Management Company, the environmental initiatives are possible to exist among located enterprises. For example, in order to improve urban goods distribution, the FV Management Companies of GVZ Bremen promoted voluntary cooperation among different carriers and facility service providers. In this program, nine participating companies consolidated their deliveries into environmentally friendly trucks, though the service was halted after government subsidies for the program were removed [68].

From the perspective of KM, this article proposes a promising orientation for enhancing the FV management ability drawing on the practical experiences: to be a knowledge cluster and information/knowledge sharing platform. More specific, firstly, the FV management clusters the knowledge about general administration skills and experiences as well as information about located enterprises to facilitate better cooperation actions among members; secondly, it provides the information-related FV's situations especially the strengths to potential settlers/users, usually through presentations at meetings and participation of trade fairs; thirdly, it also offers knowledge-added services, such as organization of staff training and advanced qualification, logistics consultation. In addition, the FV management acts like a knowing absorber to learn policies, environmental concepts, and skills, so as to introduce them into FVs. Meanwhile, the FV management gives feedback to investors and public authorities for more finding and policy supports.

5.2.2 *Stakeholders involvement*

Multi-stakeholder contexts in development involve various actors from national or governmental organizations, international organizations, civil society, and the private sector encompassing various disciplines such as urban development and rural development [69]. Consequently, stakeholder involvement/or participation represents an approach to sustainable development. Constructive stakeholder involvement should be a process of sharing views through genuine dialogue between the stakeholders and the management of the organization [70].

Stakeholder involvement becomes an essential factor in organizing KM for FVs sustainability:

- Capture and communicate stakeholder requirements (especially suppliers and customers), for the benefit realization of FVs;
- Make available policies and regulations, training material, and background information needed to push FVs sustainable development;
- Facilitate knowing industrial dynamics, likely establish a transparent trade market, thus reducing social logistics cost;
- Knowledge offered by some competitive logistics companies is probably pooled in FV-managing Company/associations, and though knowledge sharing platform, the pooled knowledge can be beneficial to the growth of small logistics services providers.

According to the different stakeholders' needs and contributions orienting FVs sustainability, this article proposes a range of stakeholder involvement activities as shown in Table 5.

Table 4 Examples of FV management companies in practices

FVs	Components	Functions in practice
Interporto Bologna	Four members from the municipality of Bologna Two members from the Province of Bologna One member each from the Chamber of Commerce, Bank institutes, Trenitalia SpA, Association Indistriali Bologna, and the Association of Bolognese Road Transport [66]	Entrepreneurial activities, such as terminal management and promotion, real estate, a shunting operator, and lending their expertise to the development of other FVs throughout Italy [1]
GVZ Bremen (GVZE Development Company)	FV members Private companies (i.e., DB AG—German Railway Company) City of Bremen (≥25 %) [67]	General management, services, consulting, communication, public relations, projects, workshops, Intermodal Transport Promotion Centre [67]

Table 5 Stakeholder involvement activities

Stakeholder category	Stakeholder involvement activities
Suppliers/customers	Analysis of the needs of suppliers/customers
	Supplier/customers satisfaction survey concerning the logistics services
	Research on customers satisfactory during after-sale phase
	Focus groups with consumer associations
	Promote publicity toward potential customers
Shareholders (owner)	Meeting with the financial committee
	Reporting and planning financial affairs
	Discussing extension program
Managers	Communicating and engaging stakeholders
	FV sustainability reporting (at regular period)
	Organization of staff training and advanced qualification
	Organization of cooperative services
Employee	Satisfactory survey with the salary, the value of self-realization, work environment, security
	Employee questionnaire about the sustainability report
Located companies	Collecting suggestions from located companies on the overall strategy
	Holding companies meetings
	Knowing about requirements and considering them into next scheme
	Coordinating located companies for environmental operating
	Be the representatives to compose the supervisory board
Public transport authorities	Discuss panels, direct interactions
	Be representatives to compose the supervisory board
	Consulting for traffic route optimization
	Learning regulations and laws on traffic issues
	Signing cooperation deals
Other transport actors	Seeking cooperation opportunities in transportation chain to save deliver time and cost
	Ding research projects
Development and operating company	Co-designing structure and offering jobs
	Reacting feedbacks from leasing agents, and maintenance and operations staff, etc.
Other FVs	Exchanging visits for direct communicating
	Establishing virtual network for mutual learning and training
Industries	Interacting via industrial exhibitions
	Contacting industrial companies face to face
	Delivering the requirements and information of industrial companies to all located companies in FVs
	Offering consultancies to industrial companies on logistics arrangements
Inhabitants	Inhabitants satisfaction survey about their living communities concerning noise, sewages, exhaust gas
	Offering seminars about situations
	Guiding inhabitants to visit FVs and let them knowing more
Natural environment	Regarding natural environment as an essential stakeholder
	Generating statistical data of CO_2 emission
Promotion offices (chamber of commerce, economic council)	Handing over reports to promotion offices, involving development situations, facts, and performance evaluation
	Asking for assistances in case of financial problems
	Participating in events organized by promotion offices
National government (public authorities)	Making master plan for the national strategies on traffic/logistics
	Establishing supporting policy measures for FVs
	Integrating FVs projects into public infrastructure facilities

Table 5 continued

Stakeholder category	Stakeholder involvement activities
Professional unions (e.g., DGG, Europlatform)	Assessing multiple FVs performance within a certain area
	Editing and publishing books, reports, papers about FVs developments
	Sustainability performance survey on FVs and additionally giving proposals and suggestions
	Organizing conferences and workshops for discussion of FVs
	Offering consultation services
Local authorities (e.g., state government)	Weighing the proposed FVs projects and see if they are practicable
	Assisting national government executing strategies and measures
	Integrating FVs development into urban planning
	Participating in building and managing FVs
Special interest groups (e.g., environmental organizations)	Attaching the importance to their counsels
	Exposing the facts to special interest groups
	Open, honest communications
Universities/research institutes	Involving Universities/research institutes to cooperation projects
	Keeping in touch with each other for logistician talents reserves
	Establishing online campus, offering e-learning platform
Experts	Be representatives to compose the supervisory board

5.3 Checklist for building FVs sustainability capability

The purpose of this checklist (See Table 6) is to provide a set of guidelines for building FVs sustainability capability, thereby converting knowledge into sustainability performance of FVs. The checklist is developed from SBSC introduced above, as well as built on the FVs practical experiences and KM implementation, which is expected to be a promising tool used by FVs practitioners.

6 Conclusions

Facing the challenges posed by regional population, freight growth, and containerization, FVs are considered a consolidated logistics solution. The wide use of this solution is not only valuable in emerging countries where huge trade volume exist, but also in developed countries where functionalities beyond reducing transport cost of FVs are proposed. The foundation of this article was that sustainability is a strategic goal of FV projects. It recognized the double nature of FVs, private nature, and public nature. With regard to this, FVs are inherently polluting entities meanwhile positively influencing regional sustainability. Thus, the broad economic, social, and environmental consequences yielded by the FVs were presented.

KM has received considerable attention as critical to ensure sustainable competitive advantages in the marketplace. The emerging field of KM is identified by this article as a potential source of valuable insights with which to obtain sustainability performance of FVs. Considering the "integration" and "collaboration" in the concepts of logistics and supply chain management, two characteristics of KM in the context of FVs were distinguished from general industrial clusters: multi-levels of knowledge mapping and collaborative KM. The logistics strategy development and sustainability performance are enabled by retrieving and analyzing useful intangible resources/knowledge assets and integrated solutions in a timely and cost-effective manner. Exposure of several reasons are as follows: cultivate mindset and understanding of sustainable strategy for FVs' development; clarify the responsibility and accountability in FVs development; foster the commitment and cooperation of logistics service providers via knowledge sharing; access to technologies used in operations; access to information about transport services, operators, and shipments in intermodal scope. In addition, the SBSC evolved from BSC convinces that knowledge-related perspective is the foundation and guarantee for sustainable development strategy in FVs.

KM actions (knowledge acquisition, knowledge sharing, and knowledge utilization) facilitate the synergy effects involving: synergy of firms within a FV, synergy of FVs and ecological environment, synergy of FVs and regional development. Specifically, knowing status of logistics market and customer preferences, recognizing the value of new knowledge for lifting logistics services efficiency, tracking the regulations policies and regulations on transportation, improves friendly competition and cooperation of enterprises within the same area in FVs, promote positive interactions with other FVs and local authorizes, green

Table 6 Checklist for building FVs sustainability capability

Learning and growth "The foundation for all strategy" [64]—sustainable development strategy included; Gets to the bottom of FVs competencies, (use of) technology infrastructure, and climate for sustainable action, including those of the executive team
An increasing awareness that benefits embedded in data, information, and knowledge
The learning ability of involved actors in FVs in fields of logistics-related operations and value-added services
Well informed about local demand and settled enterprises
Master the art of matching operating competency and commitment to key stakeholders' expectations and requirements
Cohesion ability of different divisions of responsibilities in FVs
Lessons learned from successful FVs
Initiative in a knowing of social responsibility, environmental policy, and sustainability issues
Information and knowledge sharing solutions on FVs' operational performance
Considerations concerning future investment in new infrastructure and eco-friendly equipments
Provide career training for various divisions of the FV
Operational process Improvements in technology, core competencies, efficiency, increased productivity, reduced waste…; Synergy activities (e.g., consolidated shipments and warehouse) through information exchange
Integrative using and administrating infrastructure
A combination of information(time, accuracy, and details of contents) during logistics operations
Rapid responds to changing customer requirements
Application of innovation and new technologies for greening logistics activities
Consolidated shipments and warehousing among settled enterprises based on information sharing
Distribution processing facilitation for handling, storage, dispatching
Transporting in environment-friendly approaches
Transportation planning, route optimization level, and intermodality flexibility
Consolidated integrated logistics operations: order processing and assignment, inventory management, warehouse operations, transportation and shipping, yard management
Involvement in projects or activities helping resolving urban/industrial trouble problems
Stakeholder relationships Integrate, balance, and satisfy the needs and requirements of FV's key stakeholders; Doing so is the direct way to obtain sustainability performance
Trust, preference, long-term order from customers
Reputation attractiveness for potential customers
Mutual satisfaction between the FV management level and settled enterprises
Honors as good partners with urban programers, Municipal Bureau of Foreign Trade and Economic Cooperation, Ministry of Transportation, etc.
Affiliate with other organizations such as sector associations, Eco-efficiency Centre, Environmental Groups/Organizations/NGOs, etc.
Stakeholders involvement activities (See Table 5)
Current sustainability level Reflection of current sustainable development capability; Will be the feedback also the provision for next KM cycle
Economic profitability
Investors' return
Measurement of customer service and productivity
Number of jobs offered by the FV
Waste treatment in FVs up to the standard of Environmental Protection Agency
Energy cost saving and proposed room to improve
Calculation and internalization of external costs (i.e. air and noise pollution, congestion)
Increased employee' job satisfaction and work output
Active effect on local industrial logistics development
Contribution for releasing urban congestion

packaging and warehousing, low-emission vehicles, environmental friendly intermodality, and alternative fuels, etc.

This article proposed a roadmap of organizing these KM actions to build FVs' sustainability capability. The roadmap is structured from three layers: socioeconomic layer, functional layer, and auditing layer. These three layers interact with others by "knowledge expansion," "knowledge processing," "knowledge gap discovery". To support the success of this roadmap, two key elements were identified including human ability and stakeholders' involvement. The former is typically concerned with both the logistics practitioners and FV management. Finally, a checklist for building FVs sustainable development capacity was generated following the route of SBSC. Hopefully, it can be referred by FVs operators or decision makers to convert knowledge into sustainability performance of FVs.

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