Journal of Cleaner Production 86 (2015) 389–402

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

# Study and evaluation on sustainable industrial development in the Mekong Delta of Vietnam

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A R T I C L E I N F O

*Article history:*
Received 7 December 2013
Received in revised form
20 August 2014
Accepted 26 August 2014
Available online 4 September 2014

*Keywords:*
Sustainable industrial development
Mekong Delta Vietnam
Indicator system
Principal component analysis

A B S T R A C T

The process of industrial development in the Mekong Delta of Vietnam has achieved many encouraging results. However, the theory and practice of sustainable development is relatively backward, in particular sustainable industrial development lacks clear visions, targets and indicators for sustainable development. Many efforts have been made to build an indicator system that aims to assess and monitor sustainable industrial development at different levels. However, the arguments in selecting indicators and methods to evaluate sustainable industrial development of the Mekong Delta are many and highly contested. The article has built an indicator system for evaluating sustainable industrial development based on the content of industrial development and some basic principles that should be followed by the system, along with the current status of the industrial development in the Mekong Delta. Comprising the three pillars of sustainable development in general, this system includes the three aspects of sustainable development, namely, economic, society, and environmental subsystem. With this indicator system and principal component analysis method, the case study has taken a quantitative approach to assess sustainable industrial development in the Mekong Delta. The detailed subsystem of calculations and discussions indicates that industrial development in the Mekong Delta is unsustainable. The efficiency in developing the industrial sector to create the socio-economic growth and promote the Mekong Delta's environment exhibited a downward trend. Further, the authors rank the sustainability of industrial development in 13 provinces and city of the Mekong Delta. Finally, some pieces of advice are offered for accelerating sustainable industrial development in the Mekong Delta of Vietnam. Overall, this article incorporates a quantitative analysis based on ranking and comparing of sustainable industrial factors that can prove to be useful for any innovative, emergent developing nation wishing to implement sustainable industrial development policies.



## 1. Introduction

Vietnam is one of the fastest-growing economies in Southeast Asia, and is going through a transformation from a centrally planned economy to a socialist-oriented market economy. The process of industrial development in Vietnam in general and the Mekong Delta in particular in recent decades, especially after 25 years of reform and opening, has achieved many encouraging results (Nguyen, 2012). However, a Joint Donor Report to the Vietnam Consultative Group Meeting in 2012 indicated "Rapid growth has revealed new structural problems. The quality and sustainability of growth remain a source of concern, given the resource-intensive pattern of growth, high levels of pollution, lack of diversification and value addition in exports, and the declining contribution of productivity to growth" (WB, 2012). In 2011, the Mekong Delta consisted of 12 provinces and a single centrally administered city (Fig. 1); it has a population of about 17.3 million. The Mekong Delta region accounts for more than 20% of the population in the country (PMDBS, 2007–2011).

The Mekong Delta is the largest rice and fruit producing and aquaculture area in Vietnam. It produces about 50% of the rice, 52% of the seafood, 70% of the fruits in the entire country (PMDBS, 2007–2011). The Mekong Delta has great potential for the development of rural industry—especially agro-processing and seafood processing for domestic and export demand. Seafood processing for export is a key industry, with an average increase of 21.8% between 2007 and 2011 (PMDBS, 2007–2011); it consistently has the highest proportion of production and growth rate in the industrial structure of the region. The industrial region has been developed with the 3 axes: (a) Long An–Tien Giang–Can Tho, (b) Can Tho–Soc Trang–Bac Lieu–Ca Mau, and (c) Can Tho–An Giang–Kien Giang. The region has boosted co-operation with Ho Chi Minh City and the

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http://dx.doi.org/10.1016/j.jclepro.2014.08.087
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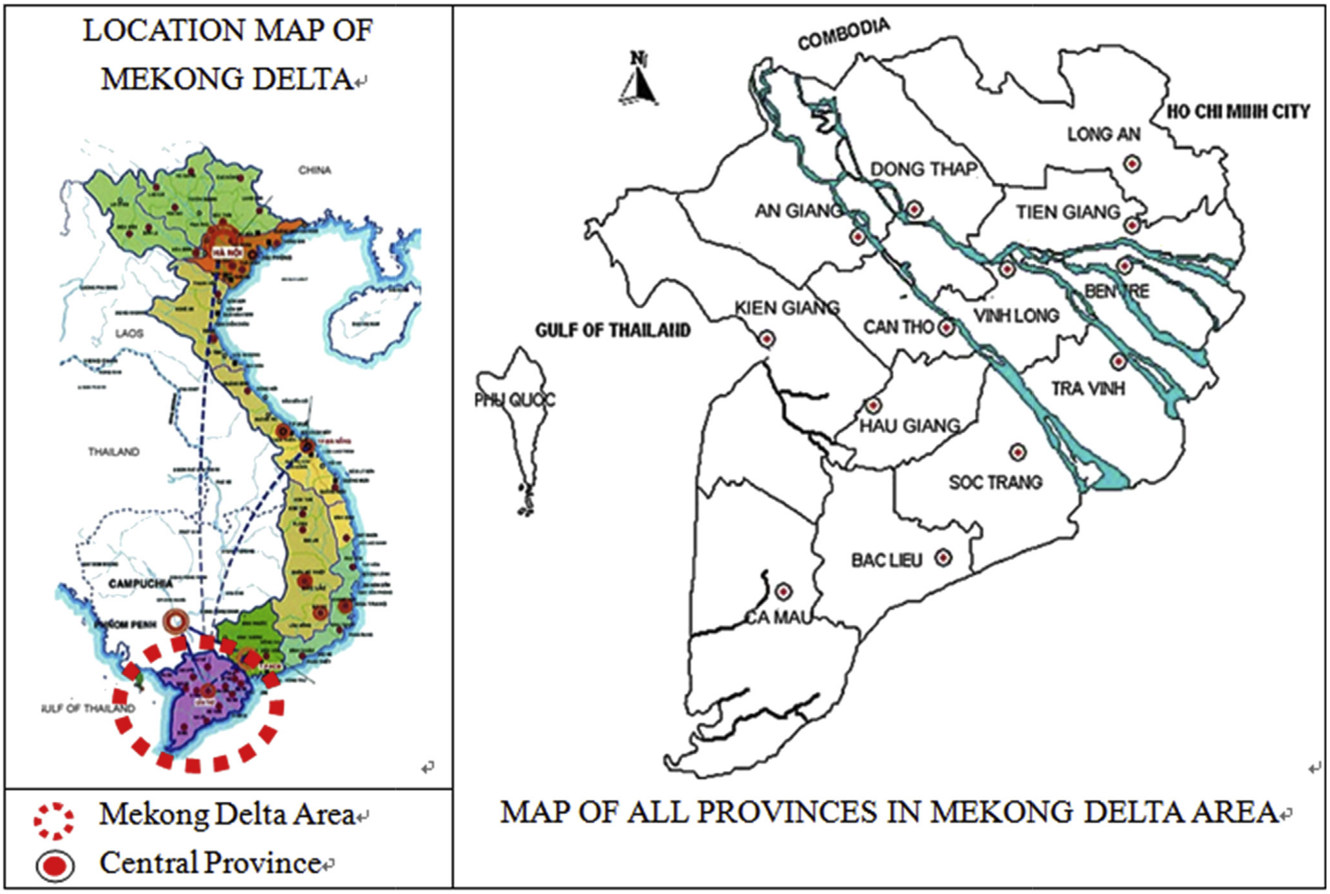


**Fig. 1.** Provinces and city in the Mekong Delta Region (MCV, 2010).

southeastern region for development. Can Tho is the central region, and it specializes in heavy and hi-tech industries, fishery and agricultural machinery, consumer goods, and technology-based sectors; it also provides high value adding to raw products.

Industry in the Mekong Delta has developed rapidly. The primary industry proportion of Gross Dominic Product (GDP) in 2011 decreased from 45.01% to 42.91%, whereas the secondary industry proportion increased from 24.65% to 25.54% and the tertiary industry proportion increased from 30.18% to 31.55% (PMDBS, 2007–2011). However, the industrial development of the Mekong Delta shows many drawbacks such as big capital investment, low quality of production and consumption of natural resources, and serious environmental pollution, that have been harmful to resources and environment (MIT, 2011; EAPMD, 2007–2011). In addition, the urban domestic garbage and sewage treatment rates are still hovering at a low level, although carbon dioxide emissions have been at the forefront of the nation's priorities (EAPMD, 2007–2011).

Compared to developed nations, Vietnam is a developing nation attempting to practice the concept of sustainable development even though the socio-economic development is still in infancy. However, there is a lack of sustainable development research in Vietnam (Nguyen, 2012)—and especially so for the Mekong Delta. In order to bridge between the literature and the current situation of the Mekong Delta, this paper proposes a quantitative approach through an indicator system and principal component analysis to assess sustainable industrial development in the Mekong Delta.

The framework of this case study included six sections. In Section 2, we review the literature that contributes to the emergence and evolution of sustainable development and sustainable industrial development concepts and indicator systems which are under development and use by numerous scholars. We also introduce the governance instruments of sustainable development. In Section 3, we construct an indicator system for evaluating sustainable industrial development of the Mekong Delta. Then, standardization processing data is calculated to conduct research principal component analysis. Section 4 analyzes of results and discussion. Section 5 proposes policies and advices on accelerating sustainable industrial development in the Mekong Delta. Finally, Section 6 summarizes the major conclusions of this article.

## 2. Literature review

In the following section, the literature in sustainable development and sustainable industrial development, sustainable development indicator system, and governance for sustainable development will be described.

### *2.1. Sustainable development and sustainable industrial development*

The concept of sustainable development gained worldwide recognition at the World Environment and Development Conference in 1987 when numerous socio-environmental directives were established. It is defined as development which "meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987). As outlined in the Rio Declaration and Agenda 21, which is a product of the United

Nation Conference on Environment and Development held in Rio de Janeiro – Brazil in 1992, sustainable development has become the goal of the global society, and impacts the development of national socio-economic strategies (UNCED, 1992; McCormick et al., 2013). The World Summit on Sustainable Development in 2002 described sustainable development as including three pillars, i.e. social, environmental, and economic as symbolized by the summit motto "People, Planet, Prosperity" (Moldan et al., 2012). It means, in a straightforward definition, "the nations are able to achieve positive economic and social development, without excess environmental degradation, in a way that both protects the rights and opportunities of coming generations and contributes to compatible approaches elsewhere" (Dalal-Clayton and Bass, 2002). The concept of sustainable development is about a healthy future for humanity resulting from the growing realization of the global links of increasing environmental awareness with improving the social and economic conditions affecting poverty and inequality (Grutter and Egler, 2004; Hopwood et al., 2005). The United Nations Secretary's 2012 report underscores that "sustainable development provides the best opportunity for people to choose their future" (UNSGHLPS, 2012) and "to eradicate poverty, reduce inequality and make growth inclusive, and production and consumption more sustainable" (UNSGHLPS, 2012). Sustainable development is therefore characterized by both "living within the ecological limits and meeting the needs of everyone" (Lorek and Spangenberg, 2014).

Researchers and administrators began to introduce the concept of sustainable development to the industrial areas and formed the concept of industrial sustainable development—industrial ecology (Shi and Chertow, 2010; Sakr et al., 2011), industrial symbiosis (Boons et al., 2011; Gonela and Zhang, 2014), sustainable consumption and production (Tukker et al., 2008; Berg and Hukkinen, 2011). They considered that some measures should be performed by government, enterprises, international cooperation, culture and education, finance capital and other sectors, which ensure improving the ability of industrial development to be sustainable (Li et al., 2012; Jiao and Boons, 2014). The challenge is that although industrial sectors have begun to subscribe to the concept of sustainable development they may not necessarily comprehend how to operationalize this concept to balance economic development and social improvement with natural resource use and environmental protection (Cohen-Rosenthal and Musnikow, 2003; Tseng et al., 2009). When greener industries, eco-industrial parks (Jung et al., 2013; Tian et al., 2014) integrate environmental requirements into their design and manufacture processes including value chain supervision to prevent unsustainable exploitation of resources and irreversible harm to the environment, it marks a pivotal achievement and self evident realization of the principles of sustainable economic development (Herva et al., 2011; Khalili and Duecker, 2013). The characteristics of sustainable development are driving industrialization to a new road, which feature high-tech manufacture, cleaner production, low resources consumption, less environmental pollution, and a full display of the advantages in human resources (Bonilla et al., 2010; Li and Chen, 2011).

The industrial sector, through its role in improving the well-being of society, has contributed seriously to pollution and exploitation of the ecological environment. The rapid industrialization of many countries in Asia—which have rapidly increased the levels of land, water, and air pollution—have raised concerns about the un-sustainability of current economic development models (Tseng et al., 2013). The resources found in the natural environment (which are also the basic needs for human survival) are the fundamental drivers of sustainable socio-economic development for these regions (Fernández and Ruiz, 2009; Zhang et al., 2012b). Unsustainable consumption of natural resources and manufacture patterns—which are described as a major challenge for developed and developing countries (Castro Camioto et al., 2014)—has taken human civilization to the edge of global disaster (Lehtoranta et al., 2011; Brizga et al., 2014). The limitation of natural resources in the environment restrains economic growth, but under the more characteristic, traditional economic developing model has lead to higher consumption of natural resources, higher pollution, and lower end benefits which ultimately, seriously obstructs economic development (Yang et al., 2011) and brings havoc to an already fragile environment (Zhang et al., 2013). The features of sustainable industrial development are lower consumption of inputs, lower emissions, and higher efficiency in socio-economic development (Ronchi et al., 2002; Mu et al., 2011). Consequently, sustainable industrial development is a new model of economic development that can achieve sustainable development and resolve the conflict between socio-economic development and environmental protection.

### 2.2. Sustainable development indicator system

In recent years, numerous frameworks and indicators have been researched to assess sustainable development systems. The indicator system must include the three pillars of sustainable development—the environmental, economic, and social pillars of sustainable development (Azapagic and Perdan, 2000; Brian, 2004). Programmatic indicators of sustainability are important for assessing, monitoring, and operating upon various policies and programs of socio-economic development (Geng et al., 2012). With the recognition that the prevalent indicators of economic and social growth (e.g. Gross Domestic Product (GDP) and the unemployment rate) are not appropriate for achieving the comprehensive sustainable economic development goals which incorporate protection of the environment along with economic and social development, it is necessary to select a few principal indicators which are truly able to measure all of the dimensions of sustainable economic growth (Ronchi et al., 2002). Golusin (2006) suggested that the purpose of indicators is to enable the success of public environmental protection management, to integrate sustainable development policy into the industrial sector, to integrate environmental issues into developmental planning and broaden decision making; and finally to promote the state of the art in sustainable development. Boundary of indicator system should be established first when assessing an industrial system (Mu et al., 2011). The indicator system can be used for forecasting and assessing economic, environmental, and social effects (Mascarenhas et al., 2010). The indicators need to be measured qualitatively and quantitatively, be admissible to the general public, be cost effective; and be connected to the environmental management and policy of government (Moldan et al., 2012). In most of cases, the difficulty is not in the availability of data but rather in the selecting, explaining, and using of the indicators (Samuela et al., 2013). However, the literature does not suggest a standardized framework for the development of these sustainability indicators. Weilhoefer (2011) and Hak et al. (2012) affirm that there is no common method nor is there yet an agreement on a common set of criteria for these indicators.

### 2.3. Governance for sustainable development

Governance for sustainable development refers to processes of socio-political governance oriented towards the achievement of sustainable development. Governance for sustainable development comprises of public argument, political decision-making, policy formation and performance, and complex interactions among public authorities, private business and civil society (Meadowcroft, 2007). In addition, governance for sustainable development is about improving practices of socio-political governance to conduct a more environmentally sustainable development (WCED, 1987). As reflected in Agenda 21, sustainable development requires massive, large-scale planning with its call for "national strategies, plans, policies and processes" (UN, 1994). Governance structures establish negotiation processes, confirm goals, impact motivations, build criteria, execute distribution functions, monitor acceptance, exert and impose penalties, begin and decrease conflict; and resolve debates among actors (Kemp et al., 2005). The United Nations Environment Programme has suggested that industrial systems may represent the ultimate integration of the economic, environmental, and social dimensions of sustainable industrial development (Lehtoranta et al., 2011). The assessments and processes of sustainable development are necessary in the political debate at all levels in order to preserve credibility and transparency and in order to offer a learning process (Mickwitz et al., 2011).

The strategies of sustainable development often focus on satisfying the objectives of environmental protection by putting forth an investment plan to ameliorate the existing environmental infrastructure facilities (Fang et al., 2007; Park et al., 2008). Meadowcroft (1999) suggested that planning as a means of improving sustainable development arose at a time when a rather suspect view had arisen of planning in general. As is evident in Our Common Future and Agenda 21, the accession of the concept of sustainable development in planning is a governance process by which policymakers search to structure a certain agenda and present recommendations for action (UN, 2012; Persson, 2013). Typically, an unsustainable economic development model reflects a picture of urban and industrial concentration resulting in an increasing number of land use tensions between the planning and construction of important highways and infrastructure projects and the degradation of irreplaceable environmental treasures (Elabras Veiga and Magrini, 2009). Therefore, the design process of sustainability policies needs to ask what human trends, established institutions, and existing or planned infrastructure projects are more likely to challenge or accept the set of proposed regulations that can contribute to or further inhibit human prosperity (Safarzyńska, 2013).

## 3. Construction of sustainable industrial development indicator system

The paper has built an indicator system for evaluating sustainable industrial development based on the content of industrial development and some basic principles that should be followed by the system, along with the current status of the industrial development in the Mekong Delta.

### 3.1. Basis for designing a sustainable industrial development indicator system

Industrialization can be seen as a catalyst that contributes economic development, social transformation, and modernization, at the same time, however, industrialization can also be perceived as the main culprit of resources consumption and endangerment of the environment. Sustainable industrial development issues figure conspicuously in sustainable development debate cutting across all the economic, social, and environmental dimensions (UNEP, 2002). Therefore, the basic for designing the indicator system of sustainable industrial development has been provided in the role of industrial economy in sustainable development. A sustainable development indicator can normally be interpreted as a quantitative tool that assesses changes while measuring and selecting progress towards the sustainable use and management of environmental, economic, and social aspects (UN, 2007a; IGSNRR, 2007). The indicator system would have had to meet the following criteria (UNIDO, 2007): (i) Contain globally comparable indicators which could be a cross-country comparison, (ii) Ensure to survey and measure all the three pillars of sustainability (the economic, social, and environmental pillars), and (iii) Indicate sufficient data of the industrial economic sector.

### 3.2. Principles to generate the indicator system

We now build an indicator system for evaluating sustainable industrial development following a basic design based on our review of the literature in the section above which abides by the following principles:

(i) The indicator system is required to include a statistical calculating system about economic, social, and environmental factors as a foundation. Meanwhile, the indicator system cannot be limited to only statistical indicators, and should spread to include comprehensive indicators of sustainable development reflected by new concepts and contents, such as indicators of natural resource environment issues, sustainability and social harmony (IGSNRR, 2007).
(ii) A principle that integrates scientific knowledge with operability. The selection of specific indicators should sufficiently contain the strategic objectives of sustainable industrial development, while also considering the difficulty and reliability of the data obtained (Yang et al., 2011; Zhang et al., 2012a).
(iii) The indicators are structured systematically with a comprehending hierarchy. The indicator system should sufficiently reflect all dimensions of the progress of sustainable industrial development, covering all known economic, social and environmental aspects. The indicator system should be obviously classified and avoid the overlap of indicators (UNIDO, 2007; Zhang et al., 2012a).

### 3.3. Generate sustainable development evaluation indicator system

There is a need for quantitative indicators to evaluate sustainable industrial development. It is necessary because of the claims recommended above that the industrial economic sector provides a major contribution to socio-economic development and affects all three pillars of sustainable development (MPI, 2005; UNIDO, 2007). Azapagic and Perdan (2000) presented indicators of sustainable development for industry as a general framework with three modules of economic, social, and environmental indicators. The evaluation indicator system should comprehensively reflect the strategic goals of sustainable development (Veleva and Ellenbecker, 2001; Bai et al., 2014) and build on an analytical hierarchy process structure model (Sólnes, 2003; Zhang et al., 2012a). A kind of indicator system used for evaluating circular economy development was built by Yang et al. (2011). In addition, Yang et al. (2013) proposed an index system for evaluating the transformation of industrial development with numerous indicators of economic development, human capital, independent innovation, industrial structure adjustment, and upgrading people's living standards and resources; and protecting if not improving the environment.

According to the literature referenced, as shown in Table 1, the proposed indicator system is based on three pillars of sustainable development: environmental, economic, and social factors. Since a comprehensive indicator system is not available due to the difficulties of collecting data, the only indicators that can be used for advanced analysis to evaluate sustainable industrial development

**Table 1**
Sustainable industrial development assessment indicator system.

| Subsystems | Individual indicators | Unit | References |
|---|---|---|---|
| Economy | $X_1$: Gross domestic product | Million VND | Azapagic and Perdan (2000), MPI (2005), UNIDO (2007), Yang et al. (2011). |
| | $X_2$: Value-added of industry | Million VND | |
| | $X_3$: Investment in fixed assets | Million VND | |
| | $X_4$: The primary industry | % | |
| | $X_5$: The secondary industry | % | |
| | $X_6$: The tertiary industry | % | |
| | $X_7$: GDP growth | % | |
| | $X_8$: Government financial income increased value | Million VND | |
| | $X_9$: Per capita GDP | Million VND | |
| Society | $X_{10}$: The population density | People/$Km^2$ | MPI (2005), UNIDO (2007), Yang et al. (2011, 2013) |
| | $X_{11}$: The natural population growth rate | % | |
| | $X_{12}$: Total employed population by industry | People | |
| | $X_{13}$: Total population | People | |
| | $X_{14}$: Population in University | People | |
| | $X_{15}$: Per capita consumption expenditure | Million VND | |
| | $X_{16}$: Engel's coefficients | % | |
| | $X_{17}$: The consumer price index | % | |
| | $X_{18}$: Urbanization rate | % | |
| Environment | $X_{19}$: Arable land | Hectare | Sólnes (2003), MPI (2005), Zhang et al. (2012a), Yang et al. (2013) |
| | $X_{20}$: Forest coverage | % | |
| | $X_{21}$: Total electricity generation | 1000 kWh | |
| | $X_{22}$: Total energy consumption | 1000 Ton | |
| | $X_{23}$: Investment in environmental protection | Million VND | |
| | $X_{24}$: Volume $CO_2$ emissions from industry | 1000 Ton | |
| | $X_{25}$: Volume industrial solid waste | 1000 Ton | |
| | $X_{26}$: Volume domestic sewage discharged | 1000 $m^3$ | |
| | $X_{27}$: Volume industrial sewage discharged | 1000 $m^3$ | |

in the Mekong Delta of Vietnam are recently acquirable, publicly available statistics and documents. Some indicators are difficult to collect or quantify so will not be incorporated in this indicator system (e.g., ethics indicators, intergenerational equity, preservation of cultural values, and satisfaction of social needs).

### 3.4. Data collection

Historical data were gathered from the Mekong Delta of Vietnam Statistical Yearbook in 2007–2011 (PMDBS, 2007–2011), the World Bank Statistical Yearbook (WB, 2007–2011), and Environmental Status Bulletin of Provinces in the Mekong Delta (EAPMD, 2007–2011). These data are classified and processed simply to generate a table that can represent the differences of sustainable industrial development in the Mekong Delta of Vietnam (see Tables 2.1–2.3) taking as an example the economic, social, and environmental subsystems using the available data of 2011.

### 3.5. Standardization data processing

Principal component analysis (PCA), that is a multivariate statistical analysis method (Wu et al., 2007; Jolliffe, 2010), accounts for the variance–covariance structure and decreases the original data space into a smaller-dimension space based on capturing the variance of the data (Wang et al., 2005) and consists of the following steps: construct a data matrix, standardize variables, calculate the component matrix and component score coefficient matrix, find eigenvalues and eigenvectors, select principal components (based on stopping rules), interpret the results and calculate scores (Hosseini and Kaneko, 2011).

Therefore, standardization of data must be conducted to eliminate the effect of indicator dimension. The paper uses standardization processing, which is a statistical transformation that permits to work with variables which are expressed in terms of different units (Bersimis and Georgakellos, 2013; Li et al., 2012). Standardization processing may be succeeded by using:

$$x_{ij}^* = \frac{x_{ij} - \bar{x}_i}{s_i} \quad \text{for } i = 1,2,\ldots,13;\ j = 1,2,\ldots,9 \tag{1}$$

where $x_{ij}$ is the area $i$ and the value of indicator $j$, $\bar{x}_i$ is the average value of indicator $j$, $s_i$ is the standard deviation of indicator $j$.

Based on equation (1), by using SPSS 16.0 statistical software (Zhang, 2009), the standardized data are obtained, as shown in Tables 3.1–3.3.

### 3.6. Factor solution process

The purpose of factor solution process is to calculate the component matrix and component score coefficient matrix, find eigenvalues and eigenvectors, select principal components, interpret the results, and determine comprehensive scores.

- The factor solution of economic subsystem

  SPSS statistical software was used to calculate the initial eigenvalues, the contribution rate and the cumulative contribution rate, as shown in Table 4.

  Using Table 4 and the principle of more than 85% of the total variance contribution rate, when the number of principal component equals three, the accumulation contribution rate reached 88.51%. Therefore, select three principal components to express full information of primitive indexes, taking these three principal component factors as the first factor $F_{11}$, the second factor $F_{12}$ and the third factor $F_{13}$ separately, then obtain factor loading. Table 5 gives the standardized original variable with three principal components represent the approximate linear expression. The goal of factor analysis calculates component factor scores, which can be obtained by the matrix of factor score, as shown in Table 6.

  From the component score coefficient matrix, the principal component factor expression is as follows:

$$F_{11} = \left(0.150{*}X_1^* + 0.195{*}X_2^* + \cdots + 0.184{*}X_9^*\right){*}\sqrt{4.891} \tag{2}$$

$$F_{12} = \left(0.178{*}X_1^* - 0.082{*}X_2^* + \cdots - 0.009{*}X_9^*\right){*}\sqrt{1.959} \tag{3}$$

$$F_{13} = \left(-0.368{*}X_1^* - 0.132{*}X_2^* + \cdots - 0.252{*}X_9^*\right){*}\sqrt{1.116} \tag{4}$$

The results of factor analysis can be used for comprehensive estimates. We can gain the integrated score with the comprehensive estimates formula:

$$F_1 = \alpha_{11}F_{11} + \alpha_{12}F_{12} + \cdots + \alpha_{1k}F_{1k} \tag{5}$$

where $\alpha$ is the weight of coefficients, which can be calculated according to the contribution rate of eigenvalues. Based on Table 4, we can calculate $\alpha_{11} = 0.614$, $\alpha_{12} = 0.246$, $\alpha_{13} = 0.140$. Thus, the comprehensive score of Economic subsystem is as follows:

$$F_1 = 0.614F_{11} + 0.246F_{12} + 0.140F_{13} \tag{6}$$

**Table 2.1**
The data of sustainable industrial development assessment indicator system in the Mekong Delta — economic subsystem.

| Indicators | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | $X_7$ | $X_8$ | $X_9$ |
|---|---|---|---|---|---|---|---|---|---|
| An Giang | 58,851,498 | 5,476,011 | 7,860,414 | 33.74 | 12.16 | 54.1 | 11.07 | 11,143,706 | 27.49 |
| Bac Lieu | 21,690,487 | 4,089,592 | 5,602,746 | 51.7 | 24.52 | 23.78 | 12 | 3,260,430 | 24.84 |
| Ben Tre | 29,783,700 | 3,559,200 | 9,791,400 | 50.76 | 16.56 | 32.68 | 11.26 | 5,292,047 | 23.68 |
| Cam Mau | 28,457,041 | 9,224,129 | 14,090,660 | 38.8 | 36.7 | 24.5 | 10 | 4,704,041 | 23.4 |
| Can Tho | 59,158,859 | 22,745,841 | 31,794,892 | 11.54 | 43.33 | 45.12 | 14.64 | 6,245,269 | 48.92 |
| Dong Thap | 36,098,722 | 3,945,313 | 2,390,797 | 50.26 | 23.15 | 26.59 | 13.55 | 5,731,012 | 21.57 |
| Hau Giang | 15,116,397 | 3,597,511 | 9,630,990 | 31.73 | 31.32 | 36.95 | 14.12 | 4,995,150 | 19.66 |
| Kien Giang | 61,794,874 | 11,015,926 | 20,293,600 | 41.99 | 33.84 | 24.17 | 12.06 | 3,327,000 | 35.89 |
| Long An | 44,493,153 | 13,648,832 | 16,748,430 | 35.72 | 35.38 | 28.9 | 12.2 | 5,881,750 | 30.69 |
| Soc Trang | 37,406,406 | 5,434,501 | 5,241,519 | 52.36 | 18.46 | 29.19 | 8.05 | 6,951,600 | 28.69 |
| Tien Giang | 46,688,404 | 9,890,131 | 14,892,674 | 47.2 | 27.1 | 25.7 | 10.5 | 6,311,431 | 27.75 |
| Tra Vinh | 18,896,742 | 1,757,973 | 6,001,722 | 62.15 | 13.12 | 24.73 | 12.93 | 5,227,355 | 18.66 |
| Vinh Long | 29,042,792 | 3,692,161 | 8,259,197 | 49.93 | 16.38 | 33.69 | 9.92 | 2,606,386 | 28.24 |

**Table 2.2**
The data of sustainable industrial development assessment indicator system in the Mekong Delta — social subsystem.

| Indicators | $X_{10}$ | $X_{11}$ | $X_{12}$ | $X_{13}$ | $X_{14}$ | $X_{15}$ | $X_{16}$ | $X_{17}$ | $X_{18}$ |
|---|---|---|---|---|---|---|---|---|---|
| An Giang | 608 | 1.03 | 89,490 | 2,150,999 | 8674 | 12.34 | 52.3 | 16.93 | 29.89 |
| Bac Lieu | 340 | 1.2 | 32,221 | 873,293 | 6518 | 11.71 | 48.28 | 15.68 | 26.87 |
| Ben Tre | 533 | 0.65 | 97,097 | 1,257,782 | 2605 | 13.85 | 53.89 | 28.16 | 10.03 |
| Cam Mau | 230 | 1.03 | 37,967 | 1,216,175 | 3390 | 13.85 | 52.89 | 17.01 | 21.53 |
| Can Tho | 863 | 1.03 | 83,814 | 1,209,192 | 41,170 | 18.89 | 52.19 | 15.52 | 66.15 |
| Dong Thap | 496 | 1 | 79,537 | 1,673,184 | 13,231 | 12.25 | 51.26 | 16.83 | 17.76 |
| Hau Giang | 480 | 1.12 | 22,577 | 768,761 | 12,687 | 13.71 | 53.78 | 15.58 | 23.66 |
| Kien Giang | 271 | 1.06 | 73,773 | 1,721,763 | 7674 | 15.45 | 53.71 | 17.16 | 27.19 |
| Long An | 323 | 0.88 | 163,344 | 1,449,915 | 8677 | 18.91 | 53.98 | 17.55 | 17.79 |
| Soc Trang | 394 | 0.93 | 51,936 | 1,303,662 | 9820 | 17.11 | 54.98 | 18.49 | 27.63 |
| Tien Giang | 671 | 0.97 | 93,965 | 1,682,601 | 3051 | 16.56 | 54.85 | 19.1 | 14.73 |
| Tra Vinh | 443 | 0.11 | 66,085 | 1,012,648 | 1001 | 13.85 | 54.98 | 17.32 | 15.68 |
| Vinh Long | 683 | 0.87 | 71,732 | 1,028,550 | 6160 | 12.18 | 54.18 | 15.64 | 15.48 |

**Table 2.3**
The data of sustainable industrial development assessment indicator system in the Mekong Delta — environment subsystem.

| Indicators | $X_{19}$ | $X_{20}$ | $X_{21}$ | $X_{22}$ | $X_{23}$ | $X_{24}$ | $X_{25}$ | $X_{26}$ | $X_{27}$ |
|---|---|---|---|---|---|---|---|---|---|
| An Giang | 297,399 | 3.93 | 2,465,690.2 | 1561.8 | 111,437 | 1191.8 | 47.69 | 280.91 | 230.16 |
| Bac Lieu | 225,569 | 5.2 | 1,063,781.1 | 620.45 | 32,604 | 483.87 | 70.33 | 140.8 | 92.86 |
| Ben Tre | 179,436 | 1.57 | 1,526,086.3 | 888.92 | 52,920 | 696.91 | 80.58 | 185.93 | 136.62 |
| Cam Mau | 462,815 | 20.6 | 1,476,080.3 | 858.7 | 47,040 | 673.85 | 98.86 | 145.94 | 136.62 |
| Can Tho | 115,432 | 0.16 | 1,906,063 | 1277.5 | 93,679 | 870.98 | 123.36 | 145.11 | 145.75 |
| Dong Thap | 247,549 | 2.09 | 2,032,998.2 | 1183.5 | 57,310 | 927.07 | 142.85 | 200.78 | 170.86 |
| Hau Giang | 140,457 | 3.18 | 929,104.9 | 540.25 | 49,952 | 425.95 | 76.47 | 102.65 | 92.15 |
| Kien Giang | 576,452 | 14.37 | 2,086,423.16 | 1211.9 | 33,270 | 953.99 | 138.43 | 216.61 | 165.71 |
| Long An | 361,308 | 9.64 | 1,757,689.52 | 1022.4 | 58,818 | 803.36 | 135.98 | 208.76 | 172.14 |
| Soc Trang | 410,325 | 3.21 | 1,579,265.87 | 918.96 | 69,510 | 722.33 | 112.58 | 176.44 | 134.29 |
| Tien Giang | 372,085 | 2.98 | 2,051,898.2 | 1191.5 | 63,114 | 932.29 | 132.46 | 207.91 | 148.61 |
| Tra Vinh | 321,246 | 2.52 | 1,223,580.8 | 712.17 | 52,274 | 561.08 | 98.48 | 134.52 | 98.012 |
| Vinh Long | 220,392 | 2.12 | 1,247,453.61 | 726.39 | 26,064 | 569.89 | 95.52 | 143.43 | 98.012 |

**Table 3.1**
Standardized data sheet of statistical indicator system of the Mekong Delta — economic subsystem.

| Indicators | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | $X_7$ | $X_8$ | $X_9$ |
|---|---|---|---|---|---|---|---|---|---|
| An Giang | 1.359 | −0.357 | −0.490 | −0.714 | −1.340 | 2.458 | −0.348 | 2.642 | −0.020 |
| Bac Lieu | −1.006 | −0.597 | −0.775 | 0.684 | −0.102 | −0.846 | 0.153 | −1.057 | −0.355 |
| Ben Tre | −0.491 | −0.688 | −0.246 | 0.610 | −0.899 | 0.124 | −0.245 | −0.104 | −0.501 |
| Ca Mau | −0.576 | 0.290 | 0.297 | −0.320 | 1.117 | −0.768 | −0.925 | −0.380 | −0.536 |
| Can Tho | 1.379 | 2.626 | 2.534 | −2.441 | 1.781 | 1.479 | 1.576 | 0.343 | 2.682 |
| Dong Thap | −0.089 | −0.622 | −1.181 | 0.572 | −0.239 | −0.540 | 0.989 | 0.102 | −0.767 |
| Hau Giang | −1.425 | −0.682 | −0.266 | −0.870 | 0.579 | 0.589 | 1.296 | −0.243 | −1.008 |
| Kien Giang | 1.547 | 0.600 | 1.081 | −0.072 | 0.831 | −0.804 | 0.186 | −1.026 | 1.039 |
| Long An | 0.445 | 1.055 | 0.633 | −0.560 | 0.985 | −0.288 | 0.261 | 0.173 | 0.383 |
| Soc Trang | −0.006 | −0.364 | −0.821 | 0.735 | −0.709 | −0.257 | −1.975 | 0.675 | 0.131 |
| Tien Giang | 0.585 | 0.405 | 0.399 | 0.333 | 0.156 | −0.637 | −0.655 | 0.374 | 0.012 |
| Tra Vinh | −1.184 | −1.000 | −0.725 | 1.497 | −1.243 | −0.743 | 0.655 | −0.134 | −1.134 |
| Vinh Long | −0.538 | −0.665 | −0.440 | 0.546 | −0.917 | 0.234 | −0.968 | −1.364 | 0.074 |

**Table 3.2**
Standardized data sheet of statistical indicator system of the Mekong Delta – social subsystem.

| Indicators | $X_{10}$ | $X_{11}$ | $X_{12}$ | $X_{13}$ | $X_{14}$ | $X_{15}$ | $X_{16}$ | $X_{17}$ | $X_{18}$ |
|---|---|---|---|---|---|---|---|---|---|
| An Giang | 0.659 | 0.420 | 0.427 | 2.089 | −0.090 | −0.930 | −0.470 | −0.253 | 0.408 |
| Bac Lieu | −0.804 | 1.036 | −1.165 | −1.180 | −0.301 | −1.182 | −2.629 | −0.630 | 0.192 |
| Ben Tre | 0.250 | −0.955 | 0.639 | −0.196 | −0.684 | −0.326 | 0.384 | 3.136 | −1.012 |
| Ca Mau | −1.405 | 0.420 | −1.005 | −0.303 | −0.607 | −0.326 | −0.153 | −0.228 | −0.190 |
| Can Tho | 2.052 | 0.420 | 0.270 | −0.321 | 3.094 | 1.688 | −0.529 | −0.678 | 2.999 |
| Dong Thap | 0.047 | 0.312 | 0.151 | 0.867 | 0.357 | −0.966 | −1.028 | −0.283 | −0.459 |
| Hau Giang | −0.040 | 0.746 | −1.433 | −1.448 | 0.303 | −0.382 | 0.325 | −0.660 | −0.037 |
| Kien Giang | −1.181 | 0.529 | −0.010 | 0.991 | −0.188 | 0.313 | 0.288 | −0.183 | 0.215 |
| Long An | −0.897 | −0.123 | 2.481 | 0.295 | −0.089 | 1.696 | 0.433 | −0.065 | −0.457 |
| Soc Trang | −0.510 | 0.058 | −0.617 | −0.079 | 0.023 | 0.977 | 0.970 | 0.218 | 0.246 |
| Tien Giang | 1.003 | 0.203 | 0.552 | 0.891 | −0.640 | 0.757 | 0.900 | 0.402 | −0.676 |
| Tra Vinh | −0.242 | −2.910 | −0.223 | −0.824 | −0.841 | −0.326 | 0.970 | −0.135 | −0.608 |
| Vinh Long | 1.069 | −0.159 | −0.066 | −0.783 | −0.336 | −0.994 | 0.540 | −0.642 | −0.622 |

In the same way:

- The comprehensive score of social subsystem is as follows:

$$F_2 = 0.360F_{21} + 0.283F_{22} + 0.160F_{23} + 0.115F_{24} + 0.082F_{25} \quad (7)$$

- The comprehensive score of environment subsystem is as follows:

$$F_3 = 0.644F_{31} + 0.246F_{32} + 0.110F_{33} \quad (8)$$

In the same way, we can output solution for other years, such as 2007 and 2009.

### 3.7. Evaluation scores of sustainable industrial development

With the value of the indicator evaluation function of each subsystem above, the final score of each subsystem can be evaluated and ranked. The final scores are shown in Tables 7.1–7.3.

## 4. Analysis of results and discussion

According to the final scores in Tables 7.1–7.3, the analysis of results and discussion of each subsystem is presented.

### 4.1. Economic subsystem

Fig. 2 shows the final score of economic subsystem and ranking of provinces and city in the Mekong Delta of Vietnam.

Based on Fig. 2, we can divide the Mekong Delta into three categories. The best category is composed of Can Tho city, An Giang, Kien Giang, and Long An provinces, which are a developed group with strong industrial economy. The average category includes four provinces: Ca Mau, Tien Giang, Hau Giang, and Ben Tre provinces, which are comprised of the average development provinces with the general industrial economy. The worst category consists of five provinces: Dong Thap, Soc Trang, Vinh Long, Bac Lieu, and Tra Vinh, which are less developed area of industrial economy compared to the others of the Mekong Delta.

The final score in Table 7.1 shows that overall economic development of the Mekong Delta was unsustainable from 2007 to 2011. For example, An Giang province's final score was $F_1 = 1.604$, 0.457 and 1.437 in 2007, 2009 and 2011 respectively; Soc Trang province was $F_1 = -0.401$, −1.762 and −0.0804 in turn; Tien Giang province was $F_1 = 0.200$, 0.692 and −0.008 respectively. However, the statistical data also shows that GDP growth of the Mekong Delta has decreased gradually from 2007 to 2011. For example, Can Tho city's GDP growth rate was 16.25% (in 2007) and 14.64% (in 2011); An Giang province was 13.48% and 11.07% respectively; Long An province was 13.50% and 12.20% in turn (PMDBS, 2007–2011). In addition, the Mekong Delta still follows an irrational economic structure with low GDP in the industrial sector. For instance, Kien Giang province's industrial sector contributed 33.84% to the overall GDP in 2011, with 41.99% from agriculture and the remaining 24.17% from service sector; Vinh Long province was 16.38% to the overall GDP in 2011, with 49.93% from agricultural sector and the remaining 33.69% from service sector; and Tra Vinh province with industrial contribution of 13.12% to the overall GDP in 2011, in which 62.15% from agricultural sector and the remaining 24.73% from service sector (PMDBS, 2007–2011).

**Table 3.3**
Standardized data sheet of statistical indicator system of the Mekong Delta – environment subsystem.

| Indicators | $X_{19}$ | $X_{20}$ | $X_{21}$ | $X_{22}$ | $X_{23}$ | $X_{24}$ | $X_{25}$ | $X_{26}$ | $X_{27}$ |
|---|---|---|---|---|---|---|---|---|---|
| An Giang | −0.037 | −0.267 | 1.805 | 1.970 | 2.263 | 2.001 | −1.888 | 2.220 | 2.264 |
| Bac Lieu | −0.576 | −0.052 | −1.267 | −1.206 | −1.047 | −1.241 | −1.131 | −0.749 | −1.189 |
| Ben Tre | −0.922 | −0.666 | −0.254 | −0.301 | −0.194 | −0.266 | −0.788 | 0.208 | −0.088 |
| Ca Mau | 1.204 | 2.554 | −0.364 | −0.403 | −0.441 | −0.371 | −0.176 | −0.640 | −0.088 |
| Can Tho | −1.403 | −0.904 | 0.579 | 1.010 | 1.518 | 0.532 | 0.644 | −0.658 | 0.141 |
| Dong Thap | −0.411 | −0.578 | 0.857 | 0.693 | −0.010 | 0.789 | 1.296 | 0.522 | 0.773 |
| Hau Giang | −1.215 | −0.393 | −1.562 | −1.477 | −0.319 | −1.507 | −0.925 | −1.557 | −1.207 |
| Kien Giang | 2.057 | 1.500 | 0.974 | 0.789 | −1.019 | 0.912 | 1.148 | 0.858 | 0.643 |
| Long An | 0.442 | 0.700 | 0.254 | 0.150 | 0.054 | 0.222 | 1.066 | 0.691 | 0.805 |
| Soc Trang | 0.810 | −0.388 | −0.138 | −0.199 | 0.503 | −0.149 | 0.283 | 0.006 | −0.147 |
| Tien Giang | 0.523 | −0.427 | 0.898 | 0.720 | 0.234 | 0.813 | 0.948 | 0.673 | 0.213 |
| Tra Vinh | 0.142 | −0.505 | −0.917 | −0.897 | −0.221 | −0.888 | −0.189 | −0.882 | −1.059 |
| Vinh Long | −0.615 | −0.573 | −0.865 | −0.849 | −1.322 | −0.847 | −0.288 | −0.693 | −1.059 |

**Table 4**
Total variance explained.

| Component | Initial eigenvalues | | | Extraction sums of squared loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % |
| 1 | 4.891 | 54.345 | 54.345 | 4.891 | 54.345 | 54.345 |
| 2 | 1.959 | 21.764 | 76.108 | 1.959 | 21.764 | 76.108 |
| 3 | 1.116 | 12.399 | 88.508 | 1.116 | 12.399 | 88.508 |
| 4 | 0.428 | 4.757 | 93.265 | | | |
| 5 | 0.384 | 4.271 | 97.536 | | | |
| 6 | 0.129 | 1.436 | 98.971 | | | |
| 7 | 0.081 | 0.897 | 99.869 | | | |
| 8 | 0.012 | 0.131 | 100.000 | | | |
| 9 | 5.260E−9 | 5.844E−8 | 100.000 | | | |

### 4.2. Social subsystem

In the same way, based on Table 7.2, we can get Fig. 3, which is the final score of social subsystem and ranking of provinces and city in the Mekong Delta of Vietnam.

Fig. 3 shows the results of social development in the Mekong Delta, which could be divided into three categories. The best category consists of Can Tho city, An Giang, Tien Giang, and Long An provinces, which are understood as the social development areas with good society. The final score of this category is highest for Can Tho city's $F_2 = 1.517$. The average category includes Dong Thap, Ben Tre, Soc Trang, and Kien Giang provinces. Because their final score are lower than the best category, such as Dong Thap province's $F_2 = 0.074$ while An Giang province's $F_2 = 0.866$, this category is treated as the average in social development and the worst category is composed of Vinh Long, Hau Giang, Ca Mau, Bac Lieu, and Tra Vinh provinces. The provinces listed above are understood as encompassing the worst social development group with Tra Vinh province obtaining the lowest final score of $F_2 = -1.010$.

The industrialization and urbanization of these provinces can be understood as a key driver of socio-economic transformation and social development, meanwhile, economic growth has translated into improved living conditions (Garschagen et al., 2012). The Mekong Delta's major urban centers such as Can Tho city, Long Xuyen of An Giang, My Tho of Tien Giang, Vinh Long or Rach Gia of Kien Giang are the main places for processing and trading the Mekong Delta's agricultural produces but also for political administration as well as social and environmental functions. The resultant analysis and statistical data indicate that living conditions of residents increased in importance, and the majority of employees are found in the industrial sector. For example, An Giang province had an urbanization rate increasing from 28.81% (in 2007) to 29.89% (in 2011), total employed population from 76,965 to 89,490 people, and population in university from 6391 to 8674 people. For Dong Thap province, urbanization rate increased from 16.58% (in 2007) to 17.76 (in 2011), total employed population increased from 59,276 to 79,537 people, population in university from 9909 to 13,231 people (PMDBS, 2007–2011). However, the skill level of the labor force is still low, and lack of formal training causes difficulties and issues for industry development (MIT, 2011).

**Table 5**
Component matrix.

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| $X_1$ | 0.735 | 0.349 | −0.410 |
| $X_2$ | 0.955 | −0.161 | −0.147 |
| $X_3$ | 0.931 | −0.238 | −0.087 |
| $X_4$ | −0.903 | −0.117 | −0.285 |
| $X_5$ | 0.747 | −0.554 | 0.077 |
| $X_6$ | 0.451 | 0.767 | 0.315 |
| $X_7$ | 0.383 | −0.225 | 0.806 |
| $X_8$ | 0.205 | 0.892 | 0.048 |
| $X_9$ | 0.898 | −0.017 | −0.282 |

**Table 6**
Component score coefficient matrix.

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| $X_1$ | 0.150 | 0.178 | −0.368 |
| $X_2$ | 0.195 | −0.082 | −0.132 |
| $X_3$ | 0.190 | −0.122 | −0.078 |
| $X_4$ | −0.185 | −0.060 | −0.255 |
| $X_5$ | 0.153 | −0.283 | 0.069 |
| $X_6$ | 0.092 | 0.391 | 0.282 |
| $X_7$ | 0.078 | −0.115 | 0.723 |
| $X_8$ | 0.042 | 0.455 | 0.043 |
| $X_9$ | 0.184 | −0.009 | −0.252 |

### 4.3. Environmental subsystem

Based on Table 7.3, we can get Fig. 4, which is the final score of environmental subsystem and ranking of provinces and city in the Mekong Delta of Vietnam.

According to ranking of the environmental subsystem at Fig. 4, we can also divide provinces and city of the Mekong Delta into three categories. The best category consists of An Giang, Kien Giang, Tien Giang, and Dong Thap provinces, as the group has a better quality in environment. The final score of this group is highest, such as, An Giang province's $F_3 = 2.645$. The average category contains Long An, Can Tho city, Ca Mau, and Soc Trang provinces. The final scores of these provinces are lower than the best category for this sustainable environmental factor. Long An province's $F_3 = 1.028$ while Kien Giang province's $F_3 = 2.160$. Thus, this category is treated as an average quality environment. Finally, the worst category includes Ben Tre, Tra Vinh, Vinh Long, Bac Lieu, and Hau Giang provinces, where the final scores prove that these provinces are in poor environmental quality. For example, Hau Giang province's final score $F_3 = -2.81$ is lowest of region.

In the Mekong Delta, provinces and city with arable land, forest coverage and investment in environment protection indicators are generally high, while $CO_2$ emissions, sewage, and industrial solid waste in the processing rate is not fast. However, the Mekong Delta's environment exhibited a downward trend. For example Dong Thap province in the best category had 247,549 ha of arable area, 2.09% of forest coverage and 57.31 billion VND (US$1 = VND21,008 in 2011) for investing in environment protection, while total energy consumption was 1184 thousand tons (1009 thousand tons in 2007), volume industrial solid waste was 142.85 thousand tons (108.98 thousand tons in 2007). In case of Soc Trang province in average category, the arable land was 410,325 ha, forest coverage was 3.21%, and investment in environment protection was 69.51 billion VND, while total energy consumption was 918.96 thousand tons (776.61 thousand tons in 2007), volume industrial solid waste was 112.58 thousand tons (83.79 thousand tons in 2007) (PMDBS, 2007–2011).

In accordance with the above analysis and statistical data from 2007 to 2011 as well as the scientific literature, we can frame the existing problems of industrial development in the Mekong Delta, as follows:

(1) Efficient industrial development created economic growth as well as an improved society and environment. The industrial sector contributed 25.54% of GDP in 2011, in which 42.92% of

**Table 7.1**
The final score of economic subsystem and ranking of sustainable industrial development in the Mekong Delta of Vietnam.

| Areas | Economic subsystem | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2007 | | 2009 | | 2011 | | Average score | |
| | $F_1$ | Ranking | $F_1$ | Ranking | $F_1$ | Ranking | $F_1$ | Ranking |
| An Giang | 1.604 | 2 | 0.457 | 5 | 1.437 | 2 | 1.166 | 2 |
| Bac Lieu | −1.469 | 13 | −1.668 | 11 | −1.267 | 12 | −1.468 | 12 |
| Ben Tre | −0.620 | 9 | −1.184 | 8 | −0.736 | 9 | −0.847 | 8 |
| Ca Mau | −0.195 | 6 | 0.371 | 6 | −0.356 | 7 | −0.060 | 6 |
| Can Tho | 3.593 | 1 | 6.082 | 1 | 3.713 | 1 | 4.463 | 1 |
| Dong Thap | −0.520 | 8 | −1.506 | 9 | −0.731 | 8 | −0.919 | 9 |
| Hau Giang | −1.127 | 11 | −0.626 | 7 | −0.036 | 6 | −0.596 | 7 |
| Kien Giang | 0.648 | 4 | 1.832 | 2 | 0.591 | 4 | 1.024 | 3 |
| Long An | 0.684 | 3 | 1.178 | 3 | 0.823 | 3 | 0.895 | 4 |
| Soc Trang | −0.401 | 7 | −1.762 | 12 | −0.805 | 10 | −0.989 | 10 |
| Tien Giang | 0.200 | 5 | 0.692 | 4 | −0.008 | 5 | 0.295 | 5 |
| Tra Vinh | −1.366 | 12 | −2.339 | 13 | −1.612 | 13 | −1.772 | 13 |
| Vinh Long | −1.031 | 10 | −1.527 | 10 | −1.013 | 11 | −1.190 | 11 |

**Table 7.2**
The final score of social subsystem and ranking of sustainable industrial development in the Mekong Delta of Vietnam.

| Areas | Social subsystem | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2007 | | 2009 | | 2011 | | Average score | |
| | $F_2$ | Ranking | $F_2$ | Ranking | $F_2$ | Ranking | $F_2$ | Ranking |
| An Giang | 0.915 | 2 | 1.098 | 2 | 0.585 | 2 | 0.866 | 2 |
| Bac Lieu | −0.786 | 12 | −1.023 | 13 | −0.496 | 10 | −0.768 | 12 |
| Ben Tre | −0.298 | 9 | 0.322 | 4 | −0.247 | 8 | −0.074 | 6 |
| Ca Mau | −0.603 | 10 | −0.483 | 11 | −0.713 | 12 | −0.599 | 11 |
| Can Tho | 1.048 | 1 | 1.423 | 1 | 2.08 | 1 | 1.517 | 1 |
| Dong Thap | −0.064 | 7 | 0.145 | 5 | 0.142 | 5 | 0.074 | 5 |
| Hau Giang | −0.644 | 11 | −0.435 | 10 | −0.497 | 11 | −0.525 | 10 |
| Kien Giang | −0.039 | 6 | −0.305 | 9 | 0.005 | 6 | −0.113 | 8 |
| Long An | 0.814 | 4 | −0.049 | 7 | 0.407 | 3 | 0.391 | 4 |
| Soc Trang | 0.144 | 5 | −0.294 | 8 | −0.091 | 7 | −0.080 | 7 |
| Tien Giang | 0.912 | 3 | 0.459 | 3 | 0.265 | 4 | 0.545 | 3 |
| Tra Vinh | −1.146 | 13 | −0.837 | 12 | −1.055 | 13 | −1.013 | 13 |
| Vinh Long | −0.253 | 8 | −0.021 | 6 | −0.388 | 9 | −0.221 | 9 |

contribution from agricultural sector and the remaining 31.54% by the service sector (PMDBS, 2007–2011). Yet, the contribution of the industrial sector to GDP in the Mekong Delta is still far below the national level with industrial sector accounted for 41% of the GDP in 2011 (PMDBS, 2007–2011).

(2) The industrial production is both highly distributed and highly concentrated. For example, Can Tho city (18%), Long An province (16%), and Kien Giang province (11%) account for nearly half of the industrial production in the Mekong Delta (PMDBS, 2007–2011) while the other provinces account for a much lower rate. Meanwhile, the above ranking results show that there exists regional disparity among the developing provinces of the Mekong Delta.

(3) According to statistics data from 2007 to 2011, the most important industrial sector is the food-related industry, such

**Table 7.3**
The final score of environment subsystem and ranking of sustainable industrial development in the Mekong Delta of Vietnam.

| Areas | Environment subsystem | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2007 | | 2009 | | 2011 | | Average score | |
| | $F_3$ | Ranking | $F_3$ | Ranking | $F_3$ | Ranking | $F_3$ | Ranking |
| An Giang | 2.679 | 1 | 2.899 | 1 | 2.357 | 1 | 2.645 | 1 |
| Bac Lieu | −2.439 | 12 | −2.294 | 12 | −2.005 | 12 | −2.246 | 12 |
| Ben Tre | −0.678 | 9 | −0.669 | 9 | −0.705 | 9 | −0.684 | 9 |
| Ca Mau | 0.192 | 7 | 0.069 | 7 | 0.033 | 8 | 0.098 | 7 |
| Can Tho | 0.431 | 6 | 0.245 | 6 | 0.291 | 6 | 0.322 | 6 |
| Dong Thap | 1.385 | 4 | 1.229 | 4 | 1.12 | 4 | 1.245 | 4 |
| Hau Giang | −2.954 | 13 | −2.957 | 13 | −2.519 | 13 | −2.810 | 13 |
| Kien Giang | 2.329 | 2 | 2.169 | 2 | 1.982 | 2 | 2.160 | 2 |
| Long An | 0.888 | 5 | 1.194 | 5 | 1.002 | 5 | 1.028 | 5 |
| Soc Trang | −0.054 | 8 | 0.013 | 8 | 0.079 | 7 | 0.013 | 8 |
| Tien Giang | 1.588 | 3 | 1.431 | 3 | 1.21 | 3 | 1.410 | 3 |
| Tra Vinh | −1.533 | 10 | −1.521 | 10 | −1.318 | 10 | −1.457 | 10 |
| Vinh Long | −1.835 | 11 | −1.807 | 11 | −1.526 | 11 | −1.722 | 11 |

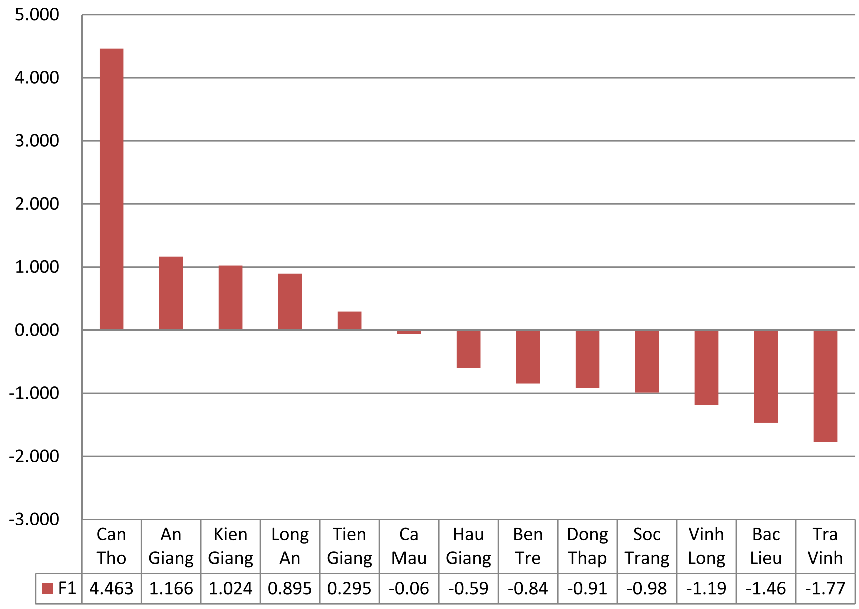


**Fig. 2.** The final score and ranking from the highest to the lowest of economic subsystem.

as the processing of food from aquaculture, fisheries, rice. In addition, the development of equipment and machinery can be used in aquaculture, agriculture, and other related industries. Therefore, it is the conclusion of this analysis that the Mekong Delta should invest in industrial sectors that can take full advantage of these opportunities for sustainable economic development.

(4) Industrial economic growth in the Mekong Delta has translated into improved living conditions with the majority of employees found employed in the industrial sector. However, the skill level of human resources is still very low lacking formal training which in and of itself causes other disjointed but related difficulties and issues for sustainable industrial development in the Mekong Delta.

(5) $CO_2$ emissions, industrial solid waste, urban domestic garbage; and industrial and urban sewage have increased annually but not at a rate that would be expected to overwhelm the existing waste processing facilities. Nonetheless, the current waste processing rate is too low to meet the current industrial waste produced at today's current level of development in the Mekong Delta which is an indication of a severe under-development in the capacity of waste management that would be needed to meet the demands of industrial waste generation arising from further industrial development putting additional stress on the already fragile environment.

In addition, the area of arable land and forest land has been severely reduced due to increased industrialization and urbanization which have been exciting excessive pressure on the limited environmental resources showing that the government adopted industrial development master plan needs improvement.

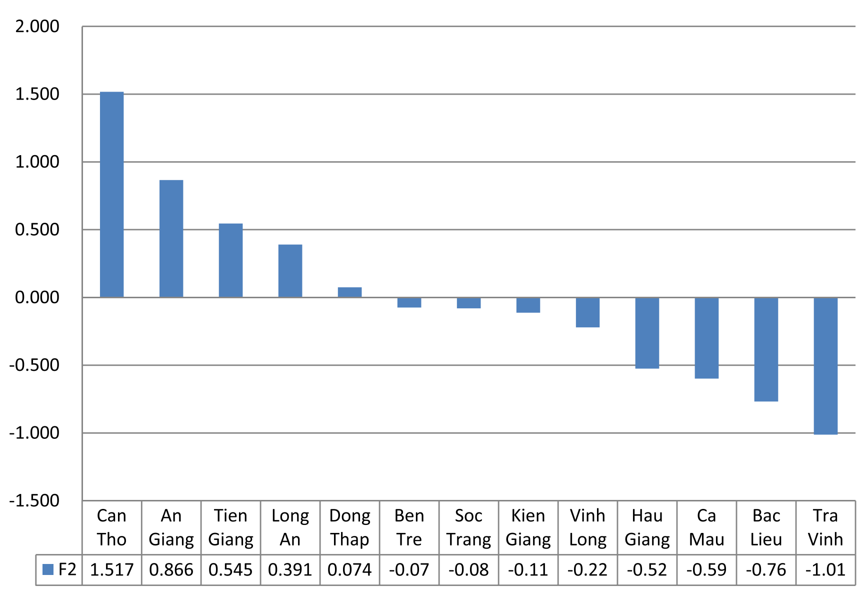


**Fig. 3.** The final score and ranking from the highest to the lowest of social subsystem.

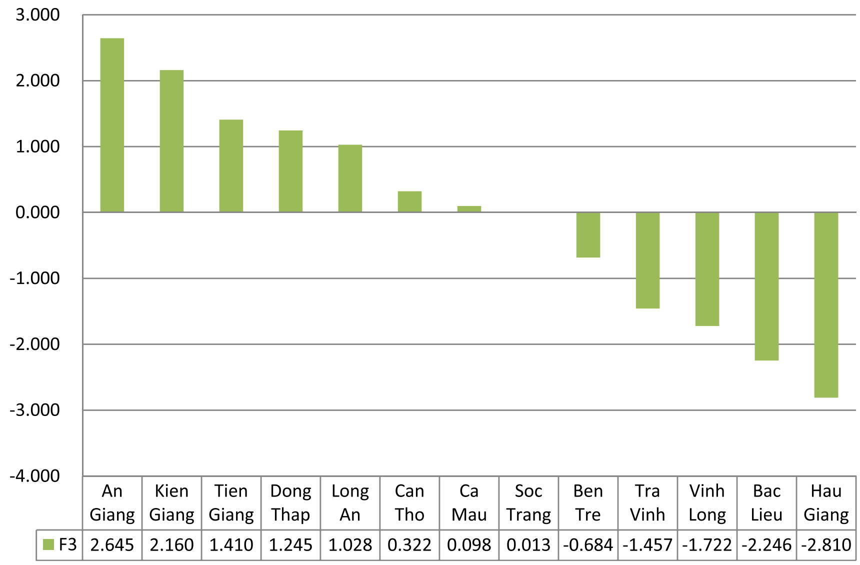


**Fig. 4.** The final score and ranking from the highest to the lowest of environment subsystem.

## 5. Policies and advices on accelerating sustainable industrial development in the Mekong Delta of Vietnam

According to the above existing problems of industrial development in the Mekong Delta and the concepts of governance on sustainable development, we propose the following policies to accelerate sustainable industrial development in the Mekong Delta of Vietnam.

### *5.1. Changing mode of economic development and optimizing industrial economy*

The analysis result shows that contribution of the industrial sector to GDP in the Mekong Delta is still low. Therefore, the Mekong Delta should restructure the economy by increasing the proportions of industries, construction, and services thus rebalancing the proportion of GDP coming from the agriculture and aquaculture industries. Economic restructuring is shifting between two types of economies, such as from manufacturing to service economy or agriculture to manufacturing economy (Xu and Tan, 2001; Tarp et al., 2003). The restructuring could be made by changing the mode of economy toward industry service hi-tech agriculture in 2020 and service industry hi-tech agriculture after 2020 (Ha, 2012).

Meanwhile, to improve the level of industrialization and promote industrial structure optimization and updating, the Mekong Delta must change the current mode of economic growth characterized by high pollution, high emission, and low efficiency to a new mode of industrialization characterized by high tech, rich economic returns, less resource consumption and less pollution.

### *5.2. Selecting priority industry, key industry and developing supporting industry*

The industrial sector plays a major role in the Mekong Delta's economic development process. The most important industrial sector is the food-related industry, such as the processing of food from aquaculture, fisheries, rice, and the production of equipment and machinery for agriculture and aquaculture related industries (Garschagen et al., 2012). The Mekong Delta should invest in industrial sectors that take advantage of these strong fields (i.e. agricultural processing and fish processing) and gradually develop other industries in the future with high economic returns such as industrial petroleum, energy, thermoelectricity, and heavy machinery (Perkins and Vu, 2010).

Consequently, the Mekong Delta also focuses on industrial investment promotion, support for small and medium-sized enterprises, and competitive sectors such as agro-forestry–fishery, garments, leather and footwear, electronics, information technology, mechanical products, pharmaceuticals; and consumer goods. Apart from hi-tech and open economic zones, facilities for heavy industries, such as oil and gas, metallurgy, chemicals, fertilizers, and construction materials, need to be planned for the future sustainable economic development of the Mekong Delta. Small and medium-scale industrial clusters are also encouraged to be set up in rural areas. The region will boost trade and apply quality and environmental management systems that meet international standards. Besides technological and management solutions to improve production efficiency, the Mekong Delta region will focus its resources on production and exports, especially in the food processing industry. It will strengthen multi-sector trading as well as work closely with other regional provinces and city such as Ho Chi Minh City to continue to improve and sustain its economic development.

### *5.3. Completing the industrial development master plan and developing infrastructure facilities in the Mekong Delta*

In literature review section of this paper we reported that Persson (2013) recommended that acceptance of sustainable development concept in planning is a part of the governance process. And Elabras Veiga and Magrini (2009) stated that an unsustainable economic development model reflects a picture of compact urban and industrial concentration, an increasing number of land use tensions, the planning and construction of important highways and infrastructure projects, and degeneration of principal environmental areas.

Consequently, the Mekong Delta needs to complete an industrial development master plan with incorporation of sustainable economic development theories and practices. The Ministry of Construction of Vietnam (2010) approved an industrial development master plan with the following orientation and structure development. 1) For the Central region in Can Tho City determining and using a layout of hi-tech industry, and promoting clean industry and its supporting industries, 2) For the Northeastern region comprised of the Long An and Tien Giang provinces adjacent to Ho Chi Minh City, provide a layout plan for agro-forestry processing and agricultural mechanics, to include the production of more consumer goods and to initiate the industry of building and repairing ships, 3) For the Southwest region comprised of the Tra Vinh, An Giang, Soc Trang, Bac Lieu, Ca Mau, and Kien Giang provinces, layout a plan for gas, electric, and agro-processing industry, seafood processing, and even protein industries, with the initiation of industries related to building materials, electronics, and its supporting industries.

Engaging the government industrial development master plan requires developing infrastructure facilities in the Mekong Delta such as building industrial parks in the industrial axes of the Long An-Tien Giang-Can Tho, Can Tho-Soc, Trang-Bac Lieu-Ca Mau, and Can Tho-An Giang-Kien Giang provinces (MCV, 2010). However, such master planning given the available resources of the Mekong Delta will not allow building a complete infrastructure system that can meet the social economic development requirements of the Mekong Delta—even if it were theoretically possible to accelerate the progress of major projects such as the Ca Mau Gas-Electric-Protein project, the O Mon (Can Tho), the Thermoelectric Center, and the Coastal Tra Vinh Thermoelectric Project.

### 5.4. Enhancing social consensus

The goals of sustainable industrial development are socio-economic development and environmental protection. Enhancing social consensus about exploiting and using finite natural resources and environmental protection in a sustainable way are the contents of the scheme toward which sustainable industrial development must be focused (Daly, 2002; Lorek and Spangenberg, 2014). Therefore, addressing unsolvable inadequacies and major conflicts between the goals of socio-economic development and environmental protection need to operate with the consensus of local government and civil society.

The extent to which industrial development effectively decreases poverty and inequality depends on the pattern of industrialization (UN, 2007b). However, the Mekong Delta's civil society still lacks adequate understanding of the importance of sustainable industrial development. Thus, increasing academic information exchange, presenting results of recent achievements, and discussing of common problems on sustainable industrial development are useful to improve public awareness of sustainable development in the Mekong Delta.

## 6. Conclusions

Many institutions and projects around the world have been working on the development of indicators and evaluating methods to better evaluate and assess sustainable industrial development. At the Mekong Delta of Vietnam, this allocation of projects has been poorly assessed in terms of governance impacts and the different related uses and has not been linked to political agreements on evaluating sustainable industrial development.

This article provides an interesting case to study the outcomes for provinces and one city of the Mekong Delta that used a customized indicator system to evaluate sustainable industrial development using a quantitative approach, the principal component analysis method. Indicators were designed from three subsystems of economy, environment, and society, 27 indicators in total. The detailed subsystem of calculations and discussions indicated that the industrial development in the Mekong Delta is in a state of unsustainable. The contribution of the industrial sector to GDP in the Mekong Delta is still far below the national level. The efficiency in developing the industrial sector to create the socio-economic growth and promote the Mekong Delta's environment exhibited a downward trend. The data analysis and discussions presented here can be used for facilitating improved governmental policies for sustainable industrial development in the Mekong Delta. The suggested policies can likewise be taken as applicable for other developing regions having a similar set of conditions as the Mekong Delta.

In spite of the restraints and troubles demonstrated in this case study, it is possible to recognize valuable outcomes, guidelines, and ideas on industrial development policies for other developing provinces and cities both in Vietnam and abroad. We believe that this article incorporates a valuable quantitative analysis based on ranking and comparing of sustainable industrial factors that can prove to be useful for any innovative, emergent developing nation wishing to implement sustainable industrial development policies. Furthermore, this article illustrates that sustainable industrial development shapes the institutional framework conditions that allow the transformation of the socio-economic potentials of the Mekong Delta following the three pillars of sustainable development—economy, society, and environment. It is our hope that the respective provinces' governmental bodies of the Mekong Delta put into action the most efficient, most practical, solid policies to implement sustainable industrial development based on this analysis.

We do not pretend to cover all the problems that exist in the Mekong Delta which certainly also need further investigation—such as the consequences arising from the failure of the eco-industry to meet the needs of sustainable development, the low impact, non-innovative achievements of some industrial technologies that carry with them relatively high environmental pollution, and many more that cannot be mentioned in their entirety. Our work, however, is nonetheless a solid, first step towards the implementation of policies that are fact-based supported by rigorous statistical analysis for a practical implementation and fostering of the sustainable economic development of the Mekong Delta region.

## Acknowledgements

The authors greatly appreciate chief editor the anonymous referees for the valuable and helpful suggestions to improve the paper. The research is supported by Program for New Century Excellent Talents in University (NCET-13-0219), Research Fund for the Doctoral Program of Higher Education of China (20130172110029), and the Fundamental Research Funds for the Central Universities, SCUT (2013ZZ0093, x2gsD2133310).

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