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Original Research Paper

Haze Pollution Control Strategies in China from the Perspective of Energy Conservation and Emission Reduction

Mingdang Li†
Law School, China Anyang Normal University, Anyang, Henan, 455000, China
†Corresponding author: Mingdang Li

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ABSTRACT

Haze pollution has been effectively controlled through the vigorous implementation of China's measures for energy conservation and emission reduction in recent years. However, China's industrial development level and energy utilization rate remain low, and this condition seriously affects the efficiency of energy conservation and emission reduction. As a consequence, the desired effect of haze pollution control is not achieved. This study aims to analyse the current situation of China's haze pollution, explore the internal function mechanism of energy conservation, emission reduction, and haze pollution control, effectively identify the key links of energy conservation and emission reduction work, and effectively control haze pollution. Statistical data on China's haze pollution from 2000 to 2013 are collected to analyse the current situation and regional distribution of haze pollution. The current problems of energy conservation and emission reduction are identified, the intrinsic functional relationship among energy conservation, emission reduction, and haze pollution is clarified, and policy measures to control China's haze pollution are proposed from the perspective of energy conservation and emission reduction. Results indicate that China suffers from serious haze pollution, and the overall presentation area is imbalanced. Haze governance is mainly affected by five factors, namely, the government's lack of incentives to promote the development of energy technologies, the energy resource structure that is mainly based on high coal consumption, heavy industries that account for an excessively large portion of the industrial structure, the traffic transport structure characterized by high motor ownership, and the large amount of dust in construction sites during the urbanization process. Implementing energy conservation and emission reduction can effectively alleviate haze pollution. The findings of this research are highly significant because they provide full understanding of China's haze pollution level, promote the effectiveness of controlling haze pollution through energy conservation and emission reduction, and help achieve coordination between economic and environmental development.

INTRODUCTION

The global environmental pollution caused by industrial development has received worldwide attention. Various governments in the world have paid high economic and social costs to control haze pollution. Haze is a mixture of PM2.5 particles, dust, aerosols, and other particles floating in the air. It is a weather phenomenon generated in a relatively stable state. However, the air pollution caused by haze weather poses a serious threat to the biosphere and human health and hinders social and economic development significantly. As a developing country, China depends largely on its resources. In recent years, many northern, central, and southern cities in China gradually experienced haze weather, which harms people, animals, plants, and the environment and restricts economic development. Urban haze weather is mainly caused by large urbanization scale, poor atmospheric dispersion, distribution of mixed industrial and production areas, and highly concentrated pollution. The pollution caused by industrial enterprises, automobile exhaust emissions on roads, floating dust caused by coal combustion, and floating dust on streets are the main sources of atmospheric pollutants.

Given the low per-capita share of resources in China and the adoption of an extensive development mode in the past three decades, China has gradually encountered the haze pollution problem experienced by developed countries in the industrialization process. In the past century, haze pollution has exerted serious effects on resources, the environment, social and economic development, and other areas. Faced with this grim situation, the Chinese government proposed to solve resource and environment problems by transforming the economic development mode and making structural adjustments. Energy conservation and emission reduction were placed on the agenda as important operating measures. The specific targets of energy conservation and emission reduction were identified to effectively alleviate haze pollution. Therefore, faced with extreme resource and environment pressures and arduous economic and social development tasks, exploring specific measures and control objectives for energy conservation and emission reduction and

ultimately controlling haze pollution in China are of theoretical and practical significance in protecting China's environmental resources and achieving sustainable economic and social development.

EARLIER STUDIES

Most studies on the prevention and control of haze pollution are macro investigations that focused on legislation and government intervention. Foreign scholars devoted specific attention to the micro-behaviours and activities of enterprises and explored various means to achieve energy conservation and emission reduction, reduce carbon emissions effectively, and minimize the formation of haze pollution. Many studies have explored the reduction of haze pollution through energy conservation and emission reduction. Grossman indicated that with economic development, the emissions of environmental pollutants have gradually increased and then decreased (Grossman et al. 1991). Aaheim studied the CO_2 reduction energy-saving projects of Hungary and found that CO_2 emissions can be controlled and that the regional pollution treatment rate and degree of building facility corrosion can be reduced (Aaheim et al. 1999). Mohareb reported that enterprises should effectively alleviate haze pollution through clean production and recycling and should not advocate the disposal method of burying wastes (Mohareb et al. 2011). Stuart suggested that factories and enterprises in urban areas be supervised by environmental protection authorities; the sewage behaviours of factories and enterprises in outskirts should also be supervised by relevant departments (Stuart et al. 2009). Aaron found that China's haze weather is mainly concentrated in northern, central, and eastern China covering Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta and reported that industrial production is the main cause of haze pollution (Aaron et al. 2010). Steinberg argued that haze pollution in cities with a large proportion of industrial enterprises is mainly caused by these high-pollution industries (Steinberg et al. 2012). Given that haze is a product of economic development, many studies focused on how to mitigate haze pollution by levying energy, environmental, and other taxes or adopting compulsory government regulations. For instance, Miranda studied the environmental tax policies of Switzerland and found that Switzerland encourages companies to select different types of fuel to distinguish environmental tax subsidies and uses environmental taxes to encourage consumers to save energy; these energy conservation and emission reduction policies can effectively improve the implementation effect (Miranda et al. 2002). Liu reported that the government should standardize industrial construction and product energy consumption, establish industry access thresholds, regulate production, and adopt other methods to implement energy conservation and emission reduction effectively and reduce haze pollution (Liu et al. 2002). Tolmasquim analysed the effects of the Brazilian government's energy conservation and emission reduction measures in the 1990s and found that the success of the measures is due to the government's active adjustment of the trade structure (Tolmasquim et al. 2003). Chen indicated that the government should increase legal governance and promote clean production and recycling but should not advocate the disposal method of burying wastes (Chen et al. 2008). Mushkat found that countries in Southeast Asia alleviate urban haze through cross-region cooperation and the legal mechanisms of the Association of Southeast Asian Nations (Mushkat 2014). Allan established the 2000 Scottish energy-economy-environment computable general equilibrium model and analysed the effect of carbon tax on CO_2 emission reduction and the economy (Allan et al. 2014). Cao Xiaojuan analysed the important roles of carbon taxes and subsidies, carbon transactions and subsidies, carbon trading, and other incentive policy instruments in EU climate policies (Cao 2014). These previous studies indicated that the majority of foreign scholars used the quantization effect to explore the reduction of haze pollution through energy conservation and emission reduction from a technical perspective. Domestic scholars generally conducted qualitative and quantitative studies to examine China's haze problem from a macro perspective. The present study analyses the current situation of haze pollution in China and its regional distribution from 2000 to 2013, investigates the current status and problems in energy conservation and emission reduction, and explores the relationship among energy conservation, emission reduction, and haze pollution. Targeted policy measures are also proposed for haze governance in China.

SITUATION OF CHINA'S ENERGY CONSERVATION AND EMISSION REDUCTION

A contradiction exists among energy conservation, emission reduction and economic development: China is currently in the middle stage of industrialization characterized by the accelerated development of heavy industries. The historical experiences of the UK, the United States, Japan, and other developed countries indicate that when industrialization enters the period characterized by accelerated development of heavy industries, the speed of industrialization and economic development increases, energy consumption constantly increases, and the emissions of greenhouse gases and pollutants progressively increase. China is a large developing country, and given the upgrading of the domestic consumption structure and the increasing energy demands and export growth, China is expected to remain in a period im-

portant for the development of heavy industries until 2020. The high increment rate of energy consumption volume and pollutant emission is an undeniable fact. Currently, a conflict exists between the unlimited expansion of heavy industries in China and the country's limited resources and environment. This conflict will further expand and intensify with the development of heavy industries. The long-term conflict between energy consumption and pollution can be solved only through the fundamental transformation of the economic growth mode. Changing China's extensive pattern of economic growth, which is characterized by high energy consumption and high pollution, is imperative. However, when transforming the economic growth mode, the government should exert efforts to solve the distorted factor prices, improve the indicators and mechanisms for the performance evaluation of social and economic development, and develop an institutional and policy environment that is conducive to innovation. These tasks cannot be completed in a short time. In the process of transforming the economic growth mode and protecting the environment, many factors that support China's economic growth will require substantial changes. For example, the costs of labour, land, and other production factors will increase. Energy and other important resources will be subjected to significant constraints and pressure, and financial risks will increase. Evidently, addressing high energy consumption and high pollution problems in a short period of time would be difficult and old energy and environmental problems may occur repeatedly.

The coal-dominated energy resource structure will pose a long-term constraint on energy conservation and emission reduction: China has abundant coal but poor gas resources. Such resource endowment indicates that China's energy resource structure is irrational. Thus, a coal-based energy resource structure is formed, and this structure is not expected to fundamentally change in a long period of time and will inevitably become a factor that limits the long-term development of China's energy conservation and emission reduction. The amount of carbon dioxide emission caused by coal consumption is much higher than that caused by oil and natural gas consumption. Hence, China's carbon dioxide emission per unit of energy is expected to be at a high level for a long period of time. In addition, dust and other pollutants generated from coal production are the main sources of air pollution and greenhouse gases. Given the limitation in resource endowment, China will encounter difficulties in the process of fundamentally solving the problems caused by having a coal-dominated energy resource structure. Given that such an energy resource structure will exist for a long time, China has to withstand extreme pressure when implementing energy conservation and emission reduction measures and developing low-carbon development models. China also needs to pay a higher price than other countries in terms of capital and technology.

The long-term integrated mechanism of systematic energy conservation and emission reduction has not been formed: To complete the tasks of energy conservation and emission reduction, several regions in China adopt compulsory measures to restrict production and electricity. From the market perspective, such temporary energy-saving practices significantly damage enterprise production, people's lives, and social and economic development. With regard to enterprise production, although brownouts, restricted production, and other measures adopted to conserve energy and reduce emissions can decrease the energy consumption of enterprises in a short time, these measures also disrupt the normal production, business planning, and deployment processes of enterprises, thereby leading to incalculable economic losses and eventually affecting the economic efficiency of enterprises. With regard to residents, people's lives are greatly affected when brownouts are implemented. Local governments should establish a long-term integrated mechanism of energy conservation and emission reduction as soon as possible. With such a scientific integrated mechanism of energy conservation and emission reduction, local governments would not place too much emphasis on economic development and attracting investment but would regard energy conservation and emission reduction as important reference indicators for the government's performance evaluation.

The new technologies related to energy conservation and emission reduction are not fully implemented: As a developing country, China is and will remain at the middle stage of development for a long time. China's energy production and utilization rate, industrial production level, environmental protection level, and other technologies are backward because of the low level of economic development and lack of key technologies for energy conservation and emission reduction. China's lack of key development technologies and poor ability to produce key equipment render the environmental protection system weak. Consequently, China lags far behind developed countries. Meanwhile, backward technologies in many key industries in China still account for a large proportion. As a result of the existence of such a large number of backward technologies and the lack of advanced technologies, China's industrial production and infrastructure construction are characterized by high emission. Furthermore, new energy-saving emission-reducing technologies and products in the current market are costly. Consequently, the consumer market is weak, and a virtuous cycle of R&D-promotion-R&D cannot be formed. The general promotion and extensive application of energy-saving technologies are thus hindered. These objective facts

significantly increase the costs of transforming into a low carbon development mode and pose increased pressure on China to reduce energy consumption and gaseous emissions.

RELATIONSHIP AMONG HAZE POLLUTION ENERGY CONSERVATION AND EMISSION REDUCTION

Haze weather can be caused by many factors. From the perspective of technology, adverse climate conditions may cause persistent accumulation of air pollutants. From an economic perspective, deteriorated haze pollution is caused by the government's lack of incentives to promote the development of energy technologies, the energy resource structure that is mainly based on high coal consumption, heavy industries that account for an excessively large proportion of the industrial structure, the traffic transport structure characterized by high motor ownership, and the large amount of dust in construction sites during urbanization.

Insufficient incentives to promote environmental technological progress may easily aggravate haze pollution: For a long time, the Chinese government has strived to achieve rapid economic growth. Local governments tend to pursue rapid gross domestic product (GDP) growth because of the requirements for government performance evaluation, and large-scale investment attraction is the most direct means to increase GDP. This policy leads capital flow to heavy industries, which are characterized by high energy consumption and high pollution, thus increasing their proportion. Given its lack of industrial investment in environmental protection, China lacks incentives to promote desulfurization, denitrification, dust removal, and other environmental protection technologies. This condition is not conducive to enterprise innovation and research and development of new environmental technologies. No market demands for advanced pollution control technologies exist because very few enterprises are subject to environmental regulation, and environmental technology industries lose their incentives for long-term development. For example, in China, only power plants are subject to environmental regulation. They have a high installation rate of desulfurization and denitration devices. Other industries seldom use these devices, but several thermal power plants often use these devices to save costs. The fundamental cause of this imbalance is the government's lack of regulation over environmental pollution, which leads to insufficient demands for clean technologies.

The coal-based energy consumption structure aggregates the formation of haze: The air pollutants generated from coal consumption are the main cause of China's large-scale haze pollution and are the largest source of PM2.5 particles. China's energy structure of "abundant coal, limited oil and gas" indicates that the coal-based energy consumption structure cannot be changed in a short period of time, as given in Table 1. This coal-based energy consumption structure with a low calorific value exerts significant effects on the external environment. However, in China, coal-fired power plants that have a strong ability to control pollutants account for only about 50% of the total number of coal-fired power plants. This percentage is far below the world's average level. The effects of coal gasification and coal-fired power coal on environment quality are much less severe than those of other coal-burning modes for the following reasons. First, coal-fired power is clean and efficient. Second, with the adjustment of the thermal power structure and urban space layout, an increasing number of thermal power plants begin to move out of urban areas to reduce effects on the urban environment. Research has shown that the damage of the pollution source on humans is proportional to population density and inversely proportional to distance. Therefore, although the negative effect of coal consumption is small, the direct combustion of coal causes particulate pollutants to be directly discharged into the atmosphere and become the main components of atmospheric pollutants.

The oversized proportion of heavy industries in the industrial structure aggravates haze pollution: The oversized proportion of heavy industries is another main cause of the large amount of industrial emissions. Although the government has repeatedly emphasized that the economic structure should be adjusted, the ratio of consumption over GDP is increased. In fact, the proportion of investment has constantly increased, and heavy industries with high energy consumption and high pollution account for an excessively large proportion of GDP. This irrational industrial structure driven by investment poses great pressure on China's energy consumption and environmental protection. In the process of industrialization, the amount of industrial emissions increases rapidly. National industrial emissions also exhibit a significant increase that is significantly higher than the industrial growth rate over the same period. During the "Eleventh Five-Year" period, China achieved significant progress in energy conservation and emission reduction, but the industrial structure characterized by "high input, high energy consumption, high pollution" was basically unchanged.

The traffic transport structure characterized by high motor ownership aggravates haze pollution: The number of private cars has increased rapidly with the improvement of people's living standards. Therefore, the exhaust generated by gasoline- and diesel-powered vehicles constantly increases, and this exhaust is also a main cause of air pollution. The pollution caused by automotive exhaust in recent years was very serious, as shown in Table 2.

Table 1: Statistics on the change in China's energy resource structure during the main years (1980-2012) (Unit: %)

	1980	1990	1995	2000	2005	2010	2012
Coal	72.2	76.2	74.6	69.2	70.8	68	67.1
Oil	22.7	16.6	17.5	22.2	19.8	19	18.4
Natural gas	3.2	2.1	1.8	2.2	2.6	4.4	5.3
Hydropower, nuclear power and wind power	3.4	5.1	6.1	6.4	6.8	8.6	9.2

Note: Data were collected from China Environmental Statistics Yearbook 2010–2013 and were sorted out.

Table 2: Vehicle exhaust pollution in China from 2012 to 2013.

Year	Total particulate matter	Nitrogen oxide	Carbon monoxide	Hydrocarbons
2012	62.139	640.029	3471.669	438.158
2013	59.425	640.553	3439.73	431.205

Note: Data were collected from China Environmental Statistics Yearbook 2013-2014.

The large amount of dust in construction sites in the process of urbanization is another important source of haze pollution: Urbanization is an inevitable stage in China's economic and social development, and it involves the rapid expansion of real estate and construction industries. However, construction enterprises have poor environmental awareness. This poor awareness coupled with the absence of an external constraint result in a large amount of dust in construction sites. These dust directly spread to the atmosphere and exert serious effects on air quality. Construction companies pursue economic interests excessively and ignore the adverse effect of pollution on the society and the atmosphere. Most construction sites have a long construction period, lenient management, and inappropriate dust control measures. As a result, construction sites generally create widespread dust and serious pollution.

POLICY RECOMMENDATIONS FOR HAZE POLLUTION CONTROL

Improving the energy utilization rate and developing clean energy: In the context of China's rapid economic development, protecting the environment by reducing energy consumption is infeasible. China must improve its manufacturing technologies according to the existing energy consumption level, improve its energy utilization efficiency, and utilize less energy to achieve considerable economic growth. China should shut down small and medium-sized enterprises that have low energy efficiency and high emissions, strengthen the management of large enterprises, encourage innovation, and change the current trend of "high emissions, exclusive development." Steel, cement, power generation, chemical, and other industries with high energy consumption and high emission must adopt innovative energy utilization patterns and practice energy recycling. In addition, the government should vigorously encourage the use of clean energy. It should encourage the use of solar energy and wind energy in cities and biogas in rural areas to reduce air pollution caused by burning straws. Government departments should maximize tax revenues and financial measures to affect the total amount of coal consumption. For example, commercial banks should establish a financing access mechanism for coal consumption departments, regard technology, techniques, and environmental protection as filtering conditions, optimize the coal consumption industry, and achieve the goal of controlling total consumption. Meanwhile, industries that possess excessive production capacity and high coal consumption should accelerate industrial restructuring and governance and reduce environmental pollution.

Strengthening energy conservation and emission reduction and improving the appraisal system of haze governance: Air pollution prevention and control are used to evaluate the performance of local officials. China should adopt top-down evaluation methods, that is, governments at high levels should evaluate governments at low levels. This ap-

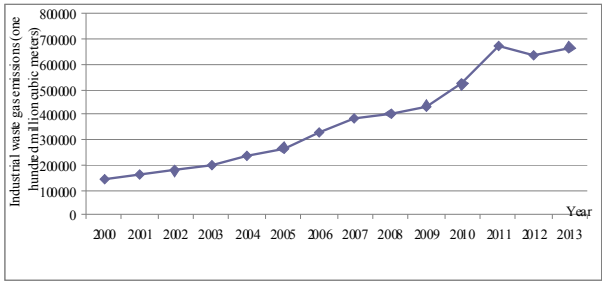

Fig. 1: China's industrial waste gas emissions from 2000 to 2013. (Data collected from China Environmental Statistics Yearbook 2010-2013).

proach is conducive to improving the implementation efficiency of governments at low levels and enhancing the performance of controlling environmental management. The government should encourage the public to participate actively in environmental protection and create a good atmosphere of environmental protection in the entire society. Changing the main body of air pollution prevention and control is the government's monotonous task, and China should combine government assessment with public supervision and expert guidance. The effective combination of government assessment, public supervision, and expert guidance can give play to the scientific guidance and advantages of expert groups and make full use of the public's collective wisdom. Meanwhile, China should establish and improve the government-led consultation system that encourages full participation of the masses, build an open and transparent communication platform, and ensure that civil institutions, organizations, the media, and the masses can actively supervise and protect the environment.

Improving the public participation system of haze governance and establishing haze monitoring and early warning mechanisms: In terms of haze pollution prevention and control, China lacks mature experience in legislation, judicature, law enforcement, and other aspects, and the theoretical system of air pollution prevention still requires improvement. Therefore, the public participation system of haze governance must be improved as soon as possible, and the regulations on public participation in haze pollution prevention and control must be segmented. Relevant rules and supporting measures must be formulated to improve the public participation system. Citizens are direct victims of haze pollution, and they have the right to know the air quality status. The government should publish the air quality status to protect the citizens' right to know. The government should strengthen the monitoring and forecasting of haze pollution because the damages of haze can only be reduced by strengthening relevant monitoring and forecasting. Currently, haze weather monitoring and forecasting are implemented through various means. For example, the Internet, mobile devices, and other interactive platforms with a wide audience and high transmission speed can be utilized to timely monitor and release haze and air pollution information. The public can then take appropriate protective measures according to the forecasts. Doing so would also observe the people's right to know. Moreover, China should develop contingency plans for haze pollution and guide and supervise the development of preventive programs. In the case of severe haze, China should take necessary measures to restrict traffic flow and relevant production, limit or shut down companies that cause serious pollution, concentrate on reducing haze, and minimize the damages caused by haze.

CONCLUSION

An in-depth analysis of the current status and regional distribution of China's haze pollution was conducted. The implementation of energy conservation and emission reduction was explored, the means to alleviate haze pollution were discussed, and targeted energy conservation and emission reduction measures were presented for government administration departments. With data on haze pollution in China from 2003 to 2014, the overall situation and regional distribution of haze pollution were analysed. The current status and problems of energy conservation and emission reduction and the relationship among haze pollution, energy conservation, and emission reduction were examined. Policy measures to alleviate haze pollution from the perspective of energy conservation and emission reduction were proposed. The results indicate that the overall condition of China's haze pollution is very serious, and the regional distribution is imbalanced. Insufficient incentives to promote technological progress, the energy resource structure, the industrial structure, the transport structure, and the large amount of dust in construction sites are the five management factors that affect haze governance. An effective policy suggestion was proposed: control haze pollution by strengthening the adjustment of the industrial structure and upgrading the energy resource structure and other measures from the perspective of energy conservation and emission reduction. These results enhance our understanding of the current situation of China's overall haze pollution. Haze governance countermeasures were explored from the perspective of energy conservation and emission reduction. However, this study analysed the overall situation of China's haze pollution, energy conservation, and emission reduction according to the limitations of time series data from 2000 to 2013. Future research should further explore the regional difference in haze pollution in China's economically developed and underdeveloped provinces, the causal relationship between energy conservation and emission reduction, the haze governance effect in different provinces, and the coordination and governance of haze pollution in different regions.

REFERENCES

Aaheim, H. A., Kristin, A. and Seip, H. M. 1999. Climate change and local pollution effects–an integrated approach. Mitigation and Adaptation Strategies for Global Change, 4(1): 61-81.

Aaron, V. D., Martin, R. V. and Michael, B. et al. 2010. Global estimates of ambient fine particulate matter concentrations from satellite-based aerosol optical depth: development and application. Environmental Health Perspectives, 118(6):847-855.

Allan, G., Lecca, P. and McGregor, P. et al. 2014. The economic and environmental impact of a carbon tax for Scotland: A computable general equilibrium analysis. Ecological Economics, 100 (100): 40-50.

Cao Xiaojuan. 2014. Combination of Incentive Policy Instrument in Climate Policy: EU Practices and Its Inspiration. Journal of China University of Geosciences (Social Sciences Edition), 14(4): 60-66.

Chen, T. C. and Lin, C. F. 2008. Greenhouse gases emissions from waste management practices using Life Cycle Inventory model. Journal of Hazardous Materials, 155(1): 23-31.

Grossman, G. M. and Krueger, A. B. 1991. Environmental impacts of a North American free trade agreement. Social Science Electronic Publishing, 8(2): 223-250.

Liu, W. Q., Gan, L. and Zhang, X. L. 2002. Cost-competitive incentives for wind energy development in China: institutional dynamics and policy changes. Energy Policy, 30(9): 753-765.

Miranda, M. L. and Hale, B. W. 2002. A taxing environment: evaluating the multiple objectives of environmental taxes. Environmental Science & Technology, 36(24): 5289-5295.

Mohareb, E. A., MacLean, H. L. and Kennedy, C. A. 2011. Greenhouse gas emissions from waste management-Assessment of quantification methods. Journal of the Air & Waste Management Association, 61(5): 480-493.

Mushkat, R. 2014. Environmental Cooperation in Southeast Asia: ASEAN's Regime for Transboundary Haze Pollution. Melbourne Journal of International Law, 15(1): 236-255.

Steinberg, D. A. and Shih, V. C. 2012. Interest Group Influence in Authoritarian States: The Political Determinants of Chinese Exchange Rate Policy. Comparative Political Studies, 45(11): 1405-1434.

Stuart, A. L., Mudhasakul, S. and Sriwatanapongse, W. 2009. The social distribution of neighborhood-scale air pollution and monitoring protection. Journal of the Air & Waste Management Association, 59(5): 591-602.

Tolmasquim, M. T. and Machado, G. 2003. Energy and carbon embodied in the international trade of Brazil. Mitigation and Adaptation Strategies for Global Change, 8(2): 139-155.