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# A Study of DSR Indicator Framework for Sustainable Development in Taiwan

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## ABSTRACT

This study explores the building of a framework of DSR (Driving-force-State-Response) indicator system for sustainable development in Taiwan. The system is based on the Commission on Sustainable Development (CSD) Working List of Indicators of the United Nations in 1996. This study includes quantitative methods for evaluating a DSR system. The results of this research indicate that the historical data in Taiwan agree with the relationship in the DSR indicator framework for sustainable development. The results also indicate that the complex system in this research can be used to develop an integrated framework for a system with cause-effect logic and feedback for making a program of sustainable development at the national level in Taiwan. A test of regression fit between decision variables and objectives is taken. Response variables in four dimensions (life expectancy at birth, green income per capita, water resource quality (Biochemical Oxygen Demand, BOD), and air quality (Pollutants Standard Index, PSI) are carefully selected. The parameters of each objective function are estimated with national statistical data collected in Taiwan between 1989 and 2002. The results will be made available to the government to assist it in its efforts to measure progress toward sustainable development.

***Key Words*:** sustainable development, DSR framework, test of regression fit

# 台灣永續發展 DSR 架構研究

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## 摘　要

基於聯合國永續發展架構爲基礎，本研究試圖建構出台灣永續發展 DSR 系統架構，且首開進行 DSR 量化系統檢定，以說明台灣的歷史資料符合永續發展 DSR 架構關係，結果顯示，未來台灣進行永續發展規劃時，可以納入該系統架構，而成爲具有邏輯因果及回饋關係的架構體系。本研究利用所建制的永續發展多目標規劃系統，選定永續發展的四個構面變數（平均餘命、人均綠色所得、水資源品質（BOD）及空氣品質（PSI）)，進行決策變數與目標變數間之迴歸配適度檢定，而所得結果，可做爲國家追求永續發展施政之參考。

**關鍵詞**：永續發展，DSR 架構，迴歸適合度檢定

## I. INTRODUCTION

Over the past few decades, the striking levels of economic growth achieved in Taiwan has been accompanied by environmental degradation that exceeds the maximum loading of environmental self-purification and the carrying capacity of supporting ecosystems in this island. Obviously, efforts should be made as early as possible to assist Taiwan to plan the strategies towards sustainable development. The classic definition of sustainable development, “meeting the needs of present without compromising the ability of future generations to meet their needs”, was produced with the Brundtland report by the United Nation’s World Commission on Environment and Development (1987) entitled “Our Common Future”. This broad concept gained prominence at the 1992 United Nations Conference on Environment and Development (1992) in Rio De Janeiro, Brazil, now known as the Earth Summit. The concept of sustainable development in the dynamic operation concerns for the ecosystem’s health, social justice, and ideals of responsibility to future generations. Such a broad conception is likely to give rise to various different interpretations, since people all have different goals and sensitives.

Danaher (1998) illustrates that the concept of sustainable development remains a multi-dimensional term and is increasingly becoming more important as a policy objective and as a policy tool. Krotscheck and Narodoslawsky’s (1998) social economic environmental research does not exclusively deal with ecological aspects of human activities, but includes social and economic factors on the same level. Spangenberg (2002) states that objectives of sustainable development are defined for the economic, social, and environment dimension, but for sustainability characteristic they must be complemented by core institutional objectives. Giddings, Hopwood, and O’Brien (2002) summarize Haughton’s five equity principles as principles of sustainable development, that is, futurity-inter-generational equity; social justice-intra-generational equity; transfrontier responsibility-geographical equity; procedural equity-people treated openly and fairly; inter-species equity-importance of biodiversity.

The Organization for Economic Cooperation and Development (1991) has developed the application and research of the Pressure-State-Response (PSR) framework for environmental indicator and has also adapted the indicator strategies for sustainable development. The PSR framework indicates that the pressure from the human influences and activities, when combined with environmental conditions, causes environmental state change. As the environmental capacity changes, societal response policy tools include institution, regulations, financial measure or the change of management strategies. According to the Driving-force-State-Response (DSR) characteristics of the indicators on the Commission on Sustainable Development (CSD) of United Nations, the DSR indicator system is adapted to be developed. The Driving-force-Pressure-State-Impact-Response (DPSIR) indicator system is based on the PSR framework. Such an empirical research of sustainable development is likely to give rise to various different approaches. For example, Yang and Wong (1995) analyze the problem of sustainable development in Taiwan with multiobjective programming. Wein, Tsai, Fan, and Zeng (2003) integrate the system of population, resource, environment and economic with multi-objective programming to measure sustainable development in Beijing. Gil and Sleszynski (2003) have computed the index of sustainable economic welfare (ISEW) measuring sustainable development in Poland for the years 1980-97. Walmsley (2002) applies the DPSIR indicator framework for developing indicator of sustainable development and for identifying key issues in catchment management in South Africa. Yoon and Lee (2003) evaluate climate changes and air pollution with DPSER model for sustainability of cities in Korea.[1]

Little empirical research of DSR indicator framework has made a significant contribution in enhancing the systematic test among indicators and integrating the themes of sustainable development. Based on United Nations indicator framework for sustainable development, this paper aims at building the indicator system of sustainable development in Taiwan, making regression analysis for DSR system, finding key indicators of each individual dimension of sustainable development. This paper explores that such a process generates as a means for nation to understand what specific actions to take in order to promote sustainable development.

## II. REGRESSION ANALYSIS FOR FOUR DIMENSIONS OF SUSTAINABLE DEVELOPMENT IN TAIWAN

This paper is based on a DSR indicator framework on CSD of United Nations. Regarding Taiwan's social-economic background and data acquirability, indicators are selected and modified to build the indicator system available for sustainable development in Taiwan (see Figure 1). For testing the relationship in this DSR indicator system of sustainable development in Taiwan, nine regression equations are designed, driving-force indicators or response indicators represent where response variables are mostly the state indicators and independent variables. Based on degree of freedom, independent variables are used to sum up with the available weight by expert consulting in order to make regression analysis (weight selection seen in note of Table 1). Data needed is mostly from the publication of National Statistics in Taiwan. In data process, each regression equation is reformed to be the normalized translog equation by normalization along with taking natural logarithm. The software of SAS is used in the regression analysis. The findings illustrate that the regression fit in each equation is generally high and most regression parameters show significant (see Table 1). These results indicate that the historical data in Taiwan meets the relationship in DSR indicator framework of sustainable development. The detailed result of each regression equation is as following:

### 1. The Equation of Demographic Dynamics and Sustainability

The population density is representative of the objective in this theme of demographic dynamics and sustainability. The decision variables are selected with the driving-force indicator of the population growth rate, net migration rate, and total fertility rate, respectively.

The indicator of population density has close linkages with other demographic indicators, particularly the population growth rate, net migration rate, life expectancy at birth, and total fertility rate as well as human settlement indicators. Population growth represents one of the crucial elements affecting long-term sustainability. The population growth rate and the net migration rate can increase environmental degradation and usually has implications for indicators related to natural resource depletion, desertification, and land use change.

The findings of regression analysis indicate that the regression fit is very high ($R^2$=0.9786) and the regression parameter is very significant. Meanwhile, the negative regression parameter of the population growth rate exhibits the fact that the population growth rate is smaller than the land area increasing rate.[2] The positive relationship of both net migration rate and total fertility rate indicates that the

[1] Pressure indicators measure the pressures that are exerted on resources and ecosystem from human activities; state indicators assess the condition of the resource or ecosystem as a result of the pressures; response indicators relate to the societal response via policies, programmes and laws etc.

[2] The reason is that the rate of population growth at the end of year is relatively slower than of land area increasing (36,181.8718 $km^2$ in 1997 and 36,188.0354 $km^2$ in 1998 for one small island involved).

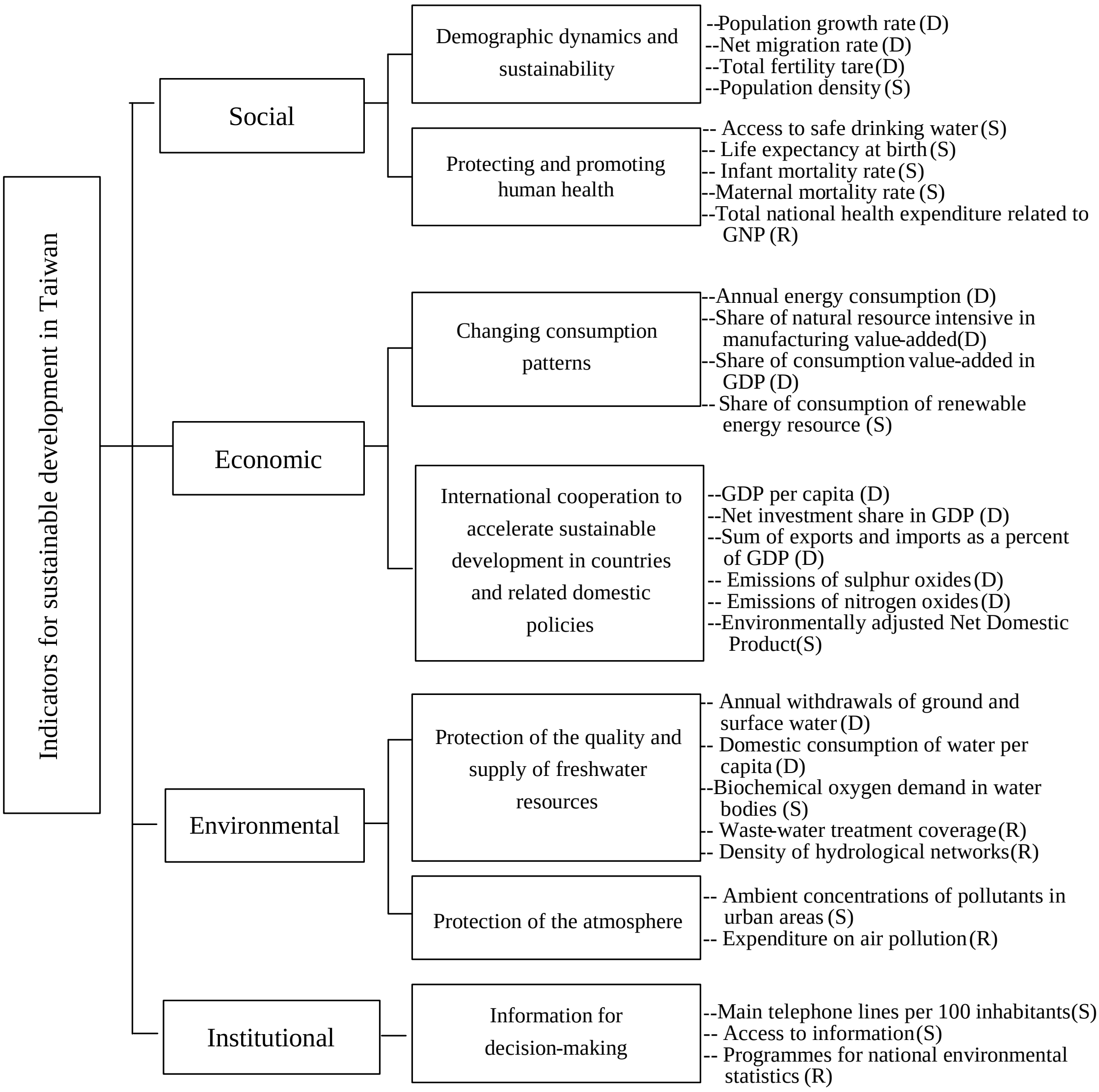


**Fig. 1. The DSR indicator framework of sustainable development in Taiwan**

population density increases as each indicator increases.

**2. The Equation of Protecting and Promoting Human Health**

National health is assigned to agent response variable in the theme of protecting and promoting human health. This objective indicator is combined with four state indicators of saturation rate of tap water, life expectancy at birth, infant mortality rate (IMR), and maternal mortality rate (MMR). Independent variable is selected with the response indicator of total national health expenditure related to GDP.

National health is considered to have close linkages with access to safe drinking water, life expectancy at birth, IMR, and MMR. Accessibility to safe drinking water is of fundamental significance to lowering the faecal risk and frequency of associated diseases. Life expectancy at birth is an indicator of mortality conditions and health conditions. The IMR is sensitive indicator of availability, utilization and quality of health care. The MMR reflects the risk to mothers during pregnancy and childbirth and is also influenced by availability and utilization of health care facilities. Health and sustainable development are intimately interconnected. The measure of total national expenditure related to GDP provides a first indication of the priorities granted to health as compared to other sectors within the same country.

The findings of regression analysis indicate that the regression fit is high ($R^2$=0.7575) and the regression parameter (0.8703) is significant but less than 1. These results explore that total national health expenditure is inelastic, that is, national health only increases 0.87% as the share of total national health expenditure increases 1%.

**Table 1. The comparison of regression analysis in four dimensions of sustainable development**

| Category | Theme | Sub-theme | Objective | Decision variable | $R^2$ | P-value | Notes |
|---|---|---|---|---|---|---|---|
| SOCIAL | Demographic dynamics and sustainability | --- | $Y_1$: Population density | $X_{11}$: Population growth<br>$X_{12}$: Net migration rate<br>$X_{13}$: Total fertility rate | 0.9786 | <0.001(***)<br><0.001(***)<br>0.0003(***) | Period for statistical data: 1992-2001 |
| | | | $Y_1$= 0.000246 -1.7559 $X_{11}$ + 1.5361 $X_{12}$+ 1.5183 $X_{13}$ | | | | |
| | Protecting and promoting human health | --- | $Y_2$: National health | $X_{21}$: Total national health expenditure related to GDP | 0.7575 | 0.0011(**) | "National health" is equally combined with the following variables:<br>● Access to safe drinking water<br>● life expectancy at birth<br>● infant mortality rate<br>● maternal morality rate<br>Period for statistical data: 1992-2001 |
| | | | $Y_2$= 0.000003 +0.8703 $X_{21}$ | | | | |
| ECONOMIC | Changing consumption patterns | --- | $Y_3$: Clean Production | $X_{31}$: Resource quantity | 0.9539 | <0.0001(***) | "Resource quantity" is equally combined with the following variables:<br>● Annual energy consumption.<br>● share of consumption of renewable energy resources<br>Under the assumption of supply equal to demand, "Clean Production" is equally combined with the following variables<br>● Share of manufacturing value-added in GDP (80%)<br>● Share of consumption of renewable energy resources (20%)<br>Period for statistical data: 1992-2001 |
| | | | $Y_3$= 2.77442E-11 -0.6387 $X_{31}$ | | | | |
| | International cooperation to accelerate sustainable development in developing countries and related domestic policies | --- | $Y_4$: Environmentally adjusted net Domestic product | $X_{41}$: Economic value-added<br>$X_{42}$: environmental emissions | 0.9906 | 0.0486(*)<br>0.0401(*) | "economic value-added" is equally combined with the following variables:<br>● GDP per capita<br>● net investment share in GDP<br>● sum of exports and imports as a percent of GDP<br>"environmental emissions" is equally combined with the following variables:<br>● emissions of sulphur oxides<br>● emissions of nitrogen oxides.<br>Period for statistical data: 1996-2000 |
| | | | $Y_4$=7.453088E-7+0.4975 $X_{41}$ –0.5516$X_{42}$ | | | | |
| ENVIRONMENTAL | Protection of the quality and supply of freshwater resources | The quality of water resources | $Y_5$: Biochemical oxygen demand in water bodies (BOD) | $X_{51}$: Annual withdrawals of ground and surface water<br>$X_{52}$: Domestic consumption of water per capita | 0.7896 | 0.0853<br>0.0078(**) | Period for statistical data: 1992-2000 |
| | | | $Y_5$= -0.00609+0.3899 $X_{51}$ –0.7419$X_{52}$ | | | | |
| | | The usage of water resources | $Y_6$: Use of water resource | $X_{61}$: Water resource management | 0.7795 | 0.0016(**) | "Water resource management" is equally combined with the following variables:<br>● waste-water treatment<br>● density of hydrological networks<br>besides "waste-water treatment" is equally combined with the following variables:<br>● saturation rate of public sanitary sewer(2/3)<br>● pollution control of business waste-water(1/3)<br>"Use of water resource" is equally combined with the following variables: :<br>● Annual withdrawals of ground and surface water.<br>● Domestic consumption of water per capita.<br>Period for statistical data: 1992-2000 |
| | | | $Y_6$= 0.00216+0.8829 $X_{61}$ | | | | |
| | Protection of the atmosphere | Air pollution | $Y_7$: Ambient concentration s of pollutants | $X_{71}$: Emission of sulphur oxides<br>$X_{72}$: Emission on nitrogen oxides | 0.6149 | 0.0268(**)<br>0.5011 | Period for statistical data: 1992-2001 |
| | | | $Y_7$= 0.0000013+0.9363 $X_{71}$- 0.2378 $X_{72}$ | | | | |
| | | Pollution abatement | $Y_8$: Quantity of emissions | $X_{81}$: Expenditure on air pollution abatement | 0.8292 | 0.0003(***) | "Quantity of emissions" is equally combined with the following variables:<br>● Emission of sulphur oxides (80%)<br>● Emission of nitrogen oxides (20%)<br>Period for statistical data: 1992-2001 |
| | | | $Y_8$= -0.00000155+0.9106$X_{81}$ | | | | |
| INSTITUTIONAL | Information for decision-making | --- | $Y_9$: decision information | $X_{91}$: programmes for national environmental statistics | 0.5300 | 0.1009 | "decision information" is equally combined with the following variables:<br>● Main telephone lines per 100 inhabitants (30%)<br>● Access to information (70%)<br>"Access to information" is equally combined with the following variables:<br>● home penetration rate of cable TV (15%)<br>● number of newspaper per 100 households (25%)<br>● internet growth (60%)<br>Period for statistical data: 1996-2001 |
| | | | $Y_9$= 0.00000789+0.72799$X_{91}$ | | | | |

***P<0.001, **P<0.01, *P<0.05

**3. The Equation of Changing Consumption Patterns**

The response variable is clean production combined with two state indicators of share of manufacturing value added in GDP and share of consumption of renewable energy resources. The resource quantity (the combination with two driving-force indicators of annual energy consumption and share of natural-resource intensive industries in manufacturing value-added) is independent variable.

Clean production today is for a healthier world tomorrow, that is, human societies and the world's ecosystems maintain stability and diversity. Clean production is considered to have linkage with two indicators as above. Manufacturing production is as a key economic activity and as a growth determinant. Share of manufacturing value added in GDP reflects the stage of country development in terms of availability of human resources and capital, both essential requirements in the drive towards sustainable development. Dependence on non-renewable resources can be regarded as unsustainable in the long term. Renewable resources can supply energy, which is a key aspect of consumption and production continuously under sustainable management practices. Resource quantity has implications for indicators related to annual energy consumption and share of natural-resource intensive industries in manufacturing value-added. Energy production, use, and byproducts have resulted in major impacts on the environment. The long-term aim is for development and prosperity to continue through gains in energy efficiency rather than increased production. Share of natural-resource intensive industries in manufacturing value-added is meant to represent the potential impact of the sub-sectoral structure of industrial production on the depletion of non-renewable resources. This indicator is closely linked to indicators dealing with the development of the economy and the use of non-renewable natural resources and has more general links to other socioeconomic and environmental indicators, such as generation of industrial waste.

The findings of regression analysis indicate that the regression fit is very high ($R^2$=0.9539) and the regression parameter (-0.6387) is significant. The response of clean production to resource quantity is related negative.

**4. The Equation of International Cooperation to Accelerated Sustainable Development**

Green income (environmentally adjusted net domestic product, EDP) is assigned to the agent response variable of this equation. Two independent variables are economic value-added (the equal combination of GDP per capita, net investment share in GDP, and sum of exports and imports as a percent of GDP) and emissions of air pollution (the equal combination of emissions of sulphur oxides and emissions of nitrogen oxides).

The trend of EDP can be used to measure sustainable economic growth. EDP is as economic instruments for internalizing the budgets of households and enterprises in order to encourage microeconomic behavior towards environmentally sound production and consumption. Economic value-added which measures the level and extent of total economic output, is considered to have close linkage with GDP per capita, net investment share in GDP, and sum of exports and imports as a percent of GDP. The first indicator of GDP per capita is a basic economic growth indicator and reflects changes in total production of goods and services. The second indicator of net investment share in GDP measures the stimulus to economic development process. The purpose of the last indicator is to measure the openness of a country's economy to international trade, which promotes better utilization of resources domestically and globally. Environmental emissions are considered to combine two indicators of emissions of sulphur oxides and emissions of nitrogen oxides. Both emissions are influenced by a country's industrial structure and energy consumption, which in turn is affected by both energy intensity and efficiency. These indicators are used to evaluate the environmental performance of national policies.

The regression fit is very high ($R^2$=0.9906) and each regression parameter (0.4975 and -0.5516, respectively) is significant but elasticity is less than 1. These results indicate that green income increases about 0.5% as economic value-added increases 1%, while green income decreases about 0.55% as emissions of air pollution increase 1%.

**5. The Equation of Water Resource Quality**

Biochemical oxygen demand in water bodies (BOD) is representative of quality of water resource. The independent variables are selected with two driving-force indicators of annual withdrawals of ground and surface water and domestic consumption of water per capita.

Sustainable development is heavily dependent on suitable water availability for a variety of users strict water quality standards, which have been established to protect users from health. The purpose of BOD in water bodies is to assess the quality of water available to consumers in communities for basic and commercial needs. The indicator of annual withdraws of ground and surface water can show to what extent freshwater resources are already used, and the need for adjusted supply and demand management policy. It is an important measure of a country's vulnerability to water shortages. Adequate quantities of water for meeting basic human needs are a prerequisite for existence, health and development. Per capita water consumption can be a direct indicator of effective water resource management and is related to water availability/scarcity.

The findings of regression analysis indicate that the regression fit is high ($R^2$=0.7896) and the relationship of annual withdrawals of ground and surface water and BOD is positive. BOD makes the self-purification capacity of water body down as annual withdrawals of ground and surface increases and increasing BOD shows the deterioration of water quality.

**6. The Eequation of Usage of Water Resource**

Use of water resource is the agent response variable of this equation. This indicator is combined with two driving-force indicators of the above equation of water quality. The independent variable, water resource management, is combined with wastewater treatment coverage (the combination of saturation rate of public sanitary sewer and pollution control of business wastewater) and density of hydrological networks.

Water is needed in all aspects of life. Adequate supplies of water of good quality are maintained for the entire population. These basic requirements are being met enabling actions to be planned and priorities for water supply development to be set. Integrated water resources planning and management must cover all types of interrelated freshwater bodies, including both surface water and groundwater, and duly consider water quantity and quality aspects. Wastewater treatment assesses the potential level of pollution from domestic and industrial/commercial point sources entering the aquatic environment, and monitors progress towards reducing this potential within a framework of integrated water resources management. Meanwhile, density of hydrological networks assesses the adequacy of existing hydrological networks to provide the necessary information on freshwater.

The findings of regression analysis indicate that the regression fit is high ($R^2$=0.7795) and regression parameter (0.8829) is significant. The positive relationship of the response for water consumption quantity to water management illustrates that the good mechanism for wastewater treatment can effectively promote the usage of water resource.

**7. The Equation of Air Pollution**

Air pollution standard index (PSI) measured as ambient concentrations of pollutants for the quality of air pollution is represented by the response variable of this equation.[3] The driving-force indicators of emissions of sulphur oxides and emissions of nitrogen oxides are selected as independent variables.

The great potential for human exposure to adverse environmental conditions and subsequent health problems occurs. The impacts of priority atmospheric issues relate to human health, biodiversity and health of ecosystems, and economic damage. The purpose of ambient concentrations of pollutants is to measure the exposure of people to various air pollutants. It is important to consider the indicator against national air quality standards. Emissions of sulphur oxides and of nitrogen oxides are used to describe the environmental pressure in relation to air emission abatement. Country's efforts to abate these emissions as reflected in national policies including structural changes in energy demand as well as pollution control policies and technical measures.

The findings of regression analysis indicate that the relation between emissions of nitrogen oxides and air quality is not significant, emissions of sulphur oxides and deteriorative air quality are related positive, and regression parameter is close to 1 (about 0.9363). These results illustrate deteriorative air quality follows the example of emissions of sulphur oxides at each move and emissions of sulphur oxides is the important one of main driving-forces of air pollution generated in empirical periods in Taiwan.

**8. The Equation of Air Pollution Abatement**

Quantity of emissions is the agent response variable of this equation. This indicator is combined with two driving force indicators of emissions of sulphur oxides and emissions of nitrogen oxides. The decision variable is the response indicator of expenditure of air pollution abatement.

Quantity of emissions is considered to combine emissions of sulphur oxides and of nitrogen oxides. The objective of this area is to develop strategies aiming at the reduction of emissions causing transboundary air pollution and their effects. Expenditures on air pollution abatement provide a general indication of a country's financial efforts directed towards air pollution. High abatement expenditure can be associated both with low environmental quality (the situation makes expenditure necessary) and with high environmental quality (which has improved as a result of the abatement expenditure). The purpose of the indicator is to measure expenditure on air pollution abatement as a societal response.

The findings of regression analysis indicate that the regression fit is high ($R^2$=0.8292) and regression parameter (0.9106) is significant. The positive relations between expenditure of air pollution abatement and pollution emissions has an impact on the effect which the increase degree of pollution emissions driven by macroeconomic activities in

[3] PSI>100 is referred to the ratio of days monitored as unhealthful. The larger PSI is, the more unhealthful the quality of air pollution is.

empirical periods is larger than the decrease degree of national expenditure of air pollution abatement. This impact leads to increased awareness that the national prevention policy against air pollution does not deserve to solve the problem of air pollution abatement in Taiwan.

**9. The Equation of Information for Decision-Making**

The response variable of this regression equation is decision information combined mainly with two state indicators of main telephone lines for 100 inhabitants and access to information (the combination of home penetration rate of cable TV, number of newspaper per 100 households, and internet growth). The response indicator of programmes for national environmental statistics is representative of independent variable.[4]

Appropriate policy instruments are required as an institutional framework to encourage and implement sustainable development. The integration of social, economic, and environmental factors is a particular important feature of such instruments. The policy relevance of the indicator of main telephone lines for 100 inhabitants is that telecommunications and social, economic, and institutional development are closely linked. For access to information, better-informed citizens are more likely to be committed to the goal of sustainable development strategies, when the public can have access to the wide range of information.

The regression result indicates the effect that programmes for national environmental statistics is not able to offer explanation for decision information.

## III. THE MULTIOBJECTIVE INTEGRATED MODEL FOR COORDINATION OF SOCIAL-ECONOMIC-ENVIRONMENTAL SYSTEM

The methodology of this research is required to plan the optimal strategy path of sustainable development in Taiwan and to propose a tri-layer structure (three layers such as planning, relations, and inner) with the characteristics of sustainable development system (see Figure 2). This structure cannot only reflect the characteristics of each individual indicator in itself, but also reflect the linkage among all indicators intra-dimension. Under the monitoring of the framework of indicator system framework, the methods with synthesis and decomposition are used to coordinate the system of sustainable development.

According to the above trilayer structure, the inner layer contains two models –decision variable and priority parameter. The decision variables include population growth rate, health expenditure related to GDP, GDP per capita, saturation rate of public sanitary sewer, pollution control of business wastewater, and expenditure of air pollution abatement. Meanwhile, population growth rate and health expenditure related to GDP are combined with the 4:6 weight to be health burden which is represented by key variable of social dimension; GDP per capita is representative of key variable of economic dimension; the saturation rate of public sanitary sewer and pollution control of business wastewater are combined with the weight of 6:4 to be wastewater treatment coverage which formulates key variable of water resource area in environmental dimension; expenditure of air pollution abatement is key variable of the other air area in environmental dimension. These key variables in inner layer offer the mathematical description to internal variables of subsystem on the one hand, and determine to external parameters related to both relations layer and planning layer on the other hand. The priority parameter in inner layer mainly contains structure of life expectancy at birth, allocation of green income per capita, improvement of water resource environment (BOD), and scatteration of ambient concentrations of pollutants. Based on the consequence of system analysis, these parameters are used to perform priority of each function in order to obtain refined result.

In relations layer, four key variables of social, economic, and environment (including two areas of water resource and air) describe the relationship of the two conditions and promoting each other between subsystems in a way of intra-dimension. These interactions among subsystems include connections among four dimensions. As linking indicator draws the outline of characteristics in itself, this system offers mathematical description of functions to the relations among decision variables. These relations are obtained by applying historical data to the statistical methods. The planning layer involved in diversity and dynamic flexibility of the objectives is required to adopt the goal programming technique to construct the integrated model.

There are four objective variables (or response variables) setting in the coordination of sustainable development system －life expectancy at birth (social dimension), green income per capita (economic dimension), and biochemical oxygen demand (BOD) as well as ambient concentrations of pollutants (environmental dimension). The decision variables of each individual dimension contain as following: social dimension

[4] This indicator signifies a country’s commitment to developing environment statistics for use in national level policy formulation and analysis. The number of annual official forms for reporting statistics of environment is transformed into the indicator of programmes for national environmental statistics.

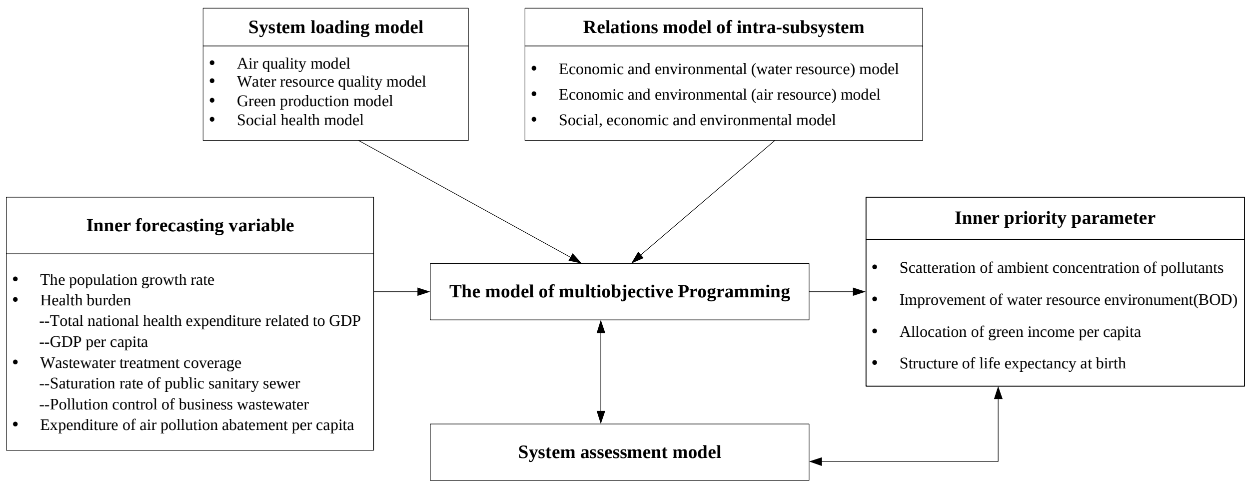


**Fig. 2. The framework of coordination for sustainable development system**

(the objective function of social health) – health burden (the combination of population growth rate and health expenditure related to GDP), GDP per capita, and expenditure of air pollution abatement per capita; economic dimension (the objective function of green production)－GDP per capita, and expenditure of air pollution abatement per capita; environmental dimension (the objective function of water quality)－GDP per capital and wastewater treatment coverage (the combination of saturation rate of public sanitary sewer and pollution control of business wastewater); environmental dimension (the objective function of air quality)－GDP per capita and expenditure of air pollution abatement per capita. These decision variables affect the objective functions and then are converted into the corresponding flexible goals. The interactive system of intra-dimension is formulated.

For establishing the constraint equation to develop the multiobjective model of integrating the sustainable development system in Taiwan, the regression analysis of intra-dimensional indicator system of sustainable development is necessary to be taken at first (see Table 2). The findings are shown as the following results: the fit of regression equation mostly shows significant; the direction of parameter sign is required to meet the economic logic. The elasticity of health burden in the equation of life expectancy at birth is -0.7455. This result shows the negative relationship between health burden and life expectancy at birth and also indicates the situation that the heavier health burden is, the lower life expectancy at birth is. The elastic parameter of GDP per capita and green income per capita close to 1 (0.99861) reflects the relationship that the latter indicator follows the example of the former indicator at each move. Each indicator of environmental dimension (such as BOD and ambient concentrations of pollutants) and is negatively related to GDP per capita. This relationship indicates that environmental quality in Taiwan has significantly improved by stricter environmental measure (such as expenditure of air pollution abatement and standard index of water quality) in these years and it appears the decoupling between economic growth and environmental pollution.

## IV. CONCLUSION

Sustainable development is a struggle to transcend and dive deeper within oneself and extend oneself out to others as a process of envelopment, a process of finding balance between outer and inner, developing new modes of comprehension, new ways of becoming. Movement towards sustainability is not solely a technical or economic issue; it is also a political process involving differing perception of the sustainable development field. For politicization of sustainable development strategies, the conceptualizations of sustainable development in the dynamic operation are generally rooted in integration of economic and environmental concerns, the ecosystem's health, social equity, resource management and ideals of responsibility to future generation.

This paper explores the building of framework on DSR indicator system of sustainable development in Taiwan. It is based on the Commission on Sustainable Development (CSD) Working List of Indicators of the United Nations in 1996. This is the initial study including quantitative approaches to evaluate the DSR indicator system. For this sustainable development system, a tri-layer structure is used to formulate a multi-objective integrated model. In the context of the results in this research, the historical data in Taiwan meets the relationship in DSR indicator framework of sustainable

**Table 2. DSR indicator framework in the intra-dimension for sustainable development**

| Dimension | objective | objective Variable | Decision variable | Parameter | P-value | $R^2$ |
|---|---|---|---|---|---|---|
| Social category | Index of social health | $Y_1$: life expectancy at birth | $X_1$: health burden (the population growth rate (40%) and total national health expenditure related to GDP( 60%)) | -0.7455 | 0.0098(*) | 0.8058 (0.0007) |
| | | | $X_2$: GDP per capita | 0.52152 | 0.0093(*) | |
| | | | $X_4$: expenditure of air pollution abatement per capita | 0.47892 | 0.0597 | |
| | $f(X_1, X_2, X_4) \geqq Y_1$ | | | | | |
| Economic category | Index of water green production | $Y_2$: Green income per capita | $X_2$: GDP per capita | 0.99861 | <0.0001 | 0.9998 (<0.0001) |
| | | | $X_4$: expenditure of air pollution abatement per capita | 0.01382 | 0.0075(**) | |
| | $f(X_2, X_4) \geqq Y_2$ | | | | | |
| Environmental category | Index of water resource quality | $Y_3$: BOD (Biochemical Oxygen Demand in water bodies) | $X_2$: GDP per capita | -1.72037 | 0.0002(***) | 0.8920 (<0.0001) |
| | | | $X_3$: wastewater treatment coverage (Saturation rate of public sanitary sewer to pollution control of business wastewater 1.5:1) | 0.85525 | 0.0221(*) | |
| | $f(X_2, X_3) \leqq Y_3$ | | | | | |
| | Index of air quality | $Y_4$: quality of air pollution (PSI>100) | $X_2$: GDP per capita | -0.87432 | <0.0001 | 0.8394 (<0.0001) |
| | | | $X_4$: expenditure of air pollution abatement per capita | -0.20837 | 0.1138 | |
| | $f(X_2, X_4) \leqq Y_4$ | | | | | |

***P<0.001, **P<0.01, *P<0.05

development. The test of regression fit between decision variables and objectives is taken at first. The response variables in four dimensions of sustainable development are carefully selected to be life expectancy at birth, green income per capita, water resource quality (BOD), and air quality (PSI). These results also indicate that the complex system in this research can be used to develop the integrated framework of system with cause-effect logic and feedback for making the program of sustainable development at national level in Taiwan.

The promotion of eco-industrial development, which provides a model of linking ecological dimensions with financing of traditional industrial parks that can be duplicated in other areas, is a good example of utilizing current infrastructure and availability of resources for environmental protection. This approach allows the government to become actively involved in low-cost environmentally sound technological systems for improving environmental quality, and promoting industries which have a comparative advantage in the area of ecologically friendly, low-cost, affordable technologies.

Further studies need to consider the stages of individual, interpersonal and cultural transformation such as education, poverty and welfare that can result in a truly global society.

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