環境保護局
Direcção dos Serviços
de Protecção Ambiental

Report on the State of the Environment of Macao

2014

Report on the State of the Environment of Macao 2014

Acknowledgement - Data Sources (in alphabetical order)

Administration of Airports Limited (ADA)
Cartography and Cadastre Bureau (DSCC)
Civic and Municipal Affairs Bureau (IACM)
Civil Aviation Authority (AACM)
Combustibles Security Committee (CSC)
Education and Youth Affairs Bureau (DSEJ)
Financial Services Bureau (DSF)
Fire Services Bureau (CB)
Gaming Inspection and Coordination Bureau (DICJ)
Health Bureau (SS)
Land, Public Works and Transport Bureau (DSSOPT)
Law Reform and International Law Bureau (DSRJDI)
Macao Customs Service (SA)
Macao Economic Services (DSE)
Macau Electricity Company Limited (CEM)
Macau Productivity and Technology Transfer Center (CPTTM)
Macao Water Supply Company Limited (SAAM)
Macao Government Tourism Office (DST)
Marine and Water Bureau (DSAMA)
Meteorological and Geophysical Bureau (SMG)
Office for the Development of Energy Sector (GDSE)
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Transport Bureau (DSAT)

In order to continuously improve the quality of the *Report on the State of the Environment of Macao* and to fulfill the demands and expectations of all social sectors, the Environmental Protection Bureau (http://www.dspa.gov.mo) welcomes your valuable comments for helping us to improve relevant work continuously. Thank you!

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Message

In recent years, in pace with the rapid economic growth, the continuous increase in residents and tourists as well as the development of the Pearl River Delta Region exert increasing heavy pressure and created new challenges to the environment of Macao.

Despite many efforts had been devoted by the SAR government in the improvement of environmental infrastructure and promotion of public awareness on environmental protection, we are aware that the results are still unsatisfactory.

Resources consumption and waste generated have been growing continuously and rapidly. In fact, there is a certain degree of difficulty in resolving the current situation.

On one hand, Macao depends on external natural resources, and on the other hand, waste treatment infrastructure needs to be reviewed in order to meet the current social needs. It is pressing to implement new environmental management strategies.

However, to achieve these objectives, it is necessary to have the cooperation and supports from the general public and the business sector. We will continue focusing on environmental education and promotion of public awareness, with the vision to improve the quality of life of residents.

Macao, in line with national goals and global trends, commits to take a step forward a more sustainable development. In this sense, environmental protection is one of the priorities of government action which we will make all of our efforts to ensure the environmental policies can contribute solid bases for the future of Macao.

Secretary for Transport and Public Works,

Raimundo Arrais do Rosário

Preface

The natural environment in which we live is evolving along with various human activities and climate change factors. Therefore, we should grasp such changes, so that we can take precautions and develop necessary measures to reduce the potential impacts and consequences of adverse factors on the environment.

Indeed, in addition to the efforts made by the Macao SAR Government, the implementation of environmental measures requires active involvement and participation by all social sectors and general public. We should build a green and low-carbon lifestyle and minimize the adverse impact of human activities on the environment; only in this way may the environmental protection work yield twice the result with half the effort.

Through publishing the *Report on the State of the Environment of Macao,* the Environmental Protection Bureau (DSPA) helps to provide citizens with an important access to realize the environmental state of Macao, so as to encourage and drive public's awareness and participation in the environmental protection work.

When reading the *Report on the State of the Environment of Macao 2014*, you may find out some reformations made therein. In this *Report*, we adjusted the way to present data and information, and simplified certain parts in order to make this *Report* more fluent and readable. This *Report* is also presented in an electronic format to make it convenient for the citizens to understand the key points. In addition, we have optimized and integrated some sub-indicators. In the future, we shall continuously improve the content of the *Report*.

In this *Report*, we can see that the atmospheric environment of Macao has been improved in 2014 compared with the past, particularly in terms of air quality and emission reduction of greenhouse gases, but the continuous driving forces and pressures exerted by social development also led to an increase in the volume of water consumption and waste generation. Generally speaking, we have seen some improvements, but there are also certain environmental conditions failing to meet expectations and worth of concern.

The environmental state of Macao has been presented before us. Our environment needs to be protected through joint efforts. We firmly believe that the vision "Building a Low Carbon Macao, Creating Green Living Together" can be achieved through relentless efforts together by the Macao SAR Government, enterprises and citizens.

Director of the Environmental Protection Bureau

Vai Hoi Ieong

1. Introduction

As the quality of environment in Macao has become one of the crucial concerns of citizens, the Macao SAR Government has promptly disclosed a series of data and information in connection with local environment through publishing the *Report on the State of the Environment of Macao* (hereinafter referred to as the *Report*), evaluating and analyzing relevant environmental indicators. The environmental state of Macao in 2014 is presented in the *Report* to all citizens to help them better understand the basic conditions and evolution of local environment in order to arouse their concern and participation to protect the environment.

This *Report* facilitates a better understanding of local environment state. It is also a useful tool for integrating various environmental data analyses, and also a prominent reference for the Macao SAR Government to formulate environmental protection policies and measures.

In the seven chapters of this *Report*, covering areas of society and economy, atmospheric environment, water resources, waste, nature conservation, ambient noise and environmental management, 19 "environmental indicators"[1] (82 sub-indicators in total) will be analyzed to illustrate the environmental state of Macao in 2014. In addition, the "Driving Force – Pressure – State – Impact – Response" (DPSIR) framework[2] (Figure 1.1) developed by the European Environment Agency (EEA) is adopted to classify environmental indicators to reflect the interrelationship among the various environmental factors. Based on the foresaid framework, the driving forces formed along with social and economic development will exert pressures on the environment and provoke evolution of the environmental state (in terms of conditions for healthy life, resource supply, biodiversity, etc.). Such changes may cause impacts on human health, ecosystem and physical environment, urging the society to adapt to or take appropriate measures against these driving forces, pressures and the evolution or impacts on the state of the environment.

[1] "Environmental indicators" are effective tools for analysis and assessment of the environmental quality of a region or a country, which are adopted by most of the countries in the world.

[2] *Environmental Indicators: Typology and Overview*. Technical Report No. 25, EEA, 1999.

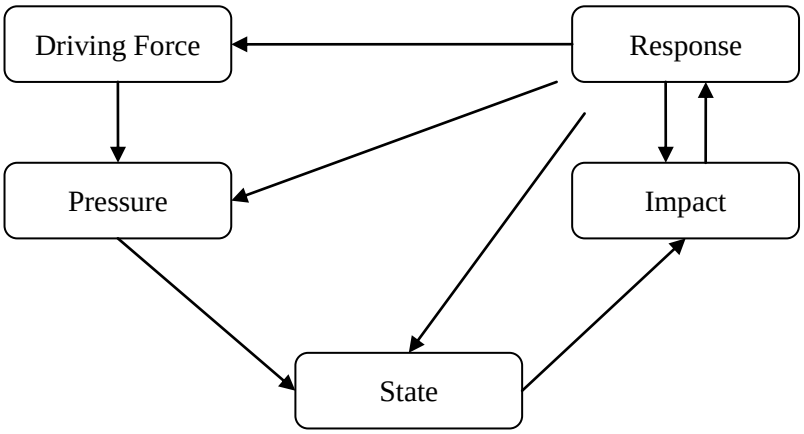


Figure 1.1 DPSIR framework

Indicator for environmental analysis in this chapter
● Social, Economic and Environmental Evolution of Macao

1.1 Social, Economic and Environmental Evolution of Macao

DPSIR Framework

D	**Driving forces✓**	**P**	**Pressures ✓**	S	States	I	Impacts	R	Responses

Social and economic development, which consequentially increases resources consumption or even the environmental pollution, is the primary driving force that exerts various pressures on the environment.

Thus, it is crucial to understand social and economic development as well as environmental evolution. The indicators for evolution of Macao's social, economic and environmental conditions are analyzed according to 10 sub-indicators, including end-year population, population density, visitor arrivals, tourism intensity, gross domestic product (GDP), land area, electricity consumption, billed water consumption, waste transferred to Incineration Plant for treatment and estimated greenhouse gas emissions, with the base year 1999.

Figure 1.2-1.3 and Table 1.1 show the changes of each sub-indicator. In 2014, the sub-indicators of end-year population, visitor arrivals, GDP, electricity consumption, billed water consumption and waste transferred to the Macao Refuse Incineration Plant for treatment all showed an increasing trend, and the population density also increased, while the estimated greenhouse gas emissions declined constantly. The land area in 2014 remained unchanged due to the on-going reclamation works in the new reclamation zones.

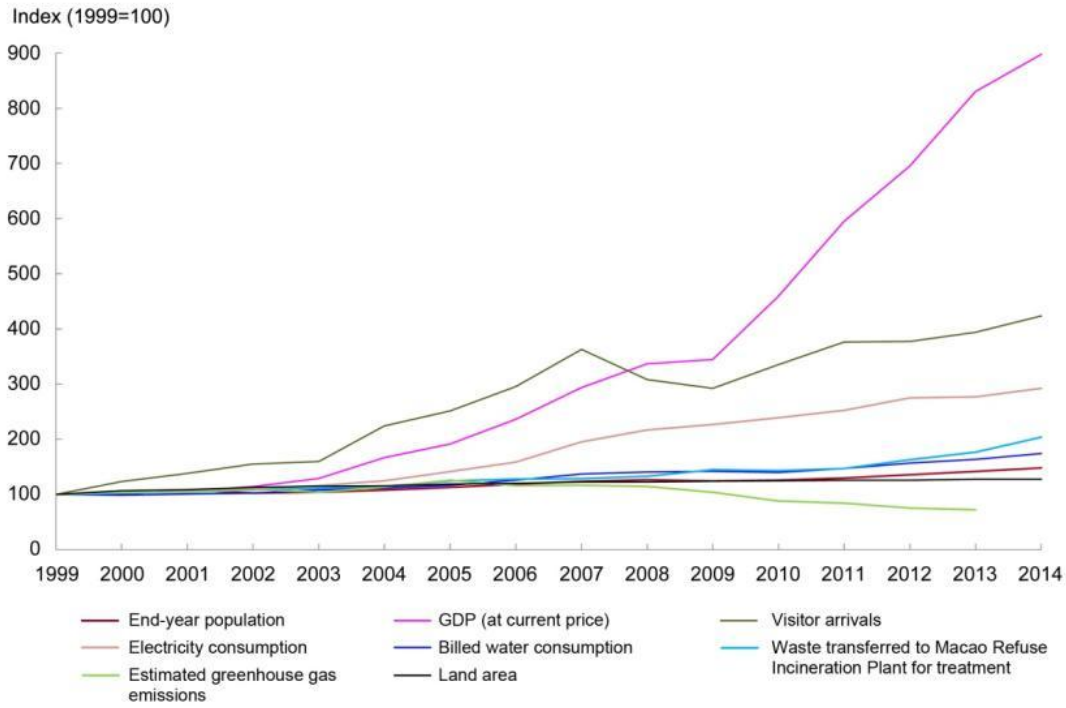


Figure 1.2 Evolution of Social, Economic and Environmental indicators of Macao
(Data sources: DSEC and DSPA, 2015)

Sustainable development emphasizes the reduction of resources demand and environmental impact during the course of development. Thus, in the stage of stepping towards sustainable development, if the curves of social and economic indicators are under a positive development trend, the curves of environmental and resource indicators should reflect a negative development trend, i.e. the speed of environmental and resource evolution should be slower than that of social and economic indicators growth.

Comparing the evolution of relevant indicators of Macao, it can be found that the GDP of 2014 had a single-digit growth rate of 8.1%, declining from the approximate 20% in 2013, and had a similar growth rate as the social and economic indicators (e.g. end-year population and visitor arrivals) and the environmental and resource indicators (e.g. electricity consumption and billed water consumption). However, it is noteworthy that the waste transferred to the Macao Refuse Incineration Plant for treatment in 2014 had a two-digit growth rate of 15.3%.

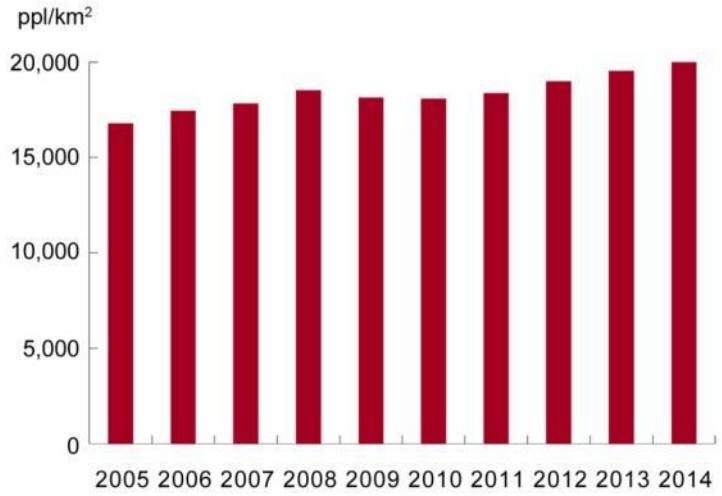


Figure 1.3 Population density

(Data source: DSEC, 2015)

Table 1.1 Numerical data as well as percentage increase/decrease of end-year population, population density, visitor arrivals, GDP (at current prices), land area, electricity consumption, billed water consumption and waste transferred to the Macao Refuse Incineration Plant for treatment between 2013 and 2014

	2013	2014	Percentage increase/decrease
Social and economic indicators			
End-year population ('000)	607.5	636.2	+4.7%
Population density (ppl/km^2)	19,535	20,518	+5.0%
Visitor arrivals (no.)	29,324,822	31,525,632	+7.5%
GDP (at current prices) (million MOP)	409,959 [1]	443,298	+8.1%
Environmental indicators			
Land area (km^2)	30.3	30.3	—
Electricity consumption (million kWh)	4,232 [2]	4,469	+5.6%
Billed water consumption ('000 m^3)	78,447	83,486	+6.4%
Waste transferred to the Macao Refuse Incineration Plant for treatment (tonne)	396,738	457,420	+15.3%

Notes: (1) [1] Revised figures of the *Gross Domestic Product (GDP) to the 4th Quarter of 2014*.

(2) [2] Revised figures of the *Energy Statistics to the 4th Quarter of 2014*.

(Data sources: DSEC and DSPA, 2015)

Macao is positioned as Global Center of Tourism and Recreation" for regional development, the total visitor arrivals in Macao in 2014 had reached 31.53 million, a 7.5% growth compared with

that in 2013. The booming tourism, along with the improvement in economic development and employment of Macao, also exerts pressures on environmental infrastructures and public services of Macao to a certain extent. Thus, the *Report* analyzed the evolution of visitor arrivals (Figure 1.2) and tourism intensity[3]. It is shown in Figure 1.4 that the tourism intensity of 2014 was lower than that of 2013. The decrease is mainly due to a slight growth of 0.4% of hotel guests with average stay nights at 1.4 nights per guest, but the population growth exceeded 4% in the same period. The tourism intensity of Macao remains at a relatively higher level compared with neighboring regions (Table 1.2).

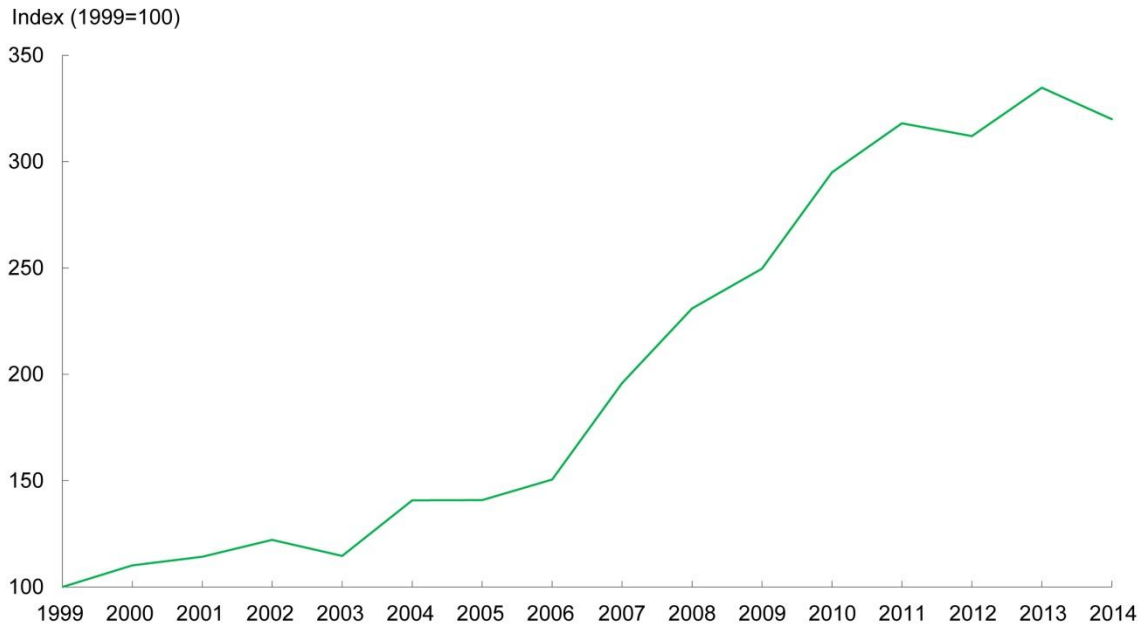


Figure 1.4 Tourism intensity

(Data sources: DST and DSEC, 2015)

Table 1.2 Environmental knowledge

Tourism intensity and population density in 2014

City/Region	Tourism intensity	Data source	Population density (ppl/km^2)	Data source
Macao	24.1	DST and DSEC	20,518	DSEC
Hong Kong	12.7	Hong Kong Tourism Board (HKTB)	6,690	Hong Kong Fact Sheets
Singapore	9.8	Yearbook of Statistics Singapore, 2015	7,615	The Singapore Department of Statistics

[3] Tourism intensity refers to the rate of annual total stay nights of hotel guests to mid-year population of Macao.

The comprehensive analysis on the evolution of social, economic and environmental indicators reflects the changing trends of relevant sub-indicators as follows:

 = Good  = Stable  = Unsatisfactory

Description	D	P	S	I	R	Trend[4]
Social, Economic and Environmental Evolution of Macao	✓	✓				
➢ End-year population						
➢ Population density						
➢ Visitor arrivals						
➢ Tourism intensity						
➢ Gross Domestic Product (GDP; at current prices)						
➢ Land area						
➢ Electricity consumption						
➢ Billed water consumption						
➢ Waste transferred to the Macao Refuse Incineration Plant for treatment						
➢ Estimated greenhouse gas emissions						
D: Driving Force, P: Pressure, S: State, I: Impact, R: Response						

The above analysis result indicates that, except for waste transferred to the Macao Refuse Incineration Plant for treatment, the environmental impact and resources consumption grow concurrently with social and economic indicators. The result indicates that Macao has a relatively poor environmental efficiency in some aspects. The environment is facing a relatively large pressure; therefore more effort should be put to enhance sustainable development.

[4] The trends of sub-indicators are assessed with a perspective of environmental protection, and are derived from the change of sub-indicator values between 2013 and 2014.

2. Atmospheric Environment

Air quality and climate change are both closely related to ecosystem and human health, and have became one of the front-burner issues in the world, among which air quality improvement is one of the priorities that the Macao SAR Government values in its administration and policy-making.

According to the report of the United Nations (UN), millions of people die prematurely because of indoor or outdoor air pollution every year. Meanwhile, the frequent occurrence of extreme severe weather caused by climate change also poses a threat to global food security and biodiversity. It is impossible for Macao to wall herself off from such environmental issues due to the inseparable relationship between Macao and her surrounding regions regarding atmospheric environment. Therefore, in addition to improving air quality continuously, Macao should also strengthen the regional cooperation as well as joint prevention and treatment, and maintain a quality atmospheric environment in order to protect public health.

Indicators for environmental analysis in this chapter
● Air Quality ● General Atmospheric Pollutant Emissions ● Greenhouse Gas Emissions ● Eco-efficiency of the Energy Sector ● Eco-efficiency of the Transport Sector

2.1 Air Quality

DPSIR Framework

D	Driving forces	P	Pressures	**S**	**States** ✓	I	Impacts	R	Responses

Air Quality Index (AQI) is converted from air pollutant concentrations. Table 2.1 lists Macao AQI revised by Meteorological and Geophysical Bureau (SMG) in 2012. Currently, five automatic air quality monitoring stations are established in Macao, namely, Calçada do Poço Station (roadside), Northern District Station [high density residential area (Macao)], Big Taipa Hill Station [ambient (Taipa)], Taipa City Station [high density residential area (Taipa)], and Concordia Industrial Park Station [ambient (Coloane)]. The total number of days monitored at the Concordia Industrial Park Station is less than half a year, so this Station is excluded from the following comparison.

Table 2.2 lists the total number of days monitored at each air quality monitoring station. Figure 2.1 shows the percentages of AQI levels under monitoring. Generally, in respect of air quality in 2014, the days recorded with "Good" and "Moderate" air quality at all stations, except the Calçada do Poço Station, exceeded 90% of the total number of days monitored. Each monitoring station had a certain decrease in the number of days recorded with "Poor" or "Very poor" air quality in 2014 compared with 2013. Only 1 day with "Very poor" air quality was recorded at the Calçada do Poço Station. Meanwhile, there was no record of "Severe" or "Harmful" air quality in 2014.

Table 2.1 Air Quality Index of Macao (adopted since 2nd July of 2012)

	Respirable suspended particulates with diameter less than 10μm (PM_{10})	Fine suspended particulates with diameter less than 2.5μm ($PM_{2.5}$)	Sulphur dioxide (SO_2)	Nitrogen dioxide (NO_2)	Ozone (O_3)	Carbon monoxide (CO)
	($\mu g/m^3$)					(mg/m^3)
Index	24-hour mean value			1-hour mean value*	8-hour mean value*	
0	0	0	0	0	0	0
50	100	35	40	100	80	5
100	150	75	125	200	160	10
200	350	150	660	750	350	17
300	420	250	1,300	1,500	600	34
400	500	350	1,700	2,000	800	46
500	600	500	2,120	2,500	1,000	57

Note: * The highest value during 24 hours is selected.

(Data source: SMG, 2015)

Table 2.2 Total number of days monitored at each monitoring station between 2013 and 2014

(Unit: day)	**2013**	**2014**
Calçada do Poço Station [roadside]	361[1]	365
Northern District Station [high density residential area (Macao)]	365[1]	365
Big Taipa Hill Station [ambient (Taipa)]	364[1]	364
Taipa City Station [high density residential area (Taipa)]	187	359
Concordia Industrial Park Station [ambient (Coloane)]	365[1]	161

Notes: (1) [1] Revised figures in accordance with the *2014 Presentation on Air Quality of Macao.*

(2) The publication of data at the Taipa City Station was resumed starting from 26th June of 2013; the location of monitoring station is currently at the Taipa Central Park.

(3) There was no data available from the Concordia Industrial Park Station since June of 2014.

(Data source: SMG – 2014 Presentation on Air Quality of Macao, 2015)

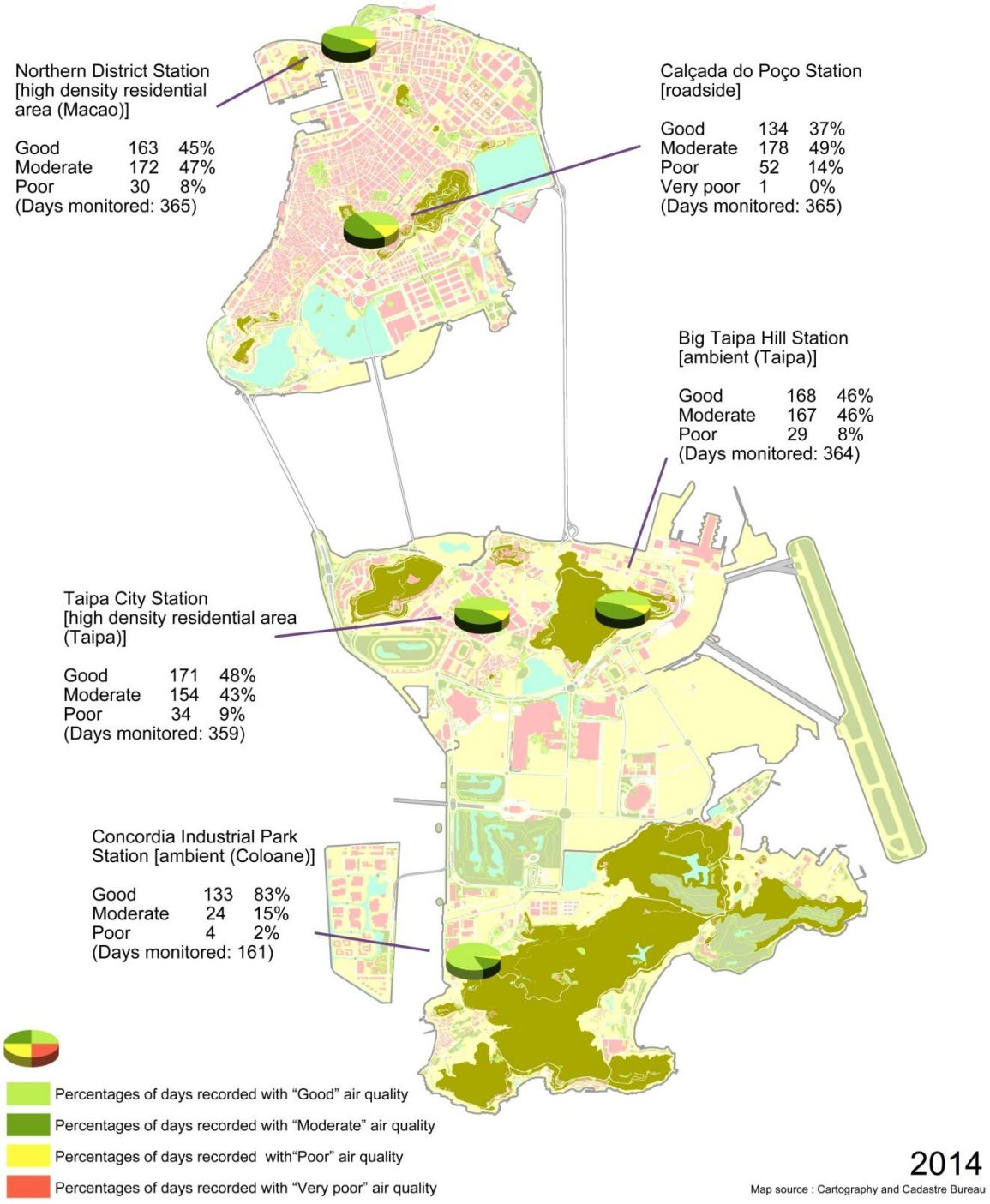
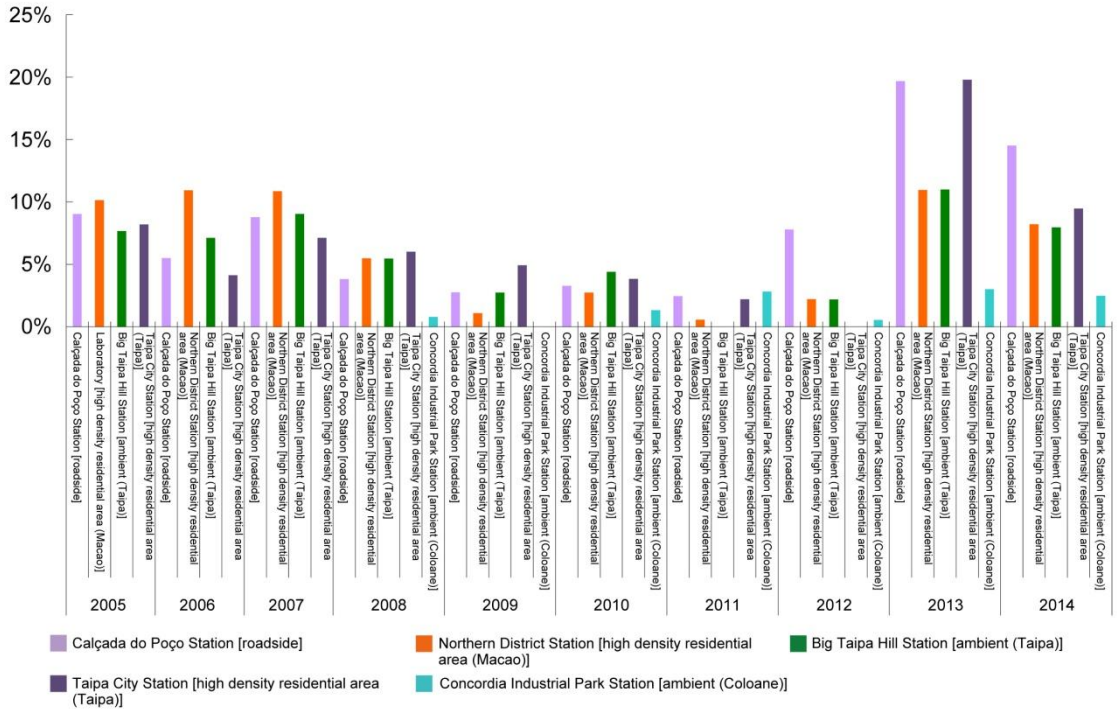


Figure 2.1 Percentage of different AQI levels of air quality monitoring stations in 2014

(Data source: SMG - 2014 Presentation on Air Quality of Macao, 2015)

Figure 2.2 shows the evolution of air quality in Macao over the years. Table 2.3 indicates the days of various air quality levels recorded by monitoring stations between 2013 and 2014 and the relative differences. Although the air quality recorded by the monitoring stations in 2014 has been improved in comparison to that in 2013, it still stands at a relative poor level in recent years. This is mainly due to many days with records of the daily mean concentrations of $PM_{2.5}$ exceeding the standard value. However, the number of days recorded with the $PM_{2.5}$ value exceeding the standard value in 2014 was less than that in 2013.



Note: (1) Based on the *2014 Presentation on Air Quality of Macao,* the data collected is calculated according to the new definition of air quality index published on 2nd July of 2012.

Figure 2.2 Percentage of days not reaching "Good" or "Moderate" air quality in the past years

(Data source: SMG - 2014 Presentation on Air Quality of Macao, 2015)

Table 2.3 Numerical data of the days of various air quality levels recorded by monitoring stations between 2013 and 2014, and the relative differences

(Unit: day)	Good			Moderate		
	2013 [1]	2014	Difference	2013 [1]	2014	Difference
Calçada do Poço Station [roadside]	117	134	+17	173	178	+5
Northern District Station [high density residential area (Macao)]	194	163	-31	131	172	+41

Big Taipa Hill Station [ambient (Taipa)]	177	168	-9	147	167	+20
Taipa City Station [high density residential area (Taipa)]	89	171	Note [2]	61	154	Note [2]
Concordia Industrial Park Station [ambient (Coloane)]	293	133	Note [2]	61	24	Note [2]

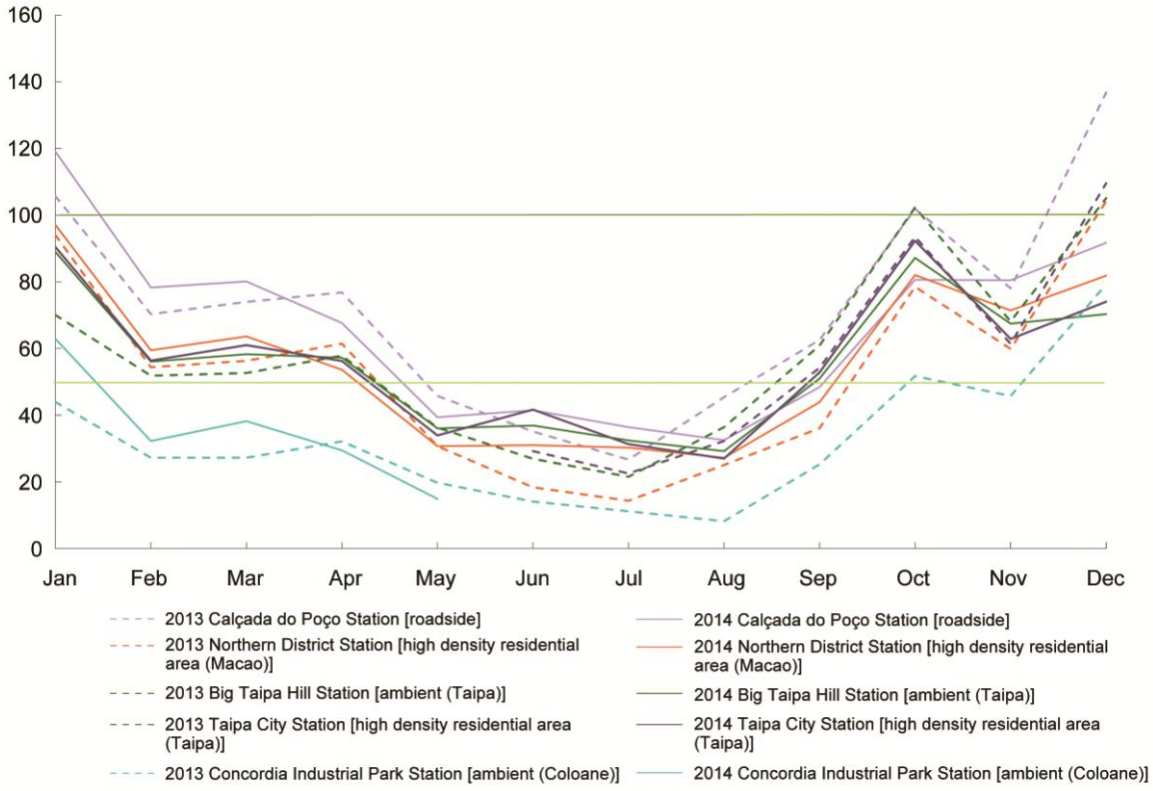
(Unit: day)	**Poor**			**Very poor**		
	2013	2014	Difference	2013	2014	Difference
Calçada do Poço Station [roadside]	65[1]	52	-13	6	1	-5
Northern District Station [high density residential area (Macao)]	40	30	-10	0	0	0
Big Taipa Hill Station [ambient (Taipa)]	40[1]	29	-11	0	0	0
Taipa City Station [high density residential area (Taipa)]	37[1]	34	Note [2]	0	0	Note [2]
Concordia Industrial Park Station [ambient (Coloane)]	11	4	Note [2]	0	0	Note [2]

Notes: (1) [1] Revised figures in accordance with the *2014 Presentation on Air Quality of Macao.*

(2) [2] Considering the comparability, the difference will not be calculated due to insufficient data.

(Data source: SMG - 2014 Presentation on Air Quality of Macao, 2015)

Figure 2.3 shows the evolution of monthly mean values of AQI in Macao. As influenced by meteorological conditions, air quality of Macao is generally better in summers but worse in winters. From May to August of 2014, the monthly mean values of AQI recorded at each monitoring station were lower than 50, while in any other months of the year, the monthly mean values at each station ranged from 50 to 100 except the Calçada do Poço Station recorded the exceedance of 100 in January of 2014.



Notes: (1) The publication of data at the Taipa City Station was resumed starting from 26th June of 2013.

(2) There was no data available for the Concordia Industrial Park Station since June of 2014.

Figure 2.3 Evolution of monthly mean values of AQI in 2014

(Data source: SMG, 2015)

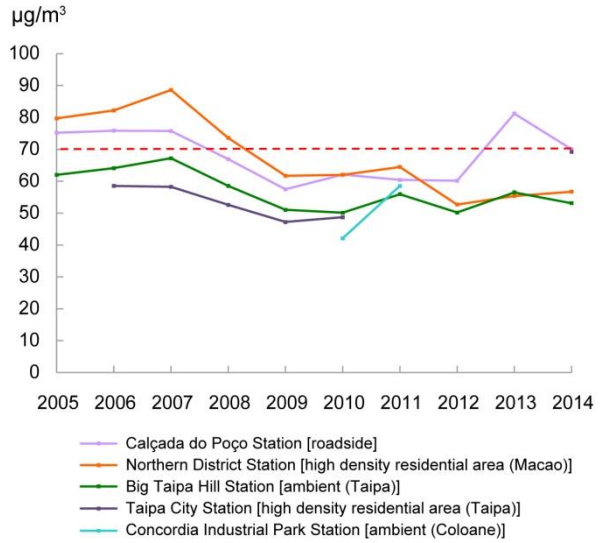
Figure 2.4 shows the evolution of annual mean concentrations of air pollutants over the years. Table 2.4 indicates that none of the annual mean concentrations of PM_{10} at any monitoring stations in 2014 exceeded the standard value, but the annual mean concentrations of $PM_{2.5}$ and NO_2 at some monitoring stations exceeded the standard values. Other air pollutants were excluded from the comparison because of lack of corresponding standard of annual mean concentrations.

In comparison with 2013, the annual mean concentrations of PM_{10} and $PM_{2.5}$ improved at all monitoring stations, except that of the Northern District Station [high density residential area (Macao)]. But the annual mean concentrations of NO_2 and SO_2 increased, particularly at the Northern District Station, which may be resulted from the on-going construction projects located in its adjacent area.

Generally speaking, in the past decade, the annual mean concentrations of SO_2 showed a descending trend while the annual mean concentrations of O_3 and CO were on the rising trend, and those of PM_{10}, $PM_{2.5}$ and NO_2 remained relatively stable comparing with past years. In addition, it should be noted that the annual mean concentrations of various air pollutants recorded at the

Northern District Station in the latest two years all increased in varying degrees, and "Good" air quality days have been replaced by more "Moderate" air quality days.

Respirable suspended particulates with diameter less than 10μm (PM_{10})



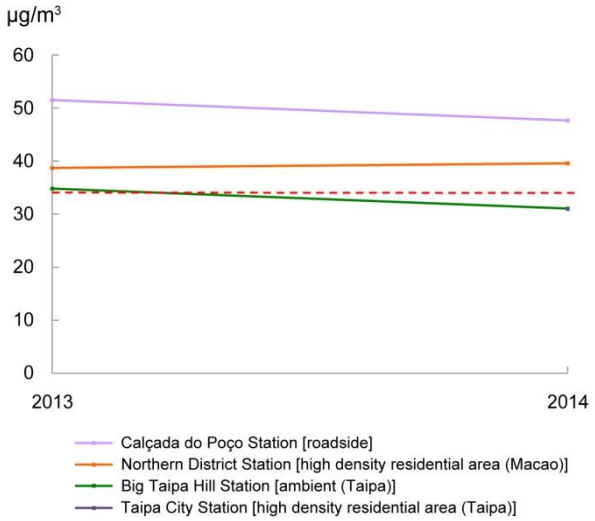
Notes:

(1) The Concordia Industrial Park Station has been put into operation since 2008.

(2) As indicated in the *2014 Presentation on Air Quality of Macao*, effective data of the Taipa City Station in 2005 and 2011-2013 and data of the Concordia Industrial Park Station in 2008, 2009 and 2012-2014 is insufficient, thus the annual mean concentrations are not stated accordingly.

(3) The red dotted line represents that the standard value of annual mean concentrations is 70μg/m^3.

Fine suspended particulates with diameter less than 2.5μm ($PM_{2.5}$)



Notes:

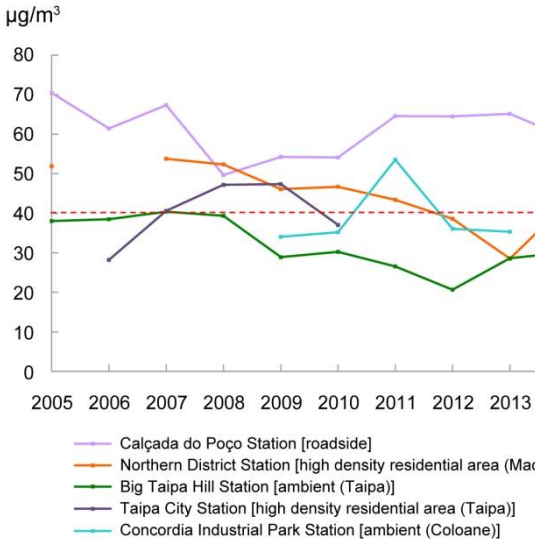
(1) The monitoring data of fine suspended particulates with diameter less than 2.5μm ($PM_{2.5}$) has been released since 2nd July of 2012.

(2) $PM_{2.5}$ has been monitored at the Taipa City Station since 2013.

(3) As indicated in the *2014 Presentation on Air Quality of Macao*, effective data of the Calçada do Poço Station, Northern District Station and Big Taipa Hill Station in 2012 and data of the Taipa City Station in 2013 is insufficient, thus the annual mean concentrations are not stated accordingly.

(4) The red dotted line represents that the standard value of annual mean concentrations is 35μg/m^3.

Nitrogen dioxide (NO_2)



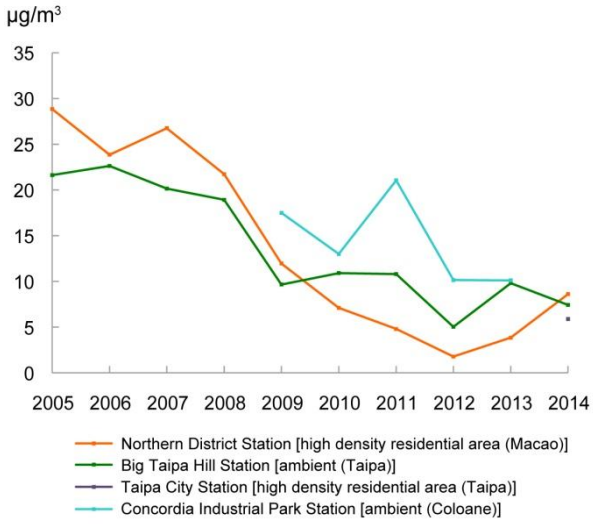
Notes:

(1) The Concordia Industrial Park Station has been put into operation since 2008.

(2) As indicated in the *2014 Presentation on Air Quality of Macao*, effective data of the Northern District Station in 2006, data of the Taipa City Station in 2005 and 2011-2013 and data of the Concordia Industrial Park Station in 2008 and 2014 is insufficient, thus the annual mean concentrations are not stated accordingly.

(3) The red dotted line represents that the standard value of annual mean concentrations is 40μg/m^3.

Sulphur dioxide (SO_2)



Notes:

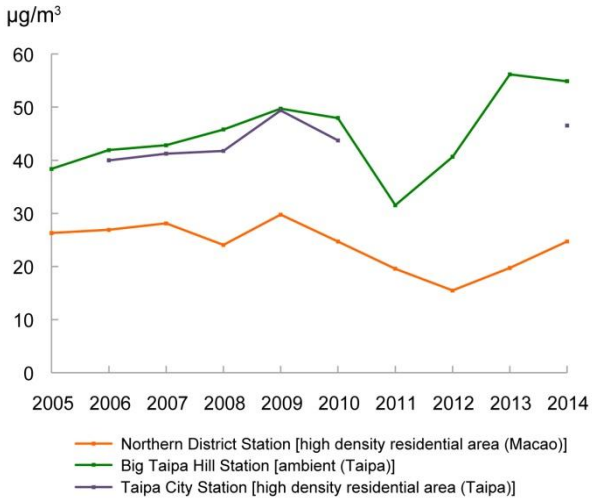
(1) SO_2 has been monitored at the Taipa City Station since 2013.

(2) The Concordia Industrial Park Station has been put into operation since 2008.

(3) As indicated in the *2014 Presentation on Air Quality of Macao*, effective data of the Taipa City Station in 2013 and data of the Concordia Industrial Park Station in 2008 and 2014 is insufficient, thus the annual mean concentrations are not stated accordingly.

(4) Standard value of annual mean concentration is not defined.

Ozone (O_3)

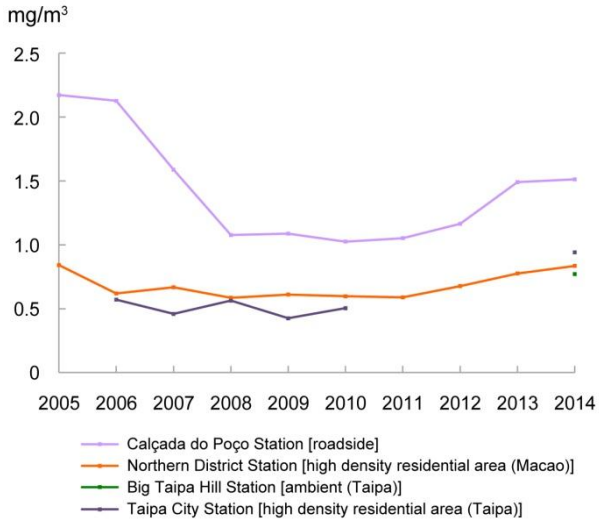


Notes:

(1) As indicated in the *2014 Presentation on Air Quality of Macao*, effective data of the Taipa City Station in 2005 and 2011-2013 is insufficient, thus the annual mean concentrations are not stated accordingly.

(2) Standard value of annual mean concentration is not defined.

Carbon monoxide (CO)



Notes:

(1) CO has been monitored at the Big Taipa Hill Station since 2013.

(2) As indicated in the *2014 Presentation on Air Quality of Macao*, effective data of the Big Taipa Hill Station in 2013 and data of the Taipa City Station in 2005 and 2011-2013 is insufficient, thus the annual mean concentrations are not stated accordingly.

(3) Standard value of annual mean concentration is not defined.

Figure 2.4 Annual mean concentrations of air pollutants in the past years

(Data source: SMG, 2015)

Table 2.4 Annual mean concentrations of air pollutants recorded at air quality monitoring stations between 2013 and 2014

- Respirable suspended particulates with diameter less than 10μm (PM_{10})

Standard value of annual mean concentration: 70μg/m^3 (Unit: μg/m^3)	**2013**	**2014**	**Percentage increase / decrease**
Calçada do Poço Station [roadside]	81.2 [r]	70.0	-13.8%
Northern District Station [high density residential area (Macao)]	55.4	56.7	+2.3%
Big Taipa Hill Station [ambient (Taipa)]	56.5	53.1	-6.0%

Taipa City Station [high density residential area (Taipa)]	Note[1]	69.2	Note[2]
Concordia Industrial Park Station [ambient (Coloane)]	Note[1]	Note[1]	Note[2]

- Fine suspended particulates with diameter less than 2.5μm ($PM_{2.5}$)

Standard value of annual mean concentration: 35μg/m^3 (Unit: μg/m^3)	**2013**	**2014**	**Percentage increase / decrease**
Calçada do Poço Station [roadside]	51.5 [r]	47.6	-7.6%
Northern District Station [high density residential area (Macao)]	38.7 [r]	39.6	+2.3%
Big Taipa Hill Station [ambient (Taipa)]	34.8 [r]	31.0	-10.9%
Taipa City Station [high density residential area (Taipa)]	Note[1]	31.0	Note[2]

- Nitrogen dioxide (NO_2)

Standard value of annual mean concentration: 40μg/m^3 (Unit: μg/m^3)	**2013**	**2014**	**Percentage increase / decrease**
Calçada do Poço Station [roadside]	65.2 [r]	59.0	-9.5%
Northern District Station [high density residential area (Macao)]	28.5	42.6	+49.5%
Big Taipa Hill Station [ambient (Taipa)]	28.6	30.1	+5.2%
Taipa City Station [high density residential area (Taipa)]	Note[1]	43.2	Note[2]
Concordia Industrial Park Station [ambient (Coloane)]	35.3 [r]	Note[1]	Note[2]

- Sulphur dioxide (SO_2)

Standard value of annual mean concentration is not defined (Unit: μg/m^3)	**2013**	**2014**	**Percentage increase / decrease**
Northern District Station [high density residential area (Macao)]	3.8	8.6	+126.3%
Big Taipa Hill Station [ambient (Taipa)]	9.8	7.4	-24.5%
Taipa City Station [high density residential area (Taipa)]	Note[1]	5.9	Note[2]
Concordia Industrial Park Station [ambient (Coloane)]	10.1 [r]	Note[1]	Note[2]

- Ozone (O_3)

Standard value of annual mean concentration is not defined (Unit: μg/m^3)	**2013**	**2014**	**Percentage increase / decrease**
Northern District Station [high density residential area (Macao)]	19.7	24.7	+25.4%
Big Taipa Hill Station [ambient (Taipa)]	56.2 [r]	54.9	-2.3%
Taipa City Station [high density residential area (Taipa)]	Note[1]	46.5	Note[2]

- Carbon monoxide (CO)

Standard value of annual mean concentration is not defined (Unit: mg/m^3)	**2013**	**2014**	**Percentage increase / decrease**
Calçada do Poço Station [roadside]	1.49 [r]	1.51	+1.3%
Northern District Station [high density residential area (Macao)]	0.78	0.84	+7.7%
Big Taipa Hill Station [ambient (Taipa)]	Note[1]	0.77	Note[2]
Taipa City Station [high density residential area (Taipa)]	Note[1]	0.94	Note[2]

Notes: (1) [1] As indicated in the *2014 Presentation on Air Quality of Macao*, the annual mean concentrations are not stated due to insufficient effective data.

(2) [2] Considering the comparability, the percentage increase/decrease will not be calculated due to insufficient data.

(3) [r] Revised figures.

(Data source: SMG, 2015)

Atmospheric pollution is a cross-regional issue. To continuously improve the air quality of Pearl River Delta (PRD) Region, the governments of Guangdong, Hong Kong SAR and Macao SAR had signed the *Guangdong-Hong Kong-Macao Cooperation Agreement for Joint Prevention and Treatment of Atmospheric Pollution* on 3rd September of 2014, under which the Big Taipa Hill Air Quality Monitoring Station (Big Taipa Hill Station) in Macao was officially admitted into the Regional Air Quality Monitoring Network[1] of PRD Region. This cooperation can help providing more detailed real-time air quality information for citizens in Guangdong, Hong Kong and Macao, serving as scientific references for the three governments for developing relevant policies, and further facilitating the Guangdong-Hong Kong-Macao cooperation for joint prevention and treatment of atmospheric pollution.

[1] Citizens may directly visit the website of "Guangdong-Hong Kong-Macao Regional Air Quality Monitoring Information System" (http://113.108.142.147:20047) or access the websites of Environmental Protection Bureau of Macao (http://www.dspa.gov.mo) / Meteorological and Geophysical Bureau (http://www.smg.gov.mo) to learn details about regional air quality changes.

2.2 General Atmospheric Pollutant Emissions

DPSIR Framework

D	Driving forces	**P**	**Pressures ✓**	S	States	I	Impacts	R	Responses

In Macao, atmospheric pollutants mainly consist of carbon monoxide (CO), sulphur oxides (SO_x), nitrogen oxides (NO_x), ammonia (NH_3), non-methane volatile organic compound (NMVOC), total suspended particulates (TSP), respirable suspended particulates with diameter less than 10μm (PM_{10}) and lead (Pb), etc.

During the preparation of the emission inventory of atmospheric pollutants and greenhouse gases, estimated emissions of atmospheric pollutants and greenhouse gases of Macao over the years as well as the changing trend of emission contributions of air pollution sources were evaluated by collecting and analyzing relevant data. During the evaluation, relevant analytical methods that better fit Macao were adopted, and the following technical information were referred for the analysis and amendments: EMEP/EEA "*Air Pollutant Emission Inventory Guidebook*"; IPCC "*Guidelines for National Greenhouse Gas Inventories*" and USEPA "*Compilation of Air Pollutant Emission Factors, AP-42*".

Figure 2.5-2.12 show the evolution of annual estimated emissions of CO, SO_x, NO_x, NH_3, NMVOC, TSP, PM_{10} and Pb by sectors up to 2013.

Compared with 2012, the estimated emissions of CO, SO_x, NH_3, NMVOC, TSP and Pb have declined in varying degrees in 2013, while the estimated emissions of NO_x and PM_{10} have increased. Among them, the estimated emissions of SO_x changed noticeably, while the estimated emissions of other pollutants changed within a range of approximately 4%. It should be noted that in 2013, except for NH_3, the estimated emissions of each pollutant from construction sector increased by over 30% compared with 2012, which was obviously related to the fact that many large-scale projects in Macao were under construction in 2013. Moreover, due to the growth of passenger and freight volume in maritime and air transport as well as the sharp increase in waste generation, the estimated emissions of pollutants from maritime transport, air transport and waste incineration increased significantly in 2013. On contrary, due to the declining local production of electricity, the estimated emissions of pollutants from local production of electricity decreased by approximately 40% in 2013 compared with that in 2012. The estimated emissions from industrial sector also decreased substantially.

Over the years, except for NH_3, the estimated emissions of various pollutants from local production of electricity were decreasing, which favors the emission reduction of SO_x, NO_x, NMVOC, TSP and PM_{10}. However, in respect of emission reduction for CO and Pb, as the increasing estimated emissions of CO and Pb from transport sector offset the reduction of CO and

Pb from local production of electricity in recent years, the total emissions have not decreased distinctly.

It is noteworthy that the estimated emission reduction of various pollutants from local production of electricity was slowing down in recent years while the estimated emissions of pollutants from other sectors were increasing. In such circumstance, the estimated emissions of some pollutants like NO_x and PM_{10} were shifted from a decreasing to an unsatisfactory increasing trend.

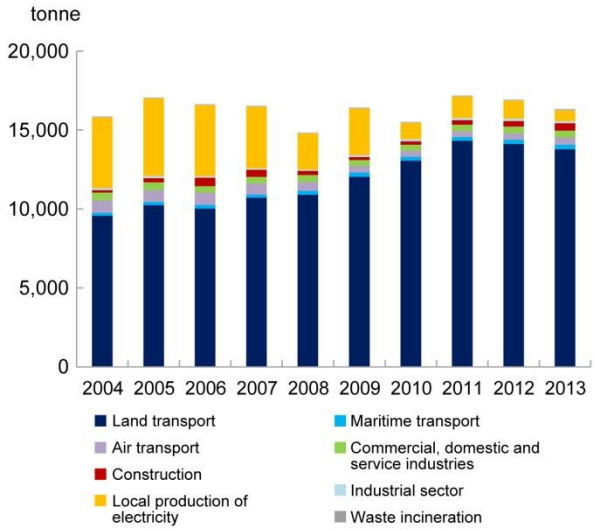


Figure 2.5 Annual estimated emissions of CO by sector in the past years

(Data source: DSPA, 2014)

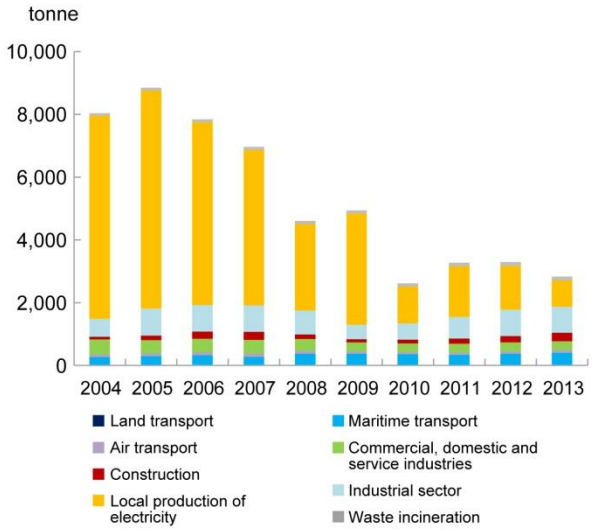


Figure 2.6 Annual estimated emissions of SOx by sector in the past years

(Data source: DSPA, 2014)

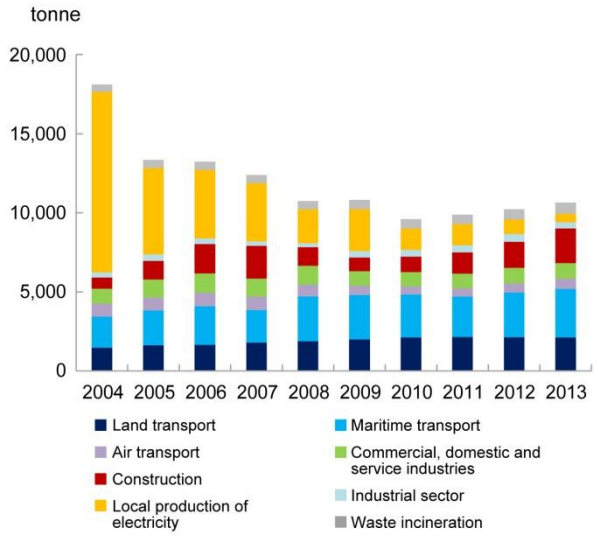


Figure 2.7 Annual estimated emissions of NOx by sector in the past years

(Data source: DSPA, 2014)

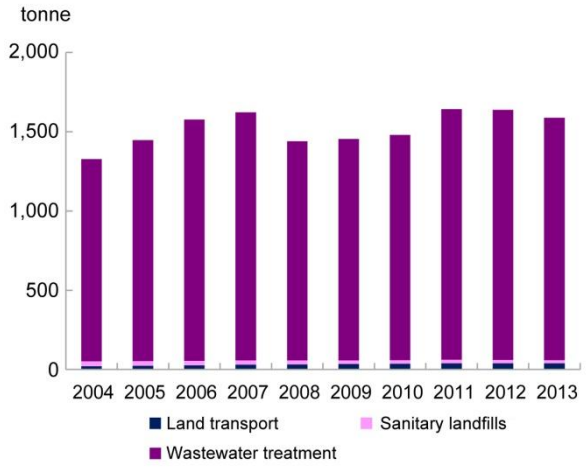


Figure 2.8 Annual estimated emissions of NH_3 by sector in the past years

(Data source: DSPA, 2014)

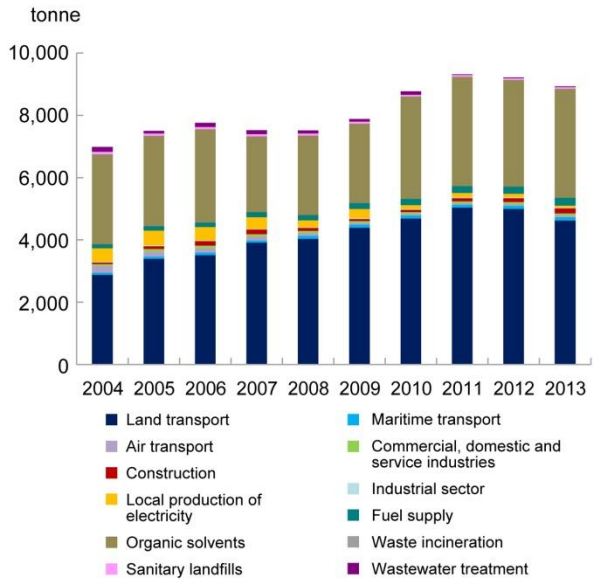


Figure 2.9 Annual estimated emissions of NMVOC by sector in the past years

(Data source: DSPA, 2014)

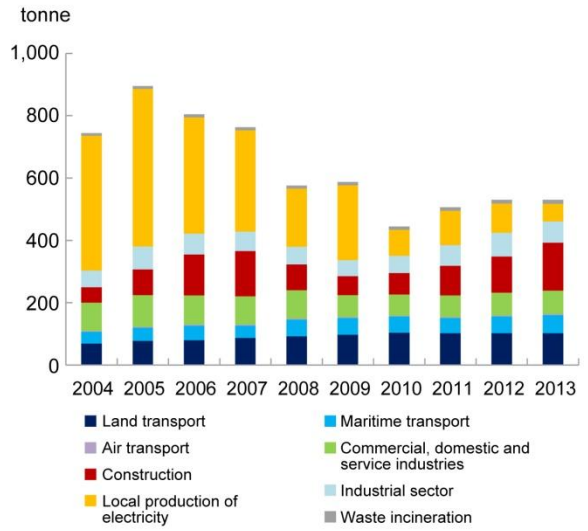


Figure 2.10 Annual estimated emissions of TSP by sector in the past years

(Data source: DSPA, 2014)

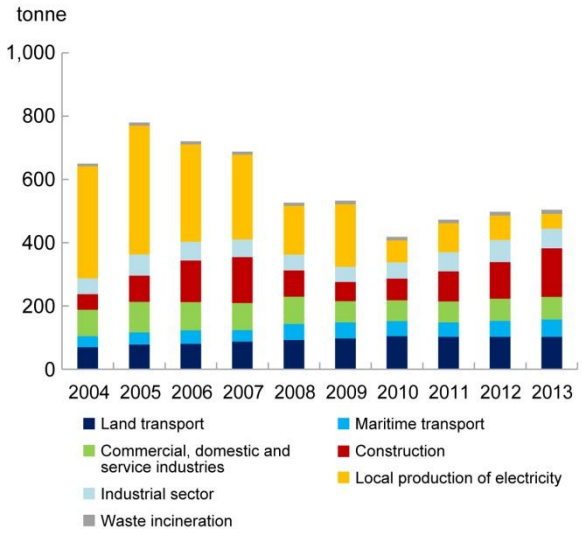


Figure 2.11 Annual estimated emissions of PM_{10} by sector in the past years

(Data source: DSPA, 2014)

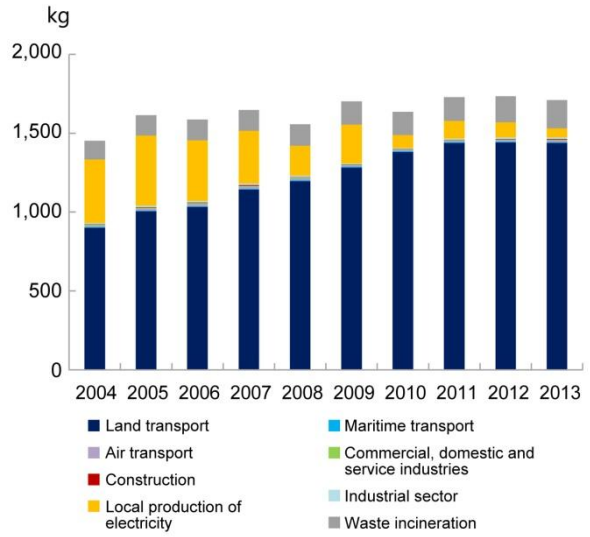


Figure 2.12 Annual estimated emissions of Pb by sector in the past years

(Data source: DSPA, 2014)

Analyzing various pollutant sources, it shows that the emissions of CO, NO_x, NMVOC and Pb have a close relationship with fuel combustion, and such emissions come mainly from transport-related sectors. Particularly, the emissions of NMVOC are related to the utilization of organic solvents like detergents, adhesives and coatings. The emissions of SO_x are mainly generated from local production of electricity, industrial sector and maritime transport, while the emissions of NH_3 are mostly generated from wastewater treatment. The emissions of TSP and PM_{10} are from a variety of sources including construction, land transport and commercial, domestic and service industries, etc. Figure 2.13 indicates the percentage of emissions of various atmospheric pollutant sources in 2013. Table 2.5 shows the respective percentage increase and decrease.

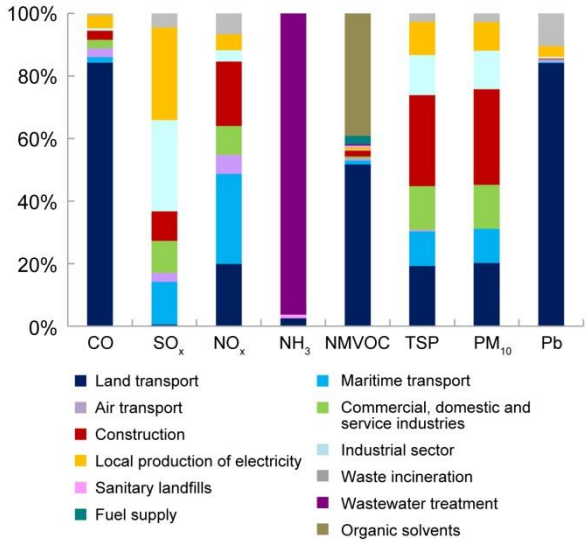


Figure 2.13 Percentage of emissions of various atmospheric pollutant sources in 2013

(Data source: DSPA, 2014)

Table 2.5 Percentage increase/decrease of estimated emissions of various atmospheric pollutants by sector between 2012 and 2013

	CO	SO_x	NO_x	NH_3	NMVOC	TSP	PM_{10}	Pb
Total estimated emissions	**-3.5%**	**-13.9%**	**+4.2%**	**-3.1%**	**-3.1%**	**-0.2%**	**+1.4%**	**-1.4%**
Land transport	-2.4%	—	-0.6%	—	-7.5%	—	—	-0.1%
Maritime transport	+8.6%	+8.6%	+8.5%		+7.9%	+7.4%	+10.0%	+20.0%
Air transport	+11.8%	+12.5%	+11.2%		+7.8%	—		+10.0%
Commercial, domestic and service industries	+3.1%	-0.3%	+1.4%		+1.5%	+1.4%	+1.4%	—
Construction	+33.3%	+33.5%	+33.4%		+33.6%	+33.9%	+33.9%	+33.3%
Industrial sector	-14.4%	-1.8%	-22.1%		-24.2%	-10.5%	-11.4%	—
Local production of electricity	-39.7%	-40.0%	-40.5%		-39.4%	-40.4%	-40.3%	-39.6%
Waste incineration	+8.4%	+7.6%	+8.1%		+14.3%	+7.7%	+7.7%	+7.9%
Sanitary landfills				-9.5%	-4.0%			
Wastewater treatment				-3.0%	+3.7%			
Fuel supply					+6.9%			
Organic solvents					+2.1%			

(Data source: DSPA, 2014)

2.3 Greenhouse Gas Emissions

DPSIR Framework

D	Driving forces✓	P	Pressures ✓	S	States	I	Impacts	R	Responses

Greenhouse gas (GHG) means any gaseous compound in the atmosphere that causes greenhouse effect. Three GHGs including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are estimated in the *Report*.

In order to analyze estimated emissions of GHGs, it is required to convert their quantity into CO_2 equivalents. Figure 2.14 shows the estimated GHG emissions over the years. In Macao, the estimated GHG emissions are closely related to estimated CO_2 emissions. The estimated emissions of GHGs and CO_2 peaked in 2005 and then declined gradually. The estimated GHG emissions in 2013 decreased compared with that in 2012, mainly resulted from the decrease in estimated CO_2 emissions. It can be seen from the annual evolution of the estimated GHG emissions from various sectors (Figure 2.15) that GHG emission reduction was mainly from local production of electricity while emission increment was from maritime and air transport, commercial, domestic and service industries, construction and waste incineration, etc. The overall reduction extent in GHG emissions was greater than their increase in 2013, thus the annual estimated emissions decreased by approximately 4%, compared with those in 2012.

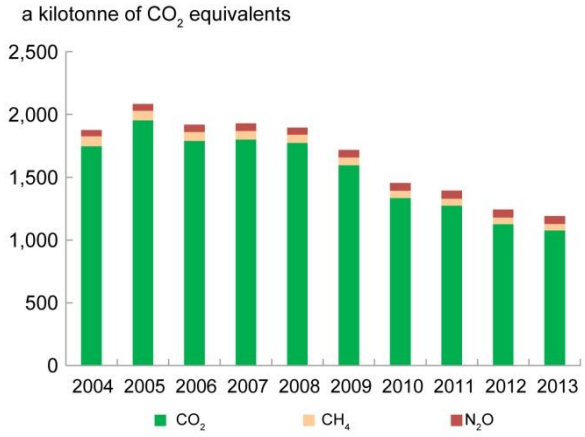


Figure 2.14 Annual estimated GHG emissions in the past years

(Data source: DSPA, 2014)

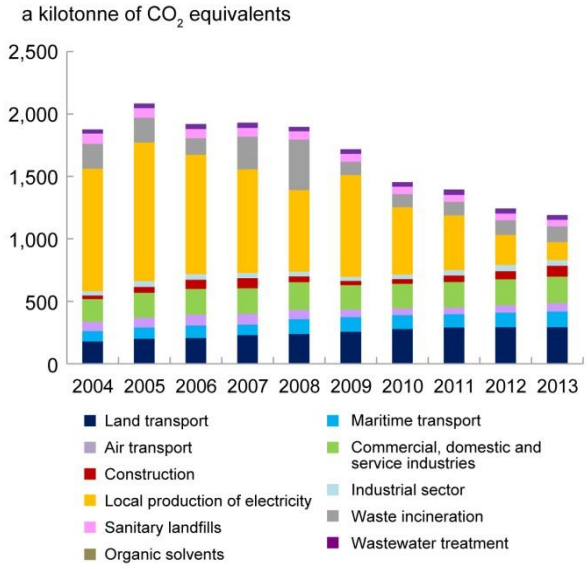


Figure 2.15 Annual estimated GHG emissions in the past years

(Data source: DSPA, 2014)

Figure 2.16-2.18 shows the evolution of estimated GHG emissions. The data indicates that the estimated emissions of CO_2 in the past years tended to decline obviously while N_2O fluctuated and

reflected an overall upward trend. Meanwhile, as the estimated emissions of CH_4 at sanitary landfills caused by domestic waste landfill in the past declined continually, it resulted in a continuous decrease in total estimated emissions of CH_4, but the estimated emissions of CH_4 from other sectors showed a slightly increasing trend.

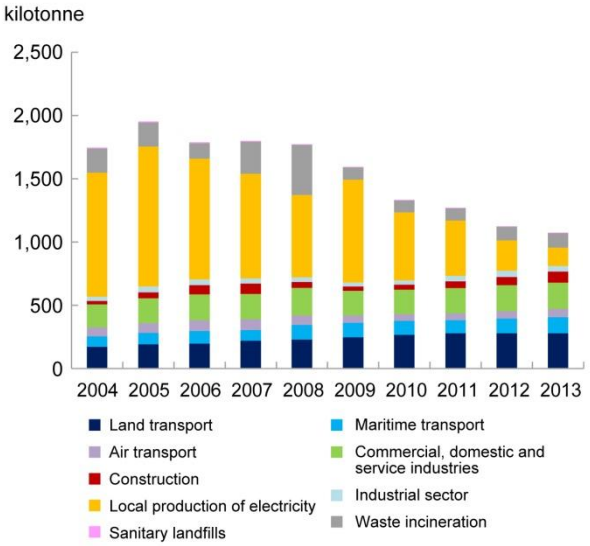


Figure 2.16 Annual estimated CO2 emissions from various sectors in the past years

(Data source: DSPA, 2014)

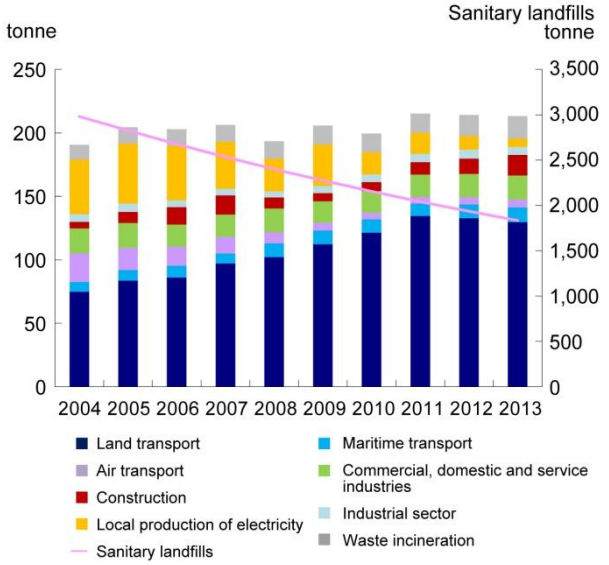


Figure 2.17 Annual estimated CH4 emissions from various sectors in the past years

(Data source: DSPA, 2014)

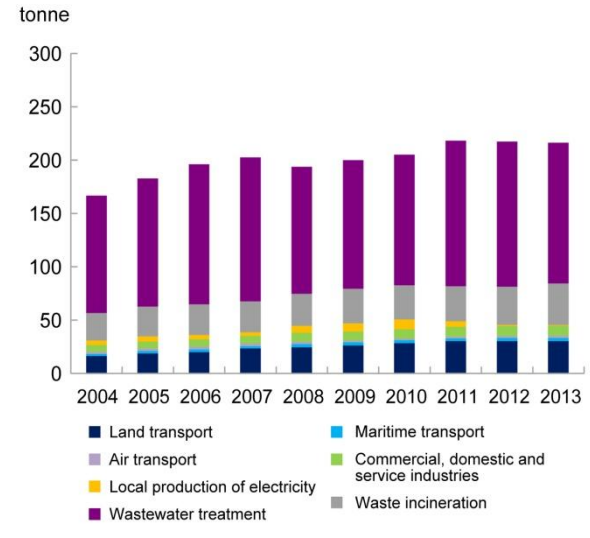


Figure 2.18 Annual estimated N2O emissions from various sectors in the past years

(Data source: DSPA, 2014)

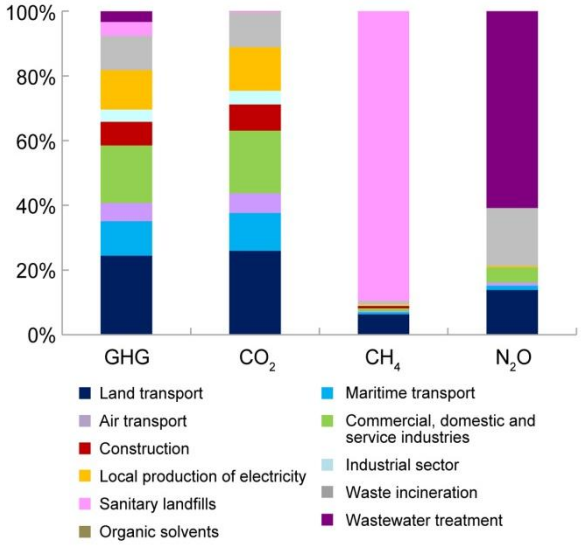


Figure 2.19 The emission percentage of various GHG emission sources in 2013

(Data source: DSPA, 2014)

Figure 2.19 summarizes the emission percentage of various GHG emission sources, and Table 2.6 shows the percentage increase/decrease in the estimated GHG emissions from various sectors. GHG emissions of Macao are mainly generated from land transport, commercial, domestic and service industries as well as local production of electricity. In particular, CO_2 emissions are mainly produced from land transport, commercial, domestic and service industries as well as local production of electricity; CH_4 emissions mainly come from sanitary landfills and land transport, and N_2O emissions are mainly from wastewater treatment.

Table 2.6 Percentage increase/decrease of estimated GHG emissions from various sectors between 2012 and 2013

	GHG	CO_2	CH_4	N_2O
Total estimated emissions	**-4.3%**	**-4.4%**	**-4.7%**	**-0.5%**
Land transport	—	—	-2.3%	—
Maritime transport	+8.5%	+8.6%	+9.1%	—
Air transport	+11.7%	+11.9%	—	—
Commercial, domestic and service industries	+1.9%	+1.5%	+5.6%	+11.1%
Construction	+33.8%	+33.8%	+33.3%	
Industrial sector	-8.2%	-8.2%	-14.3%	
Local production of electricity	-39.8%	-39.6%	-36.4%	—
Waste incineration	+7.7%	+7.5%	+5.9%	+8.3%
Sanitary landfills	-5.6%	—	-5.2%	
Wastewater treatment	-4.9%			-2.9%
Organic solvents	—	—		

(Data source: DSPA, 2014)

Carbon emission intensity is the ratio of GHG emissions to GDP, which is used to measure the relationship between the economic development and carbon emissions. If the indicator is on a decline, it means that the region is developing with a low carbon development model progressively. Figure 2.20 shows the changing trend of carbon emission intensity of Macao over the years. Calculated on the basis of the estimated GHG emissions, it can be seen that carbon emission intensity was 0.003 kilogram of CO_2 equivalents per MOP in 2013, while that was 0.004 kilogram of CO_2 equivalents per MOP in 2012. The carbon emission intensity keeps descending, and it indicates that Macao is stepping toward a relatively low carbon development direction.

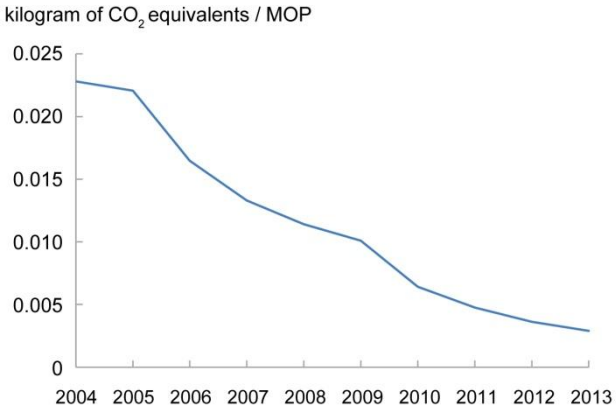


Figure 2.20 Carbon emission intensity in the past years

(Data source: DSPA, 2014)

Table 2.7 Environmental knowledge

Carbon emission intensity

City/Region	Carbon emission intensity	Data sources
Hong Kong[1]	0.021 kilogram of CO_2 equivalents / HKD	*Greenhouse Gas Emissions and Carbon Intensity in Hong Kong*, Hong Kong
Macao[2]	0.003 kilogram of CO_2 equivalents / MOP	*Report on the State of the Environment of Macao 2014*, Macao
Taipei[3]	0.004 kilogram of CO_2 equivalents / HKD	Information website of low-carbon and sustainable homeland and greenhouse gas reduction of Taipei city, Taipei

Notes: (1) [1] This is 2012 data, as related information was only updated to year 2012..

(2) [2] This is 2013 data.

(3) [3] This is 2013 data, calculated at an exchange rate of $1 NTD to $0.248 HKD.

2.4 Eco-efficiency of the Energy Sector

DPSIR Framework

D	**Driving forces✓**	**P**	**Pressures ✓**	S	States	I	Impacts	R	Responses

Eco-efficiency is broadly defined as creating more output through making more efficient utilization of energy and raw materials, or producing less pollution. In the energy sector, eco-efficiency can be improved by optimizing energy consumption efficiency or pollution control efficiency.

Figure 2.21 shows the indices of final energy consumption in Macao over the years. Since

2009, the final energy consumption has been rising steadily without decrease, while energy consumption per unit of GDP showed a descending trend, indicating a constant increase in energy utilization rate.

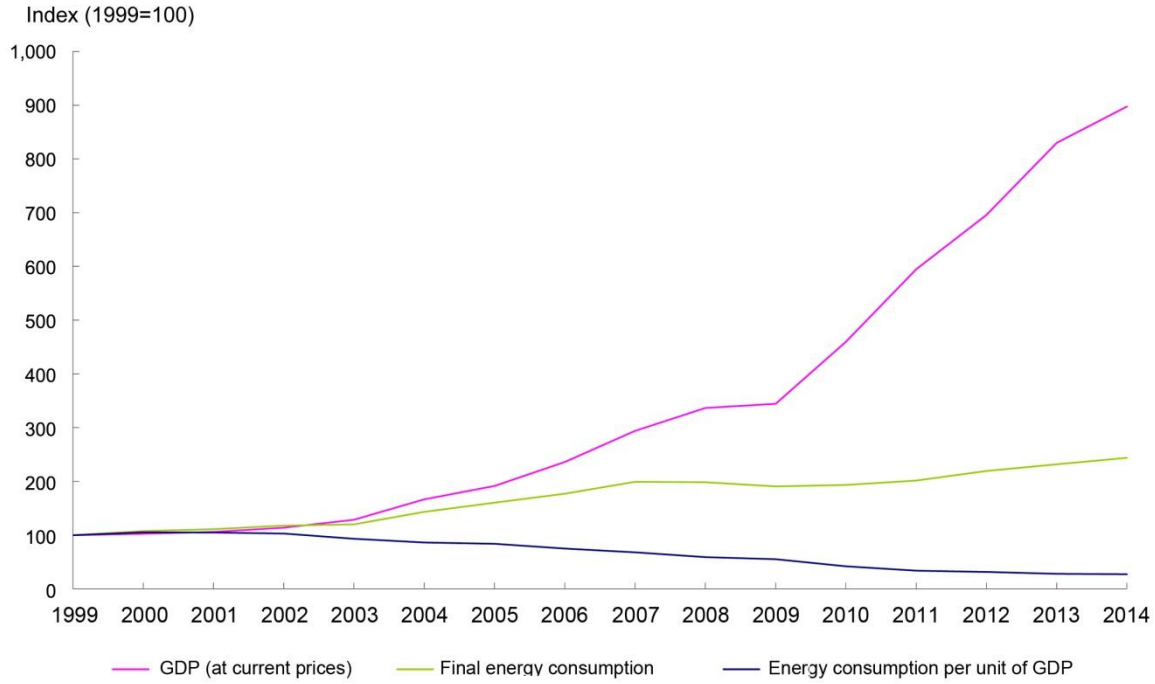
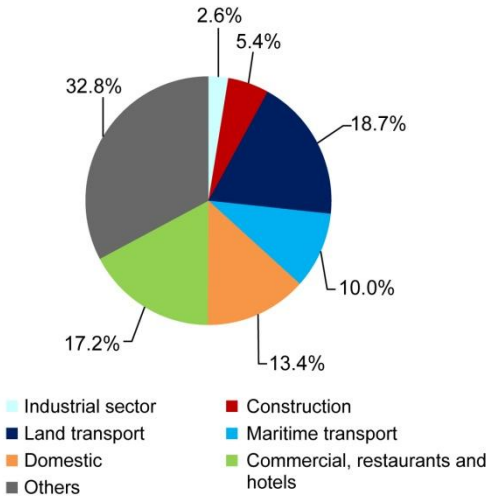


Figure 2.21 Final energy consumption in the past years

(Data source: DSEC, 2015)

As for final energy consumption, it can be seen from Figure 2.22 and Table 2.8, in 2014 the transport sector (including land and maritime transport) had the largest proportion of final energy consumption, which accounted for nearly 30% of the total final energy consumption and was increasing annually, followed by sector of commercial, restaurants and hotels with its final energy consumption in 2014 showing a slight increase compared with that in 2013. The domestic sector, the third largest proportion of final energy consumption, had a substantial increase in final energy consumption, probably due to the increasing population and the fact that the citizens use or rely on more different kinds of home or electronic appliances in their daily life. Compared with 2013 to 2014, the final energy consumption of construction gained the largest growth, but contributed a relatively low proportion to the total final energy consumption.



Notes: (1) Industrial sector excludes the consumption by the electricity supply company.

(2) According to DSEC data, information concerning aviation kerosene is not published for confidentiality reasons. Final energy consumption of each sector excludes fuel oil.

Figure 2.22 Percentage of final energy consumption by sector

(Data source: DSEC, 2015)

Table 2.8 Percentage of final energy consumption by sector and relevant percentage increase/decrease between 2013 and 2014

	2013	2014	Percentage increase/decrease
Industrial sector	3.0%	2.6%	-9.9%
Construction	4.8%	5.4%	+17.4%
Land transport	18.1%	18.7%	+8.2%
Maritime transport	10.6%	10.0%	-1.6%
Domestic	12.7%	13.4%	+10.5%
Commercial, restaurants and hotels	17.0%	17.2%	+5.1%
Others	33.9%	32.8%	+1.0%

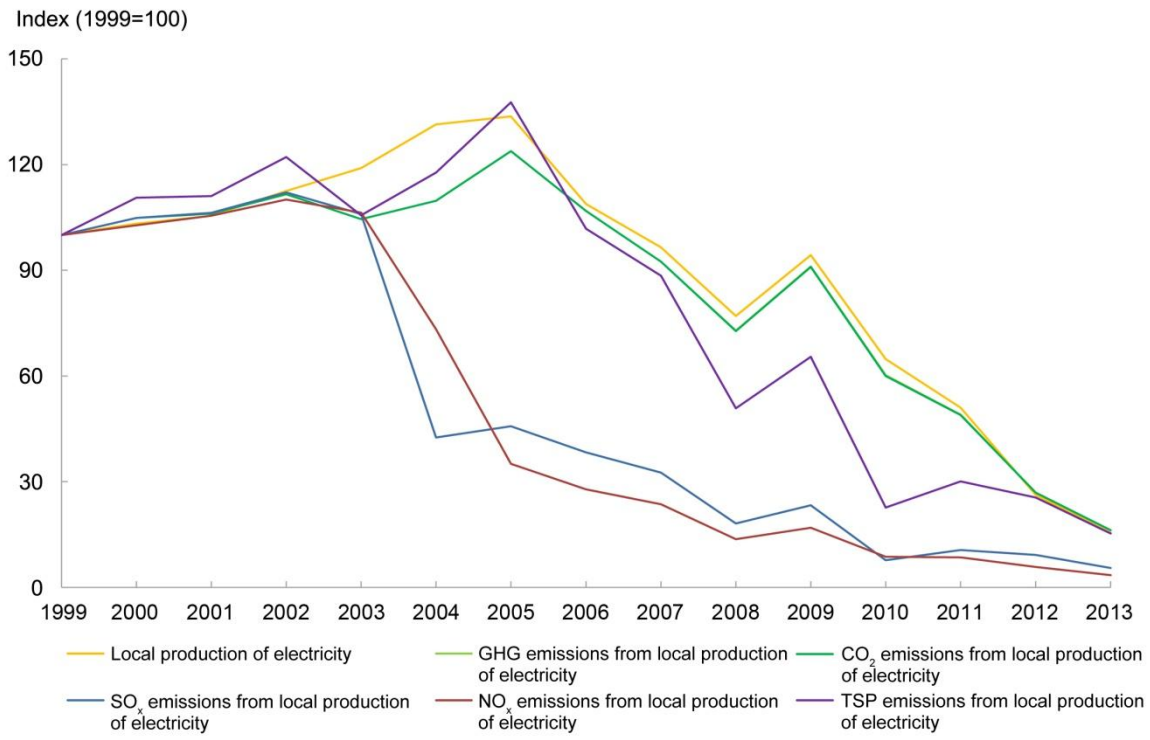
Notes: (1) Industrial sector excludes the consumption by the electricity supply company.

(2) According to DSEC data, information concerning aviation kerosene is not published for confidentiality reasons. Final energy consumption of each sector excludes the fuel oil.

(Data source: DSEC, 2015)

One effective way for eco-efficiency improvement is to increase yield and reduce pollution emissions at the same time. Figure 2.23 illustrates the changing relationship of indices between the local production of electricity and the atmospheric pollutant emissions for the past years. It can be seen that the estimated emissions of various pollutants from local production of electricity have all

declined. In recent years, the estimated emissions of GHGs and CO_2 were declining in a similar trend to the local production of electricity (two curves substantially overlapped).



Note: (1) For local production of electricity, the curve of GHG emissions substantially overlaps with that of CO_2 emissions.

Figure 2.23 Eco-efficiency of the energy sector

(Data sources: DSPA and GDSE, 2014)

As shown in Figure 2.24 for the energy structure of Macao in 2014, the proportion of electricity imported from Guangdong Power Grid Corporation in 2014 declined to certain extent, while the proportion of local production of electricity increased from 5% in 2013 to 9.3% in 2014 with a principal contribution from the electricity produced by local natural gas generation units.

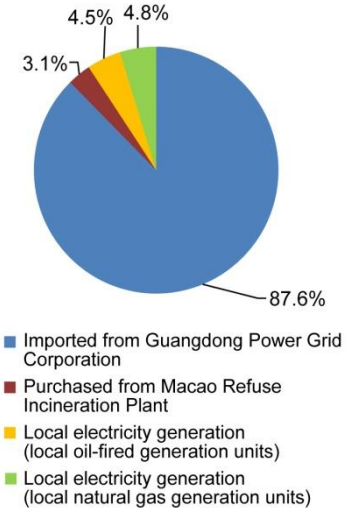


Figure 2.24 Energy structure of Macao in 2014

(Data source: GDSE, 2014)

2.5 Eco-efficiency of the Transport Sector

DPSIR Framework

D	**Driving forces✓**	**P**	**Pressures ✓**	S	States	I	Impacts	R	Responses

Transport sector is one of the main sources that render atmospheric pollutant emissions in Macao, and a pollution source that citizens are easy to feel in their daily life. From 2013 to 2014, the number of motor vehicles in Macao maintained an upward trend and increased by more than 5% (Figure 2.25 and Table 2.9). However, the total lane length of public roads increased by less than 1%, resulting in a constantly increasing motor vehicle density.

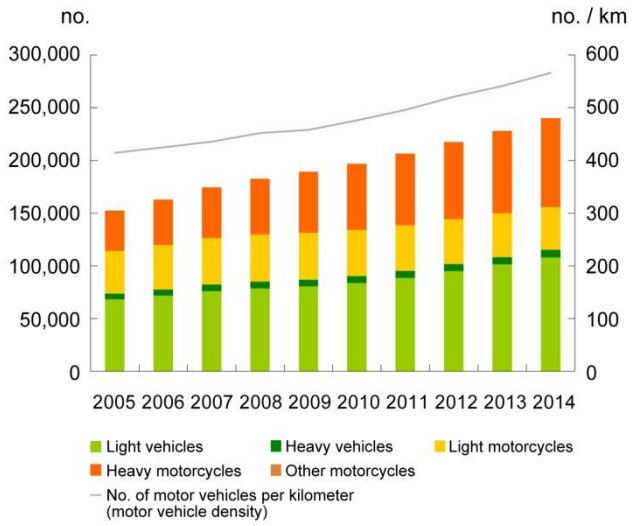


Figure 2.25 Number of motor vehicles and motor vehicle density in the past years
(Data source: DSEC, 2015)

Table 2.9 Numerical data and percentage increase/decrease of motor vehicles between 2013 and 2014

	2013	2014	Percentage increase/decrease
Total number of motor vehicles (no.)	**227,937**	**240,107**	**+5.3%**
-Light vehicles (no.)	101,547	107,991	+6.3%
-Heavy vehicles (no.)	6,937	7,210	+3.9%
-Light motorcycles (no.)	41,455	40,520	-2.3%
-Heavy motorcycles (no.)	77,930	84,303	+8.2%
-Other motorcycles (no.)	68	83	+22.1%
No. of motor vehicles per kilometer (motor vehicle density) (no./km)	541	566	+4.6%

(Data source: DSEC, 2015)

Along with the increasing number of motor vehicles, the fuel consumption from land transport increased in 2014 compared with that in 2013. For the other two categories of transport, the fuel consumption from maritime transport showed a slight decline. According to statistical data, the numbers of ferry crossings and volume of sea freight to and from Macao increased in 2014, so the reduction in fuel consumption may be attributed to the increasing utilization efficiency. As for air transport, flight movements increased significantly. If the fuel utilization efficiency of this sector remains a flat trend, the total fuel consumption will increase. Figure 2.26 and Table 2.10-2.11 display the relevant data.

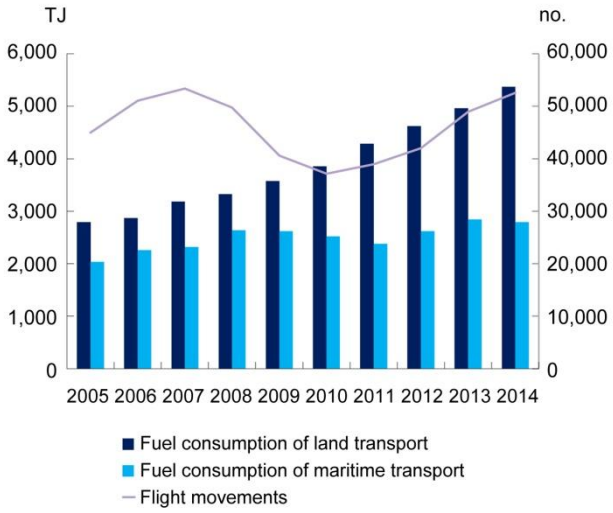


Figure 2.26 Fuel consumption of land and maritime transport as well as flight movements in the past years

(Data source: DSEC and ADA, 2015)

Table 2.10 Numerical data and percentage increase/decrease of fuel consumption of land and maritime transport between 2013 and 2014

(Unit: TJ)	**2013**	**2014**	**Percentage increase/decrease**
Fuel consumption of land transport	4,965	5,371	+8.2%
Fuel consumption of maritime transport	2,844	2,795	-1.7%

Note: (1) Only fuel consumption was included.

(Data source: DSEC, 2015)

Table 2.11 Numerical data and percentage increase/decrease of flight movements between 2013 and 2014

(Unit: no.)	**2013**	**2014**	**Percentage increase/decrease**
Flight movements	48,950	52,559	+7.4%

(Data source: ADA, 2015)

Whereas the estimated emissions from land transport occupied a main proportion of the total emissions from transport sector, the analysis of eco-efficiency of the transport sector was therefore focused on land transport. Figure 2.27 illustrates that although the consistent increase in the number of motor vehicles, the estimated emissions of main pollutants declined gradually starting from 2011, with a more obvious decrease between 2012 and 2013.

In fact, in an effort to control the emissions from motor vehicles, the Macao SAR Government

orderly developed and formulated a series of measures regarding vehicle utilization, new vehicle imports, environmentally-friendly vehicle promotion and fuel optimization, etc., including modifying the *Tax Regulation on Motor Vehicle* in 2012, adopting tax benefits for environmentally-friendly vehicles and issuing the Administrative Regulation No.1/2012 regarding the *Standards for Exhaust Emission from Newly-Imported Motor Vehicles* at the same year, so as to increase the low-emission vehicles portion in Macao, as well as continuously improve vehicle fuel oils.

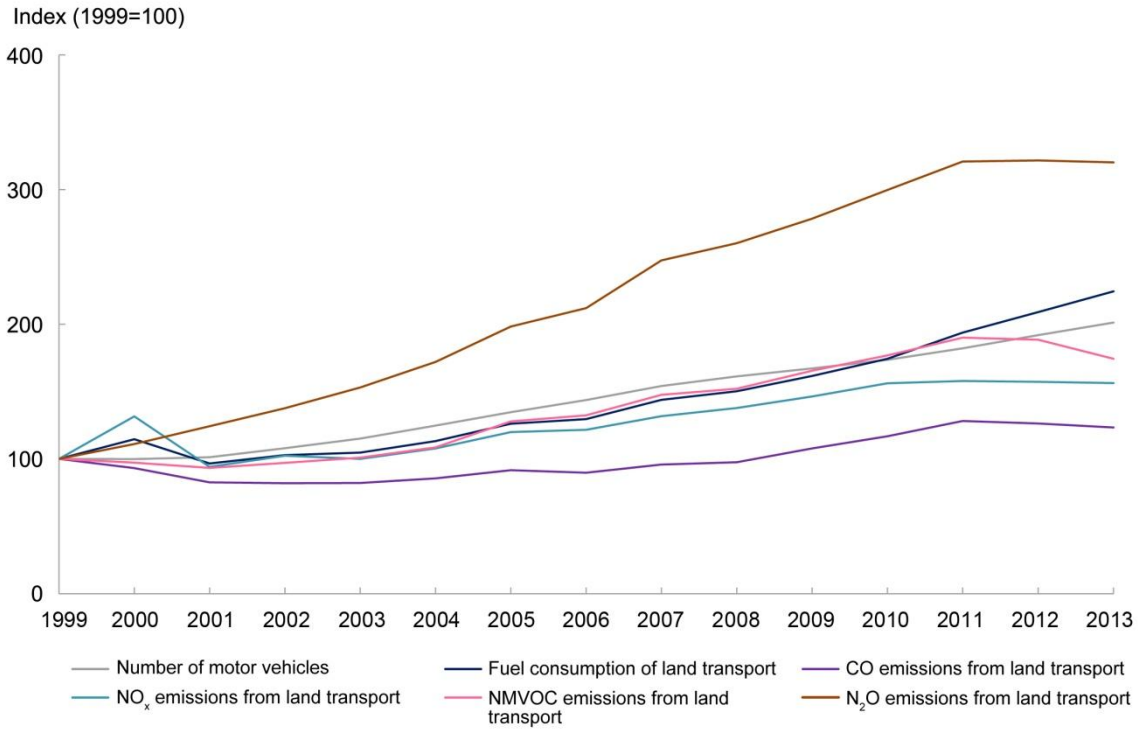


Figure 2.27 Eco-efficiency of the transport sector

(Data source: DSPA and DSEC, 2014)

The comprehensive analysis on the evolution of indicators, including air quality, atmospheric emissions, GHG emissions, eco-efficiency of the energy sector and eco-efficiency of the transport sector, reflects the changing trends of relevant sub-indicators as follows:

 = Good  = Stable  = Unsatisfactory

Description	D	P	S	I	R	Trend[2]
● Air Quality[3]			✓			
➢ Air Quality Index (AQI)						
➢ Respirable suspended particulates with diameter less than 10μm concentrations						
➢ Fine suspended particulates with diameter less than 2.5μm concentrations						
➢ Sulphur dioxide concentrations						
➢ Nitrogen dioxide concentrations						
➢ Ozone concentrations						
➢ Carbon monoxide concentrations						
● General Atmospheric Pollutant Emissions		✓				
➢ Annual estimated emissions of carbon monoxide						
➢ Annual estimated emissions of sulphur oxides						
➢ Annual estimated emissions of nitrogen oxides						
➢ Annual estimated emissions of ammonia						
➢ Annual estimated emissions of non-methane volatile organic compound						
➢ Annual estimated emissions of total suspended particulates						
➢ Annual estimated emissions of respirable suspended particulates with diameter less than 10μm						
➢ Annual estimated emissions of lead						
● Greenhouse Gas Emissions	✓	✓				
➢ Annual estimated emissions of carbon dioxide						
➢ Annual estimated emissions of methane						
➢ Annual estimated emissions of nitrous oxide						
➢ Carbon emission intensity						
● Eco-efficiency of the Energy Sector	✓	✓				
➢ Final energy consumption						
➢ Energy consumption per unit of GDP						

[2] The trends of sub-indicators are assessed with a perspective of environmental protection, and are derived from the change of sub-indicator values between 2013 and 2014

[3] Comparison of trend is made among the monitoring stations that provided sufficient and effective data between 2013 and 2014.

● Eco-efficiency of the Transport Sector	✓	✓				
➢ Number of motor vehicles						
➢ Number of motor vehicles per kilometer (Motor vehicle density)						
➢ Annual fuel consumption of land transport						
➢ Annual fuel consumption of maritime transport						
D: Driving Force, P: Pressure, S: State, I: Impact, R: Response						

According to the new AQI adopted in 2012, $PM_{2.5}$ has been added as a monitoring parameter. In 2014, the air quality in Macao was improved and the number of days recorded with "Good" and "Moderate" air quality increased compared with those in 2013, indicating that the consistent efforts to implement air pollution prevention measures and regional cooperation have a positive effect on air quality improvement. However, $PM_{2.5}$ is the major factor causing AQI of Macao exceeded 100 (i.e. "Poor" air quality level) and the increase of O_3 concentrations is also worth concerning.

Based on the results shown in the emission inventory of atmospheric pollutants and GHGs, along with the reduction in local production of electricity in 2013, the eco-efficiency of the energy sector was further improved. In addition, with the implementation of relevant policies and measures, pollutant emissions from motor vehicles were controlled more effectively in certain extent. However, the pressure on air quality imposed by land transport is still considerable and shall not be neglected.

Control of GHG emissions has been effective, and carbon emission intensity continues to decline. However, potential impacts caused by changes in the economic cycle shall deserve attention.

It is recommended not only to continuously introduce the measures for controlling and reducing the emissions of atmospheric pollutants and GHGs, but also enhance regional cooperation as well as joint prevention and treatment, so as to maintain and improve the air quality of Macao.

3. Water Resources

Global water scarcity is indisputable, and many regions in the world are being threatened by water shortage. Likewise, water is one of the precious and limited resources in Macao. In recent years, along with socioeconomic development, living quality improvement and the prosperous tourism industry, demand for water usage in Macao has been increased continuously. At the moment, under the full support from Mainland China and improvement of water storage facilities at water source, water supply in Macao is relatively stable. But, we shall stay vigilant and use water in a cherished manner. In fact, protecting water resource is a kind of environmental responsibility that everyone needs to understand and fulfill.

Indicators for environmental analysis in this chapter
● Quality of Potable Water ● Potable Water Consumption ● Quality of Coastal Waters ● Wastewater Treatment

3.1 Quality of Potable Water

DPSIR Framework

D	Driving forces	P	Pressures	**S**	**States** ✓	I	Impacts	R	Responses

Apart from a small portion through rainwater collection, most potable water of Macao is sourced from Xijiang River, the mainstream of Pearl River. The raw water from water resources and water storage facilities, after distribution to Macao, is treated in accordance with the quality requirement of potable water in the *Regulation of Water and Wastewater Drainage of Macao (RADARM)* before distribution through the network to households.

The principal problem of potable water quality of Macao is caused by salinity, which depends on chloride concentration in the water. Table 3.1 shows the salinity scale for potable water in Macao.

Table 3.1 Salinity scale for potable water in Macao

Salinity Level	Salinity Index (mg/L)	Conditions of Water Quality
Low	10-250	Water quality well within WHO guidelines for potable water quality
Moderate	251-400	All parameters within standard except chloride and sodium
Fairly high	401-600	All parameters within standard except chloride, sodium and potassium
High	>600	All parameters within standard except chloride, sodium, potassium and magnesium

(Data source: SAAM, 2015)

With substantial coordination and support by the water resources departments of Mainland China and upstream provinces in recent years, relevant water storage facilities are further improved to secure the water supply in Macao. The total rainfall in 2014 was less than that in 2013 (Figure 3.1 and Table 3.2), but under centralized dispatch of water resources from Pearl River and full utilization of the pump stations and reservoirs, the salinity level of potable water from Ilha Verde Water Treatment Plant was maintained at a low-salinity (green) level of 40mg/L (Figure 3.2 and Table 3.2).

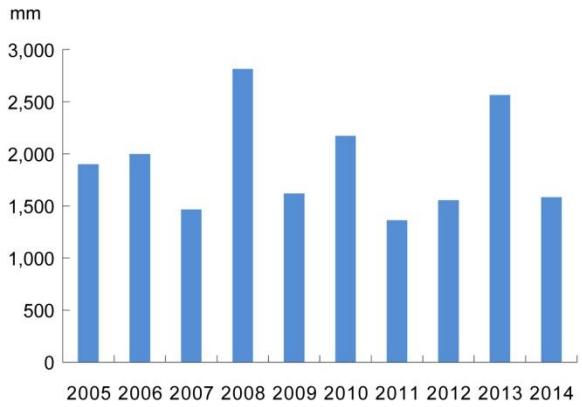


Figure3.1 Rainfall in Macao in the past years
(Data source: SMG, 2015)

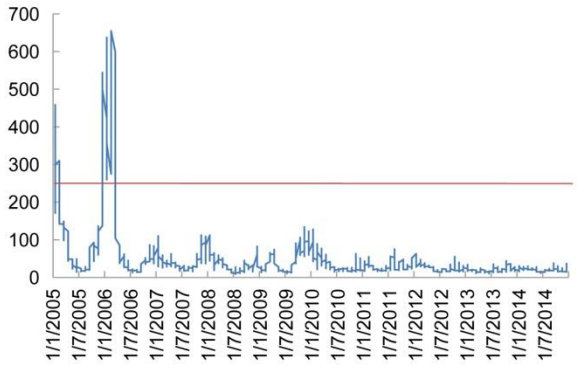


Figure 3.2 Chloride concentration of treated water from the Ilha Verde Water Treatment Plant in the past years
(Data source: IACM, 2015)

In addition, as shown in Figure 3.3 and Table 3.2, the qualified rate of coliform bacteria in the distribution networks of Macao in the past years was satisfactory, and the qualified rates all exceeded 99% in 2014.

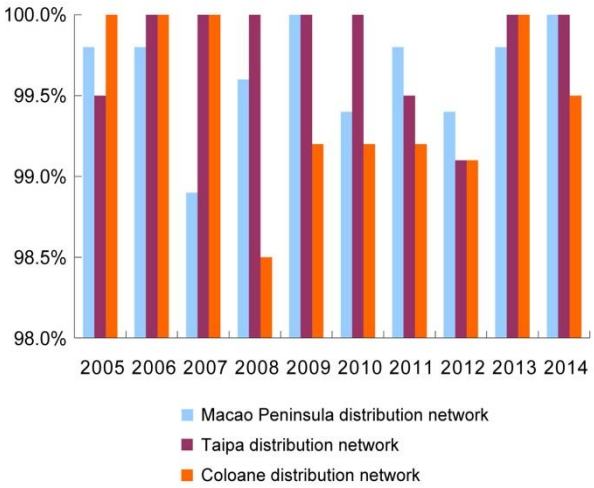


Figure 3.3 Qualified rate of coliform bacteria in the distribution networks of Macao in the past years

(Data source: IACM, 2015)

Table 3.2 Numerical data and percentage increase/decrease of total rainfall, chloride concentration of treated water from the Ilha Verde Water Treatment Plant and qualified rate of coliform bacteria in the distribution networks of Macao between 2013 and 2014

	2013	2014	Percentage increase/decrease
Total rainfall (mm)	2,565.2	1,583.8	-38.3%
Chloride concentration of treated water from the Ilha Verde Water Treatment Plant			
- Highest chloride concentration (mg/L)	43.8	37.9	-13.5%
- Annual average chloride concentration (mg/L)	19.7	20.5	+4.1%
Qualified rate of coliform bacteria in the distribution networks [1]			
- Macao Peninsula distribution network (%)	99.8	100.0	+0.2%
- Taipa distribution network (%)	100.0	100.0	—
- Coloane distribution network (%)	100.0	99.5	-0.5%

Note: (1) [1] According to Decree-law No.46/96/M, namely *Regulation of Water and Wastewater Drainage of Macao (RADARM)*, the water is conformed to the requirement of potable water if the qualified rate of tested samples reaches 95%. (Further details, please refer to Decree-law No.46/96/M, Table I-e (cont.) of Attachment I in the *RADARM*.)

(Data source: SMG and IACM, 2015)

3.2 Potable Water Consumption

DPSIR Framework

D	Driving forces	**P**	**Pressures** ✓	**S**	**States** ✓	I	Impacts	R	Responses

Figure 3.4 shows the evolution of billed water consumption and domestic water consumption in the past years. Since 2010, both indicators have shown increasing trends, with increase of 6.4% and 5.2% respectively in 2014 compared to those of 2013. The billed water consumption has maintained a rising trend over the years while domestic water consumption had a relatively steady increase.

In respect of water consumption per capita, Figure 3.5 indicates that the daily average billed water consumption per capita increased year by year. Despite a slight increase in the daily average domestic water consumption per capita in 2014 compared with that in 2013, the growth rate actually declined in the past few years and the daily average domestic water consumption per capita was lower than those of neighbouring regions (Table 3.4). Meanwhile, the water consumption per ten thousand MOP GDP in 2014 had also declined slightly compared with that in 2013 (Table 3.3).

The Macao SAR Government established the "Working Group on the Development of a Water Conservation Society" to continue the promotion and publicity on water conservation. Along with spread of education and consciousness-raising of public about water conservation, the growth in domestic water consumption was mitigated to some extent in recent years.

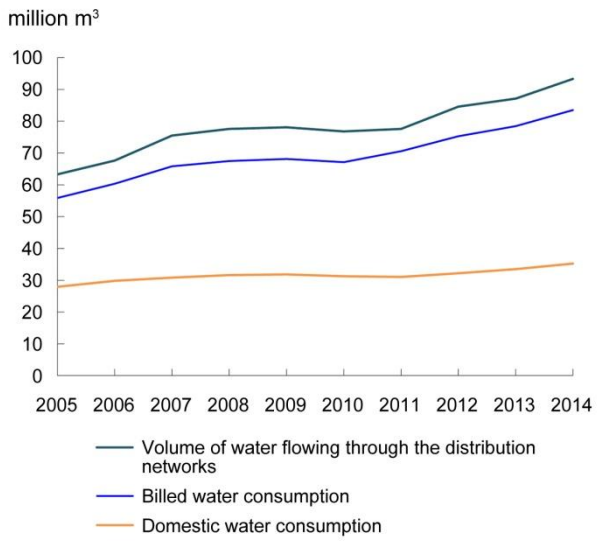


Figure 3.4 Volume of water flowing through the distribution networks, billed water consumption and domestic water consumption in the past years

(Data source: DSAMA and DSEC, 2015)

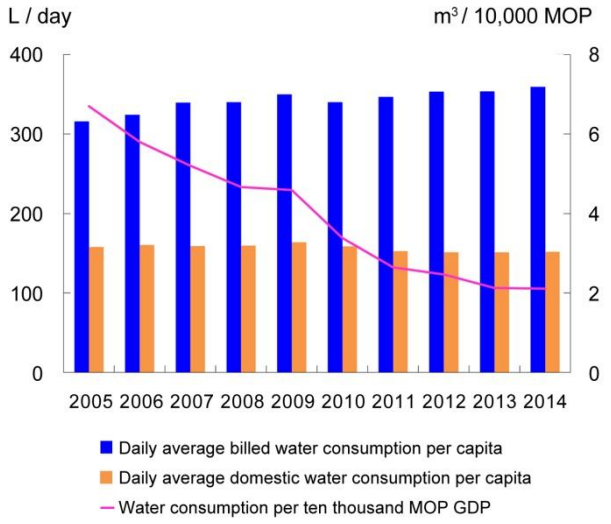


Figure 3.5 Daily average billed/domestic water consumption per capita, and water consumption per ten thousand MOP GDP

(Data source: DSAMA and DSEC, 2015)

Table 3.3 Numerical and percentage increase/decrease of billed water consumption, domestic water consumption, daily average billed/domestic water consumption per capita, and water consumption per ten thousand MOP GDP between 2013 and 2014

	2013	2014	Percentage increase/decrease
Billed water consumption ('000 m^3)	78,447	83,486	+6.4%
Domestic water consumption ('000 m^3)	33,514	35,266	+5.2%
Daily average billed water consumption per capita [1] (L/ capita·day)	353.8	359.5	+1.6%
Daily average domestic water consumption per capita [2] (L/ capita·day)	151.1	151.9	+0.5%
Water consumption per ten thousand MOP GDP [3] (m^3/10,000 MOP)	2.13[r]	2.11	-0.9%

Notes: (1) [1] Daily average billed water consumption per capita = billed water consumption for the whole year ÷ (end-year population × days of the year).

(2) [2] Daily average domestic water consumption per capita = domestic water consumption for the whole year ÷ (end-year population × days of the year).

(3) [3] Water consumption per ten thousand MOP GDP refers to the amount of water consumed for producing ten thousand MOP GDP (at current prices).

(4) [r] Revised figures.

(Data source: DSAMA and DSEC, 2015)

Table 3.4 Environmental knowledge

Daily average water consumption per capita and daily average domestic water consumption per capita in 2014

City/Region	Daily average water consumption per capita (L/capita·day)	Daily average domestic water consumption per capita (L/capita·day)	Data sources
Macao[1]	359.5	151.9	*Report on the State of the Environment of Macao 2014*, Macao
Hong Kong[2]	356.2	192.3	*Water Supplies Department Annual Report 2013/2014*, Hong Kong
Taipei[3]	327	219	Taipei City Statistical Database, Taipei

Notes: (1) [1] Daily average billed water consumption per capita = billed water consumption for the whole year ÷ (end-year population × days of the year); daily average domestic water consumption per capita = domestic water consumption for the whole year ÷ (end-year population × days of the year).

(2) [2] This is 2013 data, excluding sea water consumption. Daily average water consumption per capita = water consumption per capita ÷ days of the year; daily average domestic water consumption per capita = domestic water consumption ÷ (population served with drinking water × days of the year).

(3) [3] Daily average water consumption per capita = (water sold - municipal consumption - industrial consumption - consumption in support of Taiwan Water Corporation) ÷ (days recorded in the meter × mid-year population within the water supply area); daily average household water consumption per capita = household water consumption (water consumption - commercial consumption – government & school consumption) ÷ (days recorded in the meter × mid-year population within the water supply area)

Figure 3.6 and Table 3.5 analyze the evolution of billed water consumption by sector and the respective percentage, and indicate that commercial and domestic water consumptions have the highest percentages. The former is the major factor that increased billed water consumption.

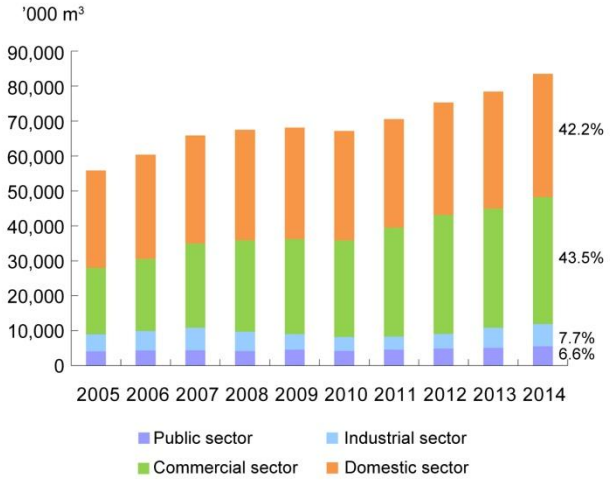


Figure 3.6 Billed water consumption by sector and the respective percentages in the past years

(Data source: DSAMA, 2015)

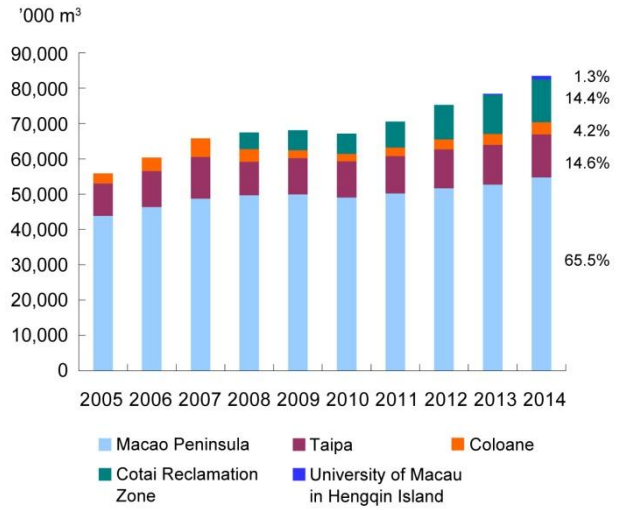


Figure 3.7 Billed water consumption by geographical area and the respective percentages in the past years

(Data source: DSAMA, 2015)

Table 3.5 Numerical data and percentage increase/decrease of billed water consumption by sector between 2013 and 2014

(Unit: '000 m^3)	2013		2014		Percentage increase/decrease
Public sector	5,105	(6.5%)	5,523	(6.6%)	+8.2%
Industrial sector	5,752	(7.3%)	6,400	(7.7%)	+11.3%
Commercial sector	34,075	(43.4%)	36,297	(43.5%)	+6.5%
Domestic sector	33,514	(42.7%)	35,266	(42.2%)	+5.2%

Note: (1) Numerical data in the brackets refers to the percentage of billed water consumption by sector over total billed water consumption in Macao. The sum may not be 100% due to round-off calculation.

(Data source: DSAMA, 2015)

In respect of regional distribution of water consumption, the billed water consumption by geographical area in 2014 increased in varying degrees compared with 2013. The most populous Macao Peninsula is still the region with the highest water consumption percentage, followed by Taipa (Figure 3.7 and Table 3.6). Along with operation of various tourism projects in Cotai Reclamation Zone in the past years, the proportion of water consumption in this zone increased concurrently. Meanwhile, the statistical data of billed water consumption of University of Macau in Hengqin Island was added in 2014.

Table 3.6 Numerical data and percentage increase/decrease of billed water consumption by geographical area between 2013 and 2014

(Unit: '000 m^3)	2013		2014		Percentage increase/decrease
Macao Peninsula	52,701	（67.2%）	54,721	（65.5%）	+3.8%
Taipa	11,260	（14.4%）	12,174	（14.6%）	+8.1%
Coloane	3,085	（3.9%）	3,487	（4.2%）	+13.0%
Cotai Reclamation Zone	11,053	（14.1%）	12,060	（14.4%）	+9.1%
University of Macau in Hengqin Island	348	（0.4%）	1,044	（1.3%）	+200.0%

Note: (1) Numerical data in the brackets refers to the percentages of billed water consumption by geographical area among total billed water consumption in Macao.

(Data source: DSAMA, 2015)

Leakage rate control in the distribution network is useful to reduce wastage on potable water. In the *Macao's Water Conservation Planning Outline*, the leakage rate in the distribution network of 2015 is targeted at 10%. Notwithstanding the increase in leakage rate of 2014 compared to that in 2013, the leakage rate was fluctuating in a declining trend in recent years (Figure 3.8 and Table 3.7).

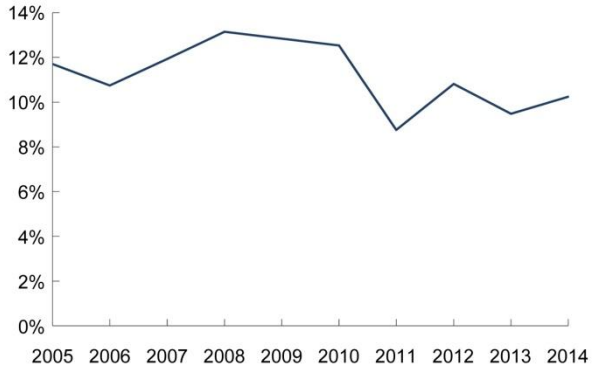


Figure 3.8 Leakage rate in the distribution network in the past years

(Data source: SAAM, 2015)

Table 3.7 Numerical data and percentage increase/decrease of leakage rate in the distribution network between 2013 and 2014

	2013	2014	Percentage increase/decrease
Leakage rate in the distribution network (%)	9.5	10.2	+7.4%

(Data source: SAAM, 2015)

3.3 Quality of Coastal Waters

DPSIR Framework

D	Driving forces	P	Pressures	**S**	**States ✓**	I	Impacts	R	Responses

To protect water environment, the Macao SAR Government continues to monitor the quality of coastal waters and public beaches in order to understand the changes of water quality. Meanwhile, the Macao SAR Government continues to implement measures like removing maritime wastes and water lettuces in addition to promoting awareness of environmental protection and maritime cleanliness with fishermen during Spring Festival and fishing-off season, for the purpose of prevention of maritime pollution.

Figure 3.9 shows the distribution of water monitoring points. According to the 2014 *Water Quality Monitoring and Assessment Report on Macao Waters* issued by the Public Health Laboratory (LSP) of SS, the Seawater Quality Standards - Category III (applicable to general industrial water consumption zones and coastal resort zones) defined in the *Sea Water Quality Standards* (GB3097-97) of China was adopted for the analysis of the water quality. Figure 3.10 and Table 3.8 show the evolution of total evaluation index, non-metal evaluation index and heavy metal evaluation index.

Despite an increase in heavy metal evaluation index of 2014 compared with 2013, the heavy metal evaluation index, in general, is at a relative low level, similar to that of 2008 after a substantial drop from peak level in 2011. However, the non-metal evaluation index fluctuated around the standard value 1.0, which means that non-metal pollutions undermined the quality of coastal waters of Macao. Driven by the increase of the two indices, the total evaluation index of 2014 showed a minor increase compared with that of 2013, but still remained at around the mid-level of 0.5.

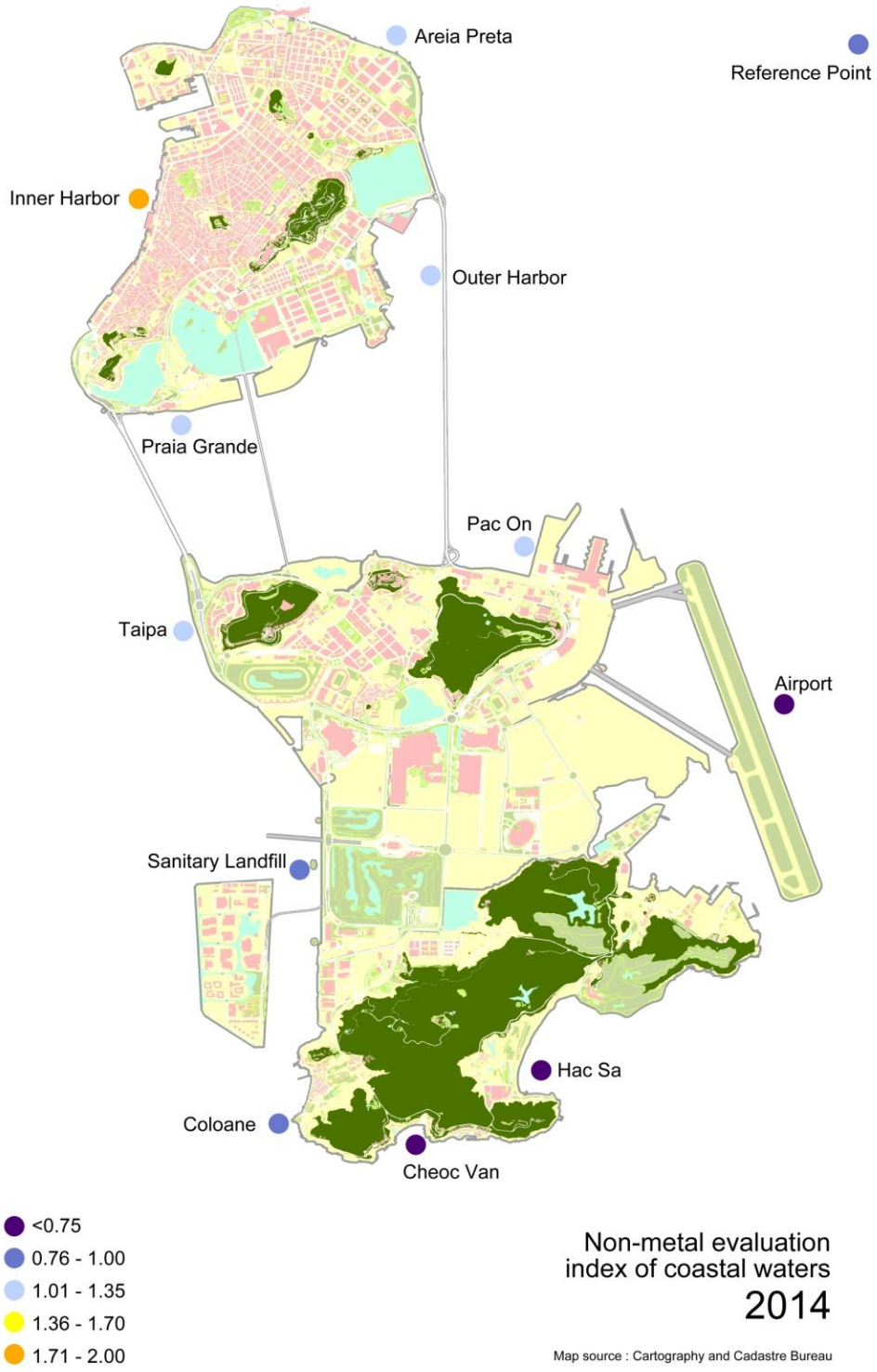
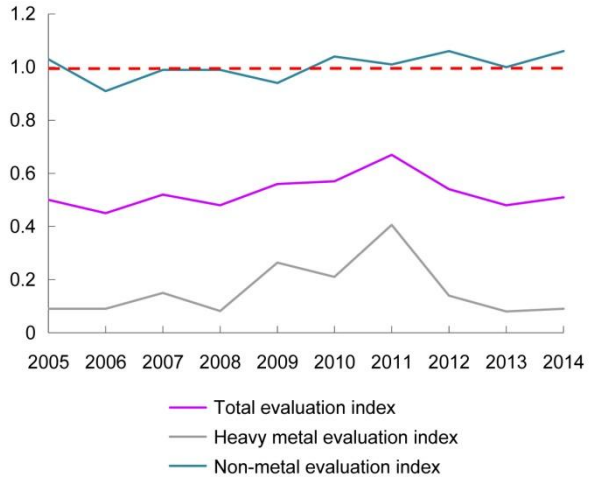


Figure 3.9 Distribution of water monitoring points in coastal waters of Macao in 2014

(Data source: SS, 2015)



Note: (1) The red dotted line indicates the upper limit (the standard value: 1.00).

Figure 3.10 Evaluation index of coastal waters of Macao in the past years

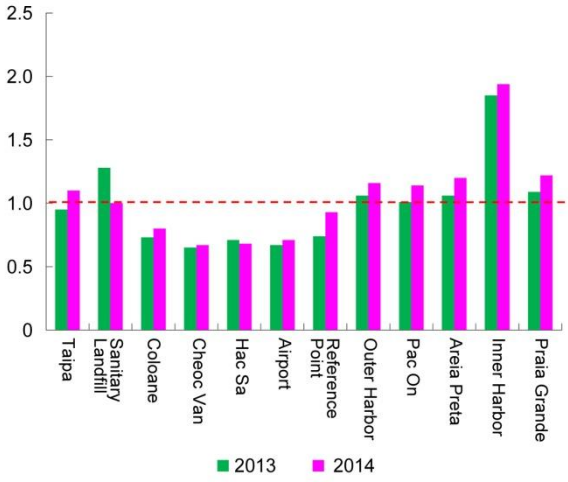
(Data source: SS, 2015)

Table 3.8 Numerical data and percentage increase/decrease of comprehensive evaluation index of coastal waters of Macao between 2013 and 2014

	2013	2014	Percentage increase/decrease
Total evaluation index	0.48	0.51	+6.3%
Heavy metal evaluation index	0.08	0.09	+12.5%
Non-metal evaluation index	1.00	1.06	+6.0%

(Data source: SS, 2015)

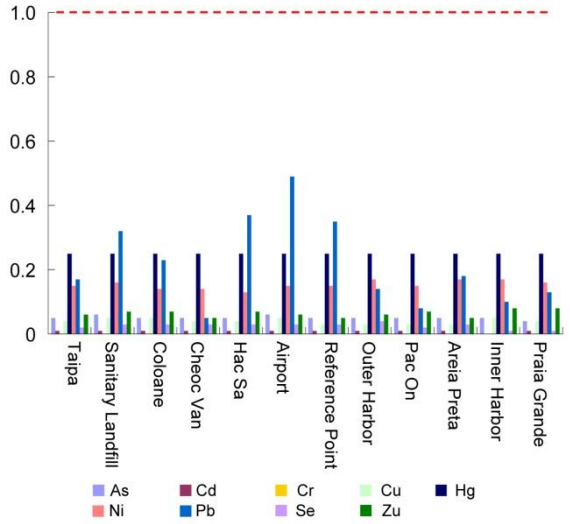
The analysis of Figure 3.11-3.12 and Table 3.9 shows the non-metal evaluation index and heavy metal evaluation index at various coastal water monitoring points in 2014. It can be seen that the non-metal evaluation indices at Taipa, Outer Harbor, Pac On, Areia Preta, Inner Harbor and Praia Grande all exceeded the standard value, with the worst condition found at Inner Harbor. Meanwhile, no heavy metal evaluation index recorded at any monitoring point exceeded the standard value. Heavy metals like lead (Pb), mercury (Hg) and nickel (Ni) were of relatively higher concentration, which overall was similar to that monitored at the reference point.



Note: (1) The red dotted line indicates the upper limit (the standard value: 1.00).

Figure 3.11 Non-metal evaluation index for water quality by monitoring point in 2014

(Data source: SS, 2015)



Note: (1) The red dotted line indicates the upper limit (the standard value: 1.00).

Figure 3.12 Heavy metal evaluation index for water quality by monitoring point in 2014

(Data source: SS, 2015)

Table 3.9 Numerical data and percentage increase/decrease of non-metal evaluation index by monitoring point between 2013 and 2014

	2013	2014	Percentage increase/decrease
Taipa	0.95	1.10	+15.8%
Sanitary Landfill	1.28	1.00	-21.9%
Coloane	0.73	0.80	+9.6%
Cheoc Van	0.65	0.67	+3.1%
Hac Sa	0.71	0.68	-4.2%
Airport	0.67	0.71	+6.0%
Reference Point	0.74	0.93	+25.7%
Outer Harbor	1.06	1.16	+9.4%
Pac On	1.01	1.14	+12.9%
Areia Preta	1.06	1.20	+13.2%
Inner Harbor	1.85	1.94	+4.9%
Praia Grande	1.09	1.22	+11.9%

(Data source: SS, 2015)

Organic pollution and eutrophication are important factors which contribute to outbreak of red tide. Hence, the *Report* reflects the eutrophication of waters through the use of eutrophic index and adopts chlorophyll-a concentrations as supporting data to determine the richness of planktonic algae.

Figure 3.13 and Table 3.10 illustrate that except for the monitoring points of Sanitary Landfill, Cheoc Van, Hac Sa and Airport, the eutrophic indices of other monitoring points in 2014 increased compared with those in 2013. As the eutrophic index showed a slight increase at the reference point, it indicated that the eutrophication of neighboring waters has been worsened, which may be related to increased maritime activities like projects at Pearl River Estuary and east coast of Macao. The monitoring point of Inner Harbor presented the worst condition of eutrophication.

The chlorophyll-a concentrations of all monitoring points decreased in 2014 compared with those in 2013, indicating a decrease of algae growth and activities in waters. (Figure 3.14 and Table 3.11)

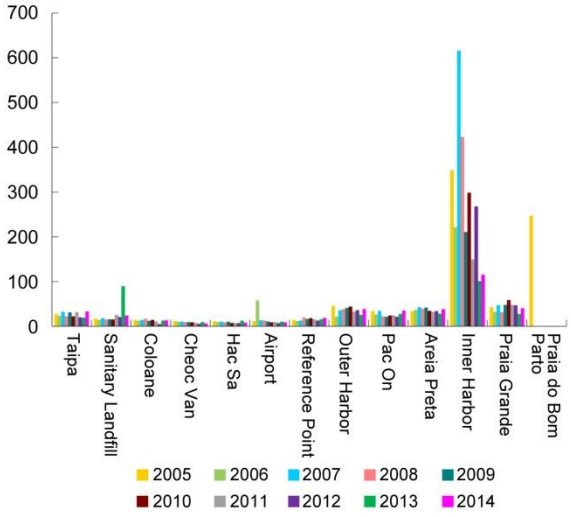


Figure 3.13 Eutrophic index by monitoring point in the past years
(Data source: SS, 2015)

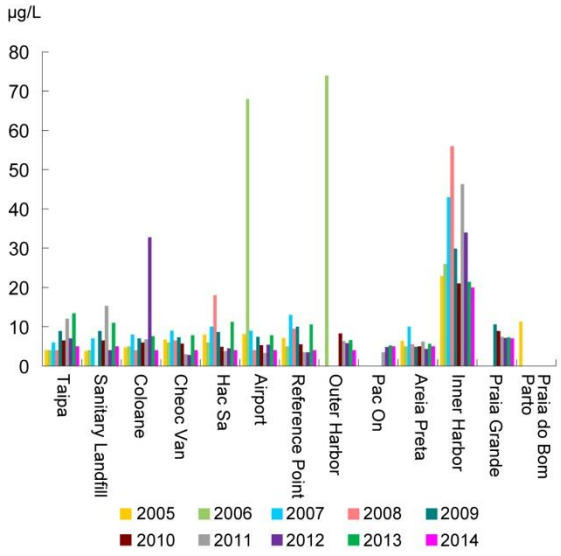


Figure 3.14 Chlorophyll-a concentration by monitoring point in the past years
(Data source: SS, 2015)

Table 3.10 Numerical data and percentage increase/decrease of eutrophic index by monitoring point between 2013 and 2014

	2013	2014	Percentage increase/decrease
Taipa	19.1	33.0	+72.8%
Sanitary Landfill	89.4	24.1	-73.0%
Coloane	12.6	13.2	+4.8%
Cheoc Van	9.3	6.5	-30.1%
Hac Sa	12.8	8.2	-35.9%
Airport	10.1	8.9	-11.9%
Reference Point	15.5	18.5	+19.4%
Outer Harbor	25.5	38.5	+51.0%
Pac On	27.4	35.1	+28.1%
Areia Preta	27.8	38.3	+37.8%
Inner Harbor	101.1	115.3	+14.0%
Praia Grande	27.6	40.3	+46.0%

(Data source: SS, 2015)

Table 3.11 Numerical data and percentage increase/decrease of chlorophyll-a concentration by monitoring point between 2013 and 2014

(Unit: μg/L)	2013	2014	Percentage increase/decrease
Taipa	13.4	5.0	-62.7%
Sanitary Landfill	11.0	5.0	-54.5%
Coloane	7.6	4.0	-47.4%
Cheoc Van	7.8	4.0	-48.7%
Hac Sa	11.2	4.0	-64.3%
Airport	7.8	4.0	-48.7%
Reference Point	10.6	4.0	-62.3%
Outer Harbor	6.6	4.0	-39.4%
Pac On	5.2	5.0	-3.8%
Areia Preta	5.6	5.0	-10.7%
Inner Harbor	21.4	20.0	-6.5%
Praia Grande	7.3	7.0	-4.1%

(Data source: SS, 2015)

Generally speaking, the quality of coastal waters of Macao in 2014 was slightly inferior to that in 2013 as reflected by the evaluation index of coastal waters of Macao.

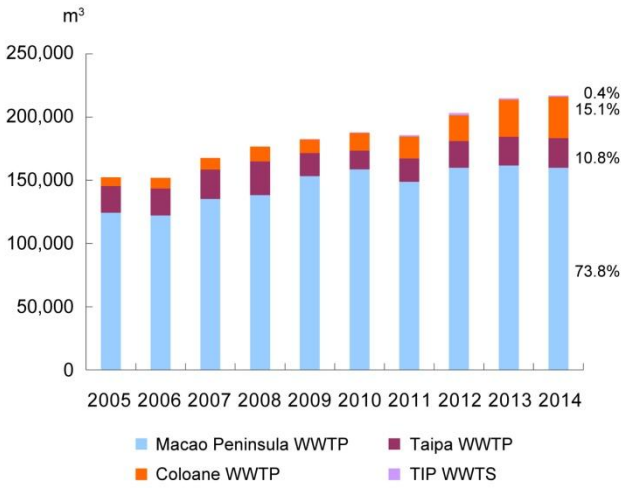
3.4 Wastewater Treatment

DPSIR Framework

D	Driving forces	**P**	**Pressures ✓**	S	States	I	Impacts	R	Responses

Wastewater shall be appropriately treated before discharging into the receiving waters to minimize the burden and pollution to water environment. Nowadays, Macao has established five wastewater treatment plants/stations (WWTPs/WWTSs), i.e. Macao Peninsula WWTP, TIP WWTS, Taipa WWTP, Macau International Airport WWTS and Coloane WWTP.

As shown in Figure 3.15 and Table 3.12, the daily mean treated volume of each WWTP/WWTS in Macao increased slightly in 2014 compared with that in 2013. Among them, Macao Peninsula WWTP accounted for the largest proportion. Besides, with the development of Shek Pai Wan and its surrounding communities, the treated volume of Coloane WWTP was increasing year by year.



Note: (1) The treated volume of Taipa WWTP includes the treated volume of Macau International Airport WWTS.

Figure 3.15 Daily mean treated volume by WWTP/WWTS and the respective percentage in the past years

(Data source: DSPA, 2015)

Table 3.12 Numerical data and percentage increase/decrease of daily mean treated volume by WWTP/WWTS of Macao between 2013 and 2014

(Unit: m^3)	2013		2014		Percentage increase /decrease
Daily mean treated volume	**214,802**		**216,808**		**+0.9%**
Macao Peninsula WWTP	161,581	（75.2%）	159,955	（73.8%）	-1.0%
Taipa WWTP	22,776	（10.6%）	23,338	（10.8%）	+2.5%
Coloane WWTP	29,408	（13.7%）	32,701	（15.1%）	+11.2%
TIP WWTS	1,037	（0.5%）	815	（0.4%）	-21.4%

Notes: (1) Numerical data in the brackets refers to the percentage of daily mean treated volume by WWTP/WWTS in Macao. The sum may not be 100% due to round-off calculation.

(2) The treated volume of Taipa WWTP includes the treated volume of Macau International Airport WWTS.

(Data source: DSPA, 2015)

The comprehensive analysis on the evolution of indicators, including quality of potable water, potable water consumption, quality of coastal waters and wastewater treatment, reflects the changing trends of relevant sub-indicators as follows:

 = Good  = Stable  = Unsatisfactory

Description	D	P	S	I	R	Trend[1]
● Quality of Potable Water			✓			
➢ Rainfall						
➢ Chloride concentration of treated water from the Ilha Verde Water Treatment Plant						
➢ Qualified rate of coliform bacteria in the distribution networks						
● Potable Water Consumption		✓	✓			
➢ Volume of water flowing through the distribution networks						
➢ Leakage rate in the distribution network						
➢ Domestic water consumption						

[1] The trends of sub-indicators are assessed with a perspective of environmental protection, and are derived from the change of sub-indicator values between 2013 and 2014.

➢ Water consumption per ten thousand MOP GDP							
➢ Daily average billed water consumption per capita							
➢ Percentage of water consumption by sector							—[2]
● Quality of Coastal Waters			✓				
➢ Non-metal evaluation index							
➢ Heavy metal evaluation index							
➢ Total evaluation index							
➢ Eutrophic index							
➢ Chlorophyll-a concentration							
● Wastewater Treatment		✓					
➢ Daily mean treated volume by WWTPs/WWTSs							
D: Driving Force, P: Pressure, S: State, I: Impact, R: Response							

The portable water in Macao had relatively good quality in 2014. In the meantime, under the *Macao Recycled Water Development Plan (2013-2022)* introduced by the Macao SAR Government and publicity of popularizing water conservation, the water conservation awareness of citizens has been enhanced and the growth rate of domestic water consumption has slowed down in recent years; however, water consumptions in other sectors grow at a faster rate, and relevant water conservation work is yet to be reinforced. Besides, specific measures shall be taken to improve further the effectiveness of water resource utilization.

On the whole, the quality of coastal waters in 2014 was poorer than that in 2013. It is recommended to reduce the pollution caused by marine activities and operations, continuously facilitate water quality monitoring work, improve the supervision on drainage network, progressively replace the existing combined sewers with separation system for rainwater and wastewater, and continue the upgrading and optimization work for wastewater treatment facilities.

Meanwhile, it is required to continue reinforcing the communication and cooperation with other regions, and establish emergency plans, in order to further protect water environment and ensure the security of water supply.

[2] It is not applicable as distribution percentage is not suitable for trend analysis.

4. Waste

Waste treatment is always an important environmental issue confronted by city administrators. In addition to choosing the appropriate waste treatment and disposal means, it is also necessary to form a complete set of efficient waste collection and waste transport, to control potential environmental hygiene problems occurring during waste treatment, and strengthen public's awareness on cherishing resources and reducing waste.

Waste can be considered as "Misplaced resource". Under the sustainable development concept, nowadays waste management strategy emphasis on reduction at source and resource recycling. In fact, waste generation is closely linked with the living habit of everyone. If everyone makes his own contribution, jointly cherish and make better use of resources, avoid wasting, and reduce waste at source or further recycle, the aforesaid waste management strategy will achieve better results.

Indicators for environmental analysis in this chapter
● Waste Generation ● Recycling and Ultimate Disposal of Waste

4.1 Waste Generation

DPSIR Framework

D	Driving forces	**P**	**Pressures** ✓	S	States	I	Impacts	R	Responses

Waste in Macao mainly comprises domestic waste, industrial and commercial waste as well as construction waste; it also includes some special and hazardous waste, waste from electricity generation, waste vehicles and sea mud, etc.

Among them, domestic waste and industrial and commercial waste are usually transferred to Macao Refuse Incineration Plant for environmental sound treatment through incineration. As shown in Figure 4.1 and Table 4.1, the waste transferred to Macao Refuse Incineration Plant for treatment and the daily mean quantity of urban domestic waste per capita in 2014, compared with those in 2013, had increased by 15.3% and 9.4% respectively and remained at a highest level in recent years It should be noted that the waste transferred to Macao Refuse Incineration Plant for treatment and the daily mean quantity of urban domestic waste per capita experienced a much higher growth rate than that of the end-year population and visitor arrivals (4.7% and 7.5% respectively), which on one hand could be caused by the noticeable increase in quantity of waste generated by citizens in their daily life and on the other hand by the increase in quantity of industrial and commercial waste. The above situation should be of urgent concern.

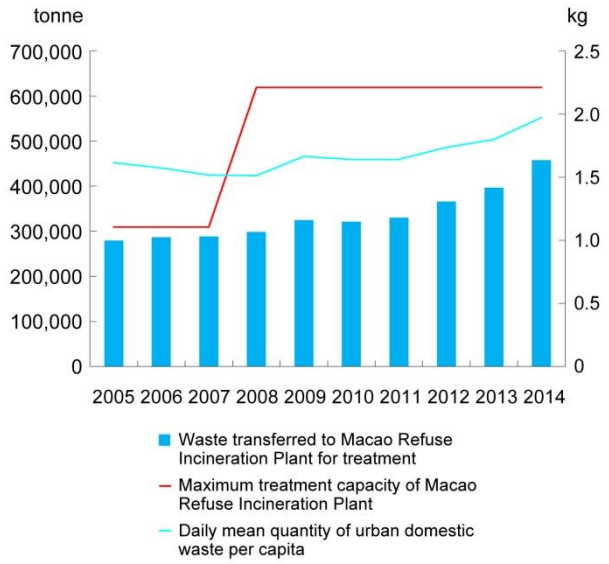


Figure 4.1 Waste transferred to Macao Refuse Incineration Plant for treatment and daily mean quantity of urban domestic waste per capita in the past years

(Data source: DSPA, 2015)

Table 4.1 Numerical data and percentage increase/decrease of waste transferred to Macao Refuse Incineration Plant for treatment, daily mean quantity of urban domestic waste per capita, quantity of special and hazardous waste and waste generated by the electricity supply company between 2013 and 2014

	2013	2014	Percentage increase/decrease
Waste transferred to Macao Refuse Incineration Plant for treatment [1] (tonne)	396,738	457,420	+15.3%
Daily mean quantity of urban domestic waste per capita (kg)	1.80	1.97	+9.4%
Quantity of special and hazardous waste (tonne)	2,667	3,118	+16.9%
Quantity of waste generated by the electricity supply company (tonne)	1,830.2	2,164.0	+18.2%

Note: (1) [1] Quantify of waste transferred to the Macao Refuse Incineration Plant for treatment includes urban domestic waste, medical waste and dehydrated sludge.

(Data source: DSPA, 2015)

Table 4.2 Environmental Knowledge

Daily mean quantity of domestic waste per capita in 2013

City/Region	Daily mean quantity of domestic waste per capita (kg/capita · day)	Data source
Macao	1.80 [1]	*Report on the State of the Environment of Macao 2014*, Macao
Beijing	0.87 [2]	*Beijing Statistical Yearbook 2014*, Beijing
Shanghai	0.83 [2]	*China Statistical Yearbook 2014*, China
Guangzhou	0.84 [2]	*Guangzhou Statistics Information Handbook 2014*, Guangzhou
Hong Kong	1.33 [3]	*Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2013*, Hong Kong
Taipei	0.27 [4]	Taipei Statistical Database, Taipei

Notes: (1) [1] Daily mean quantity of urban domestic waste per capita = quantity of urban domestic waste ÷ mid-year population ÷ days of the period.

(2) [2] Daily mean quantity of domestic waste for removal per capita = removal quantity of domestic waste ÷ resident population (end-year) ÷ days of the period.

(3) [3] Daily mean quantity of municipal solid waste per capita = quantity of municipal solid waste (daily mean quantity) ÷ mid-year population; municipal solid waste includes: domestic waste + commercial waste + industrial waste.

(4) [4] Daily mean quantity of waste for removal per capita = removal quantity of waste ÷ days of the period ÷ mid-year population within the waste removal area. Waste for removal includes waste treated through incineration and sanitary landfill as well as sludge, but excluding recyclable resources, industrial waste and transferred waste.

In respect of the physical composition of urban domestic waste, wood and paper/cardboard (Figure 4.2 and Table 4.3) accounted for higher proportion in 2014 compared with 2013. It gained a significant increase in proportion, attributed to the increase of industrial and commercial waste, packaging waste, and waste of printing materials. At the same time, plastics reduced obviously in proportion.

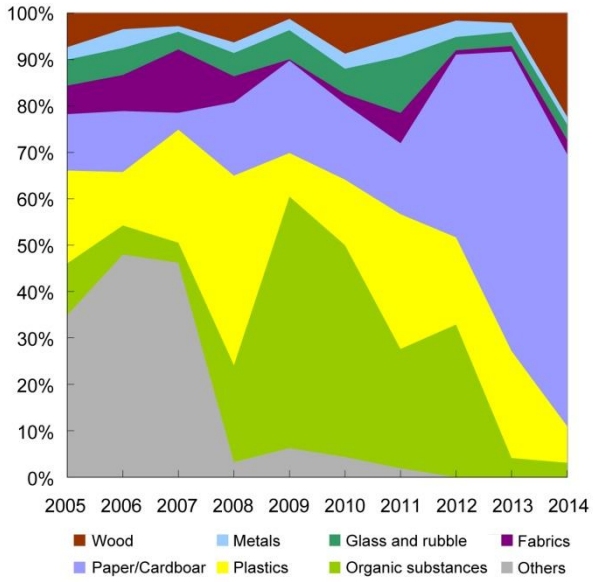


Figure 4.2 Physical composition of urban domestic waste in the past years

(Data source: DSPA, 2015)

Table 4.3 Physical composition of urban domestic waste between 2013 and 2014

	2013	2014
Wood	2.1%	22.3%
Metals	2.0%	1.7%
Glass and rubble	3.0%	3.3%
Fabrics	1.2%	3.1%
Paper / cardboard	64.5%	58.7%
Plastics	23.1%	7.9%
Organic substances	4.1%	3.1%

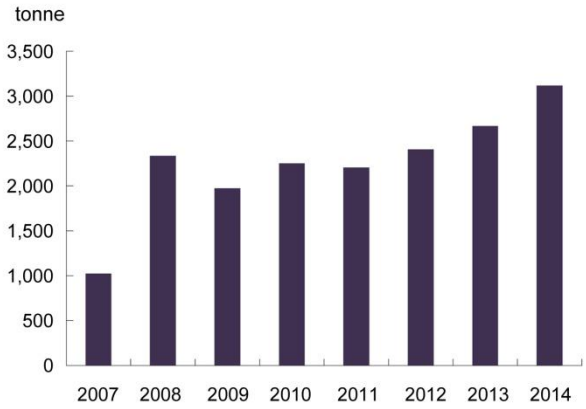
Note: (1) The sum may not be 100% due to round-off calculation.

(Data source: DSPA, 2015)

Besides the urban domestic waste, there is also a variety of other type of waste generated in Macao. Figure 4.3-4.5 and Table 4.1 and 4.4 respectively show the quantity of special and hazardous waste transferred for treatment, waste generated by electricity supply company and quantity of waste vehicles over the years.

Among them, special and hazardous waste transferred for treatment mainly comprises waste tires and slaughterhouse waste, and also includes hazardous waste, medical waste, carcasses of horses and dogs, waste oil and solidified hazardous waste, etc.. Waste generated by electricity supply company includes oil waste, fly ash, incombustibles and others. Such waste increased substantially in 2014 compared with that in 2013. The quantity of waste vehicles in 2014 was 9,390,

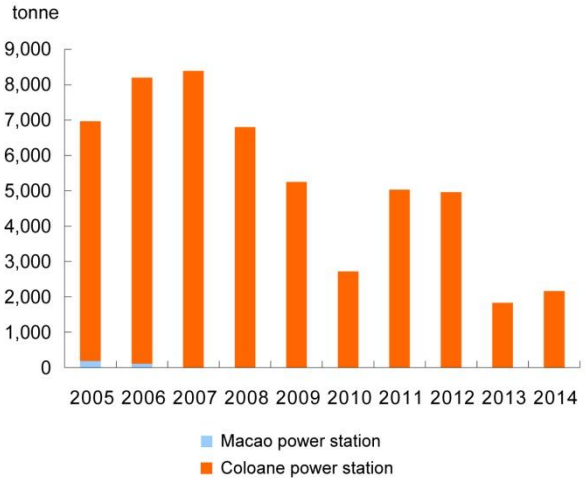
a slight increase compared with that in 2013. This quantity took up 4% of the total quantity of vehicles and 46% of the total quantity of newly registered vehicles respectively in 2014.



Note: (1) The Special and Hazardous Waste Treatment Plant in Macao has been put into operation since May of 2007, thus its annual treated quantity data was published from the year of 2008.

Figure 4.3 Quantity of special and hazardous waste transferred for treatment in the past years

(Data source: DSPA, 2015)



Note: (1) Operation of the Macao power station has been terminated since 2007.

Figure 4.4 Solid waste generated by the electricity supply company in the past years

(Data source: CEM, 2015)

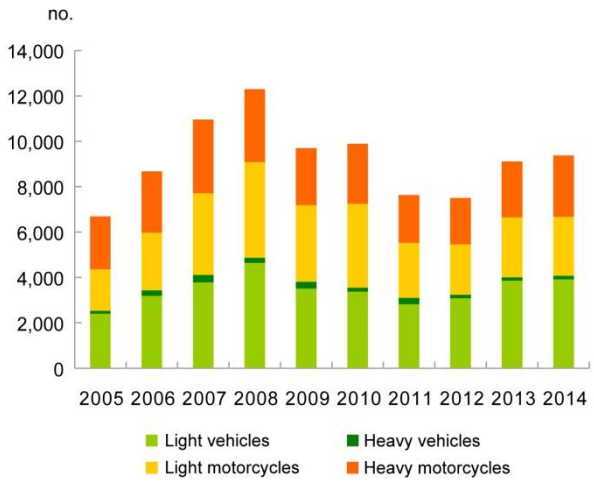


Figure 4.5 Quantity of waste vehicles in the past years

(Data source: DSAT, 2015)

Table 4.4 Numerical data and percentage increase/decrease of quantity of waste vehicles between 2013 and 2014

(Unit: no.)	**2013**	**2014**	**Percentage increase/decrease**
Total number of waste vehicles	**9,122**	**9,390**	+2.9%
- Light vehicles	3,856	3,920	+1.7%
- Heavy vehicles	146	153	+4.8%
- Light motorcycles	2,646	2,597	-1.9%
- Heavy motorcycles	2,464	2,709	+9.9%

Note: (1) There were 2 waste industrial machines and 8 semi-trailers in 2013, 2 waste industrial machines and 9 semi-trailers in 2014 respectively.

(Data source: DSAT, 2015)

4.2 Recycling and Ultimate Disposal of Waste

DPSIR Framework

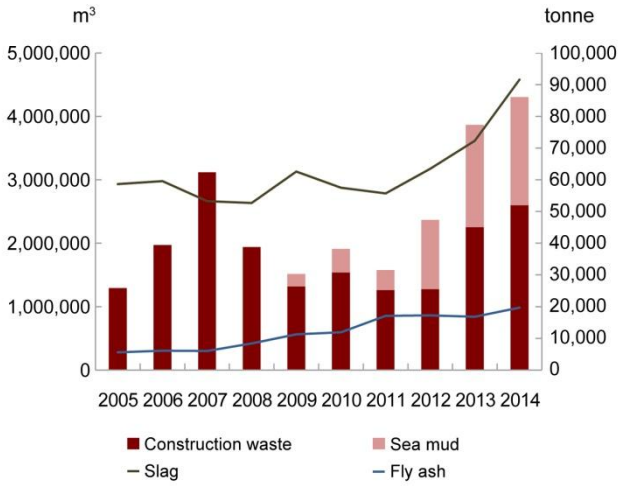
D	Driving forces	P	Pressures	S	States	I	Impacts	**R**	**Responses✓**

After incineration, the remaining fly ash, slag, construction waste, sea mud will be ultimately disposed in landfill.

Figure 4.6 shows the changing quantities of waste disposed in landfill over the years. Among them, quantities of fly ash and slag are related to the waste quantity transferred to the Macao Refuse

Incineration Plant for treatment, and they increased substantially by 17.0% and 26.7% respectively in 2014 compared with 2013.

In 2014, the construction waste saw a dramatic increase of 15.4% compared with that in 2013, which exerted tremendous and inevitable pressure on the construction waste landfill. At the moment, the Macao SAR Government is exploring a potential project of regional cooperation for the treatment the inert construction material after its pre-treatment, in order to mitigate the pressure.



Note: (1) Sea mud is a kind of excavation material generated in civil works, its data was published from the year of 2009.

Figure 4.6 Waste disposed in landfill in the past years

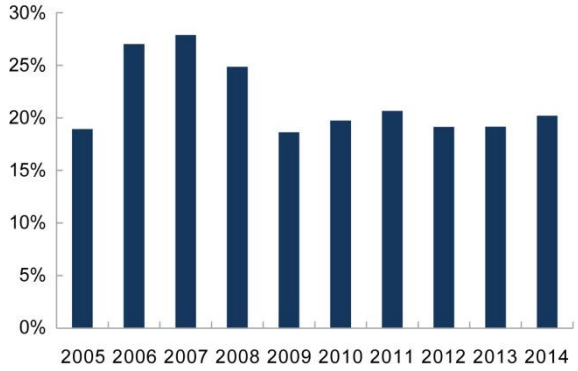
(Data source: DSPA, 2015)

Table 4.5 Numerical data and percentage increase/decrease of volume of construction waste, sea mud, slag and fly ash between 2013 and 2014

	2013	2014	Percentage increase/decrease
Construction waste (m^3)	2,251,877	2,597,652	+15.4%
Sea mud (m^3)	1,616,290	1,708,785	+5.7%
Slag (tonne)	72,311	91,601	+26.7%
Fly ash (tonne)	16,816	19,672	+17.0%

(Data source: DSPA, 2015)

In fact, most of the waste can be utilized as resources. At present, recyclable waste in Macao mainly includes paper, plastics, waste metals and glass, and the recovery rate is estimated by analyzing the DSEC import and export data. Figure 4.7 shows that the recovery rate of recyclable waste remains at a relatively stable level (approximately 18-20%) in recent years.



Notes: (1) It includes plastics, rubber, paper, metals and other recoverable waste.

(2) Since the waste collected in Macao has been mainly exported to the mainland and other countries for recycling, the above estimation is made with reference to the DSEC import and export data, including statistics of recyclable paper (code: 4707), recyclable plastics (codes: 3915, 4012), and recyclable metals (codes: 7204, 7404, 7602), etc.

Figure 4.7 Recovery rate of recyclable waste in the past years

(Data source: DSEC, 2015)

In order to improve the recovery rate of recyclable waste, DSPA and Civic and Municipal Affairs Bureau (IACM) have both strengthened and carried out sorting and recycling activities for various recyclable wastes in recent years. Generally speaking, both the number of participants taking part in sorting and recycling activities as well as the total recycling volume of recyclable waste increased substantially in 2014 compared with that in 2013 (Table 4.6), indicating that the recycling awareness of citizens has been improved. However, it is noteworthy that the growth of recycling volume is still far from sufficient to offset the rapid increase in the waste transferred to the Macao Refuse Incineration Plant for treatment.

Table 4.6 Volume of recycled waste between 2013 and 2014 [1]

	2013	2014	Percentage increase/decrease
Volume of recycled paper (kg)	914,760	3,013,095	+229.4%
Volume of recycled plastics (kg)	214,762	357,794	+66.6%
Volume of recycled metals (kg)	41,563	113,273	+172.5%
Volume of recycled aluminum/iron cans (no.)	624,985	675,221	+8.0%
Volume of recycled glass (kg)	157,576 [r]	504,966	+220.5%

Notes: (1) [1] Including the volume of waste recycled in the "EcoFun-Waste sorting can be fun" scheme organized by DSPA as well as that in the "Waste Separation and Recycling Programme" and "Glass bottles recycling" scheme organized by IACM.

(2) [r] Revised figures.

(Data source: DSEC, 2015)

The comprehensive analysis on the evolution of indicators, such as waste generation, recycling and ultimate disposal of waste, reflects the changing trends of relevant sub-indicators as follows:

 = Good  = Stable  = Unsatisfactory

Description	D	P	S	I	R	Trend[1]
● Waste Generation		✓				
➢ Daily mean quantity of urban domestic waste per capita						
➢ Physical composition of urban waste						— [2]
➢ Special and hazardous waste transferred for treatment						
➢ Solid waste generated by the electricity supply company						
➢ Type and quantity of waste vehicles						
● Recycling and Ultimate Disposal of Waste					✓	
➢ Landfill quantity of construction waste						
➢ Landfill quantity of slag						
➢ Landfill quantity of fly ash						
➢ Recovery rate of recyclable waste						
D: Driving Force, P: Pressure, S: State, I: Impact, R: Response						

In 2014, the quantity of urban waste per capita in Macao was more than double compared with Beijing and Shanghai, and nearly six times that of Taipei (Table 4.2 Environmental Knowledge). Although the new plant of Macao Refuse Incineration Plant has been put into operation since 2008, doubling daily treatment capacity to 1,728 tonnes, however in just 6 years the rapid increase in quantity of waste in Macao has already occupied nearly 50% of the newly-added treatment capacity of Macao Refuse Incineration Plant. Notwithstanding the growth of recovery rate of recyclable waste in recent years, it still falls far behind the volume of waste generation. Meanwhile, as many large-scale construction projects in Cotai are under progress, construction waste also increases significantly.

[1] The trends of sub-indicators are assessed with a perspective of environmental protection, and are derived from the change of sub-indicator values between 2013 and 2014.

[2] It is not applicable as distribution percentage is not suitable for trend analysis.

In conclusion, it demands immediate attention to promote waste reduction at source and resource recycling, as well as to improve the recovery rate of recyclable waste. Comprehensive waste management policies shall be established timely, and policy measures in respect of economic instruments, infrastructure optimization, establishment and improvement of relevant laws and regulations, publicity and education, etc., shall be taken in order to facilitate the development of a resource conservation and recycling oriented society.

5. Nature Conservation

Macao, a densely-populated city with limited land resources, is short of spaces for development and expansion of natural and green areas or such areas may even be undermined due to the social development needs. Therefore, the existing green area is precious natural resource for Macao. Actually, green area not only allows citizens to be close to nature and in touch with nature, but also provide habitat and reproduction spaces for animals and plants, so as to facilitate the conservation and optimization of biological diversity.

Indicator for environmental analysis in this chapter
● Green Area

5.1. Green Area

DPSIR Framework

D	Driving forces	P	Pressures	**S**	**States** ✓	I	Impacts	**R**	**Responses**✓

Figure 5.1 shows the distribution of Macao green area in 2014.

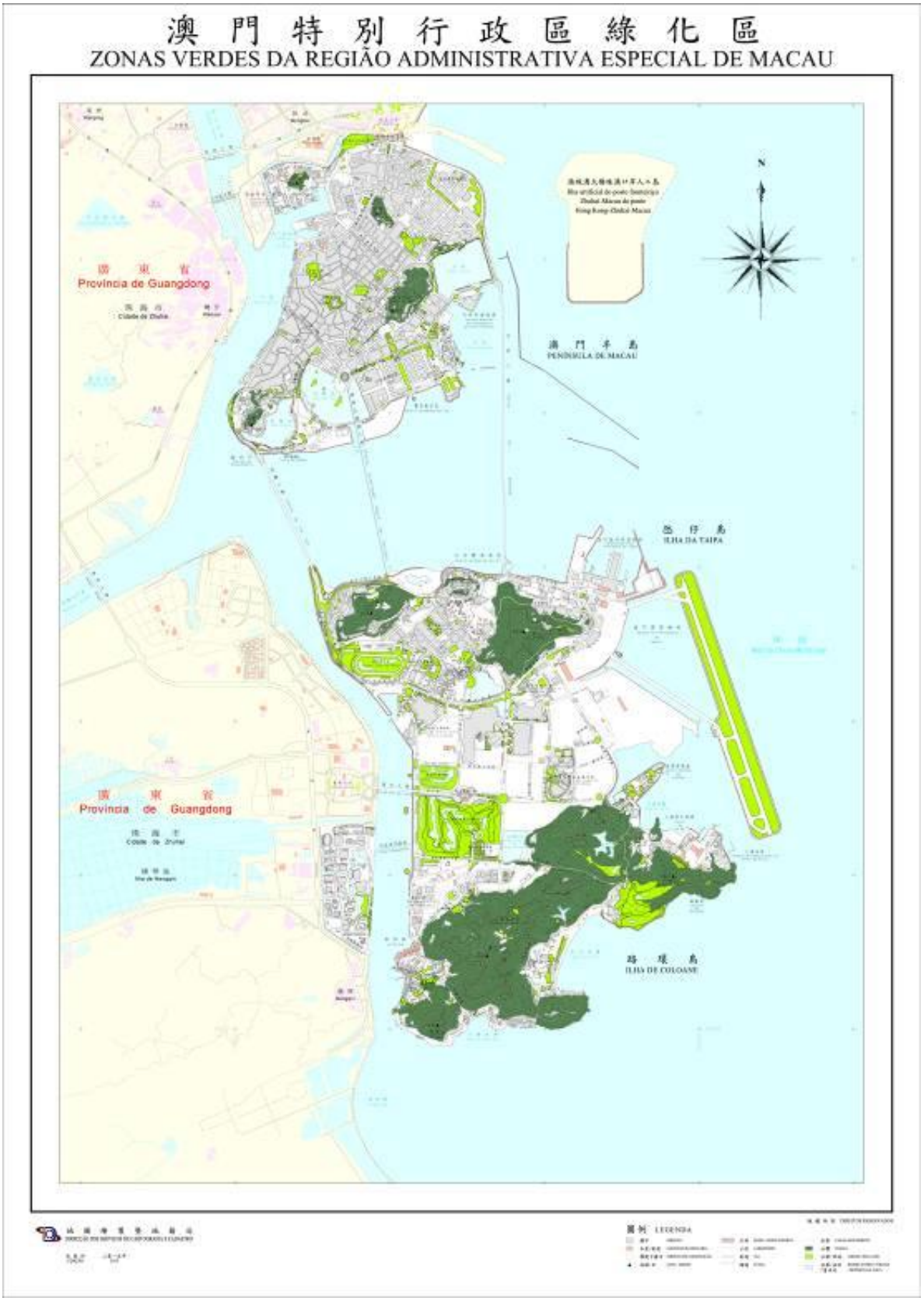


Figure 5.1 Macao green area in 2014

(Data source: DSCC, 2015)

The IACM data shows that the green area under its jurisdiction (Figure 5.2 and Table 5.1) increased considerably during the period from 2007 to 2010, and is basically keeping at the same level thereafter. In the mean time, the population of Macao has been growing faster year by year since 2011, resulting in a gradual reduction of the overall green area per capita. The green area per capita in Macao in 2014 has dropped to a lower level as in 2009.

As for the distribution of green area in 2014, it is mainly located in Coloane, followed by Macao Peninsula and Taipa, and Cotai Reclamation Zone has the least green area.

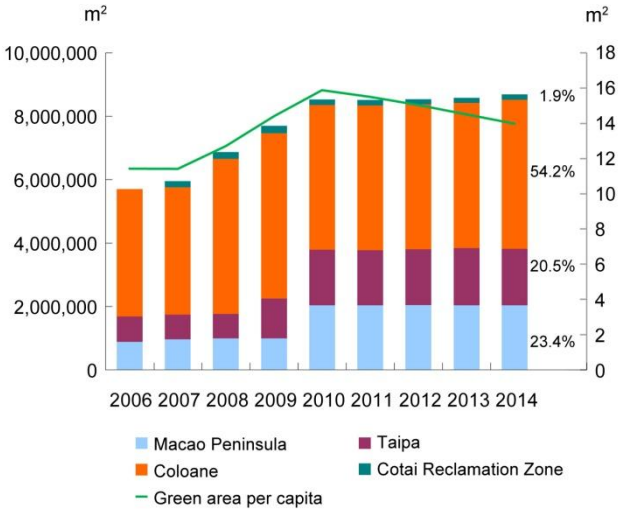


Figure 5.2 The green area, respective percentages and per capita green area of Macao in the past years

(Data source: IACM, 2015)

Table 5.1 Numerical data and percentage increase/decrease of green area distribution under the jurisdiction of IACM between 2013 and 2014

(Unit: m^2)	**2013**	**2014**	**Percentage increase /decrease**
Green area	**8,586,795**	**8,690,873**	**+1.2%**
-Macao Peninsula	2,031,847 （23.7%）	2,035,340 （23.4%）	+0.2%
-Taipa	1,813,996 （21.1%）	1,781,654 （20.5%）	-1.8%
-Coloane	4,585,576 （53.4%）	4,711,034 （54.2%）	+2.7%
-Cotai Reclamation Zone	155,376 （1.8%）	162,845 （1.9%）	+4.8%
Green area per capita (m^2/capita)	14.5	14.0	-3.4%

Notes: (1) The green area under jurisdiction of IACM (including water conservation area).

(2) Numerical data in the brackets refers to the percentages of the respective green area of different regions in relation to the total green area of Macao.

(Data source: IACM, 2015)

By category, the green space for leisure and recreation in Macao occupied an area similar to that of the green space for ecological landscape in 2014, followed by the green space for traffic infrastructure, while the nursery for urban greening was the least area. Detailed percentages can be found in Figure 5.3 and Table 5.2..

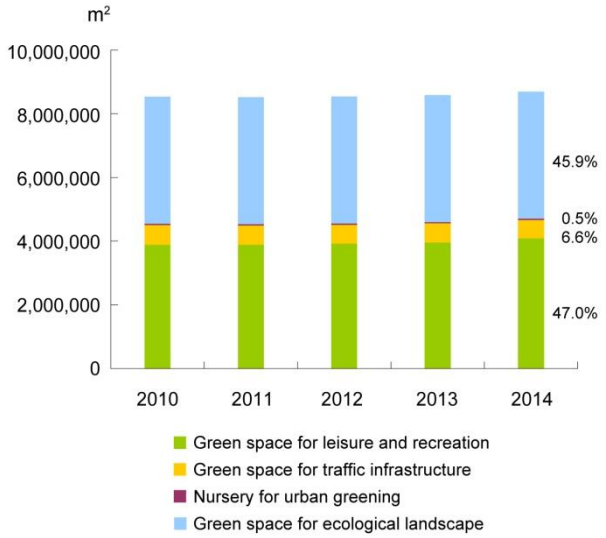


Figure 5.3 Green area by category and the respective percentages in the past years
(Data source: IACM, 2015)

Table 5.2 Numerical data and percentage increase/decrease of green area distribution under the jurisdiction of IACM by category between 2013 and 2014

(Unit: m^2)	**2013**		**2014**		**Percentage increase/decrease**
Green space for leisure and recreation	3,958,889	（46.1%）	4,087,196	（47.0%）	+3.2%
Green space for traffic infrastructure	601,405	（7.0%）	577,176	（6.6%）	-4.0%
Nursery for urban greening	41,611	（0.5%）	41,611	（0.5%）	—
Green space for ecological landscape	3,984,890	（46.4%）	3,984,890	（45.9%）	—

Notes: (1) The green area under jurisdiction of IACM (including water conservation area).
(2) Numerical data in the brackets refers to the percentage of the respective green area of each category in relation to the total green area of Macao.

(Data source: IACM, 2015)

As shown in Figure 5.4, since 2009 the rate of urban green area of Macao has been fluctuating slightly at around 26%. The rise in the rate of green area of Coloane in 2014 contributed to a slight increase in the rate of urban green area of Macao, compared with that in 2013; however, the rate of green area of Cotai Reclamation Zone decreased at the same time.

With limited resources in Macao, it is no doubt that the increase of green area on the existing land may restrain or even reduce the available land area for development. With the newly reclaimed Area comes into operation in the future, while alleviating land demand, it is also necessary to consider increasing the green area appropriately in the zone, so as to provide quality living environment for the citizens.

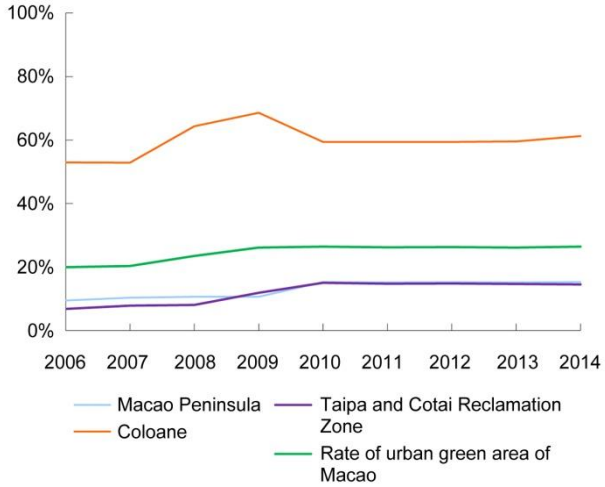


Figure 5.4 Rate of urban green area in different regions of Macao
(Data source: IACM, 2015)

Hill fire is one of the causes resulting in the reduction of green area. Figure 5.5 and Table 5.3 show that Macao had a relatively few numbers of hill fires over the past few years, but the number soars to more than 20 cases in 2014. Therefore, citizens should pay attention not to leave kindling material that might destroy the precious green area while enjoying the beautiful natural environment.

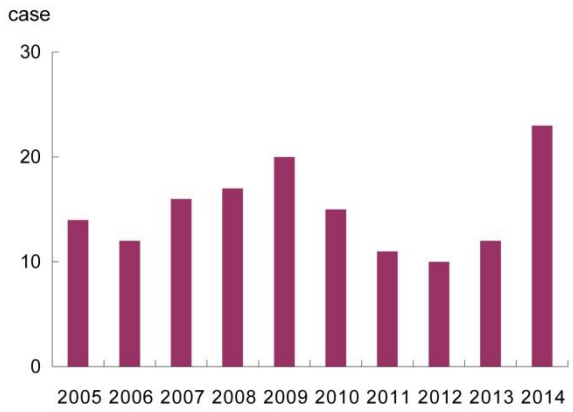


Figure 5.5 Number of hill fires in the past years
(Data source: DSEC and CB, 2015)

Table 5.3 Numerical data and percentage increase/decrease of hill fires between 2013 and 2014

(Unit: case)	**2013**	**2014**	**Percentage increase/decrease**
Number of hill fires	12	23	+91.7%

(Data source: CB, 2015)

Apart from being responsible for maintenance and improvement of green area as well as provision of habitats for species, the Macao SAR Government also endeavors to plant more trees in the limited spaces. Figure 5.6-5.7 and Table 5.4-5.5 show the numbers of tree and animal species in green area under the jurisdiction of IACM. The number of tree species in 2014 was the same with that in 2013. In addition, Table 5.4 indicates that the roadside trees in 2014 in Macao Peninsula and the islands as well as trees in the reforestation areas both increased compared with those in 2013, with the largest increase of 12.3% recorded in the roadside trees of the islands.

As for animal species, the number of insect species in 2014 decreased compared with that in 2013; the number of fish species remained unchanged, while the number of all other animal species increased, with mammals and reptiles gaining the most significant increase.

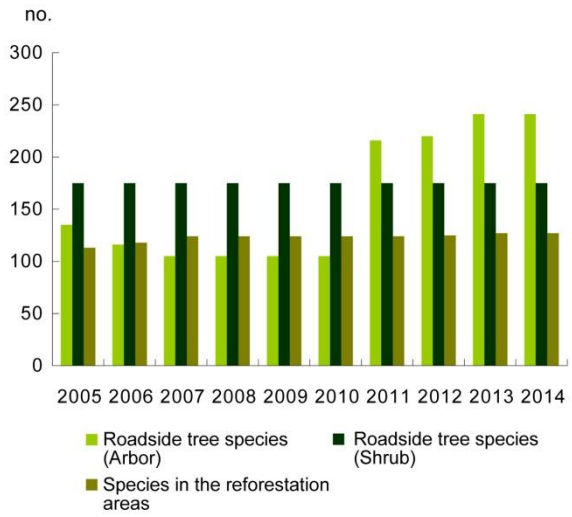
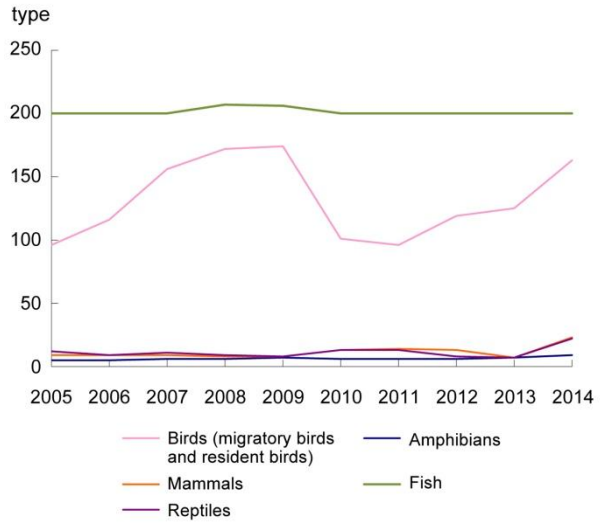


Figure 5.6 Number of tree species in Macao in the past years

(Data source: IACM, 2015)



Note: (1) There were 356 species of insects in 2014.

Figure 5.7 Number of animal species in Macao in the past years

(Data source: IACM, 2015)

Table 5.4 Number of trees and tree species in Macao between 2013 and 2014

	2013	2014	Percentage increase/decrease
Number of trees (Unit: no.)			
Roadside trees in Macao Peninsula	10,043	10,357	+3.1%
Roadside trees in the islands	7,154	8,036	+12.3%
Reforestation areas	490,672	494,782	+0.8%
Number of tree species (Unit: type)			
Roadside tree species (Arbor)	241	241	—
Roadside tree species (Shrub)	175	175	—
Reforestation areas	127	127	—

(Data source: IACM, 2015)

Table 5.5 Number of animal species in Macao between 2013 and 2014

	2013	2014	Percentage increase/decrease
Birds (migratory birds and resident birds)	125	163	+30.4%
Amphibians	7	9	+28.6%
Mammals	7	23	+228.6%
Fish (approx.)	200	200	—
Reptiles	7	22	+214.3%
Insects (approx.)	500	356	-28.8%

(Data source: IACM, 2015)

In addition to the aforesaid green area, habitats are also provided for many endangered and rare species in Cotai Ecological Zone, which is under the jurisdiction of DSPA. By the end of 2014, precious and rare animals that are listed under second class of the state protection have been found in the zone, including *Platalea minor (Black-faced Spoonbill), Egretta sacra, Platalea leucorodia, Elanus caeruleus, Milvus migrans, Circus spilonotus, Buteo buteo, Falco tinnunculus, Falco peregrinus, Centropus sinensis and Centropus bengalensis*, etc.

During the bird season of 2014, a highest number of 63 endangered Black-faced Spoonbills were recorded within the ecological zones, and nearly 72 species of birds visited the zones at peak season. By the end of 2014, there were 157 species of floating algae 351 species of advanced plants, 100 species of zooplankton, 85 species of benthos, 349 species of insects, 49 species of fish, 5 species of amphibians, 18 species of reptiles and 8 species of mammals found in the ecological

zones.

As for mangrove plants, species of mangrove including Kande*lia obovata, Avicennia marina, Aegiceras corniculatum* and *Acanthus ilicifolius* were found in the Ecological Zones in 2014. Moreover, due to the rapid growth of an alien species *Sonneratia apetala*, in Ecological Zone II, risk has been posed to other local mangroves. Therefore, in 2014, DSPA eliminated the *Acanthus ilicifolius* and *Sonneratia apetala*, which have relative lower ecological values in Ecological Zone II.

The *Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)* is applicable to the Macao SAR. In 2014, 7,210 import and re-export CITES certificates were issued (Table 5.6). A total of 33 cases of CITES violation were prosecuted in 2014, a significant decrease compared with 105 cases in 2013. The endangered species seized included agar wood, cycads, pitcher plants, cacti, orchids, ivory, snakes, and meat of hippo and crocodile, etc.

Table 5.6 Number of import and re-export CITES certificates issued by Macao Economic Service (DSE) between 2013 and 2014

(Unit: no.)	**2013**	**2014**	**Percentage increase/decrease**
CITES certificates	6,702	7,210	+7.6%

(Data source: DSE, 2015)

The comprehensive analysis on the evolution of sub-indicators, such as green area, tree and animal species, reflects the changing trends as follows:

 = Good  = Stable  = Unsatisfactory

Description	**D**	**P**	**S**	**I**	**R**	**Trend**[1]
● Green Area			✓		✓	
➢ Green area under the jurisdiction of IACM						
➢ Green area per capita						
➢ Distribution percentage of green area						—[2]
➢ Rate of urban green area						
➢ Number of tree species in Macao						

[1] The trends of sub-indicators are assessed with a perspective of environmental protection, and are derived from the change of sub-indicator values between 2013 and 2014.

[2] It is not applicable as distribution percentage is not suitable for trend analysis..

➢ Number of animal species in Macao ➢ Number of hill fires	 
D: Driving forces, P: Pressures, S: States, I: Impacts, R: Responses	

The above analysis shows the green area and the rate of urban green area in Macao have slightly increased, and species of creatures have also increased in varying degrees in recent years, but as limited by the geographic factor and the rate of population growth of Macao, the actual improvement of the aforesaid two indicators is still relatively low. In fact, in order to improve the rate and value of green area substantially with limited land resources, on one hand it is necessary to take all kinds of measures to expand the sources for the increase of green area, and on the other hand to protect the existing natural environment, and avoid the loss of green area, especially those with ecological values. In recent years, the Macao SAR Government has been continuously carrying out tree maintenance, eliminating harmful invasive species, conducting census on plants, and has also proposed the concepts of environmental functional districts in the *Environmental Protection Planning of Macao (2010-2020)*, which will help to protect more effectively the precious natural environment. It is recommended that the present and primary tasks are to implement measures as soon as possible in order to protect the limited green area with ecological values, utilize land resources effectively and improve relevant planning, so that the nature can be better protected along with the booming economy and society.

6. Ambient Noise

When noises from social activities, road traffic, construction, civil works and commercial activities have reached to a certain level, the peaceful life of citizens may be affected. As population, the number of vehicles and economic activities are increasing continuously in Macao in recent years; citizens are relatively easier to be annoyed by noise.

Indicators for environmental analysis in this chapter
● Driving Force of Noise ● Noise Levels ● Noise Complaints

6.1. Driving Force of Noise

DPSIR Framework

D	**Driving forces✓**	**P**	**Pressures ✓**	S	States	I	Impacts	R	Responses

Figure 1.3, Figure 2.25 and Figure 6.1 show the changing trends of population density, motor vehicle density and number of licensed construction establishments in Macao over the years respectively. Affected by the increase of the aforesaid factors, the driving force of ambient noise in Macao is steadily rising.

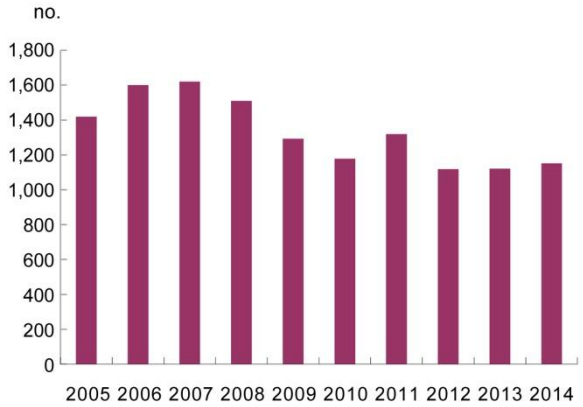


Figure 6.1 Number of licensed construction establishments in the past years
(Data source: DSSOPT, 2015)

6.2. Noise Levels

DPSIR Framework

D	Driving forces	P	Pressures	**S**	**States** ✓	I	Impacts	R	Responses

DSPA has been continuously improving the ambient noise monitoring network in Macao, including establishment of new stations. By the end of 2014, the ambient noise monitoring network in Macao consists of five 24-hour ambient noise monitoring stations, which include Horta e Costa Station, Braga Street Station and Venceslau de Morais Station in Macao Peninsula, Correia Silva Street Station in Taipa, and Ecological Zone Station newly built in Cotai Ecological Zone. The parameters monitored in the stations are as follows:

Parameter	Definition
$L_{eq,T}$	Equivalent Continuous Sound Pressure Level (L_{eq}) refers to the mean value of noise level energy during a specific period of time (T), or the energy equivalent of steady noise level along with time.
L_{10}	The noise level exceeded during 10% of the monitoring period, representing a rather high-intensity noise level during that period.
L_{90}	The noise level exceeded during 90% of the monitoring period, representing a relatively low-intensity noise level during that period.

Figure 6.2 shows the annual average hourly L_{eq} at each ambient noise monitoring station. Among them, the Horta e Costa Station, located in a busy traffic section, has the highest annual average hourly L_{eq}, followed by the Venceslau de Morais Station, while the newly-built Ecological Zone Station has the lowest level. The L_{eq} of Correia Silva Street Station and Ecological Zone Station have relatively large differences between daytime and night-time, while the differences in Horta e Costa Station, Venceslau de Morais Station and Braga Street Station were smaller

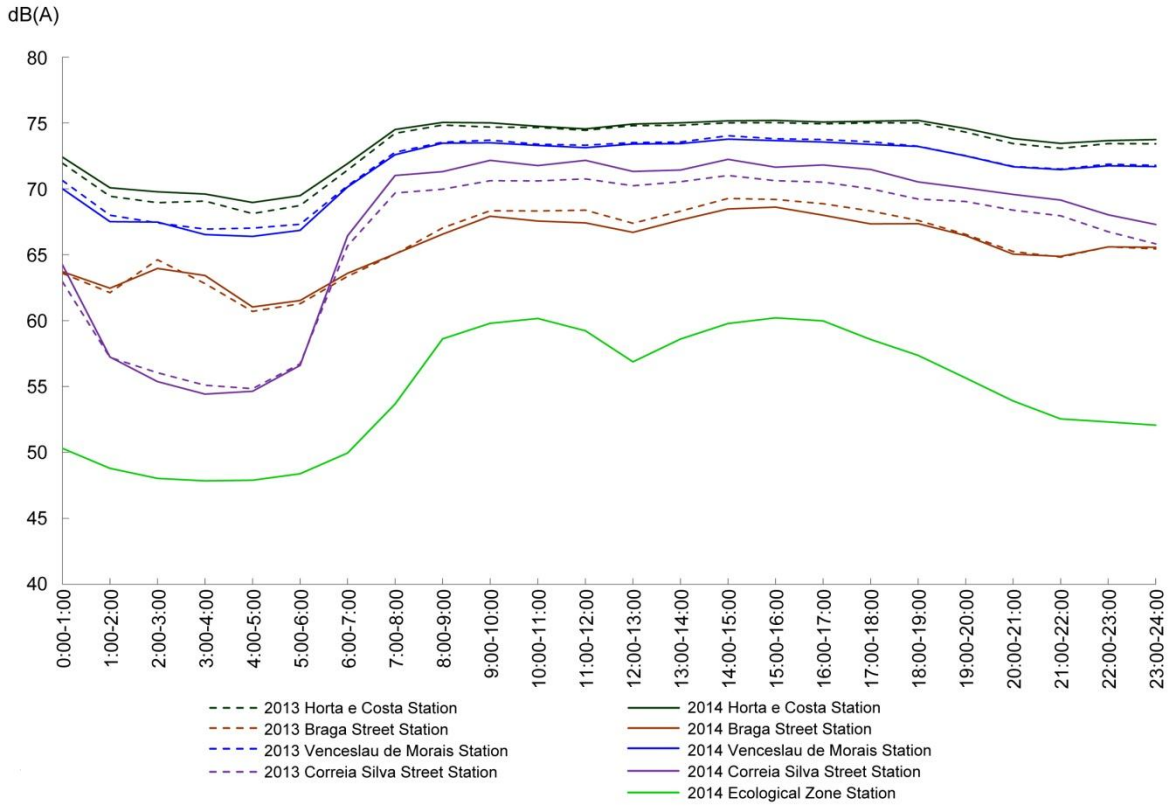


Figure 6.2 Annual average hourly Leq at each fixed ambient noise monitoring station in 2014
(Data source: DSPA, 2015)

From the analysis on annual average L_{eq} at various time intervals over the years shown in Figure 6.3~6.6 and Table 6.1~6.5, it can be seen that in 2014, the noise levels at Horta e Costa Station, Braga Street Station and Venceslau de Morais Station were similar to that in 2013. In 2014, annual average L_{eq} at Correia Silva Street Station in 24 hours and at various time intervals increased significantly compared with that in 2013 and had reached a historic high record, which may be due to the impact of construction noises generated from surrounding roads or construction projects. Besides, as the Ecological Zone Station is a newly built station, data of past years is not available for comparison.

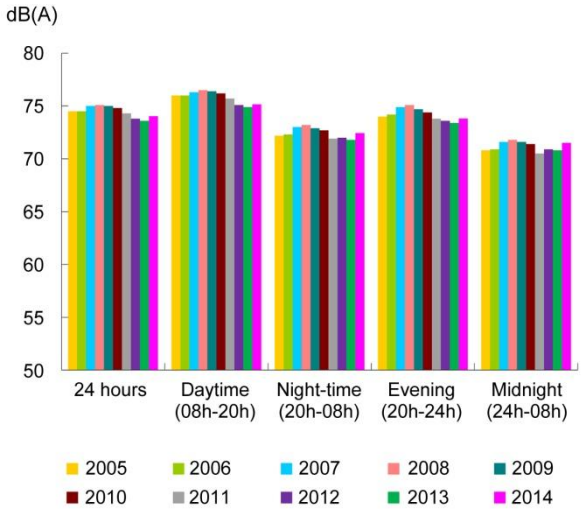


Figure 6.3 Annual average Leq at Horta e Costa Station at various time intervals in the past years

(Data source: DSPA, 2015)

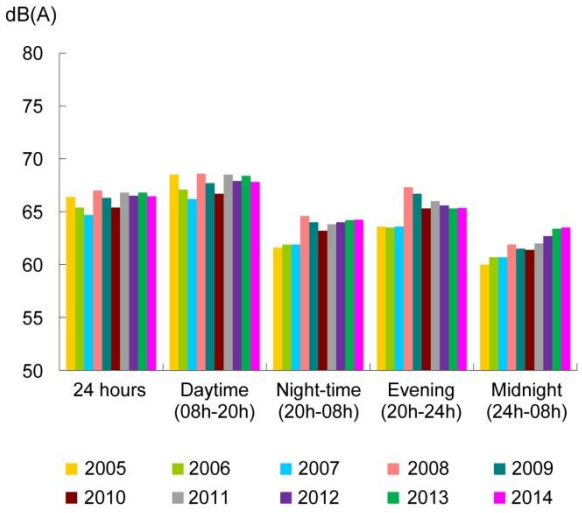


Figure 6.4 Annual average Leq at Braga Street Station at various time intervals in the past years

(Data source: DSPA, 2015)

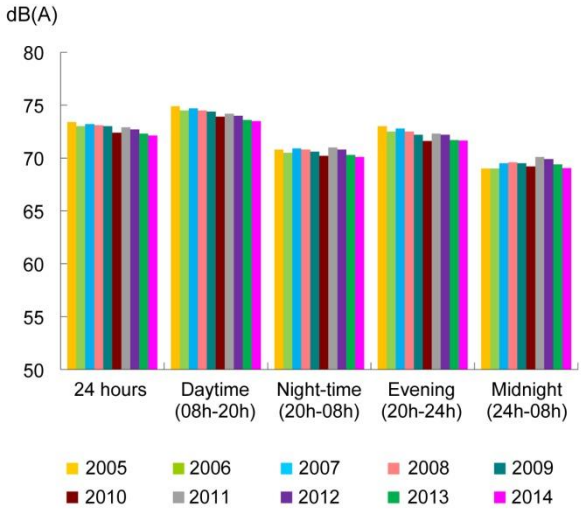


Figure 6.5 Annual average Leq at Venceslau de Morais Station at various time intervals in the past years

(Data source: DSPA, 2015)

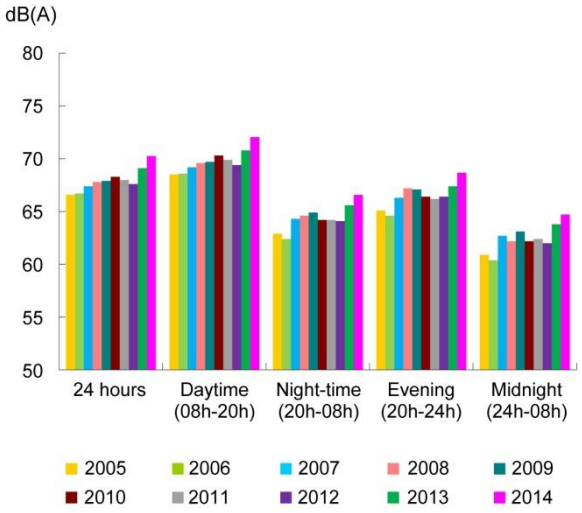


Figure 6.6 Annual average Leq at Correia Silva Street Station at various time intervals in the past years

(Data source: DSPA, 2015)

Table 6.1~6.5 also show the difference between the annual average L_{10} and $L_{90,}$ of which indicate the changing trends of noise levels. In 2014, Correia Silva Street Station had the largest difference, while Horta e Costa Station, Braga Street Station, Venceslau de Morais Station and Ecological Zone Station all had a smaller difference. It indicates that the noise impact to Correia Silva Street Station was mainly from high-intensity noise sources, such as construction projects and

road traffic. The difference between L_{10} and L_{90} at other stations also exceeded 10 dB(A), indicating that the road traffic produced significant noise impact. Compared with 2013, the difference between L_{10} and L_{90} at Horta e Costa Station and Braga Street Station was reduced in 2014, while that of Venceslau de Morais Station and Correia Silva Street Station increased slightly.

Table 6.1 Difference of annual average L_{eq} at Horta e Costa Station at various time intervals between 2012 and 2014

[Unit: dB(A)]	2012	2013	2014	2013/2104 Difference
24 hours	73.8	73.6	73.9	+0.3
Daytime (08h - 20h)	75.1	74.9	75.1	+0.2
Night-time (20h - 08h)	72.0	71.8	72.3	+0.5
Evening (20h - 24h)	73.6	73.4	73.7	+0.3
Midnight (24h - 08h)	70.9	70.8	71.3	+0.5
Difference between L_{10} and L_{90}	14.8	15.4	12.8	-2.6

(Data source: DSPA, 2015)

Table 6.2 Difference of annual average L_{eq} at Braga Street Station at various time intervals between 2012 and 2014

[Unit: dB(A)]	2012	2013	2014	2013/2104 Difference
24 hours	66.5	66.8	66.4	-0.4
Daytime (08h - 20h)	67.9	68.4	67.8	-0.6
Night-time (20h - 08h)	64.0	64.2	64.2	—
Evening (20h - 24h)	65.6	65.3	65.4	+0.1
Midnight (24h - 08h)	62.7	63.4	63.5	+0.1
Difference between L_{10} and L_{90}	12.9	13.0	12.3	-0.7

(Data source: DSPA, 2015)

Table 6.3 Difference of annual average L_{eq} at Venceslau de Morais Station at various time intervals between 2012 and 2014

[Unit: dB(A)]	2012	2013	2014	2013/2104 Difference
24 hours	72.7	72.3	72.2	-0.1
Daytime (08h - 20h)	74.0	73.6	73.5	-0.1

Night-time (20h - 08h)	70.8	70.3	70.1	-0.2
Evening (20h - 24h)	72.2	71.7	71.7	—
Midnight (24h - 08h)	69.9	69.4	69.1	-0.3
Difference between L_{10} and L_{90}	11.1	13.1	13.5	+0.4

(Data source: DSPA, 2015)

Table 6.4 Difference of annual average L_{eq} at Correia Silva Street Station at various time intervals between 2012 and 2014

[Unit: dB(A)]	**2012**	**2013**	**2014**	**2013/2104 Difference**
24 hours	67.6	69.1	70.3	+1.2
Daytime (08h - 20h)	69.4	70.8	72.1	+1.3
Night-time (20h - 08h)	64.1	65.6	66.6	+1.0
Evening (20h - 24h)	66.4	67.4	68.7	+1.3
Midnight (24h - 08h)	62.0	63.8	64.7	+0.9
Difference between L_{10} and L_{90}	22.1	20.5	23.4	+2.9

(Data source: DSPA, 2015)

Table 6.5 Difference of annual average L_{eq} at Ecological Zone Station at various time intervals in 2014

[Unit: dB(A)]	**2014**
24 hours	57.6
Daytime (08h - 20h)	59.8
Night-time (20h - 08h)	51.6
Evening (20h - 24h)	52.7
Midnight (24h - 08h)	50.5
Difference between L_{10} and L_{90}	14.2

Note: (1) The monitoring data collected at this station has been officially published since April of 2014. The above table shows the average Leq from April to December of 2014.

(Data source: DSPA, 2015)

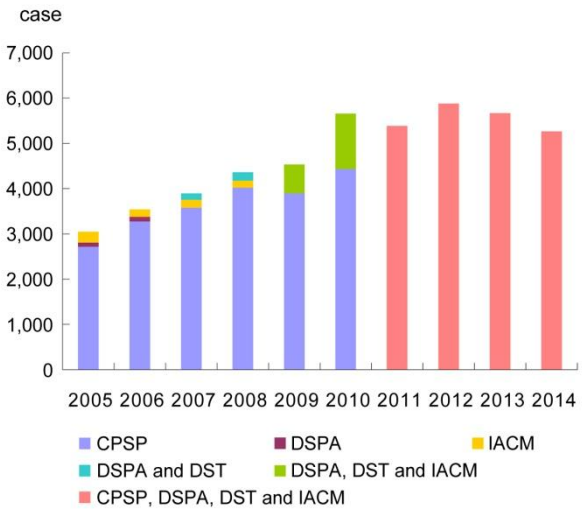
6.3. Noise Complaints

DPSIR Framework

D	Driving forces	P	Pressures	S	States	I	Impacts	**R**	**Responses✓**

The Macao SAR Government has taken a series of measures to reduce the ambient noise level in Macao, including the *Preparation Guideline of Pile Foundation (Environmental protection) Plan* issued in October of 2013 for controlling the construction noises from pile foundation projects. In addition, in 2014, based on the original Decree-law No.54/94/M - *Regulations on the Prevention and Control of Ambient Noise*, regulations on behavior or activities of noise disturbance were revised, Law No.8/2014 - *Environmental Noise Prevention and Control* was approved to control seven categories of noise pollution sources, and heavier penalty is adopted in order to better guarantee citizens' peaceful life. Moreover, the Macao SAR Government had also set up environmental protection hot line as a channel for the citizens to present relevant environmental issues to DSPA.

Figure 6.7 and Table 6.6 show the evolution of number of noise complaints received over the years. Among them, the largest number of noise complaints received in 2012, and then the number showed a gradual descending trend from 2013 to 2014. At the same time, Table 6.6 shows the number of noise complaints received by DSPA in 2014 increased significantly, indicating that more citizens would like to present the noise problems to DSPA.



Note: (1) The 2005-2006 data included the noise complaints received by CPSP, DSPA and IACM; since 2007, the data has included the noise complaints received by CPSP, DSPA, IACM and DST.

Figure 6.7 Noise complaints received in the past years

(Data source: DSEC, 2015)

Table 6.6 Numerical data and percentage increase/decrease of the noise complaints received by each relevant department between 2013 and 2014

(Unit: case)	2013	2014	Percentage increase/decrease
Total noise complaints [1]	5,667	5,268	-7.0%
- Noise complaints received by DSPA	412 （7.3%）	639 （12.1%）	+55.1%

Notes: (1) [1] It includes the noise complaints received by CPSP, DSPA, IACM and DST.

(2) Numerical data in the brackets refers to the percentage of noise complaints received by DSPA to the total number of complaint cases.

(Data source: DSEC and DSPA, 2015)

The analysis on noise complaints by category (Figure 6.8) shows that noise complaints related to social activities as well as industrial and commercial noises (including residence/disturbance from neighbors, conversation and shouting, interior decoration work, commercial establishments, music and karaoke) accounted for more than half of the total complaints in 2014. Moreover, the annual evolution of noise complaints by category can be viewed in Table 6.7, and among them, the number of noise complaints from interior decoration work had been doubled in 2014 compared with that in 2013, which is an issue of concern.

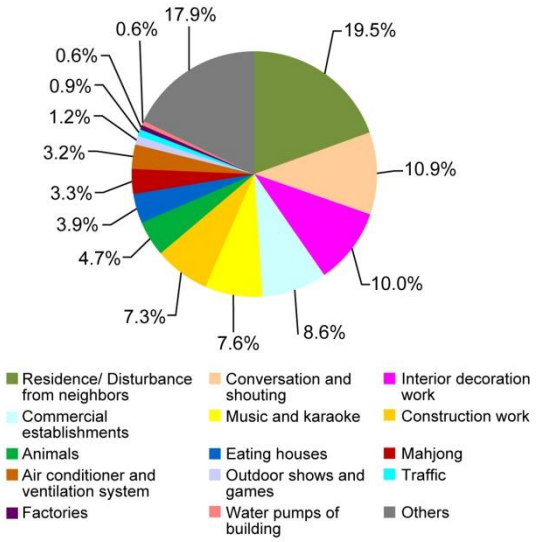


Figure 6.8 Percentages of noise complaints by category in 2014

(Data source: DSEC, 2015)

Table 6.7 Numerical data and percentage increase/decrease of the total number of noise complaints of Macao between 2013 and 2014

(Unit: case)	**2013**	**2014**	**Percentage increase/decrease**
Residence/ Disturbance from neighbors	895	1,026	+14.6%
Conversation and shouting	1,005	572	-43.1%
Interior decoration work	215	528	+145.6%
Commercial establishments	487	453	-7.0%
Music and karaoke	538	398	-26.0%
Construction work	691	386	-44.1%
Animals	276	246	-10.9%
Eating houses	235	204	-13.2%
Mahjong	159	174	+9.4%
Air conditioner and ventilation system	159	169	+6.3%
Outdoor shows and games	49	61	+24.5%
Traffic	30	47	+56.7%
Factories	57	32	-43.9%
Water pumps of building	25	30	+20.0%
Others	846	942	+11.3%

(Data source: DSEC, 2015)

According to the statistical data provided by the Public Security Police Force (CPSP) about noise complaints during daytime and night-time, about 76% complaints (mainly including conversation and shouting, residential music and beating objects) occurred at night-time, while the complaints at daytime were dominated by noises generated mainly from interior decoration and construction works.

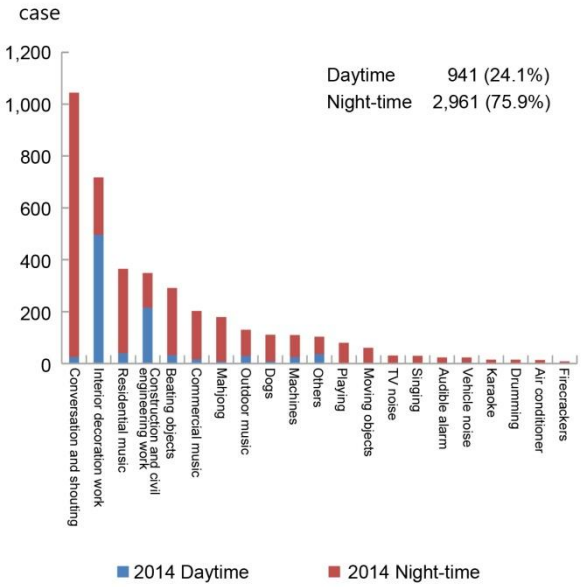


Figure 6.9 Number and percentage of noise complaints received by CPSP during daytime and night-time in 2014

(Data source: CPSP, 2015)

The comprehensive analysis on the indicators of driving force of noise, noise levels and noise complaints, reveals the changing trends of sub-indicators as follows:

= Good = Stable = Unsatisfactory

Description	D	P	S	I	R	Trend[1]
● Driving Force of Noise	✓	✓				
➢ Number of licensed construction establishments						
● Noise Levels			✓			
➢ Annual average hourly L_{eq}						
➢ Annual average L_{eq}						
➢ Annual average statistical noise level						
● Noise Complaints					✓	
➢ Annual number of noise complaints						
D: Driving Force, P: Pressure, S: State, I: Impact, R: Response						

[1] The trends of sub-indicators are assessed with a perspective of environmental protection, and are derived from the change of sub-indicator values between 2013 and 2014

In conclusion, the overall ambient noise level of Macao in 2014 is similar to that in 2013; the monitoring data shows that the overall acoustic environment in Macao is at a relatively high level. Traffic noise is the main source. Therefore, in order to improve the acoustic environment in Macao, it is required to adopt specific control through measures in respect of urban planning, vehicle management, etc. At the same time, the noise complaints of Macao are dominated by social activity noise and commercial and industrial noise; therefore, besides controlling noise sources through legislative measures and more stringent regulation, it is also required to simultaneously enhance citizens and enterprises' awareness that "Less disturbing noise, more tranquility to everyone", so as to jointly create a neighbor-friendly, harmonious and peaceful living environment.

7. Environmental Management

Apart from government-led policies, environmental protection is also the responsibility of the entire population, which needs the participation of the whole society including every citizen and every enterprise. For many years, the Macao SAR Government has not only taken policy measures to guide the enterprises to control pollution or to reduce environmental problems through more advanced pollution control means, but also cultivate the public's awareness on environmental protection through publicity and education.

Indicators for environmental analysis in this chapter
● Public Investment and Expenditure on Environmental Planning, Remediation and Infrastructure ● Public Participation and Concern ● Promotion and Implementation of Environmental Management System

7.1. Public Investment and Expenditure on Environmental Planning, Remediation and Infrastructure

DPSIR Framework

D	Driving forces	P	Pressures	S	States	I	Impacts	**R**	**Responses✓**

"Planning and environment" and "Infrastructure" are the major environmental protection related categories in the public investment and expenditure of the Macao SAR Government.

As can be seen from Figure 7.1-7.2 and Table 7.1, "Planning and environment" and "Infrastructure" accounted for 2.7% of the total public expenditure in 2014, quite similar to that during the period between 2009 and 2012, but higher than that in 2013. In 2014, environmental protection related projects in "Planning and environment" included studies in different environmental aspects, monitoring and analysis on incineration and treatment facilities, preservation and greening of ecological zones, etc; while projects in "Infrastructure" included environmental protection related projects such as solid waste collection and transportation, operation and renovation of Macao Refuse Incineration Plant and Special and Hazardous Waste Treatment Plant, operation and monitoring of landfill for construction waste, drainage network remediation, etc.

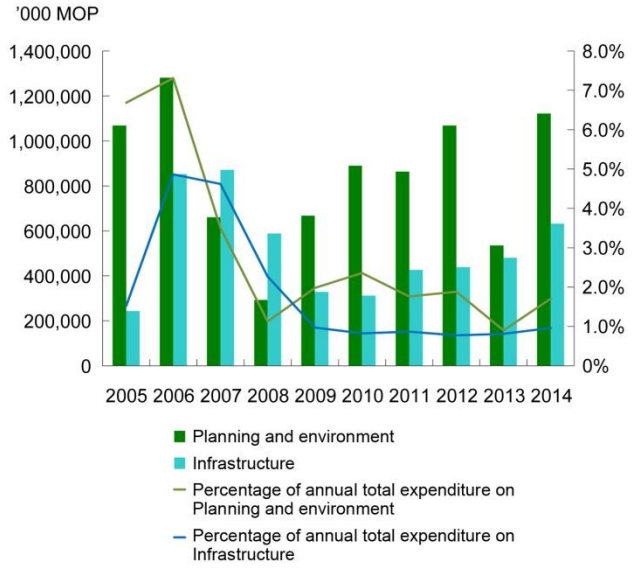


Figure 7.1 Public expenditure on "Planning and environment" and "Infra-structure" in the past years

(Data source: DSF, 2015)

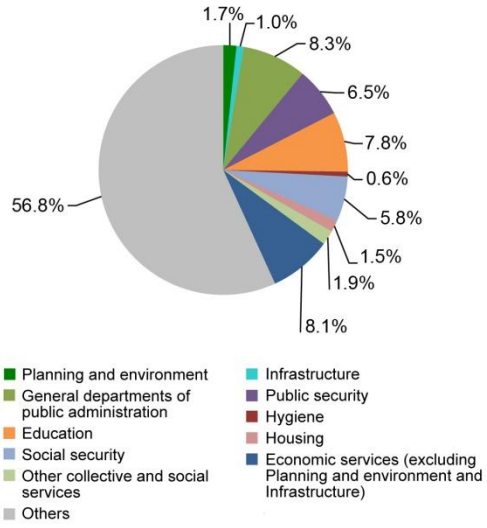


Figure 7.2 Public expenditure by function in 2014

(Data source: DSF, 2015)

Table 7.1 Numerical data and percentage increase/decrease of expenditure on "Planning and environment" and "Infrastructure" between 2013 and 2014

(Unit: '000 MOP)	**2013**		**2014**		**Percentage increase /decrease**
Planning and environment	535,243	(0.9%)	1,121,607	(1.7%)	+109.6%
Infrastructure	480,547	(0.8%)	631,976	(1.0%)	+31.5%

(Data source: DSF, 2015)

7.2. Public Participation and Concern

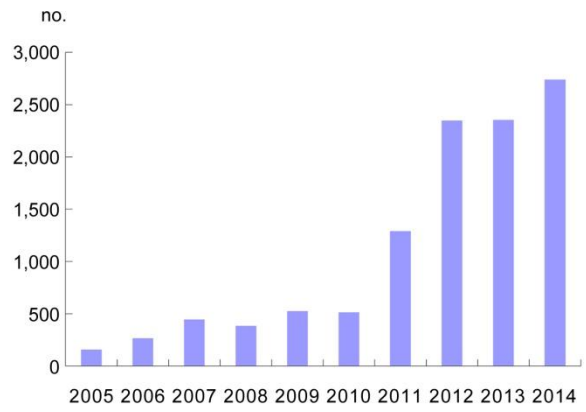
DPSIR Framework

D	Driving forces	P	Pressures	S	States	I	Impacts	**R**	**Responses✓**

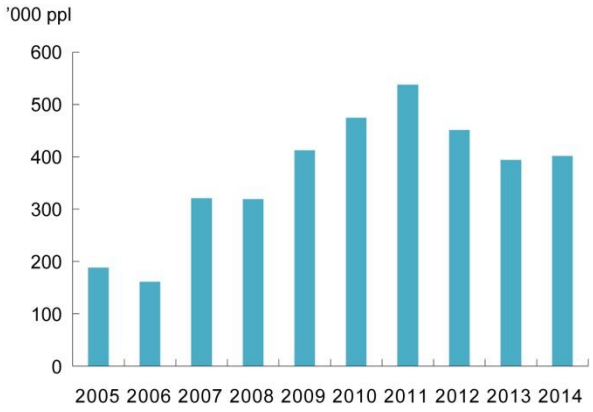
It is no doubt that public's awareness on environmental protection is connected with the effectiveness of environmental protection works. Therefore, the Macao SAR Government launches a variety of activities each year, encourages public to actively participate in environmental protection activities such as "Macao International Environmental Cooperation Forum & Exhibition"

(MIECF), “Macao Green Hotel Award”, “Macao Environmental Protection Week” Series Activities, Macao Green Week, and various energy-saving and water-conservation promotion activities, etc, so as to draw the attention of the public and all social sectors to the environment and encourage their participation in environmental protection works.

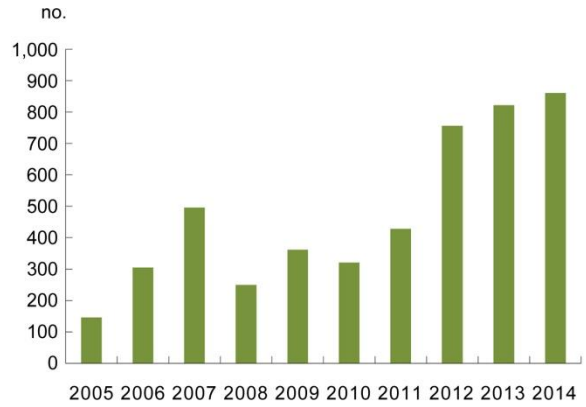
As shown in Figure 7.3 and Table 7.2, activities related to environmental education held by DSPA and ICAM, the total number of activities, participants and co-organizers in 2014 had increased compared with those in 2013. But the overall trend of total number of participants has declined since 2011 and become stable.



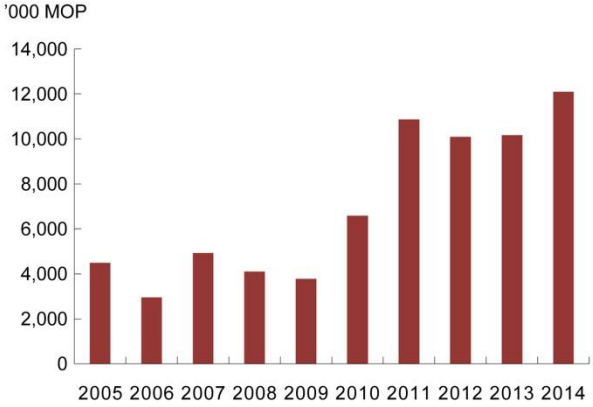
— Total number of activities —



— Total number of participants —



— Number of co-organizers —



— Expenses —

Figure 7.3 Statistics on the environmental publicity and educational activities held by DSPA and IACM in the past years

(Data source: DSEC, 2015)

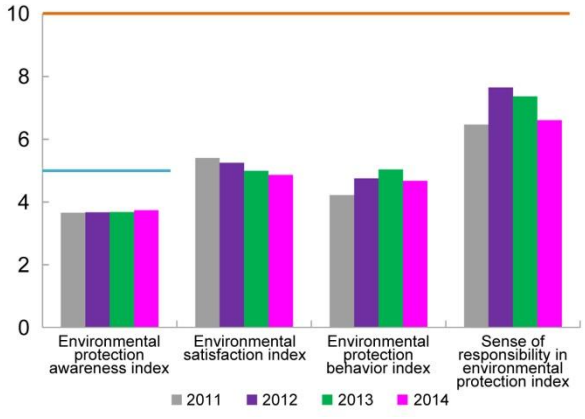
Table 7.2 Numerical data and percentage increase/decrease of environmental publicity and educational activities held by DSPA and IACM between 2013 and 2014

	2013	2014	Percentage increase/decrease
Total number of activities (no.)	2,355	2,740	+16.3%
Total number of participants ('000 ppl)	393.8 [r]	401.8	+2.0%
Number of co-organizers (no.)	822	861	+4.7%
Expenses ('000 MOP)	10,170.8 [r]	12,100.8	+19.0%

Note: (1) [r] Rounded to one decimal place.

(Data source: DSEC, 2015)

Since 2010, "Public Environmental Awareness Survey in Macao" is carried out by the Macao SAR Government each year in order to understand the status of Macao citizens' environmental consciousness. Figure 7.4 and Table 7.3 show the main results of surveys in recent years. In 2014, the Environmental protection awareness index of Macao citizens augmented and maintained at an above-average level; but the Environmental protection behavior index and Sense of responsibility in environmental protection index declined, indicating that there is a gap between thoughts and the actual behaviors of citizens on environmental protection. The Environmental satisfaction index has maintained at a below-average level, indicating that citizens have a relatively low satisfaction towards the current status of environment.



Note: (1) Blue line indicates that the full score for Environmental protection awareness index is 5; orange line indicates the full scores for the Environmental satisfaction index, Environmental protection behavior index and Sense of responsibility in environmental protection index are 10.

Figure 7.4 Index scores of Public Environmental Awareness Survey in Macao in the past years

(Data source: DSPA, 2015)

Table 7.3 Index scores of Public Environmental Awareness Survey in Macao between 2013 and 2014

	Full score	2013	2014	Difference
Environmental protection awareness index	5	3.68	3.74	+0.06
Environmental satisfaction index	10	4.99	4.86	-0.13
Environmental protection behavior index	10	5.04	4.67	-0.37
Sense of responsibility in environmental protection index	10	7.37	6.61	-0.76

(Data source: DSPA, 2015)

The Macao SAR Government provides various channels for citizens to file complaints or voice out their opinions. The environmental concerns of the citizens can be understood from complaint statistics. Figure 7.5-7.6 and Table 7.4-7.5 show the statistics on the complaints reported to DSPA and IACM.

In 2014, the number of environmental complaints presented to DSPA by the public increased significantly compared with that in 2013 mainly because of the increase complaints related to noise and air pollution.

In the meantime, the number of complaints about environmental hygiene presented to IACM by the public also increased in 2014. Among them, including cooking fumes emission, air pollution, noise disturbance, waste and other issues related to the environment, of which the increase complaints about waste issue were obvious.

The total number of complaints presented to DSPA and IACM in 2014 increased by 780, on one hand it reflects the increase on environmental issues, and on the other hand, it reflects that citizens concern more about environmental issues.

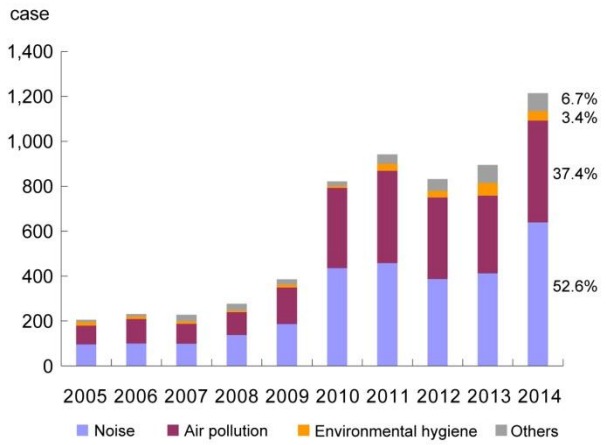


Figure 7.5 Number of environmental complaints presented to DSPA by the public and the respective percentages in the past years

(Data source: DSPA, 2015)

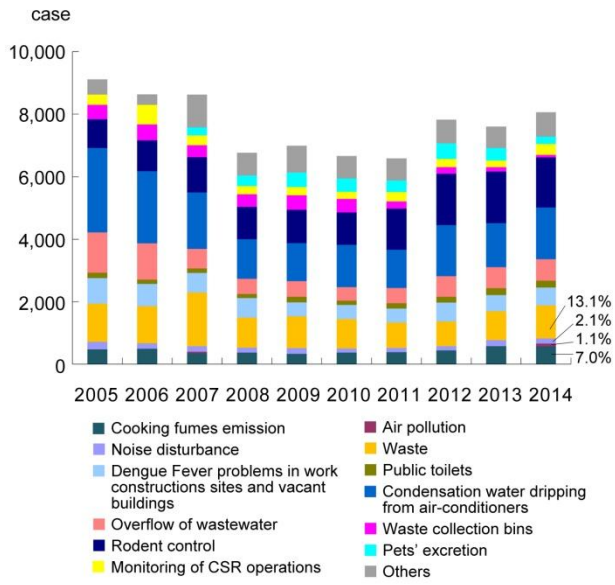


Figure 7.6 Number of environmental hygiene complaints presented to IACM by the public and the respective percentages in the past years (including cooking fumes emission, air pollution, noise disturbance, waste)

(Data source: DSPA, 2015)

Table 7.4 Numerical data and percentage increase/decrease of environmental complaints presented to DSPA by category between 2013 and 2014

(Unit: case)	**2013**	**2014**	**Percentage increase/decrease**
Total number of complaints	**895**	**1,215**	**+35.8%**
Noise	412	639	+55.1%
Air pollution	346	454	+31.2%
Environmental hygiene	57	41	-28.1%
Others	80	81	+1.3%

(Data source: DSPA, 2015)

Table 7.5 Numerical data and percentage increase/decrease of environmental hygiene complaints presented to IACM by category (cooking fumes emission, air pollution, noise disturbance, waste) between 2013 and 2014

(Unit: case)	2013	2014	Percentage increase/decrease
Total number of complaints	**7,606**	**8,066**	**+6.0%**
- Waste	925	1,059	+14.5%
- Cooking fumes emission	574	566	-1.4%
- Noise disturbance	194	166	-14.4%
- Air pollution	—[1]	91	—[1]

Note: (1) [1] No air pollution complaints were presented to IACM in 2013, therefore annual comparison cannot be made.

(Data source: IACM, 2015)

7.3. Promotion and Implementation of Environmental Management System

DPSIR Framework

D	Driving forces	P	Pressures	S	States	I	Impacts	**R**	**Responses✓**

The establishment of an effective environmental management system will enable organizations to better conform to ideas for protecting the environment and improving their environmental performance during their operation in order to achieve the goals of saving resources, reducing emission, increasing competition advantages and improving cost benefits while promoting environmental protection.

ISO14001 represents an authoritative certification of environmental management system, and Macao has an accumulated increasing number of entities awarded the ISO14001 certificate over the years (Figure 7.7 and Table 7.6), which shows that the number of local entities equipped with environmental management system is increasing gradually. However, there is still a larger room for improvement compared with the total number of entities in Macao.

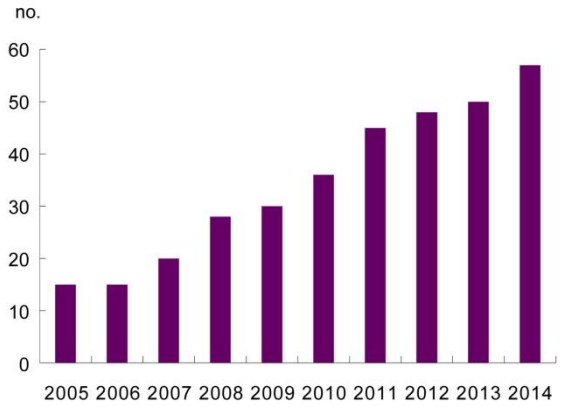


Figure 7.7 Accumulated number of entities awarded the ISO14001 Certificate on Environmental Management System in the past years

(Data source: CPTTM, 2015)

To align with Macao's positioning as a "Global Center of Tourism and Recreation" in the regional development, and to encourage and drive the hotel sector to implement environmental protection measures, the Macao SAR Government has been holding Macao Green Hotel Award activity each year since 2007 and expects that such award will drive other enterprises, schools and organizations of the society to develop in a more environmental-friendly manner. Figure 7.8 shows the number of hotels awarded this title and the number of their guestrooms in recent years, both of the two numbers increased slightly in 2014. By the end of 2014, Macao had an overall 70 hotels and 33 apartments, with a total of 28,892 guestrooms. The number of awarded hotels and their guestrooms accounted for 31% and 60% of the total number respectively.

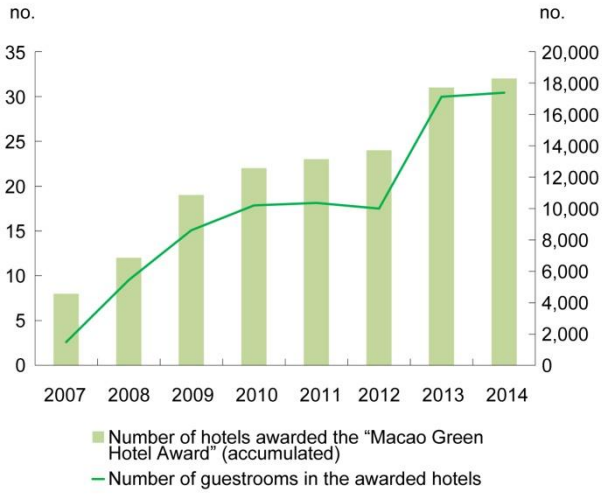


Figure 7.8 Accumulated number of hotels awarded the "Macao Green Hotel Award" between 2007 and 2014

(Data source: DSPA, 2015)

In order to raise the environmental protection awareness of personnel in different organizations, the Macao SAR Government not only organizes or co-organizes a variety of environmental management courses and seminars, but also commissions other organizations to offer such courses and seminars each year. In 2014, the Macao SAR Government offered courses and seminars including list of green management courses, energy management courses, green purchasing training courses, practical courses on environmental monitoring, etc. Both numbers of courses/seminars and participants engaged increased considerably compared with those in 2013 (Figure 7.9 and Table 7.6). In the past decade, although the number of courses and seminars related to the environmental management system and the number of participants fluctuated at times, the overall number shows increasing trends in general.

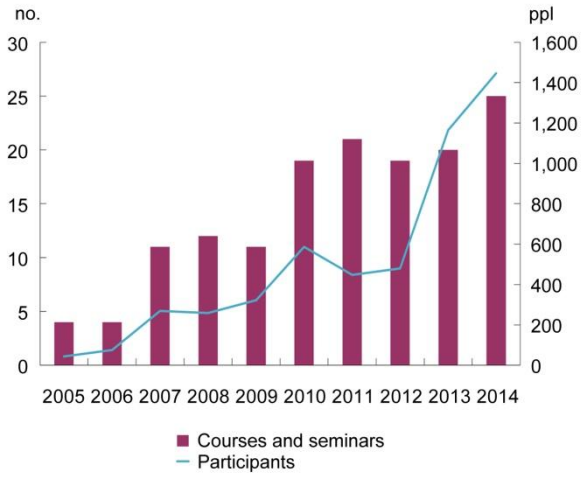


Figure 7.9 Courses and seminars related to the environmental management system in the past years

(Data source: CPTTM, 2015)

Table 7.6 Numerical data and percentage increase/decrease of information related to environmental management system between 2013 and 2014

	2013	2014	Percentage increase/decrease
Entities awarded the ISO14001 Certificate (no.)	50	57	+14.0%
Courses and seminars related to the environmental management system (no.)	20	25	+25.0%
Number of participants engaged in courses and seminars related to the environmental management system (ppl)	1,165	1,446	+24.1%

(Data source: CPTTM, 2015)

The comprehensive analysis on the evolution of indicators, including public investment and expenditure on environmental planning, remediation and infrastructure, public participation and concern, promotion and implementation of environmental management system, reflects the changing trends of relevant sub-indicators as follows:

 = Good  = Stable  = Unsatisfactory

Description	D	P	S	I	R	Trend[1]
● Public Investment and Expenditure on Environmental Planning, Remediation and Infrastructure					✓	
➢ Public expenditure on "Infrastructure" and "Planning and environment"						
● Public Participation and Concern					✓	
➢ Total number of activities						
➢ Total number of participants						
➢ Number of co-organizers						
➢ Expenses						
➢ Number and category of environmental complaints reported to the DSPA by the public						
➢ Number and category of complaints about environmental hygiene reported to the IACM by the public						
● Promotion and Implementation of Environmental Management System					✓	
➢ Number of entities awarded the ISO14001 Certificate on Environmental Management System						
➢ Number of hotels awarded the "Macao Green Hotel Award"						
➢ Courses and seminars related to the environmental management system						
➢ Number of participants engaged in the related training courses and seminars						
D: Driving Force, P: Pressure, S: State, I: Impact, R: Response						

Environmental management requires both governmental leadership and enterprises and citizens' strengthening on awareness and concern of environmental protection. All parties should jointly fulfill environmental responsibility. In 2014, the Macao SAR Government has increased its financial investment as well as the number of activities and courses related to environmental protection, and there are also more enterprises awarded the environmental management system certification or Macao Green Hotel Award. In fact, citizens and enterprises pay more attention to

[1] The trends of sub-indicators are assessed with a perspective of environmental protection, and are derived from the change of sub-indicator values between 2013 and 2014.

environmental issues and participate in various environmental protection activities indicates an improvement of environmental protection awareness of various social sectors, but it is still necessary to continue strengthening cross-departmental and cross-regional environmental cooperation, improving investment of resources into various environmental management projects, facilitate environmental management, cultivate environmental protection specialists, and encourage public and all social sectors to implement environmental actions and fulfill environmental protection responsibility in person, so as to create green living style for the whole society.

8. Conclusions

In this *Report*, the analysis on the related data of environmental elements in 2014 reflects the evolution of various driving forces, pressures and states that affect the environment of Macao. There are mixed feelings, and everyone should not only ponder and pay attention, but also participate and take actions. Environmental protection is an enduring and cross-generation task that might not get instant results, but with the joint participation, relentless practice and persistent efforts of the whole society, we do believe that the work for improving the quality of environment in Macao will be multiplied.

In reviewing the changing trends of 82 sub-indicators under 19 major environmental indicators in 2014, 15 sub-indicators (approximately 18.3%), such as AQI, carbon emission intensity and number of participants engaged in courses and seminars related to the environmental management system, etc. showed a "Good" trend. This indicates that the measures taken by the Macao SAR Government, such as establishment of laws, regulations and administrative measures, improvement of efficiency, pollution control, and environmental consciousness cultivation are becoming increasingly effective.

There were 38 sub-indicators such as estimated GHG emissions, tourism intensity, emissions of various atmospheric pollutants, rate of green area, noise levels, etc. remained "Stable" (approximately 46.3%). These sub-indicators had relatively small variations and shall be observed continuously so as to formulate strategies to bring them towards a "Good" trend.

There were also 26 sub-indicators, such as electricity consumption, billed water consumption, waste transferred to the Macao Refuse Incineration Plant for treatment, total evaluation index of coastal waters, etc., showing an "Unsatisfactory" trend (approximately 31.7%). It is shown that these aspects tended to become unsatisfactory gradually and more effective solutions shall be developed and enforced.

Compared with 21 sub-indicators showing a "Good" trend, 26 remaining "Stable" and 38 showing an "Unsatisfactory" trend in 2013, the numbers of sub-indicators showing "Good" and "Unsatisfactory" trend in 2014 decreased by 6 and 12 respectively while the number of sub indicators remaining "Stable" increased by 12. Most sub-indicators showed a flat trend, but the sub-indicators tending to be "Unsatisfactory" still account for a relatively large proportion, which is worth concerning.

Generally speaking, in the wake of rapid economic growth of Macao in 2014, the population, visitor arrivals, motor vehicles and energy consumption were also increasing. Impacted by these driving forces, the environmental pressure of Macao is also increasing.

The air quality in 2014 is improved noticeably compared with that in 2013. The proportion of

days with "Good" and "Moderate" air quality increased and the carbon emission intensity also declined continuously. It is necessary to take continuously further measures for emission control of atmospheric pollutants especially PM_{10}, $PM_{2.5}$, NO_X and O_3 and reduction of GHG emissions, and reinforce regional cooperation as well as joint pollution prevention and treatment.

Meanwhile, it is noteworthy that the quality of coastal waters was getting worse in 2014, which may be due to the pollution caused by frequent marine activities and operations as well as the worsening of regional marine water quality. It is suggested to enhance and optimize the management on wastewater treatment facilities and the drainage network in Macao, and promote regional cooperation in order to reinforce the protection for water environment and secure the safety of water supply.

Reviewing year of 2014, more attention shall be paid to the considerable increase of waste transferred to the Macao Refuse Incineration Plant for treatment. Under the circumstances that volume of domestic waste largely surpassing that of recycled waste, and subsequent increase of construction waste, it exerts a tremendous pressure for solid waste treatment in Macao. Considering such serious situation, it is necessary to pay specific attention and put forward more effective and long-term control measures to solve these problems. Through the concept of "Waste reduction at source and resource recycling", by establishment of long-term blueprint for sustainable use of resources and solid waste, continuous environmental publicity and education, optimization of environmental protection infrastructures, formulation and completion of relevant laws and regulations as well as reinforcement of regional cooperation in order to cope with the worsening waste problem in Macao.

In recent years, although the green area and most species of creatures in Macao have increased slightly, substantial protection measures for natural ecosystems are yet to be reinforced. It is suggested to promote the concept of environmental functional districts and improve relevant planning as soon as possible, and preserve green areas with ecological values, so as to protect these precious natural environments in a more effective way.

The overall ambient noise level of Macao in 2014 had a minor difference from that in 2013 and the noises came mainly from traffic. It is suggested to control noise specifically by different measures such as urban planning and vehicle management. At the same time, the noise complaints in Macao were dominated by complaints about social activities as well as industrial and commercial noise, and a good use of legislative regulation, publicity and education is necessary to build a harmonious and peaceful living environment.

As for environmental management, the following aspects of the Macao SAR Government showed an increase in 2014. This included the financial investment into environmental protection, number of activities and course offerings, entities awarded the Certificate on Environmental

Management System, "Macao Green Hotel Award" awardees, and participations of citizens; indicating that the environmental protection awareness of various social sectors has been improved. It is recommended to strengthen the resource investment into different environmental management activities, promote cross-departmental and regional cooperation, and emphasize the participation of enterprises and responsibility of the entire population, in order to create green living style for the whole society.

In order to advance the development of Macao into a green and low-carbon city suitable for living and tourism, the *Environmental Protection Planning of Macao (2010-2020)* has put forward the vision of "Building a Low Carbon Macao, Creating Green Living Together" and a series of action plans so as to facilitate the optimization and improvement of the environment in Macao. The Macao SAR Government will continue to implement relevant plans in the *Planning*, assess the efficiency of and revise the *Planning* from time to time, and call on the whole society to participate actively, such as protecting the environment, making wise use of resources, saving energy and water, and reducing emissions and waste in our daily life, so as to jointly facilitate the development of Macao into an environmental-friendly city.

Indicators analyzed in the *Report on the State of the Environment of Macao 2014*

1. The trends of sub-indicators[1] showing "Good" 

Chapter	Description	Trend in "Report on the State of the Environment of Macao"	
		2014	2012-2013
Introduction	**Social, Economic and Environmental Evolution of Macao**		
	1. Gross Domestic Product (GDP; at current prices)		
Atmospheric Environment	**Air Quality**[2]		
	2. Air Quality Index (AQI)		
	3. Respirable suspended particulates with diameter less than 10μm concentrations		
	4. Fine suspended particulates with diameter less than 2.5μm concentrations		
	General Atmospheric Pollutant Emissions		
	5. Annual estimated emissions of sulphur oxides		
	Greenhouse Gas Emissions		
	6. Carbon emission intensity		
Water Resources	**Quality of Coastal Waters**		
	7. Chlorophyll-a concentration		
Waste	**Recycling and Ultimate Disposal of Waste**		
	8. Recovery rate of recyclable waste		
Ambient Noise	**Noise Complaints**		
	9. Annual number of noise complaints		
Environmental Management	**Public Investment and Expenditure on Environmental Planning, Remediation and Infrastructure**		
	10. Public expenditure on "Infrastructure" and "Planning and environment"		
	Public Participation and Concern		
	11. Total number of activities		
	12. Expenses		
	Promotion and Implementation of Environmental Management System		
	13. Number of entities awarded the ISO14001 Certificate on Environmental Management System		
	14. Courses and seminars related to the environmental management system		

[1] The trends of sub-indicators are sourced from the evaluation on the evolution of sub-indicators between 2013 and 2014 from the perspective of environmental protection.

[2] Comparison of trend is made among the monitoring stations which have sufficient and effective data between 2013 and 2014.

Environmental Management	15. Number of participants engaged in the related training courses and seminars		
 ="Good" ;  ="Stable" ;  ="Unsatisfactory"			

2. The trends of sub-indicators remaining "Stable" 

Chapter	Description	Trend in "Report on the State of the Environment of Macao"	
		2014	2012-2013
Introduction	**Social, Economic and Environmental Evolution of Macao**		
	1. End-year population		
	2. Population density		
	3. Tourism intensity		
	4. Land area		
	5. Estimated greenhouse gas emissions		
Atmospheric Environment	**Air Quality**		
	6. Ozone concentrations		
	7. Carbon monoxide concentrations		
	General Atmospheric Pollutant Emissions		
	8. Annual estimated emissions of carbon monoxide		
	9. Annual estimated emissions of nitrogen oxides		
	10. Annual estimated emissions of ammonia		
	11. Annual estimated emissions of non-methane volatile organic compound		
	12. Annual estimated emissions of total suspended particulates		
	13. Annual estimated emissions of respirable suspended particulates with diameter less than 10μm		
	14. Annual estimated emissions of lead		
	Greenhouse Gas Emissions		
	15. Annual estimated emissions of carbon dioxide		
	16. Annual estimated emissions of methane		
	17. Annual estimated emissions of nitrous oxide		
	Eco-efficiency of the Energy Sector		
	18. Energy consumption per unit of GDP		
	Eco-efficiency of the Transport Sector		
	19. Number of motor vehicles per kilometer (Motor vehicle density)		
	20. Annual fuel consumption of maritime transport		

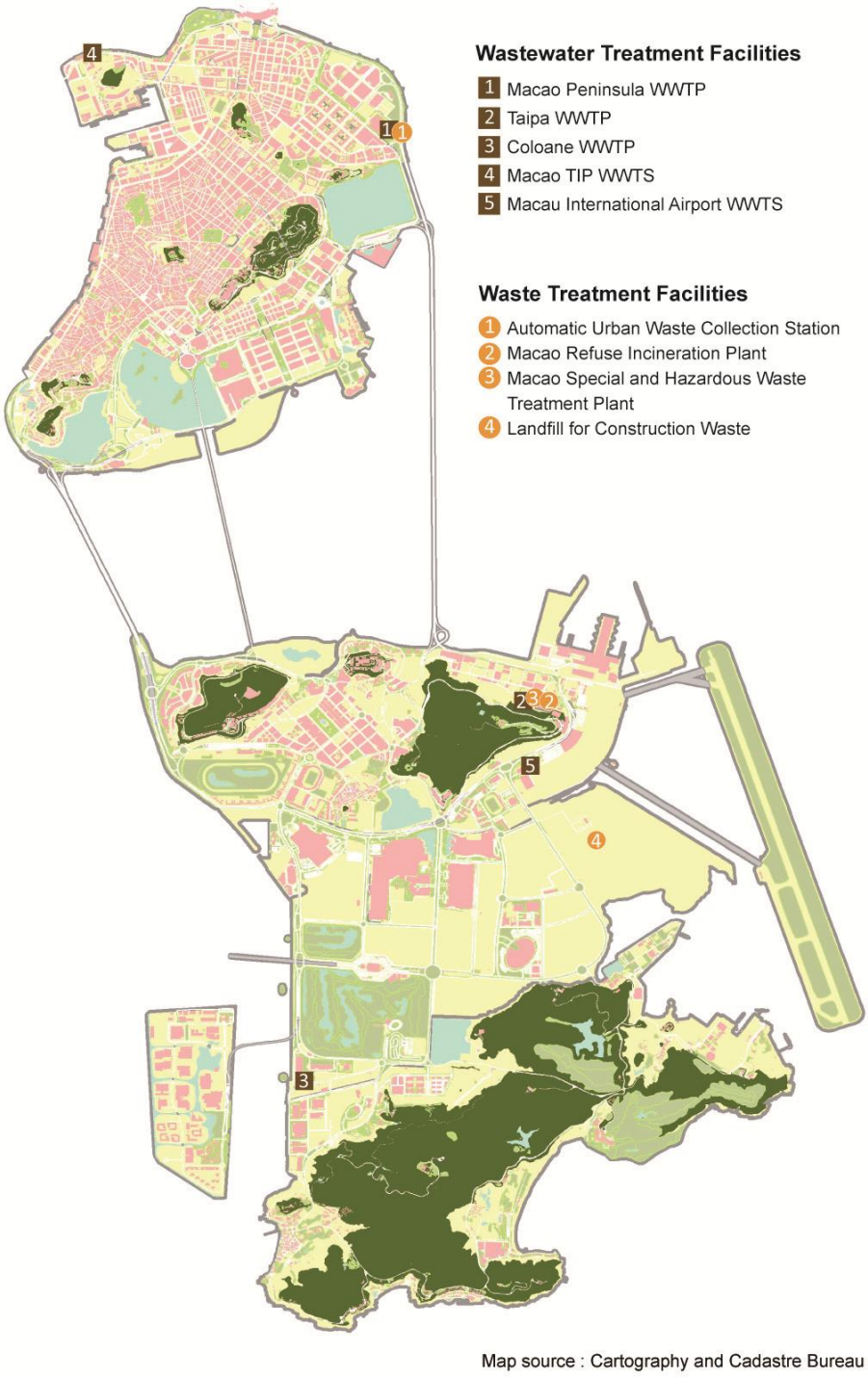
Water Resources	**Quality of Potable Water**		
	21. Chloride concentration of treated water from the Ilha Verde Water Treatment Plant		
	22. Qualified rate of coliform bacteria in the distribution networks		
	Potable Water Consumption		
	23. Water consumption per ten thousand MOP GDP		
	24. Daily average billed water consumption per capita		
	Quality of Coastal Waters		
	25. Eutrophic index		
	Wastewater Treatment		
	26. Daily mean treated volume by WWTPs/WWTSs		
Waste	**Waste Generation**		
	27. Type and quantity of waste vehicles		
Nature Conservation	**Green Area**		
	28. Green area under the jurisdiction of IACM		
	29. Green area per capita		
	30. Rate of urban green area		
	31. Number of tree species in Macao		
Ambient Noise	**Driving Force of Noise**		
	32. Number of licensed construction establishments		
	Noise Levels		
	33. Annual average hourly L_{eq}		
	34. Annual average L_{eq}		
	35. Annual average statistical noise level		
Environmental Management	**Public Participation and Concern**		
	36. Total number of participants		
	37. Number of co-organizers		
	Promotion and Implementation of Environmental Management System		
	38. Number of hotels awarded the "Macao Green Hotel Award"		
 ="Good"；  ="Stable"；  ="Unsatisfactory"			

3. The trends of sub-indicators showing "Unsatisfactory" 

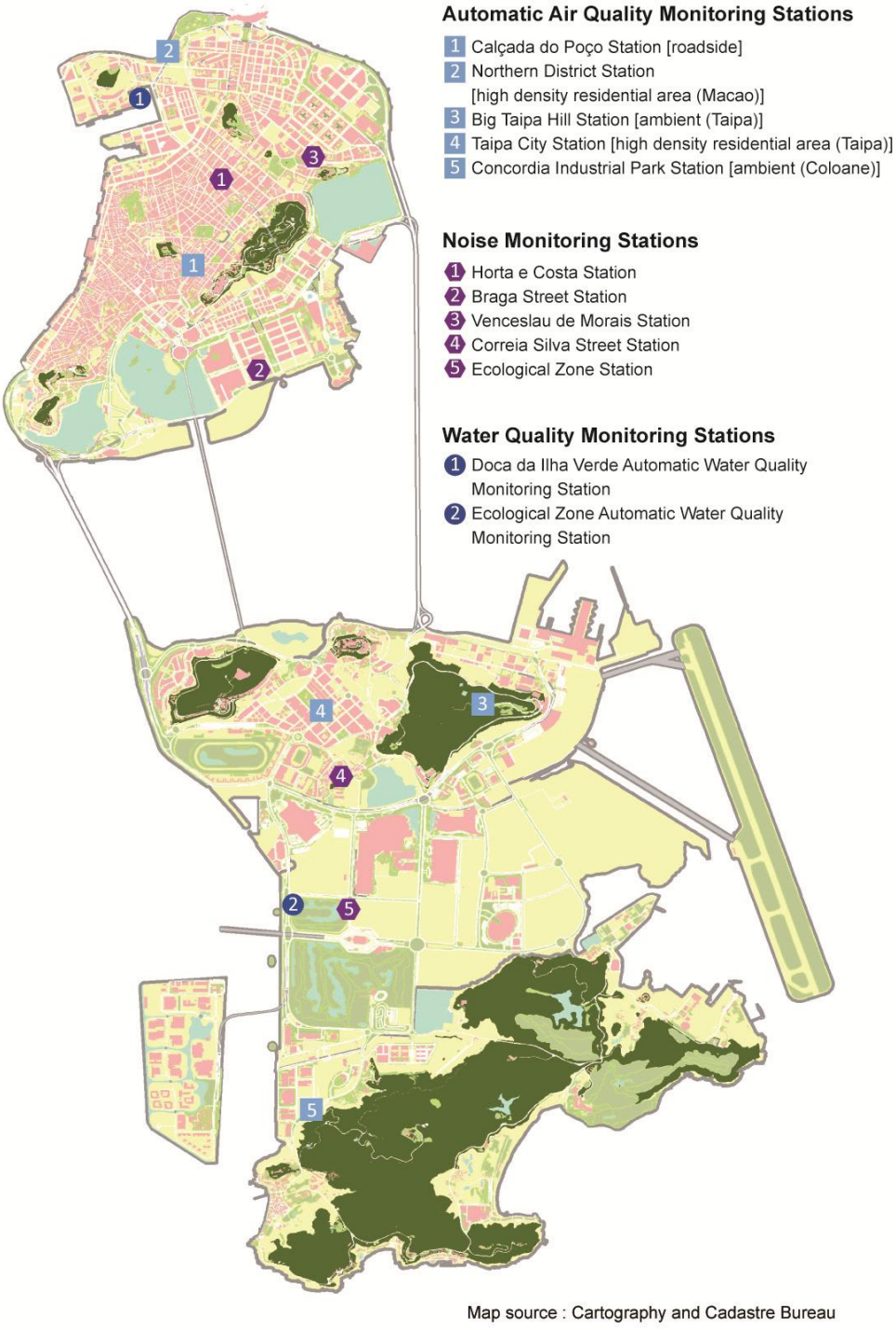
Chapter	Description	Trend in REAM 2014	Trend in REAM 2012-2013
Introduction	**Social, Economic and Environmental Evolution of Macao**		
	1. Visitor arrivals		
	2. Electricity consumption		
	3. Billed water consumption		

Introduction	4. Waste transferred to the Macao Refuse Incineration Plant for treatment		
Atmospheric Environment	**Air Quality**		
	5. Sulphur dioxide concentrations		
	6. Nitrogen dioxide concentrations		
	Eco-efficiency of the Energy Sector		
	7. Final energy consumption		
	Eco-efficiency of the Transport Sector		
	8. Number of motor vehicles		
	9. Annual fuel consumption of land transport		
Water Resources	**Quality of Potable Water**		
	10. Rainfall		
	Potable Water Consumption		
	11. Volume of water flowing through the distribution networks		
	12. Leakage rate in the distribution network		
	13. Domestic water consumption		
	Quality of Coastal Waters		
	14. Non-metal evaluation index		
	15. Heavy metal evaluation index		
	16. Total evaluation index		
Waste	**Waste Generation**		
	17. Daily mean quantity of urban domestic waste per capita		
	18. Special and hazardous waste transferred for treatment		
	19. Solid waste generated by the electricity supply company		
	Recycling and Ultimate Disposal of Waste		
	20. Landfill quantity of construction waste		
	21. Landfill quantity of slag		
	22. Landfill quantity of fly ash		
Nature Conservation	**Green Area**		
	23. Number of animal species in Macao		
	24. Number of hill fires		
Environmental Management	**Public Participation and Concern**		
	25. Number and category of environmental complaints reported to the DSPA by the public		
	26. Number and category of complaints about environmental hygiene reported to IACM by the public		
="Good" ; ="Stable" ; ="Unsatisfactory"			

Appendix



Distribution of environmental protection infrastructure in Macao



Distribution of environmental monitoring stations in Macao

Abbreviations

A	
accum.	accumulated
ADA	Administração de Aeroportos (Administration of Airports Limited)
approx.	approximately
AQI	Air Quality Index
As	Arsenic
C	
CCA	Conselho Consultivo do Ambiente (Advisory Council on the Environment)
Cd	Cadmium
CEM	Companhia de Electricidade de Macau - CEM, S.A. (Macau Electricity Company Limited)
CH_4	Methane
CITES	*Convention on International Trade in Endangered Species of Wild Fauna and Flora*
CO	Carbon monoxide
CO_2	Carbon dioxide
CPSP	Corpo de Polícia de Segurança Pública (Public Security Police Force)
CPTTM	Centro de Produtividade e de Transferência de Tecnologia de Macau (Macau Productivity and Technology Transfer Center)
Cr	Chromium
Cu	Copper
D	
dB	Decibel, sound level
DPSIR	Driving force – Pressure – State – Impact – Response
DSAMA	Direcção dos Serviços de Assuntos Marítimos e de Água (Marine and Water Bureau)
DSAT	Direcção dos Serviços para os Assuntos de Tráfego (Transport Bureau)
DSCC	Direcção dos Serviços de Cartografia e Cadastro (Cartography and Cadastre Bureau)
DSE	Direcção dos Serviços de Economia (Macao Economic Services)
DSEC	Direcção dos Serviços de Estatística e Censos (Statistics and Census Bureau)
DSEJ	Direcção dos Serviços de Educação e Juventude (Education and Youth Affairs Bureau)

DSF	Direcção dos Serviços de Finanças (Financial Services Bureau)
DSPA	Direcção dos Serviços de Protecção Ambiental (Environmental Protection Bureau)
DSRJDI	Direcção dos Serviços da Reforma Jurídica e do Direito Internacional (Law Reform and International Law Bureau)
DSSOPT	Direcção dos Serviços de Solos, Obras Públicas e Transportes (Land, Public Works and Transport Bureau)
DST	Direcção dos Serviços de Turismo (Macao Government Tourism Office)
E	
EEA	European Environment Agency
EMEP	Environmental Monitoring, Evaluation and Protection Programme
EPP	Environmentally Preferable Purchasing
G	
GB	Guobiao (Chinese National Standard)
GDP	Gross Domestic Product
GDSE	Gabinete para o Desenvolvimento do Sector Energético (Office for the Development of the Energy Sector)
GHG	Greenhouse Gas
H	
Hg	Mercury
HKD	Hong Kong Dollar
HKTB	Hong Kong Tourism Board
I	
IACM	Instituto para os Assuntos Cívicos e Municipais (Civic and Municipal Affairs Bureau)
IPIM	Instituto de Promoção do Comércio e do Investimento de Macau (Macao Trade and Investment Promotion Institute)
ISO	International Organization for Standardization
K	
kg	kilogram
kWh	kilowatt hour
L	
L	liter
L_{10}	The noise level exceeded during 10% of the monitoring period, representing a rather high-intensity noise level during that period
L_{90}	The noise level exceeded during 90% of the monitoring period, representing a relatively low-intensity noise level during that period

L_{eq}	Equivalent Continuous Sound Pressure Level (L_{eq})
LSP	Public Health Laboratory
M	
Macao SAR Government	Government of the Macao Special Administrative Region
mg	milligram
MIECF	Macao International Environmental Cooperation Forum & Exhibition
MOP	Macao Pataca
N	
N_2O	Nitrous oxide
NH_3	Ammonia
Ni	Nickel
NMVOC	Non-methane volatile organic compounds
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NTD	New Taiwan Dollar
O	
O_3	Ozone
P	
Pb	Lead
PM_{10}	Respirable suspended particulate with diameter less than 10μm
$PM_{2.5}$	Fine suspended particulate with diameter less than 2.5μm
ppl	people
PRD	Pearl River Delta
PSP	Corpo de Polícia de Segurança Pública (Public Security Police Force)
R	
RADARM	Regulation of Water and Wastewater Drainage of Macao
S	
SA	Serviços de Alfândega (Macao Customs Service)
SAAM	Sociedade de Abastecimento de água de Macau (Macao Water Supply Company Limited)
SAFP	Direcção dos Serviços de Administração e Função Pública (Public Administration and Civil Service Bureau)
Se	Selenium
SMG	Serviços Meteorológicos e Geofísicos (Meteorological and Geophysical Bureau)
SO_2	Sulphur dioxide

SO_x	Sulphur oxides
SS	Serviços de Saúde (Health Bureau)
T	
TIP	Transborder Industrial Park
TJ	Terajoule
TSP	Total suspended particulates
U	
UN	United Nations
USEPA	United States Environmental Protection Agency
W	
WWTP	wastewater treatment plants
WWTS	wastewater treatment stations
Z	
Zn	Zinc

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http://www.mep.gov.cn

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http://www.economia.gov.mo

Macao Government Tourism Office
http://www.macautourism.gov.mo

Marine and Water Bureau
http://www.marine.gov.mo

Meteorological and Geophysical Bureau
http://www.smg.gov.mo

Office for the Development of the Energy Sector
http://www.gdse.gov.mo

Public Administration and Civil Service Bureau
http://www.safp.gov.mo

Statistics and Census Bureau
http://www.dsec.gov.mo

Transport Bureau
http://www.dsat.gov.mo

International Conventions

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
http://www.basel.int

Convention of Biological Diversity
http://www.cbd.int

Convention on International Trade in Endangered Species of Wild Fauna and Flora
http://www.cites.org

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter
http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm

International Plant Protection Convention
https://www.ippc.int

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
http://www.pic.int

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http://www.pops.int

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