Asia-Pacific Economic Cooperation

**Final Report**

# APEC Low Carbon Model Town (LCMT) Project Phase 6: Feasibility Study for Mandaue City

**Cebu Province, The Philippines**

**Energy Working Group**

**November 2016**

APEC Project: EWG 01 2015A

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# ABBREVIATIONS

| | |
|---|---|
| ADB | Asian Development Bank |
| AEC | Asian Energy Systems Corporation |
| AFD | French Development Agency |
| AFETD | Alternative Fuels and Energy Technology Division |
| AGT | automated guideway transit |
| APEC | Asia-Pacific Economic Cooperation |
| BAS | Building Automation System |
| BAU | Business-as-usual |
| BERDE | Building for Ecologically Responsive Design Excellence |
| BLT | build-lease and transfer |
| BPO | business process outsourcing |
| BRT | bus rapid transit |
| BTr | Bureau of Treasury |
| CASBEE | Comprehensive Assessment System for Building Environment Efficiency |
| CBD | central business district |
| CCTV | closed-circuit television |
| CDM | clean development mechanism |
| CER | certified emission reduction |
| CFD | computational fluid dynamics |
| CICC | Cebu International Convention Center |
| CLUP | comprehensive land use plans |
| CML | Cebu, Mandaue,Lapu-Lapu |
| $CO_2$ | carbon dioxide |
| CPC | Community Project Council |
| CPDO | City Planning and Development Office |
| CTF | Clean Technology Fund |
| CWA | Clean Water Act |
| DBM | Department of Budget and Management |
| DENR | Department of Environment and Natural Resources |
| DGS | Department of General Services |
| DILG | Department of Interior and Local Government |
| DOE | Department of Energy |
| DOF | Department of Finance |
| DOTr | Department of Transportations |
| DPWH | Department of Public Works and Highways |
| EMB | Environment Management Bureau |
| ERU | emission reduction unit |
| ESCO | energy service companies |
| FAR | floor area ratio |
| GBO | Green Building Ordinance |
| GEF | Global Environmental Facility |
| GGA | green growth area |
| GHG | greenhouse gas |
| GRDP | gross regional domestic product |
| IFC | International Finance Corporation |
| INDC | Intended Nationally Determined Contributions |
| ITS | Intelligent Transport Systems |
| JCM | Joint Crediting Mechanism |
| JI | joint implementation |
| JICA | Japan International Cooperation Agency |
| LBP | Landbank of the Philippines |

| | |
|---|---|
| LC | low carbon |
| LCMT | Low-Carbon Model Town |
| LCT | low-carbon town |
| LCT-I | low-carbon town indicators |
| LDV | light duty vehicle |
| LED | light emitting device |
| LGU | local government unit |
| LGUGC | LGU Guarantee Corporation |
| LTO | Land Transportation Office |
| M&E | monitoring and evaluation |
| MCDCB | Metro Cebu Development and Coordination Board |
| MCIA | Mactan–Cebu International Airport |
| MC/TC | motorcycle/tricycle |
| MCWD | Metropolitan Cebu Water District |
| MRF | material recovery facility |
| MRV | measure, report and verify |
| MSGC | Multi-Sectoral Governance Council |
| $MtCO_2$ | Million ton carbon dioxide |
| MWh | Megawatt hour |
| NCCAP | National Climate Change Action Plan |
| NFSCC | National Framework Strategy on Climate Change |
| NMT | non-motorized transport |
| NSO | National Statistics Office |
| NSSMP | National Sewerage and Septage Management Program |
| OOTV | overall thermal transfer value |
| PGBC | The Philippine Green Building Council |
| PGS | Performance Governance System |
| PJ | Petajoule (energy unit) |
| PPP | public-private partnership |
| PUD | planned unit development |
| PV | photovoltaic |
| RA | Republic Act |
| SLF | sanitary landfill facility |
| SUV | Sport Utility Vehicle |
| TCC | Traffic Control Center |
| TJ | Terajoule (energy unit) |
| TOD | Transit-Oriented Development |
| $tCO_2$ | One ton carbon dioxide |
| ToR | terms of reference |
| USAID | United States Agency for International Development |
| UV | Utility vehicle |
| VACs | vision aligned circles |
| VAPs | vision-aligned partners |
| VECO | Visayan Electric Company, Inc |
| VOC | vehicle operating costs |
| WB | World Bank |
| WORM | weekly operations review meeting |
| WTE | waste to energy |
| WWTF | wastewater treatment facility |
| ZEB | Zero Energy Building |

# SUMMARY

## Study Objective and High-Level Vision

This feasibility study completes the sixth phase of the Asia-Pacific Economic Cooperation (APEC)-initiated Low Carbon Model Town (LCMT) Project. It focuses on the City of Mandaue, an industrial city located in the midst of Metro Cebu, the second largest metropolitan area in the Philippines. The goal of this study is to provide government officials at the local and national levels and stakeholders in Mandaue and its neighboring cities with implementable advice towards low carbon urban development.

Mandaue City is keen on pursuing low carbon development, as attested by its recent efforts in the form of city ordinances and other activities, including the integrated development of six (6) Green Growth Areas (GGAs) otherwise referred to as Planned Unit Developments (PUDs), the Green Building Ordinance, the Butuanon River management, and expanded use of the old dumpsite at Barangay Umapad as a sanitary landfill with materials recovery facilities (MRFs). The study supports those city initiatives and identifies further metropolitan-wide solutions which would be more effective compared to a lone city undertaking in low carbon development. Therefore, the LCMT concept of Mandaue is set as "**Sustainable Urban Life and Economic Activities in Cooperation with Neighboring Cities.**"

## GHG Emission Estimation and Reduction Targets

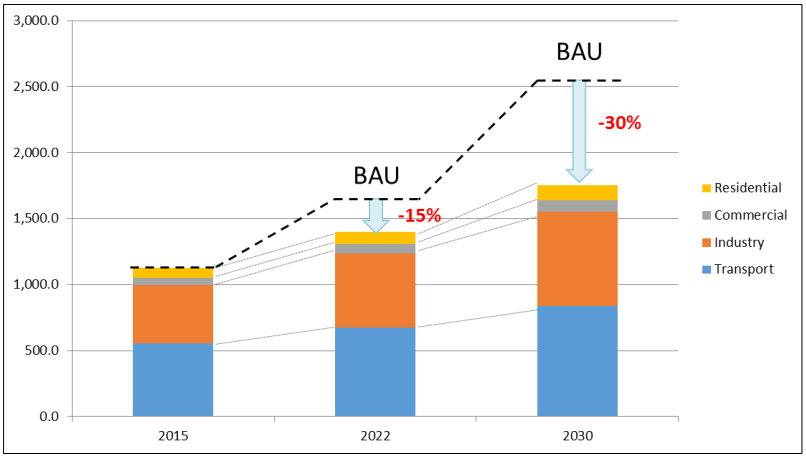
This study builds on Mandaue City's greenhouse gas (GHG) generation path towards 2030 by evaluating the city's 2015 GHG baseline, sector-specific inventories and business-as-usual (BAU) emissions projections for the years 2022 and 2030. Then, the emission reduction targets are set as 15% reduction by 2022 and 30% reduction by 2030 compared to their respective BAU scenarios.

In the year 2015 baseline, the estimated GHG emissions total 1.13 million $tCO_2$ (see Figure S1). The largest emission generation sector is transport (0.55 million $tCO_2$), followed by industry (0.45 million $tCO_2$). Those two sectors account for 89% of the city's GHG emissions. In the year 2030 BAU scenario, the total projected emissions would be 2.51 million $tCO_2$ or 223% of the 2015 baseline. The reduction target in 2030 is calculated at 0.75 million $tCO_2$.

## APEC Low Carbon Town Indicators (LCT-I)

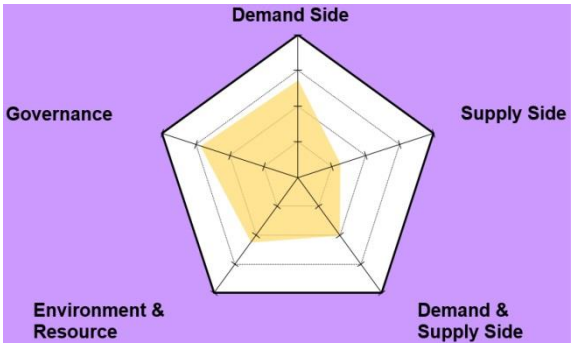
In order to identify low carbon development needs and issues in Mandaue City, the APEC Low Carbon Town Indicators (LCT-I) are used for city assessment by selected four (4) local experts, i.e., two from the city planning office, one from the city environment office and one environmental consultant. The results of their individual evaluations using the LCT-I are shown in Figure S2 and

Figure S3 (sample).

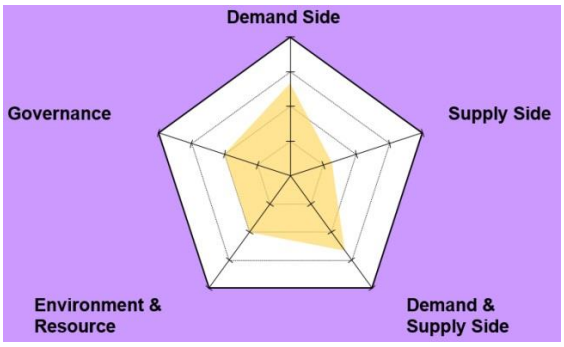



Source: APEC Study Team

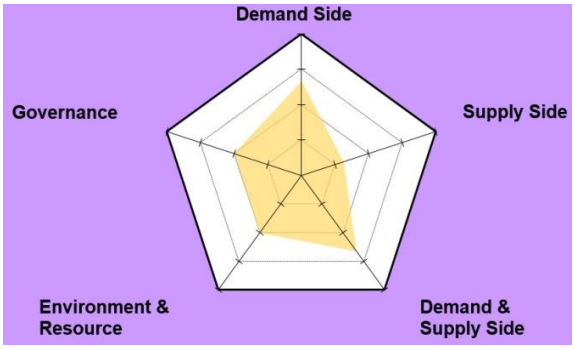
**Figure S1 GHG Emission Projections and Targets in Mandaue City**



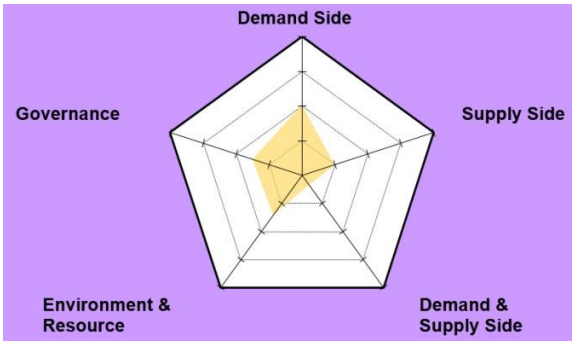

**(A) Radar Chart by Evaluator A**




**(B) Radar Chart by Evaluator B**




**(C) Radar Chart by Evaluator C**




**(D) Radar Chart by Evaluator D**

Source: APEC Study Team

**Figure S2 Radar Charts of 4 Evaluators**


Source: APEC Study Team

**Figure S3 Scores of Tiers 1 and 2 of Evaluator A (Example)**

The results show a relative similarity among the three city officials who positively assessed the city's ongoing efforts particularly in the demand and supply aspects such as energy management of buildings and areas, and in the environment and resource aspects such as water and waste management. The environmental consultant, however, questioned about their achievements in the future. All the evaluators gave low scores in the transport demand side and advanced energy supply systems such as area energy system, untapped energy and renewable energy in the supply side.

## Low Carbon Measures

The study focuses on four (4) strategic sectors (i.e., land use, transportation, other urban services, and buildings) for identifying doable low carbon measures. All the proposed LC measures are illustrated with their locations in the GGAs in Figure S4.

**Land Use Planning**: It is recommended that the city's urban structure be transformed into an environmentally sustainable one guided by two metropolitan flagship projects, the Green Loop and the AGT-CML Line.

(1) **Green Loop.** This is a concept for green corridor development encircling Cebu City, Mandaue City, Lapu-Lapu City, and the Municipality of Cordova. The city's section is divided into two – the road section along Hernan Cortes Street and the river section along Butuanon River. Enough space will be allocated for pedestrians, cyclists, public transit and the greenery along the corridor. River flow will be also rationalized between green riverbanks.

GHG emission reduction will be expected from improved river water quality and transport modal shift particularly to non-motorized trips (NMT).

(2) **Transit-Oriented Development (TOD).** The proposed Automated Guideway Transit Cebu-Mandaue-Lapu Lapu (AGT-CML) Line traverses Cebu City, Mandaue City and Lapu-Lapu City. Mandaue City is located in the middle with six stations and one depot. TOD is encouraged around each station where compact urban development and convenient station access including pedestrian facilities such as "skywalk" and modal transfer facilities such as "station square" are provided. GHG emission reduction will be expected from increased walking trips to and from the stations.

**Transportation Planning**: Since the transport sector is the largest GHG emission source in Mandaue City, it is suggested that emission reduction be undertaken in a holistic manner. It includes more efficient and safe road traffic environment, reduction in emissions intensity per vehicle unit, and reduction in vehicular traffic.

(1) **Smart Corridor.** The study proposes a smart corridor concept where LED streetlights with solar panels and wifi devices are lined along a corridor. It enables real-time road traffic and roadside monitoring for better traffic management and roadside security at the city's Traffic Control Center. LED lamps can greatly reduce electricity consumption compared with ordinary lamps. Real-time road traffic information can be provided to road users through internet traffic mobility management services so as to improve road use efficiency. A Smart City will be realized when the city has a crisscross of smart corridors.

(2) **E-Trike.** The Department of Energy (DOE) intends to replace the tricycles currently used in the city with e-trikes. The local manufacturer's e-trike demonstration project (15 units in Mandaue City) reveals that the e-trikes can get regular clients easily because of no emission, no noise and comfortable driving. The study proposes mass procurement deals for e-trikes (600 units per deal) with supporting facilities such as battery recharging stations to enjoy economy of scale or reduction in capital investment. More GHG emission reduction is expected as the number of e-trikes grows.

(3) **AGT-CML Line.** The 19.2-km long AGT-CML Line is proposed between the Cebu City Central Business District (CBD) and the Mactan Cebu International Airport (MCIA). The line demand is good for light rail. AGT, one of the light rail systems, is disaster resilient and, thus, suitable for the operation along coastline and island connections. The traffic assignment exercise shows that the project expects to reduce road traffic volume within Mandaue City by 10.8% in 2030.

**Other Urban Services Planning**: The territory of Mandaue City has been mostly urbanized. Further development, both new development and redevelopment, will be done in the designated green growth areas where energy saving and the use of renewable energy and untapped energy are keen in the provision of other urban services than transportation.

(4) **Renewable Energy.** Solar radiation of Cebu is high at 5.0-5.5 kWh/m2/day. Rooftop solar photovoltaics (PV) is a suitable option, as promoted by the Visayan Electric Company (VECO). The city's Green Building Ordinance (GBO) also encourages the use of natural energy. The study suggests that 25% of all the buildings in the GGAs should install rooftop solar panels. The PV-generated electricity will first be consumed within the buildings and any excess will be sold to VECO.

(5) **Waste-to-Energy (WTE).** The city government closed their 2-hectare sanitary landfill (SLF) at Barangay Umapad in 2009 and undertook rehabilitation activities with a MRF and other facilities but later opened an adjacent area on a temporary basis to process the city's collected residuals. Today, there are some alternatives such as development of a new SLF site within the city and contracting of a private SLF operator at Consolacion. The study suggests that a WTE plant be constructed at Barangay Umapad, which is strategically located near the second Mactan Bridge and the Cansaga Bay Bridge, to serve not only Mandaue City but also the surrounding cities.

(6) **DHC (District Heating and Cooling) and DCS (District Cooling System).** A district energy system, either DHC or DCS, can provide considerable energy-saving effects compared with individual building energy supply, e.g., 14.2% (METI Japan's survey since 1997). The study suggests that DHC be installed at GGA4 and GGA6, both new development areas with transmission of energy from the proposed WTE plant at Barangay Umapad.

**Green Building Planning**: Mandaue City established the GBO in 2015 for improving the resource efficiency of buildings, minimizing the impact of buildings on health and environment, and contributing to the global efforts in reducing GHG emissions. To operationalize the GBO, the capacity of the Green Building Office which administers and monitors compliance with the ordinance should be strengthened. To effectively adopt the Building for Ecologically Responsive Design Excellence (BERDE) Green Building Rating System, practical implementing rules and public relations among the citizens are important.

Under the GBO, all public buildings are required to hold minimum 1-star BERDE certificates while all the new buildings within the GGAs are required to hold minimum 3-star BERDE certificates. The study suggests for all the new buildings within the GGAs to invest various low-carbon building measures such as natural day lighting, roof greenery, energy efficient building envelope, low E-glass, energy efficient chiller and lighting, Building Energy Management System (BEMS), solar PV and solar water heating.

## Recommendations for LCMT Implementation

All the proposed LC measures, if they are successfully implemented, can reduce an equivalent of GHG emissions by 779,869 tons in 2030 compared to the BAU scenario in 2030 or approximately 32% of the BAU scenario (see Table S1).

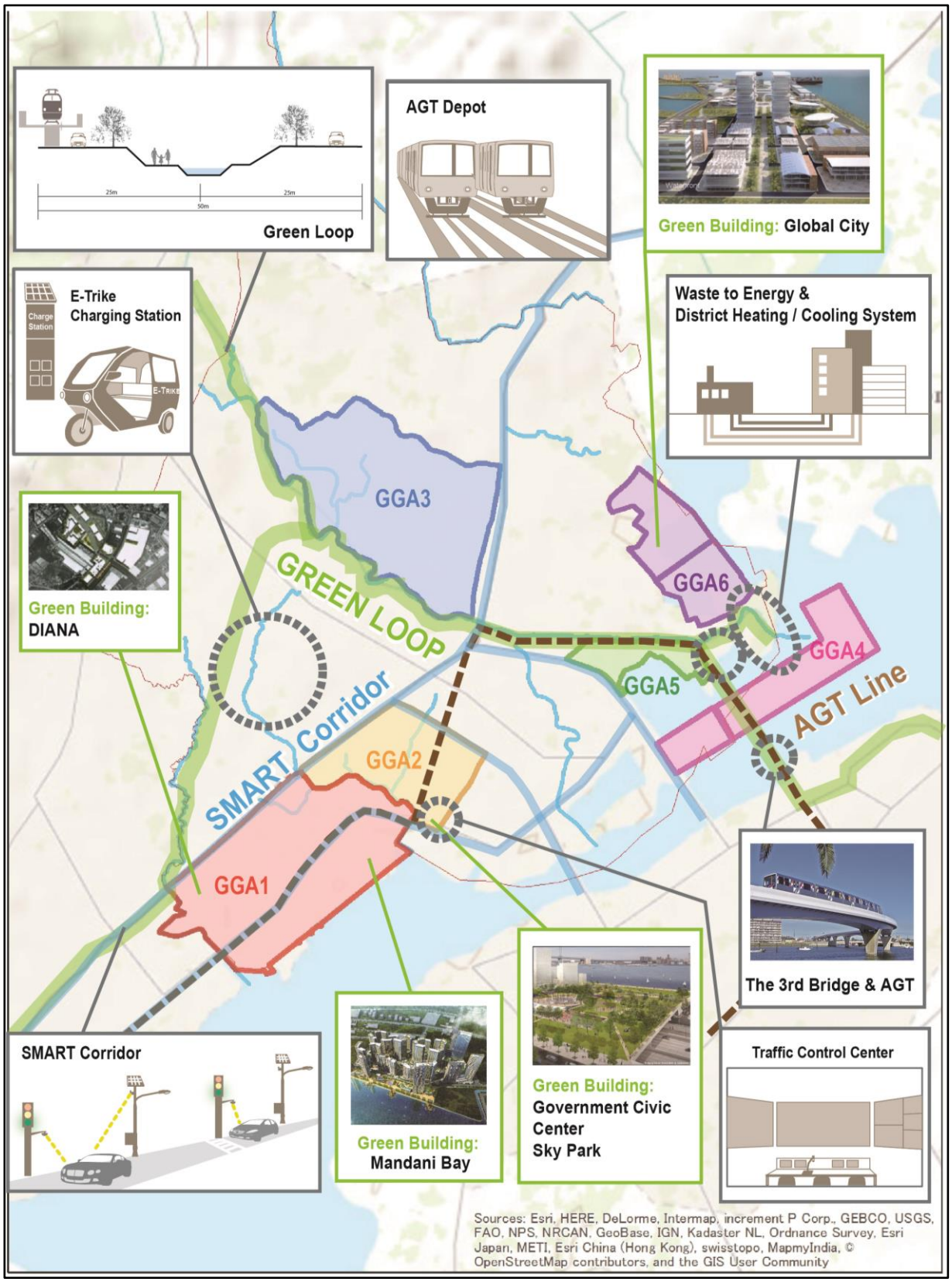
To make this happen, an aggregated capital investment of USD1,424 million is required during the planning period up to 2030. The study recommends that various available funding sources from public and private funds and/or from domestic and external funds be mobilized.

Mandaue City will have to play an important role in implementing all the proposed LC measures but its specific role assignment will be different from one measure to another. For example, the city will become an implementing body to develop smart corridors within its jurisdiction. It will regulate and coordinate private investments in green buildings, renewable energy and TOD. It will coordinate with DOE and other related central government agencies and private investors in enabling WTE, DHC/DCS and e-trike mass procurement. Although the Department of Public Works and Highways (DPWH) and the Department of Transportation (DOTr) are primarily responsible, the city will coordinate with its neighboring cities and the civil society to effectively implement the Green Loop and the AGT-CML Line.

A strong political will supported with adequate manpower on a cross-departmental collaboration is needed to implement the proposed LC measures of Mandaue. The frontrunner of the LCMT initiative is the integrated development of the GGAs which are to become the economic generators of the city. In order for Mandaue City to implement the proposed LC measures, the following three administrative and institutional layers will be further strengthened:

- The city has a working monitoring and evaluation system that looks at each specific plan/project. However, there is still room for expanding collaborative ties especially with the agencies of the member economy and other LGUs for effectively implementing the LC measures. Capacity development of all city offices should be strengthened particularly to familiarize the measure, report and verify (MRV) system of the city's LCMT development plan.
- The venue for Mandaue's wider coordination with neighboring local governments, agencies of the member economy and civil society already exists. This is the Metro Cebu Development and Coordination Board (MCDCB). Mandaue City will fully utilize MCDCB functions to implement remarkable LC measures in Metro Cebu such as e-trike mass procurement, WTE plant, the first urban rail system, and the Green Loop.
- For ease of LCMT implementation, it is recommended that support from the project affected communities be engaged from the planning stage in the form of a Community Planning Council (CPC). For the six GGAs, there will be six CPCs correspondingly. One to three barangays[1] will participate in each CPC.

[1] Barangay is the smallest administrative unit in the Philippines.




Source: APEC Study Team

**Figure S4 City-wide Low Carbon Measures in Mandaue City**

**Table S1 Outline of the Proposed Low Carbon Measures**

| Low Carbon Measure | GHG Emission Reduction Projections in 2030 | Estimation of Capital Cost | Implementing Bodies | Recommended Funding Sources |
|---|---|---|---|---|
| Green Loop | 97,526 tCO2 | PHP2,200 million | DPWH, EMB of DENR, Mandaue City, NGO | DPWH for road, riverbank and riverbed. DENR for river water quality control |
| TOD | 2,560 tCO2 | PHP1.8 million (only for design) | Private Developers, Transit Operator, Mandaue City | Local commercial bank for station front buildings. Modal transfer facilities will be built within the AGT-CML Project. |
| Smart Corridor | 5,423 tCO2 | PHP1,020 million | Mandaue City, Internet Information Provider, ESCO | Private investment in mobility management (internet free business) and LED street lighting (ESCO business). The city government will use the money from streetlight savings to develop a city-wide smart corridor. |
| E-Trikes | 1,244 tCO2 | USD34.5 million | International Financial Institution, DOE, Mandaue City | The first mass procurement of E-trikes, i.e., 5,000 units for Metro Cebu 600 units of which are for Mandue City, will be applied to the ongoing ADB-DOE's E-trike Project. |
| AGT-CML Line | 124,515 tCO2 | USD818.6 million | DOTr, Private investor | DOTr portion by IFI or DA or national budget alone, Private investment (if any) by various commercial sources |
| Renewable Energy | 63,337 tCO2 | USD356 million | Private and public developers, DOE | Local commercial bank |
| Waste To Energy | 130,255 tCO2 | USD25 million | Mandaue City or its contracted operator, DOE | Local development bank, JCM |
| DHC / DCS | 44,687 tCO2 | USD32.8 million | Private developer appointed by Mandaue City, DOE | Local development bank, JCM |
| Green Building | 310,322 tCO2 | USD86.6 million | Private and public developers | Local development bank particularly for public buildings, local commercial bank |
| TOTAL | 779,869 tCO2 | USD1,424million | | |

Source: APEC Study Team

# 1 INTRODUCTION

## 1.1 Study Scope

The APEC Low-Carbon Model Town (LCMT) Project commenced in 2010 in order to encourage the creation of low-carbon communities in urban development planning and share best practices for making such communities a reality. The LCMT Project consists of two activities, namely, (i) the development of the "Concept of the Low-Carbon Town in the APEC Region" and (ii) the "Feasibility Study" and "Policy Review" of planned development projects as examples of real-life applications of the concept.

This is the Feasibility Study for the low-carbon town development of Mandaue City as part of the APEC LCMT Project Phase 6. The project's main objective is:

> "To provide feasibility study and policy review of a low-carbon development project selected for LCMT Phase 6; checking $CO_2$ emissions reduction goals; verifying how to develop attractive and innovative development plans through the feasibility study; and making recommendation on low-carbon measures through policy review."

The Feasibility Study includes the implementation methodology and action plans for the proposed mitigation measures including potential implementing bodies and funding sources. It also help develop the Concept of the Low-Carbon Town by sharing best practices and real-world experiences on low-carbon development with town planners and policymakers.

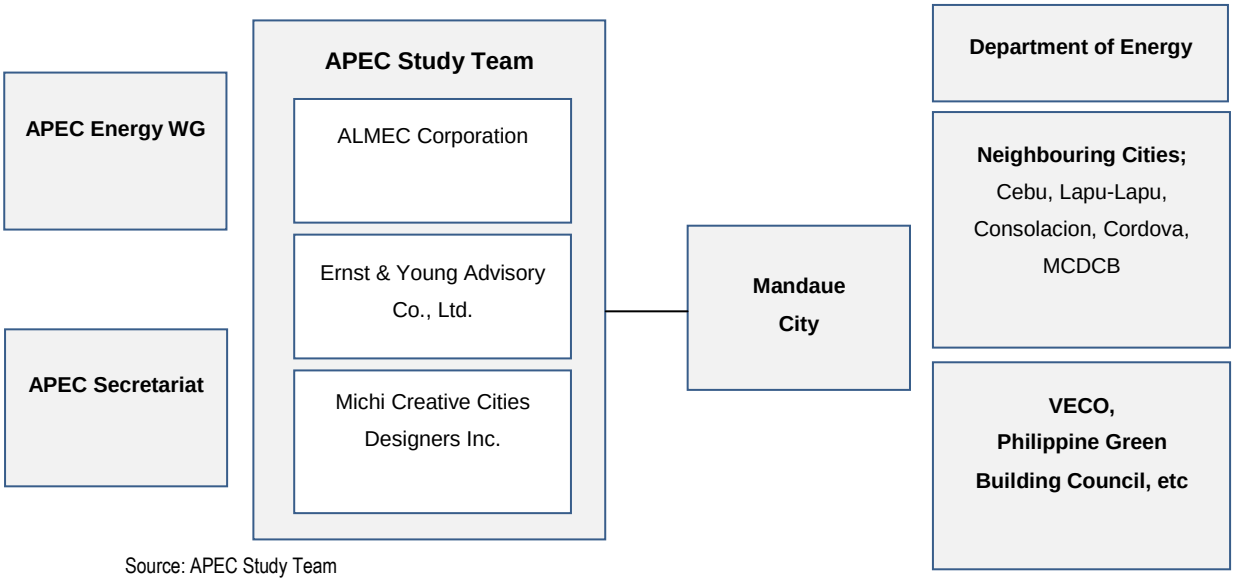
Since this is part of the APEC LCMT Project Phase 6, the previous five FS experiences will be duly referred upon while Phase 6 will focus on a low-carbon development plan in Mandaue to be developed in cooperation with neighboring cities.

## 1.2 Study Organization and Activities

### 1.2.1 Organization of the Study

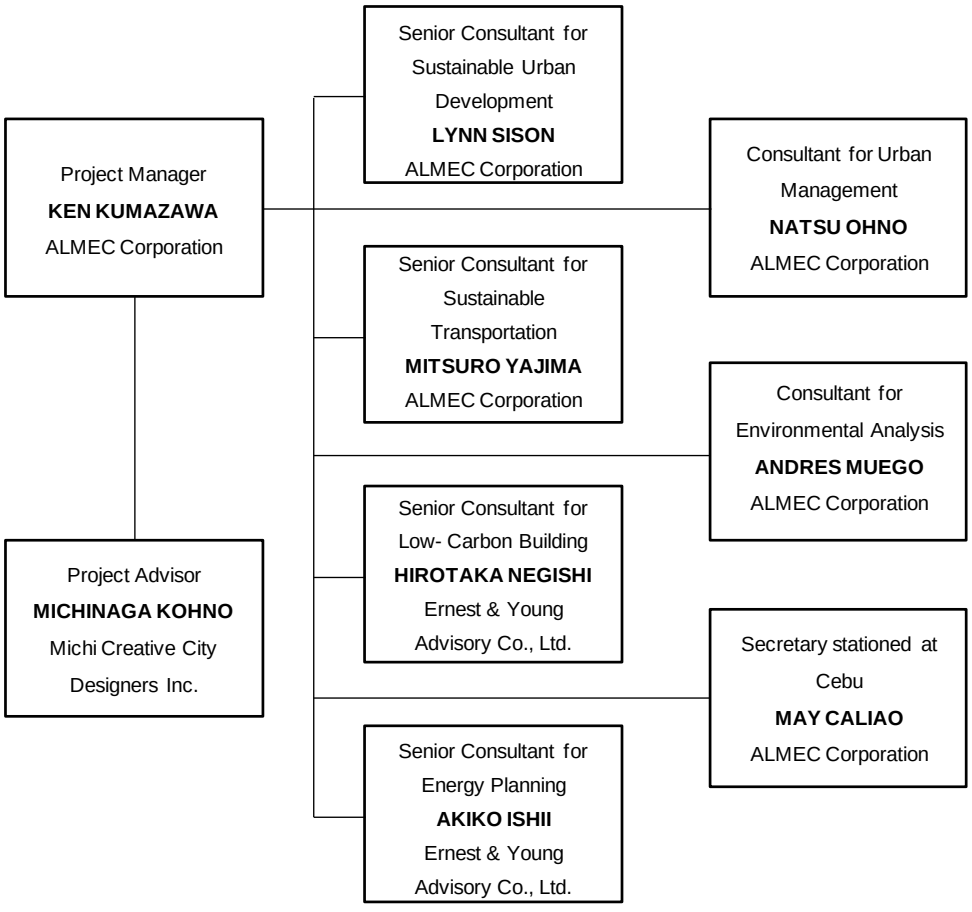
The overall study organization is shown in Figure 1.2.1 with the APEC Study Team composed of ALMEC Corporation, Ernst & Young Advisory Co., Ltd and Michi Creative City Designers Inc. The main counterpart agency for this study is Mandaue City.

Figure 1.2.2 shows eight professionals comprising the APEC Study Team. This team coordinated with other related agencies such as the Department of Energy (DOE), the Visayan Electric Company, Inc. (VECO), Philippine Green Building Council (PGBC), neighboring cities like Cebu City, Lapu-Lapu City, Municipality of Consolacion, Municipality of Cordova and the Metro Cebu Development and Coordination Board (MCDCB).




Source: APEC Study Team

**Figure 1.2.1 Organization of the Study**



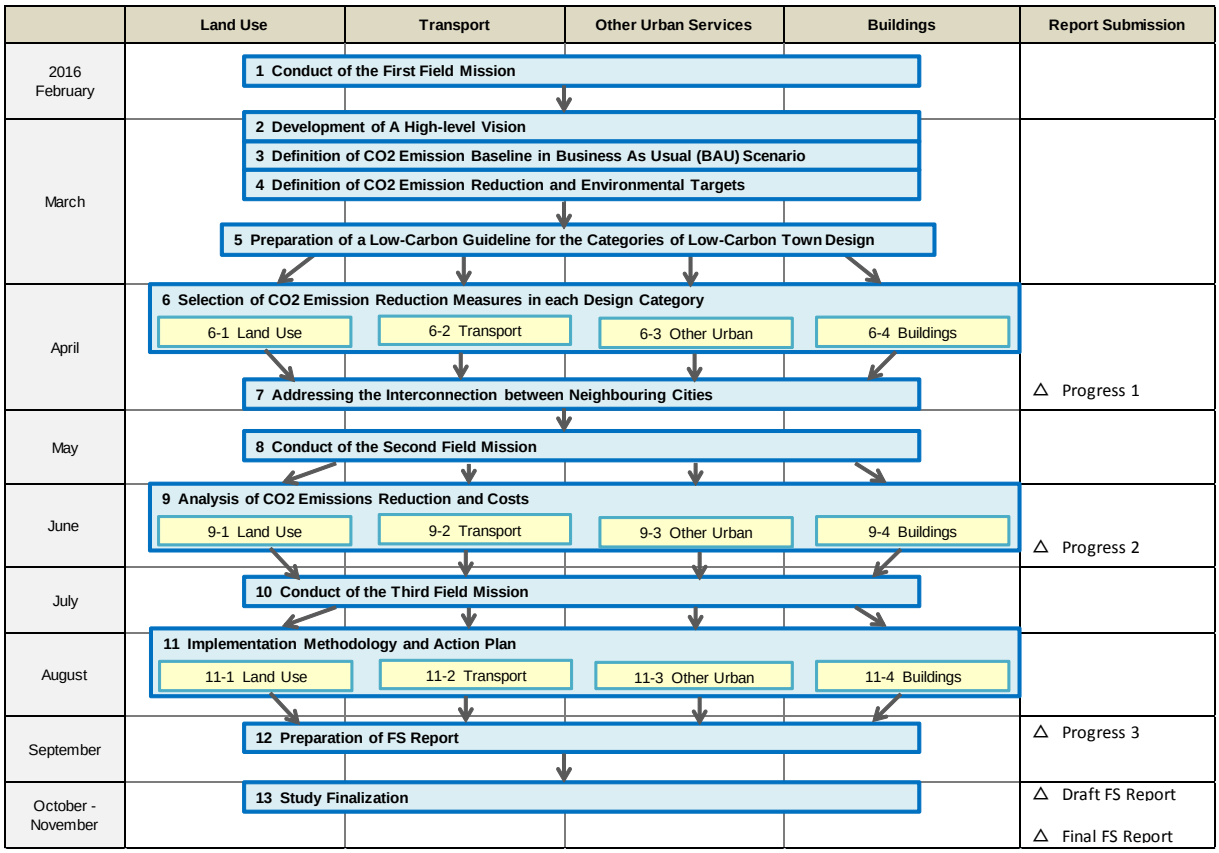

Source: APEC Study Team

**Figure 1.2.2 The Study Team**

### 1.2.2 Overall Activities

The Study Team started undertaking the Feasibility Study from 15 February 2016 and completed it on 28 October 2016. After receipt of comments from study partners, the study report was finalized in November 2016.

The work flow of this nine-month study is shown in Figure 1.2.3. Basically, the low-carbon development of the city was analyzed and planned by four categories such as land use, transport, other urban services and buildings.




Source: APEC Study Team

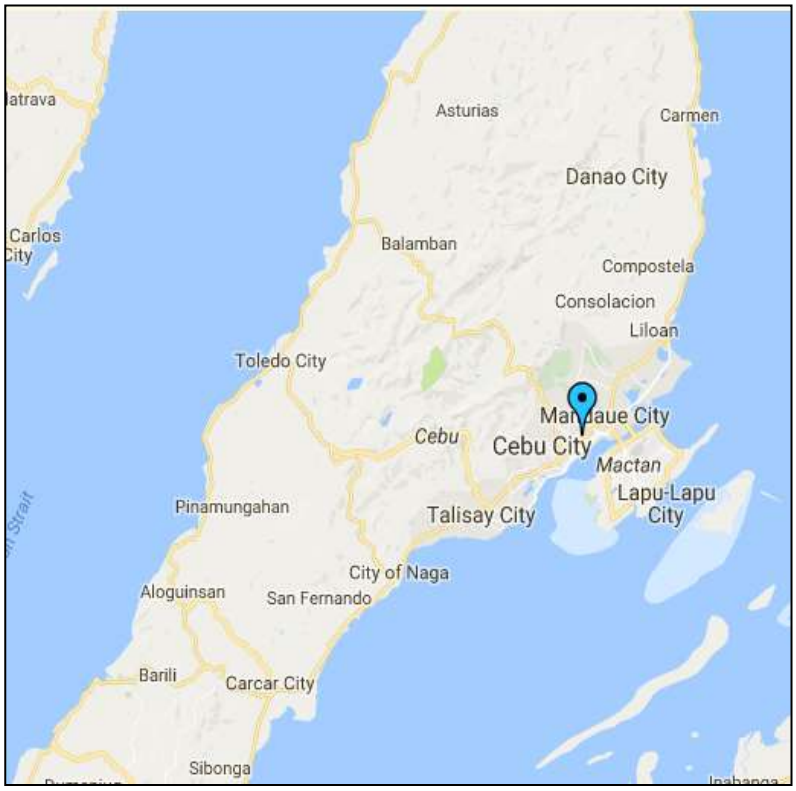
**Figure 1.2.3 Overall Study Work Flow**

# 2 OVERVIEW OF THE STUDY AREA

## 2.1 Geography

Mandaue City is a chartered city[1] located in the heart of Metro Cebu[2] of Cebu Province (see Figure 7.1.1). The city is situated on Zone 51-P, Luzon, the Philippines, at latitude 10.352834$^{o}$ and longitude 123.960915$^{o}$.

It has a land area of 32.85 square kilometers, which is only about 2.8% of the total area of Metro Cebu and less than 1% of the total land area of Cebu Province. The city links the main island of Cebu with Mactan Island, where the airport is located, via two bridges, the Mactan-Cebu Bridge and the Marcelo Fernan Bridge. It is bordered on its east side by Lapu-Lapu City in Mactan Island; on the south and west by the provincial capital that is Cebu City; and on the north by the Municipality of Consolacion. This highly urbanized city is at the junction of major roads going to the north, south, east and west of Cebu Province.




Source: Maplandia 2016

**Figure 2.1.1 Mandaue City in Province of Cebu**

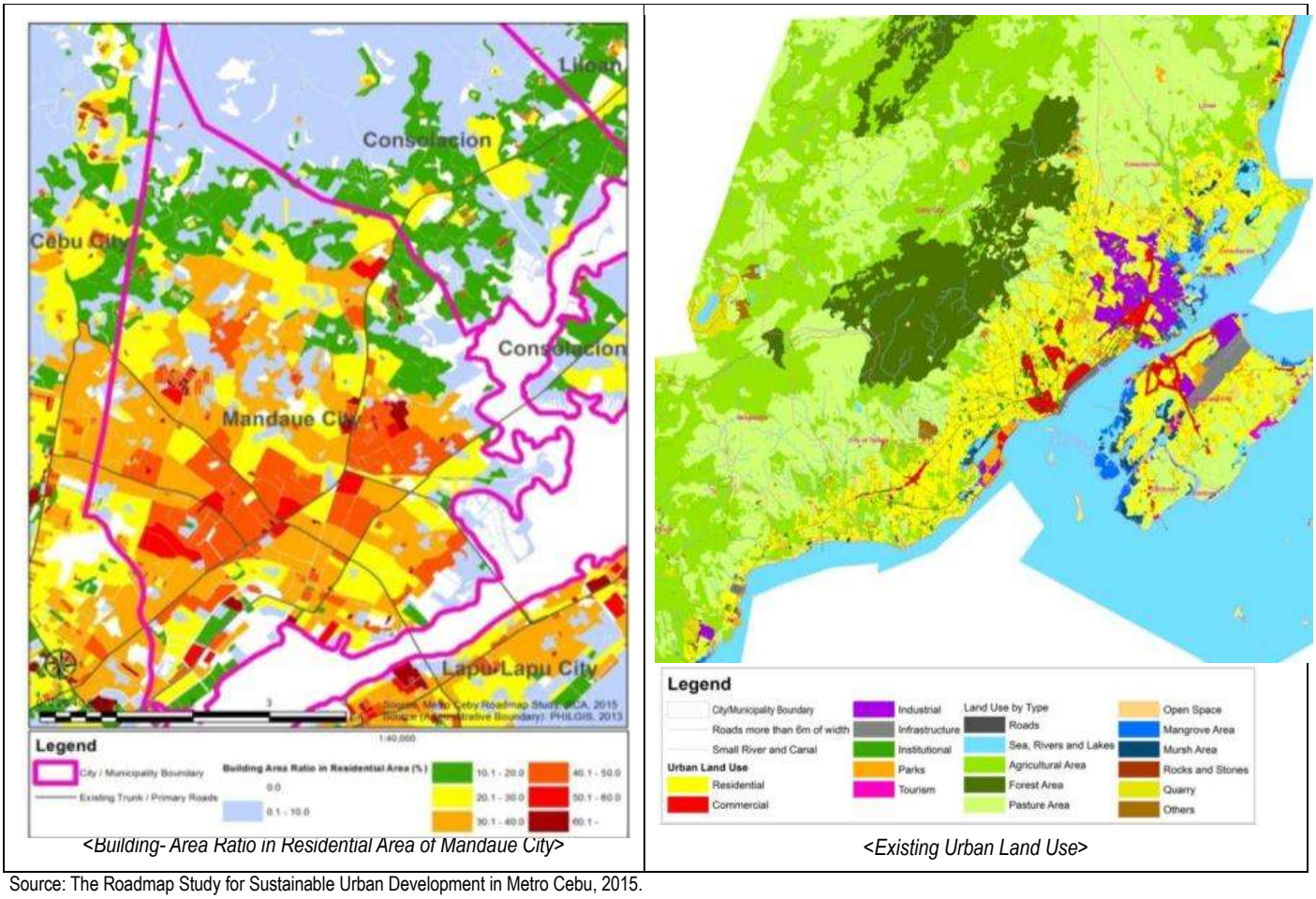
The city is the 2nd smallest local government unit (LGU) of the metropolitan area with a land area of only 32.85 square kilometers but it is the densest with about 118 persons per hectare as of 2015 member economy's census. Commercial buildings and factories are

[1] Mandaue became a chartered city on June 21, 1969 through Republic Act 5519.
[2] Composed of the cites of Cebu, Danao, Mandaue, Lapu-Lapu, Talisay, Naga and Carcar, and the municipalities of Compostela, Liloan, Consolacion, Cordova, Minglanilla, and San Fernando.

densely found along the national highway (MC Briones - Cebu North Road). Historically an industrial town, the city has 925 hectares of industrial lands that occupy over 60% of industrial land in Metro Cebu (see Figure 2.1.2).

Cebu Province is generally characterized by its hilly and mountainous terrain. In like manner, Metro Cebu is known to have the same land profile and has a limited flat land with about 72% of its area having a slope more than 18% gradient. Mandaue City, on the other hand, is one of two local government units located within the mainland Metro Cebu where the elevation of land is less than 100 m (330 ft.). About 30% of its area is flat within the 2–5% slope category and about 32% belonging to the 5–20% slope category. The remaining land areas have a 20–30% slope.

There are two major tributaries found in the city. These are the Butuanon River traversing the northern section of the city and the Mahiga Creek/Subangdaku River traversing the southern portion.




<*Building- Area Ratio in Residential Area of Mandaue City*> <*Existing Urban Land Use*>

Source: The Roadmap Study for Sustainable Urban Development in Metro Cebu, 2015.

**Figure 2.1.2 Development Characteristics of Mandaue City**

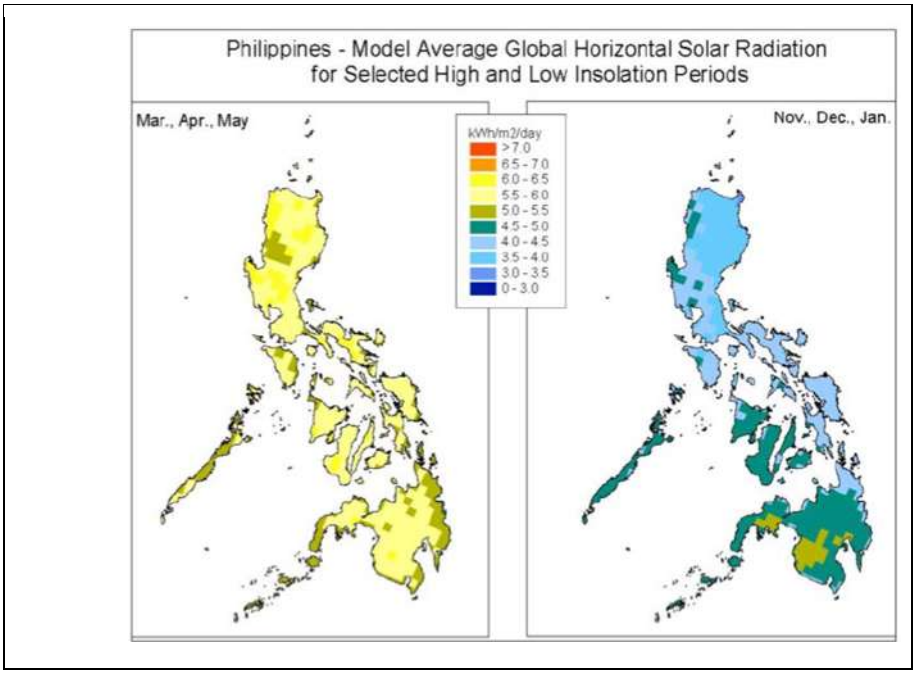
The geology of Mandaue City is, for many parts, of the sedimentary rock as it forms the backbone of Cebu Province. However, being more of the lowland of the province, alluvium has developed near the mouths of rivers and coastal areas of Mandaue.

## 2.2 Climate

According to the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)[3], the city has a tropical climate with an annual mean maximum temperature of 31.3°C and annual mean low of 24.8°C. Average relative humidity is at 81%. Rainfall is at its lowest levels from February to April and gradually increases from May to July. The annual average rainfall recorded is 1,564.5 mm while the greatest fall in one day is 276.1 mm. The average rainy days are 146 in a year. The prevailing wind is NE with speed of 3 meters per second or 10.8 kilometers per hour.

For the period 1982 to 2011, there were 30 typhoons, 15 storms and 14 tropical depressions that passed the city. Super typhoons sometimes destroy the city's infrastructure and facilities. The operation of the First Mactan Bridge was even suspended during the time of Typhoon Ruping in 1990.

In Cebu, solar radiation is high especially between March and May, i.e., 5.5-6.0 kWh/m2/day (see Figure 2.2.1). The area is considered suitable for photovoltaic energy use.




Source: The Roadmap Study for Sustainable Urban Development in Metro Cebu, JICA, 2015

**Figure 2.2.1 Solar Radiation in Selected Areas in the Philippines**

[3] PAGASA Climatological Normal Report based on an observation period which covers 1982 to 2011.

## 2.3 Demography

As of the 2010 census year by National Statistics Office (NSO), Mandaue City had a population of 331,320 with 78,394 households. The early results of the 2015 member economy's census show that the population grew to 362,564. For the ten-year period covering 2000 to 2010, the city experienced an annual average population growth rate of 2.46% and 1.89% for the period 2010 to 2015. The projected population for 2024 is 465,593.

More than one-third of the city's 27 barangays are densely populated with more than 150 persons per hectare (see Table 7.3.1) while almost half of the barangays have more than 100 persons per hectare as of 2015. On the whole, Mandaue City has an average density of 118 persons per hectare.

**Table 2.3.1 Population Densities in Mandaue City, 2010–2015**

| Barangay | Land Area (has.) | 2010 | | 2015 | |
|---|---|---|---|---|---|
| | | Population | Density pax/ha | Population | Density pax/ha |
| 1. Alang-alang | 78.37 | 12,475 | 159 | 13,457 | 172 |
| 2. Bakilid | 45.57 | 5,027 | 110 | 4,591 | 101 |
| 3. Banilad | 217.40 | 22,297 | 103 | 22,771 | 105 |
| 4. Basak | 49.93 | 7,858 | 157 | 10,606 | 212 |
| 5. Cabancalan | 132.29 | 12,202 | 92 | 14,132 | 107 |
| 6. Cambaro | 42.68 | 8,082 | 189 | 9,474 | 222 |
| 7. Canduman | 201.50 | 17,100 | 85 | 18,852 | 94 |
| 8. Casili | 93.31 | 3,743 | 40 | 4,558 | 49 |
| 9. Casuntingan | 108.96 | 13,217 | 121 | 14,690 | 135 |
| 10. Centro (Poblacion) | 29.29 | 3,236 | 110 | 3,383 | 116 |
| 11. Cubacub | 86.24 | 8,255 | 96 | 10,284 | 119 |
| 12. Guizo | 40.65 | 8,554 | 210 | 9,623 | 237 |
| 13. Ibabao- Estancia | 53.28 | 8,641 | 162 | 9,503 | 178 |
| 14. Jagobiao | 127.41 | 12,227 | 96 | 13,685 | 107 |
| 15. Labogon | 96.53 | 19,175 | 199 | 21,028 | 218 |
| 16. Looc | 90.55 | 14,438 | 159 | 17,143 | 189 |
| 17. Maguikay | 120.98 | 17,782 | 147 | 14,645 | 121 |
| 18. Mantuyong | 13.56 | 5,869 | 433 | 6,540 | 482 |
| 19. Opao | 103.68 | 9,907 | 96 | 11,457 | 111 |
| 20. Pakna-an | 174.06 | 22,957 | 135 | 26,943 | 155 |
| 21. Pasabungan | 130.67 | 16,838 | 129 | 20,335 | 156 |
| 22. Subangdaku | 125.24 | 20,333 | 162 | 17,714 | 141 |
| 23. Tabok | 128.38 | 15,709 | 122 | 18,167 | 142 |
| 24. Tawason | 160.65 | 4,891 | 30 | 4,958 | 31 |
| 25. Tingub | 103.03 | 5,780 | 56 | 6,774 | 66 |
| 26. Tipolo | 132.47 | 17,273 | 130 | 18,840 | 142 |
| 27. Umapad | 212.83 | 17,454 | 82 | 18,501 | 87 |
| CSSEAZ | 184.61 | - | - | - | - |
| Total | 3,085.04[1/] | 331,320 | 107 | 362,654 | 118 |

Source: City Planning and Development Office, Mandaue City; Philippine Statistics Office.
[1/] Total land area of Mandaue is 3,285 with the inclusion of the foreshore areas of 200.7 hectares.

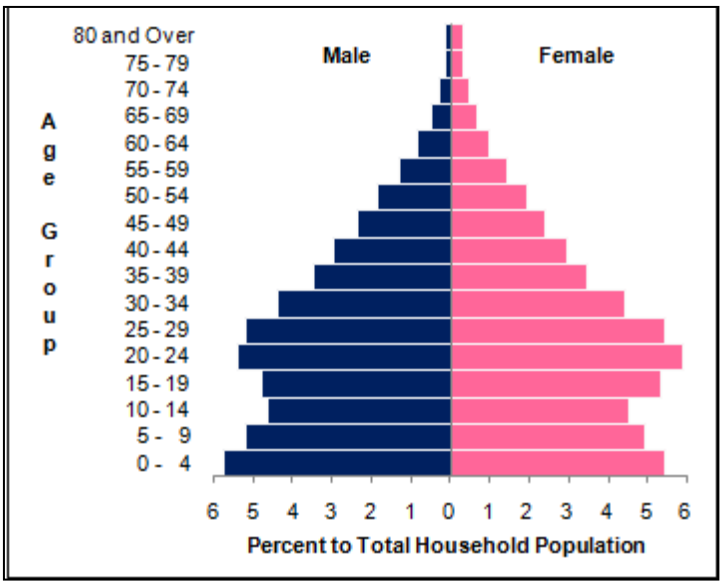
The school age group (3 to 21 years old) comprise 38% of the total population while the work age group (15 to 64 years old) make up 67% (refer to Table 2.3.2). The median age of the population of the city was 24. On the whole, there was slightly less males than females exhibiting a gender ratio of 98.6.

Literacy rate of the population is quite high at 96%.

**Table 2.3.2 Population by Gender and Age Groups**

| Population Age Group | | Male | Female | Total |
|---|---|---|---|---|
| School Going Population | Pre-school (3–6 yrs. old) | 14,511 | 13,533 | 28,044 |
| | Elementary (7–12 yrs. old) | 19,481 | 18,437 | 37,918 |
| | Secondary (13–16 yrs. old) | 11,853 | 12,022 | 23,875 |
| | Tertiary (17–21 yrs. old) | 17,529 | 19,514 | 37,043 |
| | Share to total population (%) | 19.1 | 19.2 | 38.3 |
| Work Age Population | Working Age (15–64 yrs old) | 108,848 | 112,486 | 221,334 |
| | Share to total population (%) | 32.9 | 34.0 | 66.8 |
| Dependent Population | Young (0–14 yrs old) | 51,895 | 48,925 | 100,820 |
| | Old (65 and over) | 3,709 | 5,350 | 9,059 |
| | Share to total population (%) | 16.8 | 16.4 | 33.2 |
| Total Population | | 164,452 | 166,761 | 331,213 |

Source: Calculation based on Population and Housing Data of NSO 2010.




Source: Calculation based on Population and Housing Data of NSO 2010.

**Figure 2.3.1 Age-Sex Pyramid of Household Population Mandaue City, 2010**

Over the years, the distribution of the population dictated the city's urbanization at the barangay level. In 1990, there were five barangays classified as rural. Now, there are only two remaining rural areas which are the far-flung barangays of Casili and Tawason. These are located in the north eastern portion of the city, quite inaccessible by major roads.

## 2.4 Economy

### 2.4.1 Regional Economy

The regional economy of Central Visayas has grown since 2009 triggering the increase in the gross regional domestic product (GRDP) to PHP 56,500 per capita at constant 2000 price in 2012, at an annual growth rate of 7.9%. The growth of Central Visayas' economy was driven by all three economic sectors, which recorded higher annual average growth rates than those of the Philippines. In particular, the secondary sector or industry significantly expanded its production from 2009 to 2012.

### 2.4.2 Local Economy

In following the performance of the regional economy, Mandaue City enjoys a robust and well-diversified economic base consisting of manufacturing, trading, and commercial activities. Annual gross sales or output for 2013 was placed at PHP 142 billion with about 13,372 commercial establishments accounting for approximately 65% (PHP 92 billion) of the output and 1,317 manufacturing establishment accounting for 35% (PHP 49 billion). Agriculture posted an output of PHP 278 million.

Between 2009 and 2013, annual gross sales and capital investments in the commerce and trade sub-sector have increased by an average of 11% and 7%, respectively. The number of establishments has likewise increased by an average of 2%. The manufacturing sub-sector, on the other hand, recorded annual gross sales and capital investment increases by an average of 5% and 1.5%, respectively.

The city is home to one of the biggest and modern brewery in the economy. It also hosts export oriented and quality food/beverage processor, furniture and fashion jewelry makers, and sales and service centers of the world's major car manufacturers. Investors and entrepreneurs are attracted to locate in Mandaue because of its strategic location and good business climate. Most business and economic activities tend to concentrate along the arterial roads that link the urban core to the other barangays.

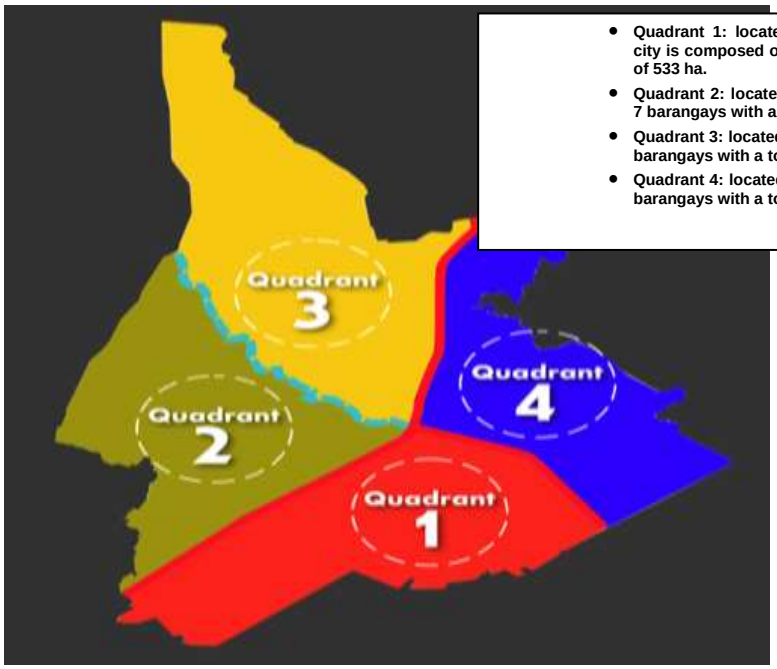
## 2.5 City Structure and Traffic Situation

### 2.5.1 Spatial Structure

The development character of the city is one of space and economic activities being dispersed and diversified. In keeping to the quadrant system of the city's plan (Figure 2.5.1), the spatial growth pattern of Mandaue has been as follows:

- Quadrants 1 and 2: Multi-nodal growth pattern (strip/linear development); and
- Quadrants 3 and 4: Trend extension growth pattern.

In order to manage future growth, strategic policies are being laid down by the city that entails the promotion of trade and commerce in Quadrants 1 and 2 and the designation of light and medium manufacturing activities in Quadrants 3 and 4. All existing manufacturing establishments located in all quadrants will be allowed to operate but discouraged from expanding or diversifying their operations.



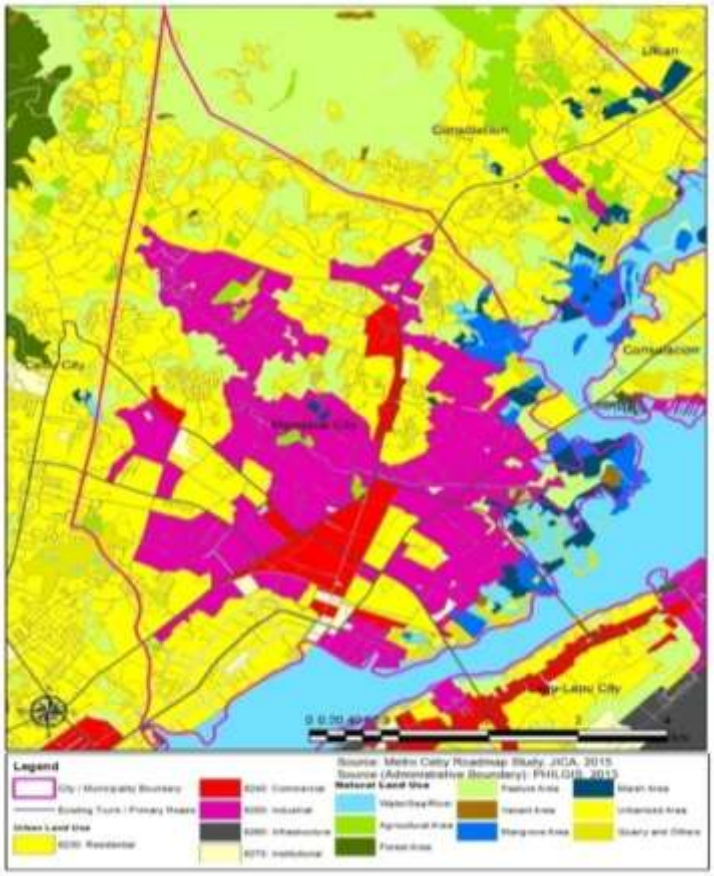

Source: CPDO of Mandaue

**Figure 2.5.1 Quadrant Spatial Designation of Mandaue City**

The urbanization pattern of the city is notably one of the linear strip form where it radiates from the urban core and continues along the major arterial roads, thereby ushering the growth of some barangays as secondary growth centers. Additionally, other interior barangays have experienced urbanization in sort of a leap-frog growth manner.

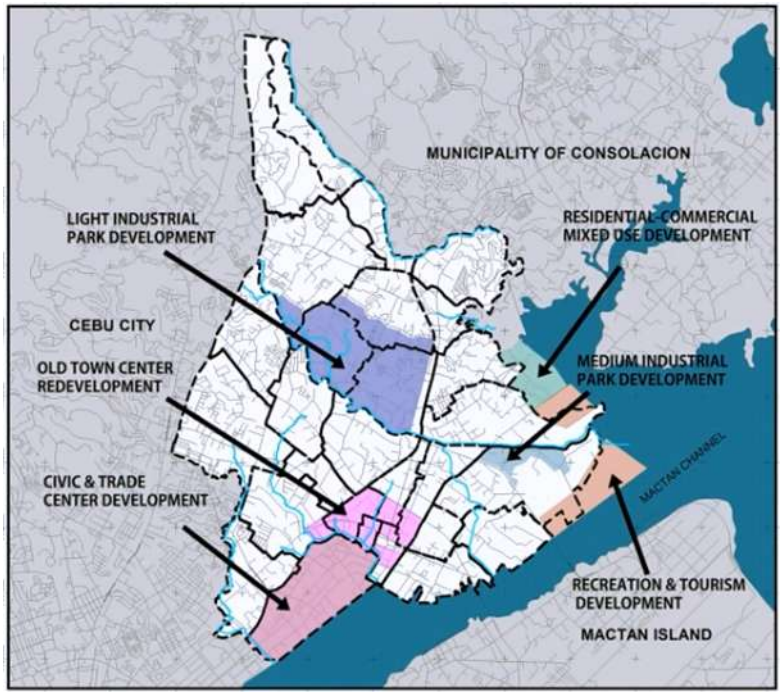
Based on its 1979 zoning ordinance, a total of 2,513 ha has been allocated for various land uses (excluding roadways, waterways, and foreshore). Out of this allocated land, only 1,995 ha are actually used while the remaining 518 ha are idle or vacant lands or used for aquamarine purposes.

The city is embarking on amending this zoning ordinance to minimize non-conforming land uses. Among others, a plan was developed for the Integrated Development of New Green Growth Areas, otherwise referred to as Planned Units of Development (PUDs). This entails the subjecting of privately owned lands to the regulatory requirements of the new Comprehensive Land Use Plan and the Green Building Code. The location of these green growth areas are shown in Figure 2.5.3.




Source: The Roadmap Study for Sustainable Urban Development in Metro Cebu, JICA, 2015

**Figure 2.5.2 Existing Land Use Pattern of Mandaue**




Source: CPDO of Mandaue

**Figure 2.5.3 Planned Green Growth Areas**

### 2.5.2 Transportation and Traffic Situation

The total length of the road network in Mandaue is 139 kilometers. There are six major arterial roads serving as entry and exit point to the adjacent areas of Cebu City, Mactan Island (Lapu-Lapu City and Cordova) and the northern portions of Metro Cebu. The following major arterial roads crisscross through Mandaue providing access to areas in the south, north, west and east of the Cebu Province:

- North Road/National Highway from Subangdaku (Cebu City) to Jagobiao (Consolacion);
- Ouano Avenue (Cebu City) – Plaridel St.,-Cansaga Road – Cansaga Bridge (Consolacion);
- Ouano Avenue (Cebu City) – Plaridel St., UN Avenue – 2nd Mactan Bridge (Mactan Island);
- UN Avenue (corner North Road) – 2nd Mactan Bridge (Mactan Island)
- A.C. Cortes Avenue from corner North Road (flyover) to 1st Mactan Bridge (Mactan Island)
- A.S. Fortuna St., from Foodland to corner National Highway/North Road;
- M.L. Quezon St. from corner Talamban Road to corner North Road (fly-over);
- H.Cortes from Ayala Access Road (Cebu City) to corner M.L. Quezon St.; and
- H. Abellano St. from Talamban (Cebu City) to corner North Road (Basak).

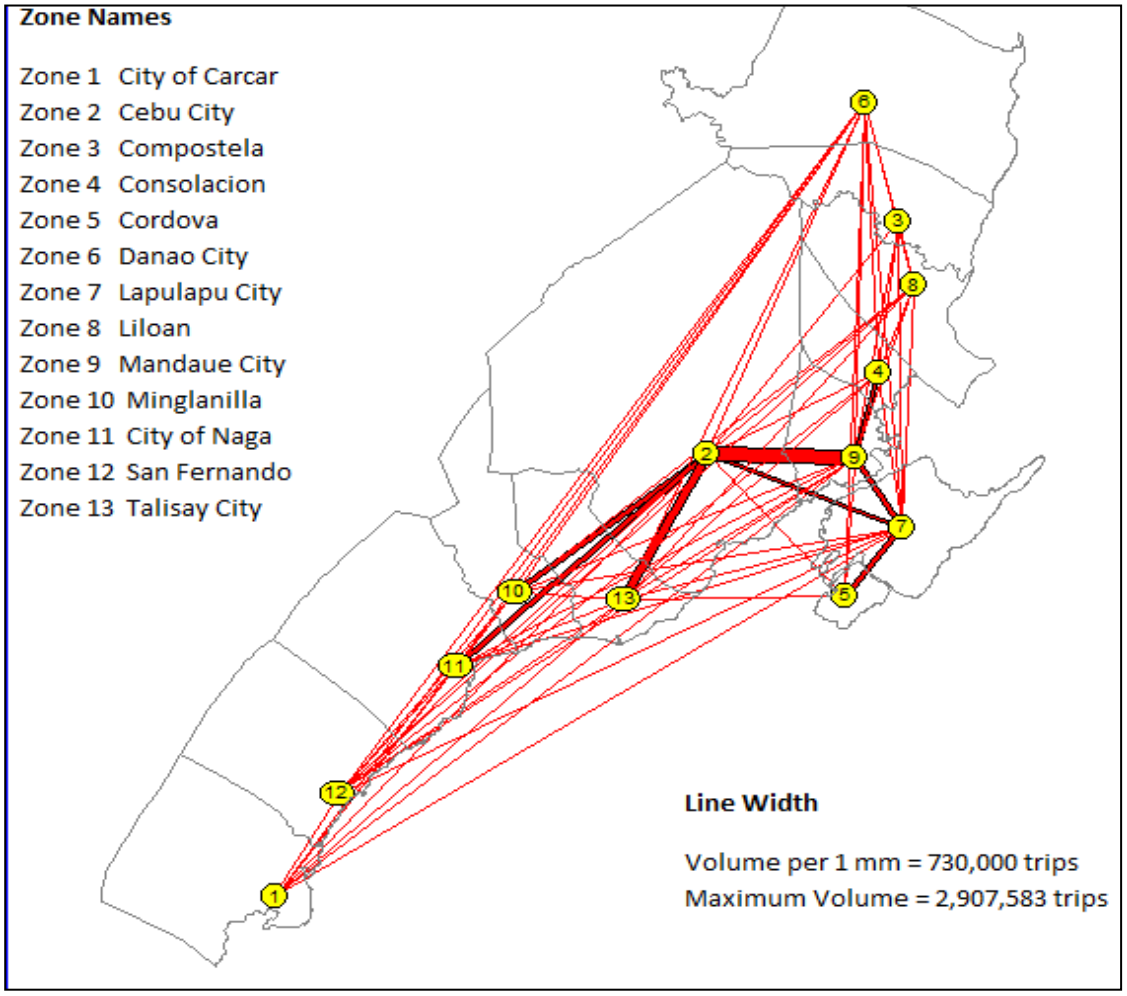
Mandaue is also a public transportation hub since the North Bus Terminal and jeepney terminals are located in the city serving the commuters within Metro Cebu and the northern towns of Cebu Province. The city provides access to the Mactan Cebu International airport and the Cebu International Port and the domestic port for interisland ships.

Based on the Home Interview Survey (HIS) of 2014 conducted during the Roadmap Study for Metro Cebu, trips made by commuters reveal the origin and destination lines by mode in the metropolis. It is apparent that the largest number of trips made is between the core urban areas composed of Cebu City, Mandaue city and Talisay City.

The 2014 HIS results also revealed that about two-thirds of the residents of Mandaue assessed the city's traffic condition as bad with two primary causes of congestions to be: first, due to increasing usage of automobiles (36%), then followed by a lack of discipline of drivers (24%).

Vehicular traffic volumes counted during the Screen line Survey conducted in 2014 show sharp peaks in the morning from 6:00 to 7:00 and in the evening from 17:00 to 18:00. See Figure 2.5.3. Daily two-way traffic volume from 7am to 7pm is estimated.

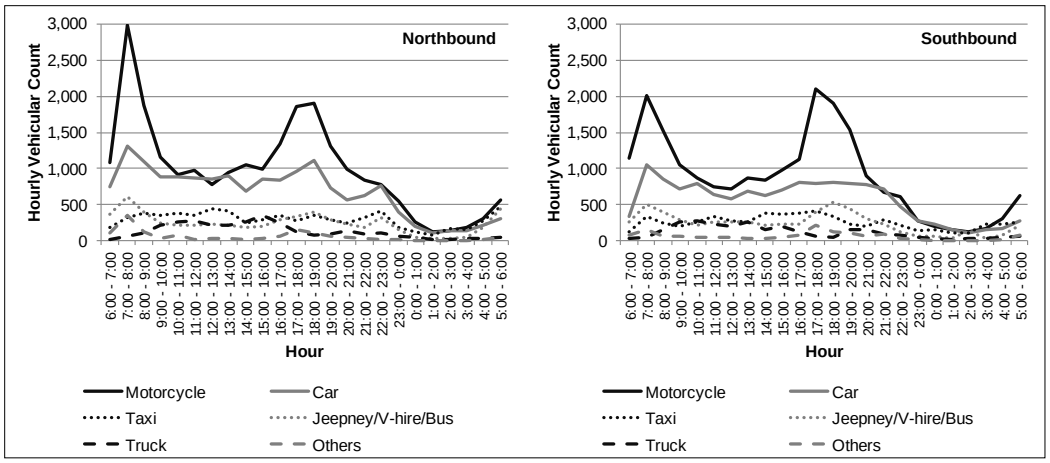
Figure 2.5.4 shows the heavily congested intersections within the urban areas as identified in the travel speed survey. This is due to the high traffic volume and the decrease in speed. Many of these intersections happen to be located in Cebu City and Mandaue City.



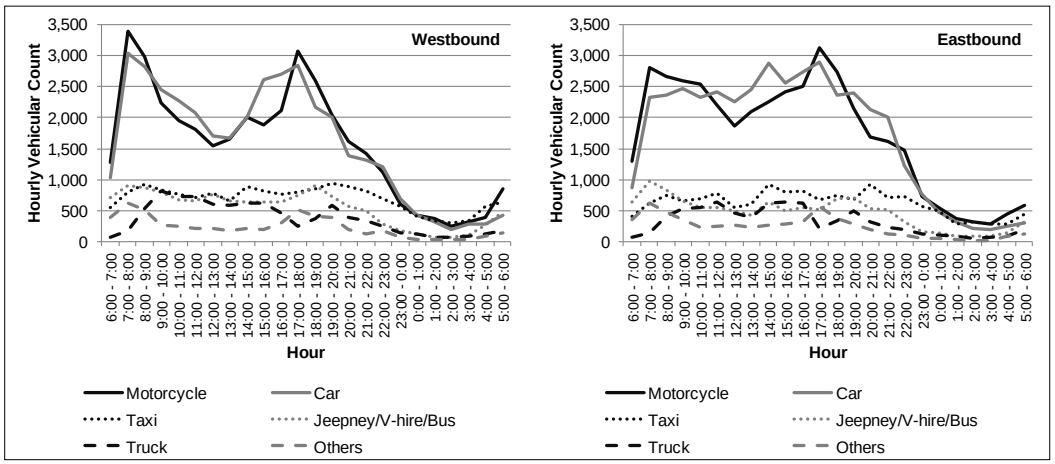

Source: The Roadmap Study for Sustainable Urban Development in Metro Cebu, JICA, 2015

**Figure 2.5.4 Desire Lines of Origin-Destination Trips**

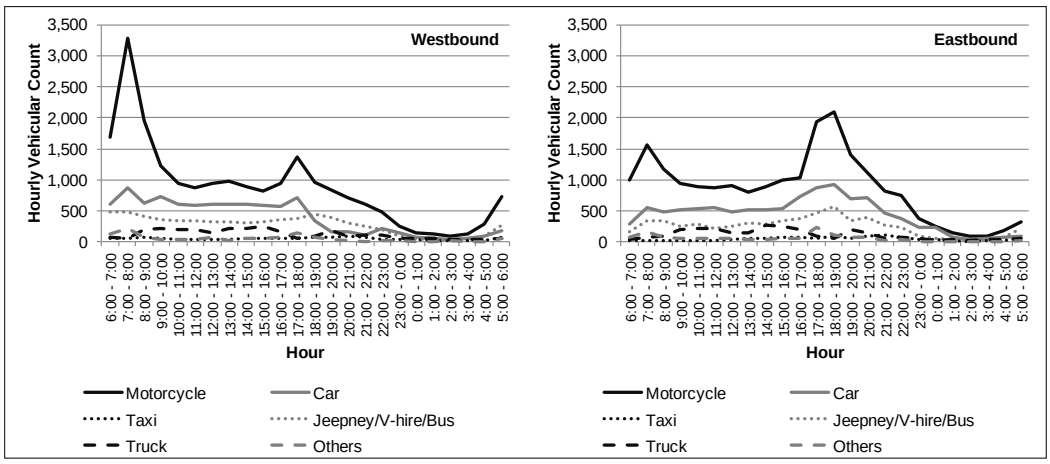
**SL 2: Stations at Mandaue-Mactan Bridge, M. Fernan Bridge, and Cebu-Mactan Ferry Terminal**




**SL3: Stations at Mahiga Bridge, Hernan Cortes St., M.C. Briones St., and Ouano Ave.**

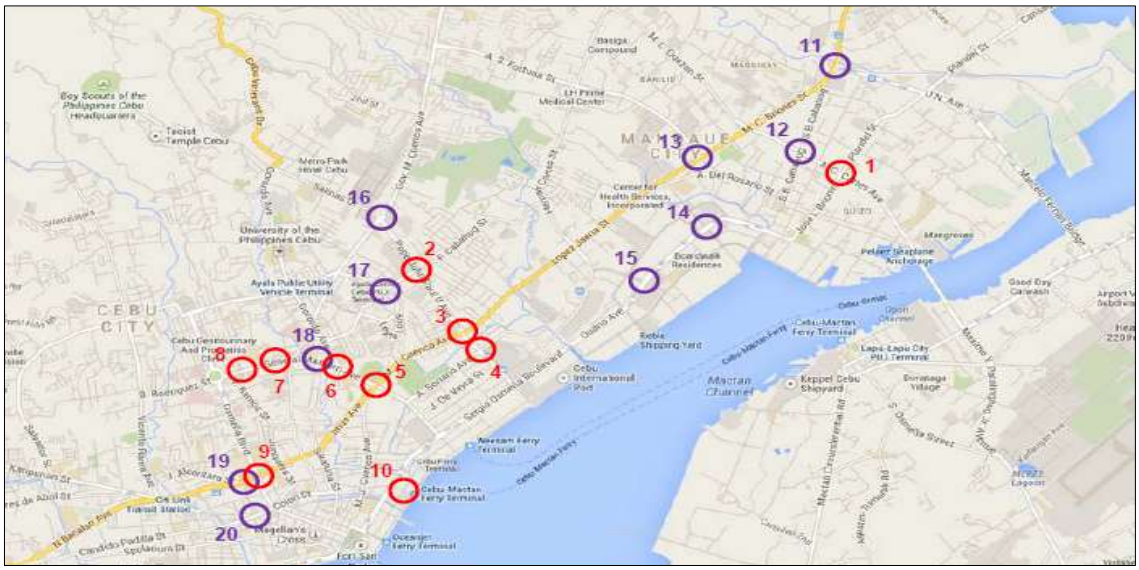



**SL4: Stations at Cebu North Road and Cansaga Bay Bridge**




Source: Screenline Survey 2014 of The Roadmap Study for Sustainable Urban Development in Metro Cebu

**Figure 2.5.5 Hourly Traffic Volumes In and Around Mandaue**




Source: Travel Speed Survey 2014 conducted by The Roadmap Study for Metro Cebu.
Note: Red circle means first priority to be improved. Blue circle means second priority to be improved. Intersections No. 1 and No. 11 to 15 are found in Mandaue City.

**Figure 2.5.6 Locations of Congested Intersections at Urban Areas**

## 2.6 Current Energy Situation

Mandaue City is 100% energized with the Visayan Electric Company, Inc. (VECO) providing all of its power needs. As of the year 2015, VECO reported the city's electricity consumption to be a total of 627 million kilowatt hours (see Table 2.6.1).

**Table 2.6.1 Electricity Consumption of Mandaue City, 2015**

| By User | Consumption (kWh) |
|---|---|
| Streetlights | 4,799,853 |
| Residential | 119,435,521 |
| Commercial | 84,996,421 |
| Industrial | 418,475,134 |
| **Total** | **627,706,928** |

Source: VECO 2016

The programs pursued by VECO for energy efficiency are as follows:

a) Cebu Unplugged: The program commenced in 2015 entailing the teaching of children about energy conservation and safety. This is for schools within the VECO franchise areas in Cebu.

b) Barangay Pulong-pulong: The program started in 2015. Discussion and presentation of the practices for energy conservation and safety were made in densely populated barangays around the VECO franchise areas.

c) Ebill: The program entails the provision of electronic bills to employees to do away with printing.

The 2014 HIS captured the average monthly household consumption of electricity in Mandaue City, which is more within the lower ranges of 50 kWh or less (58%) and 51-100 kWh (24%) as reported by the surveyed households. In terms of cost, about half of the households assess the electricity charges as reasonable while about 43% find it expensive.

# 3 LOW CARBON DEVELOPMENT FRAMEWORK

## 3.1 Member's Policy, Legislation and Institutional Framework

The Philippines Low Carbon Development policies are embedded in numerous member economy's programs designed for specific purposes that also promote low carbon development. Under the overarching principles of 'sustainable development' and 'climate change', the member economy's low carbon development policies find its way to sectoral agendas from the member economy, provincial and the city/municipal levels. An account of both general and sectoral (energy, transport, waste management, and forestry) low carbon development related policies and legislations at the member economy level are briefly described below.[1]

The 1987 Philippine Constitution enunciated the policy of the state to protect and advance the right of the Filipino people to "a balanced and healthful ecology in accord with the rhythm and harmony of nature," which provides for the protection of the environment and promotion of sustainable development in the member economy.

Along with the formulation of the Philippine Strategy for Sustainable Development (PSSD) and the Philippine Agenda 21 in 1991, the Inter-Agency Committee on Climate Change (IACCC) was created with DENR taking the lead. The Philippines was one of the first countries to set up a committee to discuss and develop positions on climate change.

The Philippine Government signed a number of international treaties on environment and climate change, among which was the Kyoto Protocol on August 2, 1994 and ratified it on November 20, 2003.

The Clean Air Act was enacted in 1999 (RA 8749), which indicated government measures to reduce air pollution and incorporate environmental protection into its development plans. It mandated various government agencies to support the Act.

The Climate Change Commission (CCC) was created under RA 9729, and its task is to mainstream climate change, in synergy with disaster risk reduction, into the national, sectoral and local development plans and programs in the member economy. Amendments were introduced for this Act in 2012 with the enactment of RA 10174.

In 2007, Administrative Order 171 was issued, creating the Presidential Task Force on Climate Change (PTFCC) to promote member economy projects, programs and actions on climate change.

[1] Based on documents from the Ateneo School of Government (November 2011), Study on Carbon Governance at Sub-national Level in the Philippines; and Transport and Traffic Planners Inc. (TTPI) (April 2010), A Strategic Approach to Climate Change in the Philippines: An Assessment of Low Carbon Interventions in the Transport and Power Sectors.

On 26 December 2008, President Arroyo issued Executive Order 774, reorganizing the PTFCC, naming the President as the Chair and organizing 14 Task Groups. The Task Groups that are directly involved in mitigation work are the following:

- Task Group on Fossil Fuels (DOTr, DPWH, DILG, OPACC, DBM) – reduce consumption of fossil fuels; reform the transport sector, to include walking, cycling, and other human-powered vehicles; and conduct consultations, mass media social marketing and mobilization campaign; and
- Task Group on Renewable Energy (DOE) – implement the Renewable Energy Law with urgency.

The National Climate Change Action Plan (NCCAP) and the National Framework Strategy on Climate Change (NFSCC), respectively signed in November 2011 and April 2012, outlined the member economy's agenda for adaptation and mitigation for 2011 to 2028 and the policy framework and the guiding principles for the member economy strategy on climate change.

Through the CCC, the NCCAP redefined its mitigation strategies to include the following:

- Accelerate the use of renewable energy and alternative energy sources (e.g., biofuels); promote efficient power generation and conservation (DOE);
- Promote production efficiency and use of low carbon technologies (DTI); promote reduction in fuel consumption through strict registration and franchising, anti-smoke belching and private emission testing centers (PETC) monitoring; conversion of engines and vehicles into fuel efficient units (DOTC);
- Develop dry land cultivation and minimize waste decomposition; promote wider use of organic fertilizer and reduce pesticide use (DA);
- Promote the wider use of 3Rs (Reduce, Recycle and Re-use) programs by LGUs and conversion of waste to energy (DILG); and
- Better management of air quality, especially in urban areas through the airshed council; reduce air pollution through strict stack monitoring and prevention of open burning; expand vegetation cover through the Green Philippines Program (DENR).

### 3.1.1 Energy

In the energy sector, the following low carbon laws, rules and regulations are in place:

- Department of Energy Act of 1992 (RA 7638), which was an act creating the Department of Energy to ensure a continuous, adequate and economic supply of energy but without sacrificing ecological concerns.
- Renewable Energy Act of 2008 (RA 9513) aims to accelerate the exploration and development of renewable energy resources, reduce the member economy's

dependence on fossil fuels, promote adoption of clean energy to mitigate climate change, and increase utilization of renewable energy by providing fiscal and non-fiscal incentives;

- Biofuels Act of 2006 (RA 9367) provides fiscal incentives and mandate the use of biofuel-blended gasoline and diesel to mitigate GHG emissions;
- Mini-Hydroelectric Power Incentive Act aims to strengthen and enhance the development of mini-hydroelectric power by granting incentives and privileges to the manufacturers;
- Presidential Decree 1442 promotes the exploration and development of geothermal sources;
- National Renewable Energy Plan (NREP) described in the Philippine Energy Market Outlook provides a timeline for the development of renewable energy in the Philippines.

To promote the improvement of energy efficiency, the following rules and regulations have also been promulgated:

- Administrative Order 110 directs the institutionalization of the Government Energy Management Program (GEMP), and sets a goal for government agencies to attain a 10% savings in their monthly fuel and electricity consumption;
- Administrative Order 183, also known as the *Palit-Ilaw* Program, directs the mandatory use of energy efficient lighting/ lighting systems (EELs) in government facilities (Sec. 1);
- National Energy Efficiency and Conservation Plan;
- Implementation of Philippine Energy Efficiency Project (PEEP); and
- The Philippine Government's National Energy Efficiency and Conservation Program or the "EC Way of Life" aims to fast track the implementation of demand-side energy efficiency measures in the member economy.

### 3.1.2 Transport

Following are the relevant laws, rules and regulations promoting low carbon development in the transport sector:

- Administrative Order 254 mandates the Department of Transportation and Communication (DOTC), [2] to lead in the formulation of an environmentally sustainable transport (EST) in the Philippines;

[2] Now referred to as Department of Transportation (DOTr)

- Executive Order No. 290 promotes the implementation of the Natural Gas Vehicle Program for Public Transport; and
- National Electric Vehicle Strategy (NEVS) is a joint partnership between the Government of the Philippines and the Asian Development Bank (ADB) that aims to reduce the member economy's carbon footprint on road transport by promoting the use of alternative fuel vehicles.

### 3.1.3 Waste Management

The Ecological Solid Waste Management Act (RA 9003) provides the legal framework to systematically address the waste management program of the member economy.

### 3.1.4 Forestry

In the forestry sector, the following programs are being implemented:

- The National Greening Program (NGP), one of the priority programs of the member economy, aims to plant 1.5 billion trees in public domain lands covering 1.5 million hectares as a climate change mitigation strategy to enhance the member's forest stock to absorb carbon dioxide; and
- REDD-plus is a broad term that describes a range of actions to reduce emissions from deforestation and forest degradation and the role of conservation of carbons stocks, sustainable management of forests and enhancement of forest carbon stocks. The Philippine National REDD-plus Strategy (PNRPS) presents a broad range of strategies and corresponding activities over a 10-year time horizon (2010-2020) and seeks to prepare forestlands managers throughout the member economy to assume responsibility in implementing REDD-plus programs, research, projects and activities with the support of international, national and local agencies, NGOs and other support groups.

## 3.2 Provincial and Metro Cebu Policy, Legislation and Institutional Framework

While Mandaue City is not one of the component cities and municipalities of Cebu province and is technically outside the jurisdiction of the province (not covered by provincial ordinances), it is still bound connected to the province through its participation in province-led initiatives and programs (e.g., Our Sustainable Cebu program). Thus, Mandaue City's low carbon development initiatives are not only linked with that of the member economy but also with the province's policy and institutional framework.

### 3.2.1 Cebu Provincial Government Legislation

- **Green and Disaster-Resilient Building Program (Ordinance No. 2014-02).**[3] The aim of Cebu Province's Green and Disaster-Resilient Building Program is to enhance long-term public health and welfare by contributing to the overall reduction of $CO_2$ production and emissions, improving the environmental and economic health of the province, protect human life, minimize property loss, and minimize the expenditures of public money associated with natural related disasters, including flooding, high-wind events, typhoon and earthquake, through the following actions:

  1) Increase energy efficiency in buildings and public works projects;
  2) Encourage water and resource conservation;
  3) Reduce waste generated by construction projects;
  4) Reduce long-term building operating and maintenance costs;
  5) Improve indoor air quality and occupant health;
  6) Contribute to the reduction of $CO_2$ production and emissions; and
  7) Establish enhanced building design, construction and operations regulations consistent with nationally/internationally recognized good practices for safeguarding life and property.

  The program is mandatory for buildings and public works projects of the provincial government as well as its component cities and municipalities, while for private projects, it is voluntary. The program provides incentives to private development projects that will participate and enroll in the green building rating system.

- **Environment Code (Ordinance No. 2012-13).** The Province adheres to the principles for attaining sustainable development and its pillars, namely, economic viability, environmental responsibility, social equity, and political/cultural vitality as defined in Agenda 21 signed and ratified by the Philippines. The Environment Code translate these sustainable development concepts into guiding principles and provide management directions for various sectors (e.g., land use, energy, biodiversity, forestry, coastal and marine, water resources), as well as promotion of sustainable approaches to development planning and environmental protection. The Code promotes the use of renewable sources of energy and encourages the use of 'smart growth codes' to influence the development of compact and walkable neighborhoods, and Transit-Oriented Development (TOD).

[3] A trailblazing ordinance as this is the first and only ordinance so far for a provincial government or any LGU that both considers the construction and operations of Green and Disaster-Resilient buildings.

- **Our Sustainable Cebu Program (Ordinance No. 2013-03).** This ordinance is geared towards building sustainable cities and municipalities of the Province by promoting and encouraging the LGUs as well as the private sector to engage in sustainable development initiatives through conferment of awards, recognitions and incentives. The ordinance seeks to institute the mechanism for considering and integrating the seven dimensions of sustainable development (i.e., spiritual, human, social, cultural, political, economic and ecological) to the participating LGUs and the private sector programs, plans and projects, thereby achieving vibrant, progressive and self-reliant communities. Furthermore, this ordinance partakes the vision of every Cebuano to create a model Cebu for both the present and the generations to come.

### 3.2.2 Metro Cebu Airshed Governing Board (MCAGB)

The Metro Cebu Airshed Development Program was instituted through Memorandum Circular (MC) No. DAO 2002-21 on October 7, 2002. As provided in its Implementing Rules and Regulations (IRR), airsheds shall be managed by a Governing Board. The Metro Cebu Airshed Governing Board is created primarily to conduct air quality management through strategic management, development of policy recommendations, and coordination of its inter-agency links.

The DENR and the Cebu Provincial Government co-chair the MCAGB, with the following members: LGUs-Cebu City, Lapu-Lapu City, Mandaue City, Naga City, Talisay City, Cordova, Consolacion, Compostela, Lilo-an, Minglanilla; Non-Government Organizations; Private Sector-San Miguel Corp., Cebu Chamber of Commerce, East Asia Utility Corp., Mandaue Chamber of Commerce, APO Cement Corp., Cebu Private Power Corp., Salcon Power Corporation; Academe-University of Southern Philippines Foundation, University of San Carlos; and Civil Society-Central Visayas Fisherfolk Development Center Inc.

### 3.2.3 The Metro Cebu Development and Coordinating Board (MCDCB)

MCDCB is a coordinating body for metro-wide planning and development created on April 1, 2011 through a Memorandum of Agreement (MOA) signed by local government executives, heads of agencies of the member economy, and leaders of the private-civil society sector.

The creation of MCDCB is a manifestation of the heightened desire of public and private stakeholders to lead and plan for a desired and collective future for Cebu. Its aim is to facilitate the formulation, coordination, and monitoring of integrated development strategies, policies, and standards for the development, initially, of Metro Cebu.

MCDCB is a consortium of the Province of Cebu; 13 cities and municipalities located on the eastern side of Cebu island, including the cities of Carcar, Naga, Talisay, Cebu, Mandaue, Lapu-Lapu and Danao and municipalities of San Fernando, Minglanilla, Cordova, Consolacion, Liloan, and Compostela; regional line agencies; and private and civil society organizations.

The organization of MCDCB is one led by the Cebu Provincial Government with the Governor as the chairperson, with the LGU (Mayor) and the private sector/civil society as co-chairs, and the National Economic and Development Authority (NEDA) serving as MCDCB secretariat.

The Ramon Aboitiz Foundation Inc. (RAFI), through the Eduardo Aboitiz Development Studies Center (EADSC), facilitates the Mega Cebu program. It anchors the Research, Program and Organizational Development (RPOD) of MCDCB, and serves as the coordinating and operations unit and process facilitator of the various functions, structures, plans, programs, and efforts of MCDCB.

### 3.2.4 The Roadmap Study for Sustainable Urban Development in Metro Cebu

In 2013, MCDCB and JICA agreed to conduct a follow-up study to formulate a roadmap and action plan to realize the Mega Cebu Vision 2050. The roadmap study promotes low carbon development through the following recommendations:

*Land Use*

- Compact urbanization in a polycentric urban structure;
- Green Loop encompassing Cebu City, Mandaue, Lapu-lapu and Cordova; and
- Promotion of TOD.

*Transport*

- Mass transit network consisting of BRT, LRT (AGT), and MRT;
- Area-wide Traffic Control (ATC); and
- Mactan Link and bypass roads.

*Other Urban Services*

- Material recovery facilities (MRF) and sanitary landfills;
- River improvement and flood control; and
- Septage services and sewerage.

## 3.3 Mandaue City

The Low Carbon Development framework for Mandaue City is anchored on its 20/20 mission "to create an environment for sustainable economic growth and a livable society through responsive governance and multisectoral involvement," which promotes strategies for development within the context of resilience and sustainability, notably in the following plans/programs and current initiatives:

- The preparation/implementation of the Comprehensive Land Use Plan (CLUP) that considers an integrated development of green growth areas;
- Implementation of Mandaue City's Green Building program;
- Green Loop;
- Metro Public Transport System (mass transport);
- Butuanon River Watershed Management Board;
- Traffic Control Center; and
- Waste Management – sanitary landfill and MRF at Barangay Umapad.

### 3.3.1 The Green Building Ordinance of Mandaue City (Ordinance No. 13-2015-1047)

The ordinance is enacted for the purpose of improving the stability and efficiency of buildings in the use of natural resources, contributing to the global efforts in reducing $CO_2$ emissions, and minimizing the impact of buildings on health and environment through the Green Building Program. The program promotes the practice of adopting sustainable features and measures in the design, construction and operation of buildings.

Compliance to the Green Building Ordinance (GBO) is mandatory for public/government buildings but voluntary for private buildings. It is also mandatory for all new buildings to be located in Planned Unit Development (PUD) areas, otherwise referred to in this study as the Green Growth Areas (GGAs). Buildings enrolled or given a Green Building rating will entitle the owner to tax credits.

Under the ordinance, a Mandaue City Green Building Board (MCGB) will be established to provide guidance in the development of necessary or appropriate rules and regulations for the implementation of the GBO.

# 4 BASELINE AND REDUCTION TARGETS OF $CO_2$ EMISSIONS

## 4.1 Setting the Base Year and Target Years

The base year is set in year 2015. According to the Intended Nationally Determined Contributions (INDC), the Philippines intend to undertake GHG or $CO_2e$ emissions reduction of about 70% by 2030 relative to its BAU scenario of 2000-2030. Reduction of GHG emissions will come from energy, transport, waste, forestry and industry sectors. The mitigation contribution is conditioned on the extent of financial resources, including technology development and transfer, and capacity building, that will be made available to the Philippines.

In terms of energy plan, the Philippine Energy Plan has been developed for the period of 2012-2030, and Energy Efficiency and Conservation Roadmap was set for 2011-2030.

In order to ensure the consistency with the above-mentioned policies, the mid-term target is set at 2030.

Mega Cebu Vision 2050 which draws a sustainable urban development vision for Metro Cebu consisting of the seven cities and six municipalities has been initiated by the Metro Cebu Development and Coordinating Board (MCDCB) with cooperation from JICA and Yokohama-city. Considering the Mega Cebu Vision 2050 set as the long-term vision for the region including Mandaue and its neighboring cities, it is considered relevant to set the long-term target at 2050.

## 4.2 Definition of $CO_2$ Emissions Baseline

Baseline scenario and emissions are considered as “business-as-usual" (BAU) scenario and emissions (i.e., emissions that would occur without any effort of reduction). Baseline emissions are calculated based on the baseline energy balance and energy efficiency data for all sectors as well as predicted future energy consumption.

## 4.3 Estimation of $CO_2$ Emission Baseline

### 4.3.1 Member Economy Baseline Emissions and Reduction Target

#### (1) Member Economy's Greenhouse Gas (GHG) Inventory

The GHG emissions inventory data of 1994 and 2000 was reported in the First and the Second National Communication to the United Nations Frame Work Convention on Climate Change.

The GHG inventory for year 2000 is the latest available data in the Philippines. According

to the Second National Communication, the emissions for the year 2000 decreased by 78% compared to its 1994 level. However, this is mainly due to the adjustment in the amount of emissions sequestered by the Land Use Change and Forestry (LUCF) sector and the large decrease of emissions in this sector is due to the change in the definition of forest and also the availability of data.

Excluding the LUCF sector, the energy sector is the largest contributor to the GHG emissions consisting of 55% of total emissions in 2000. The emissions in the energy sector have increased between 1994 to 2000 by 39% at an annual growth rate of 6.5%. Likewise, the GHG emissions from the waste sector have significantly increased between 1994 to 2000 by 64%.

**Table 4.3.1 Total GHG Emissions in 1994 and 2000**

| Sector | GHG Emission (GgCO2e) | | |
|---|---|---|---|
| | 1994 | 2000 | Change |
| Energy | 50,038 | 69,667 | 39% |
| Industrial Processes | 10,603 | 8,610 | -19% |
| Agriculture | 33,130 | 37,003 | 12% |
| Land Use Change and Forestry | -126 | -105,111 | - |
| Waste | 7,094 | 11,599 | 64% |
| **Total** | **100,739** | **21,767** | **-78%** |

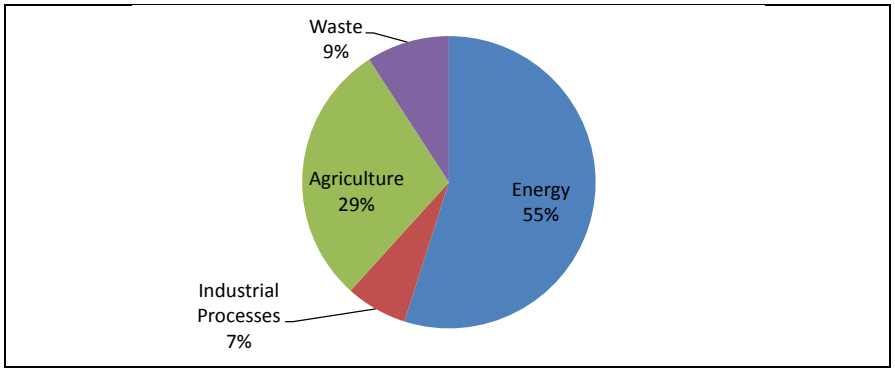
Source: Second National Communication to the United Nations Framework Convention on Climate Change, the Philippines, December 29, 2014.

Considering the type of gas, $CO_2$ emissions are from the energy sector and industrial processes. The agriculture and waste sectors' GHG emissions are mainly in the form of methane ($CH_4$) emissions accounting for 29% and 9% of total emissions, respectively.

**Table 4.3.2 Composition of Total GHG Emission ($GgCO_2e$) in 2000**

| Sector | GHG Emission (GgCO2e) | | | |
|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | Total |
| Energy | 62,499.10 | 304.14 | 2.52 | 69,667.24 |
| Industrial Processes | 8,604.74 | 0.24 | - | 8,609.78 |
| Agriculture | - | 1,209.79 | 37.41 | 37,002.69 |
| Land Use Change and Forestry | -104,040.29 | 146.28 | -0.32 | -105,111.37 |
| Waste | - | 500.67 | 3.50 | 11,599.07 |
| **Total** | **-32,936,45** | **1,968.56** | **43.11** | **21,767.41** |

Source: Second National Communication to the United Nations Framework Convention on Climate Change, the Philippines, December 29, 2014.



Source: Second National Communication to the United Nations Framework Convention on Climate Change, the Philippines, December 29, 2014.

**Figure 4.3.1 Overall Contribution to GHG Emissions in 2000 by Non-LUCF Sectors**

### (2) Emissions from the Energy Sector

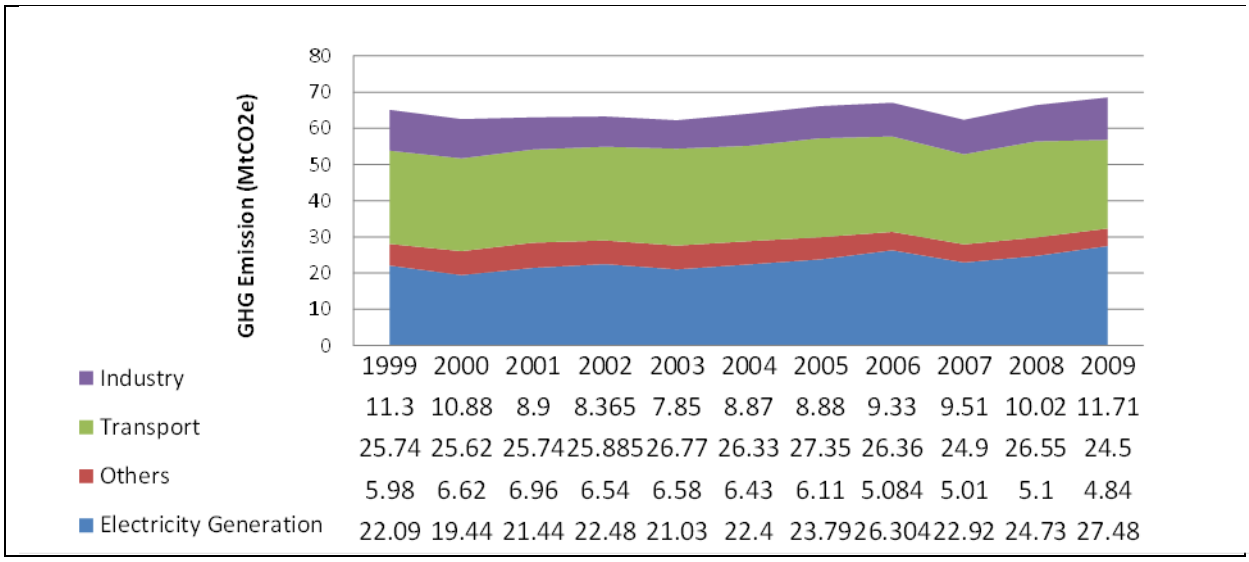
The energy sector consists of six sub-categories shown in the following table. The transport sector is the largest contributor at 37% share followed by the energy industries at 30% share of total emissions in 2000.

**Table 4.3.3 GHG Emissions from Energy Sub-Sectors in 2000**

| Sector | GHG Emission (GgCO2e) | | | | % Share |
|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | Total | |
| Energy Industries | 21,127.35 | 0.40 | 0.27 | 21,219.45 | 30 |
| Manufacturing Industries & Construction | 9,015.30 | 1.91 | 0.28 | 9,142.21 | 13 |
| Transport | 25,792.03 | 3.45 | 0.23 | 25,935.78 | 37 |
| Other Sectors | 6,564.42 | 130.29 | 1.74 | 9,839.91 | 14 |
| Solid fuels | - | 1.60 | - | 33.60 | 0 |
| Oil & Natural Gas | - | 166.49 | - | 3,496.29 | 5 |
| **Total** | **62,499.10** | **304,13** | **2.42** | **69,667.24** | **100** |

Source: Second National Communication to the United Nations Framework Convention on Climate Change, the Philippines, December 29, 2014

Data for emissions from the energy sector from 1999 to 2009 is available in the National Climate Change Action Plan 2011-2028 (NCCAP) although its sub-category is slightly different from the data in the Second National Communication. The total GHG emission of the energy sector has increased by 0.6% annually. The transport sub-sector emissions have decreased by approximately 0.5% annually for this period.




Source: Second National Communication to the United Nations Framework Convention on Climate Change, the Philippines, December 29, 2014

**Figure 4.3.2 GHG Emissions of the Energy Sector, 1999-2009 ($MtCO_2e$)**

Although the increase of GHG emissions in the energy sector from 1999 to 2009 has not been significant in that period, NCCAP indicates that the emissions from the electricity

generation sub-sector will increase to 140 $MtCO_2$ in 2030 (more than 400% increase from its 2007 level) with the continued increase in dependence on imported coal for power generation. For the transport sub-sector, the emissions will increase by more than 200% by 2030.

### 4.3.2 Baseline Emissions for Mandaue City

Ideally, the baseline emissions of Mandaue City should be calculated following the Global Protocol for Community Greenhouse Gas Emissions (GPC) which provides guidance for GHG quantification, accounting and reporting standards for cities in consistent with the 2006 IPCC Guidelines for National GHG Inventories. However, the limitation of reliable data is an issue in Mandaue City since a GHG inventory system is not yet established. For instance, there is no reliable data for fuel consumption in Mandaue City although It is expected that Mandaue City will set up an inventory system and collect reliable data in the future.

For this study, $CO_2$ baseline emissions are estimated based on best available data at the present time. For Mandaue City, electricity consumption data by sector consisting of industry, commercial, and residential is available. However, the fuel consumption data is not available for Mandaue City but only for Cebu City. Hence, the Cebu City data became the reference considering the trend assumed from the historical electricity consumption by sector of Mandaue City.

On the other hand, energy consumption data is not available for the transportation sector. So, estimation is based on the registered number of vehicles in Mandaue City. The estimation of baseline emissions are, thus, explained in the two separate sections; (1) industry, commercial, and residential sector, and (2) the transportation sector, according to the calculation method.

#### (1) Industry, Commercial and Residential Sectors

The total energy consumption data in Mandaue City is not available at present although the electricity consumption data is available (Table 4.3.4). For energy consumption data, available relevant information is the data of the neighboring Cebu City in 2010 (Table 4.3.5). Therefore, energy consumption in Cebu City is used as reference to estimate the total energy consumption in Mandaue City.

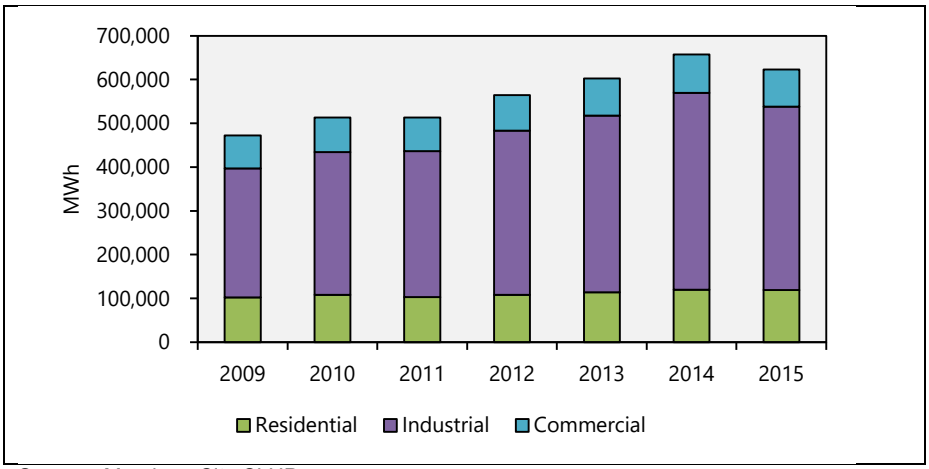
The $CO_2$ emissions baseline in Mandaue City are calculated through the following steps:

1) Calculate the energy consumption by sector of base year (2015) in Mandaue City;
2) Calculate the $CO_2$ emission by sector of base year (2015) in Mandaue City;
3) Estimate the energy consumption projection in target years, and energy baseline; and
4) Estimate the $CO_2$ emission projection in target years and emissions baseline.

**Table 4.3.4 Electricity Consumption in Mandaue City[1] (MWh)**

| Type of User | 2009 | 2010 | 2011 | 2012 | 2013[2] | 2014[3] | 2015[4] |
|---|---|---|---|---|---|---|---|
| Residential | 102,395.41 | 107,779.29 | 102,854.54 | 108,019.99 | 114,243.55 | 119,760.88 | 119,435.52 |
| Industrial | 294,478.45 | 326,348.27 | 333,821.99 | 375,254.79 | 403,565.76 | 449,521.57 | 418,475.13 |
| Commercial | 79,235.14 | 83,088.20 | 81,287.84 | 85,537.28 | 89,765.60 | 93,526.67 | 89,796.27 |
| Total (MWh) | 476,109.01 | 517,215.76 | 517,964.37 | 568,812.06 | 607,574.92 | 662,809.12 | 627,706.93 |
| Total （PJ） | 1.71 | 1.86 | 1.86 | 2.05 | 2.19 | 2.39 | 2.26 |
| Year on Year (%) | | 8.63 | 0.14 | 9.82 | 6.81 | (N/A) | 3.31[5] |

Source: Mandaue City Comprehensive Land Use Plan 2014 and 2015 VECO
[1] Within this process, electricity consumption classification is amended, where VECO use Streetlights, Residential, Commercial, Industrial. In this report, the BAU focus on calculating emission factors from Residential, Commercial, Industrial sectors. Therefore, electricity consumption by streetlights is included in the commercial sector.
[2] Data for 2013 estimates (Jan~June actual data)
[3] Data for 2014 estimates
[4] Data for 2015 is actual data from VECO
[5]Year on Year for 2015 is calculated from 2013 as 2014 data is an estimate




Source: Mandaue City CLUP

**Figure 4.3.3 Electricity Consumption in Mandaue City**

**Table 4.3.5 Cebu Energy Consumption Data in 2010 (in PJ)**

| Item | Public[1)] | Commercial | Residential | Industrial | Transportation | Total |
|---|---|---|---|---|---|---|
| Electricity | 0.10 | 0.70 | 1.20 | 1.90 | 0.00 | 3.90 |
| Gas and Diesel | 0.03 | 0.00 | 0.00 | 0.00 | 10.20 | 10.23 |
| LPG | 0.00 | 0.30 | 0.30 | 0.00 | 0.50 | 1.10 |
| Fuel Oil | 0.00 | 0.00 | 0.00 | 5.90 | 0.00 | 5.90 |
| Natural gas | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 0.13 | 1.00 | 1.50 | 7.80 | 10.70 | 21.13 |
| Sector ratio (%) | 0.62 | 4.73 | 7.10 | 36.91 | 50.64 | |

Source: World Bank, 2013
[1)] The energy consumption in public sector includes the end-use energy of city buildings, street lighting, city vehicles, water, wastewater, and solid waste management.

For energy consumption, data of Cebu consumption was classified as Public, Commercial, Residential, Industrial, and Transport sectors. Public consist of "end-use energy of city buildings, street lighting, city vehicles, water, wastewater, and solid waste management". Looking by fuel source, gas and diesel was consumed, assuming this mainly consists from consumption by "city vehicles", this was added to transport sector for the calculation hereafter.

For electricity consumption, both data for Cebu and Mandaue are available. Hence, it is compared to determine the ratio of electricity consumption of each sector between Mandaue and Cebu (Table 4.3.6 ). Considering that the ratio of population between Mandaue (331,300) and Cebu (866,200) is 0.38, the ratio of electricity consumption in commercial and residential sector correspond approximately to the population ratio. On the other hand, the industry sector accounts high proportion of electricity consumption in Mandaue City compared to Cebu City.

**Table 4.3.6 Electricity Consumption in 2010 - Comparison of Cebu and Mandaue (in PJ)**

| Area | Commercial | Residential | Industrial | Total |
|---|---|---|---|---|
| Cebu | 0.80 | 1.20 | 1.90 | 4.70 |
| Mandaue | 0.30 | 0.39 | 1.18 | 1.86 |
| Mandaue/Cebu | 0.37 | 0.32 | 0.62 | 0.40 |

Source: World Bank 2013, CLUP 2014

Based on the energy consumption data of Cebu, energy consumption by sector, except transportation, in Mandaue in 2010 is calculated by multiplying the ratio derived for each sector shown in Table 4.3.7 Estimated Energy Consumption in Mandaue in 2010. Electricity consumption of Mandaue in 2010 is taken from VECO since actual data is available (Table 4.3.7 Estimated Energy Consumption in Mandaue in 2010).

**Table 4.3.7 Estimated Energy Consumption in Mandaue in 2010 (Excluding the Transportation Sector)**

| Item | Commercial | Residential | Industrial | Total |
|---|---|---|---|---|
| Electricity (MWh) | 83,088.20 | 107,779.29 | 326,348.27 | 517,215.76 |
| Gas and Diesel (TJ) | 0.00 | 0.00 | 0.00 | 0.00 |
| LPG (TJ) | 112.17 | 185.53 | 0.00 | 297.7 |
| Fuel Oil (TJ) | 0.00 | 0.00 | 2,337.55 | 2,337.55 |
| Natural gas (TJ) | 0.00 | 0.00 | 0.00 | 0.00 |

Source: Electricity consumption data from VECO

In order to estimate energy consumption in Mandaue for 2015 based on the 2010 data

shown in Table 4.3.7 Estimated Energy Consumption in Mandaue in 2010, the growth rate of electricity consumption by sector in Mandaue City in 2010 and 2015 is used (Table 4.3.8 Electricity Consumption in Mandaue in 2010 and 2015). Electricity consumption for 2015 is provided by VECO (Table 4.3.9 Estimated Energy Consumption in Mandaue in 2015).

**Table 4.3.8 Electricity Consumption in Mandaue in 2010 and 2015**

| Type of User | 2010 (kWh) | 2015 (kWh) | Growth Rate |
|---|---|---|---|
| Residential | 107,779,292 | 119,435,521 | 1.11 |
| Industrial | 326,348,271 | 418,475,134 | 1.28 |
| Commercial | 83,088,201 | 89,796,274 | 1.08 |
| Total | 517,215,764 | 627,706,929 | 1.21 |

Source: Data for 2010 Mandaue City Comprehensive Land Use Plan 2014, data for 2015 VECO

The estimation result for the energy consumption by sector excluding transportation sector in 2015 is shown in Table 4.3.9 Estimated Energy Consumption in Mandaue in 2015.

**Table 4.3.9 Estimated Energy Consumption in Mandaue in 2015 (Excluding the Transportation Sector)**

| Item | Commercial | Residential | Industrial | Total |
|---|---|---|---|---|
| Electricity (MWh) | 89,796.27 | 119,435.52 | 418,475.13 | 627,706.93 |
| Gas and Diesel (TJ) | 0.00 | 0.00 | 0.00 | 0.00 |
| LPG (TJ) | 121.22 | 205.59 | 0.00 | 326.81 |
| Fuel Oil (TJ) | 0.00 | 0.00 | 2,997.43 | 2,997.43 |
| Natural gas (TJ) | 0.00 | 0.00 | 0.00 | 0.00 |

Source: Electricity consumption data from VECO

With the energy consumption of Mandaue in 2015, $CO_2$ baseline emissions are calculated for the following:

| | |
|---|---|
| $BE_{i,y}$ | Baseline Emission in year *y* ($tonCO_2$) |
| *FC i, y* | Energy consumption by fuel type *i* in year *y* (TJ) |
| *EF i* | Emission factor of fossil fuel type *i* (kg/TJ) |
| $EC_{electricity}$ | Electricity Consumption in year y (MWh) |
| $EF_{grid}$ | Grid Emission Factor ($tCO_2$/MWh) |

The emission factors used for the calculation are summarized in Table 4.3.10 . Emission factor of the Philippine grid electricity, stated by the member economy in the Second National Communication to the UNFCCC 2014, is applied since the Visayas grid is interconnected with the member economy's grid. For the fossil fuels, $CO_2$ emission factor reported in the 2006 IPCC Guidelines for member economy's Greenhouse Gas Inventories is used.

**Table 4.3.10 Emission Factors used for Calculations**

| Energy Source | EF | Units | Source |
|---|---|---|---|
| Electricity | 0.512 | $tCO_2$/MWh | Second National Communication |
| Gas and Diesel | 74,100 | kg/TJ | IPCC 2006 |
| LPG | 63,100 | kg/TJ | IPCC 2006 |
| Fuel Oil | 77,400 | kg/TJ | IPCC 2006 |
| Natural Gas | 64,200 | kg/TJ | IPCC 2006 |

The calculation result is shown in Table 4.3.11 . The estimated $CO_2$ emissions in Commercial, Residential, and Industrial sectors in Mandaue City are 53,625 $tCO_2$, 74,124 $tCO_2$, and 446,261 $tCO_2$ respectively.

**Table 4.3.11 Estimated $CO_2$ Emissions in 2015 in Mandaue City (Excluding the Transportation Sector)**

| Item | Commercial | Residential | Industrial | Total (in $tCO_2$) |
|---|---|---|---|---|
| Electricity | 45,976 | 61,151 | 214,259 | 321,386 |
| Gas and Diesel | 0 | 0 | 0 | 0 |
| LPG | 7,649 | 12,973 | 0 | 20,622 |
| Fuel Oil | 0 | 0 | 232,001 | 232,001 |
| Natural Gas | 0 | 0 | 0 | 0 |
| Total | 53,625 | 74,124 | 446,261 | 574,009 |

Source: APEC Study Team

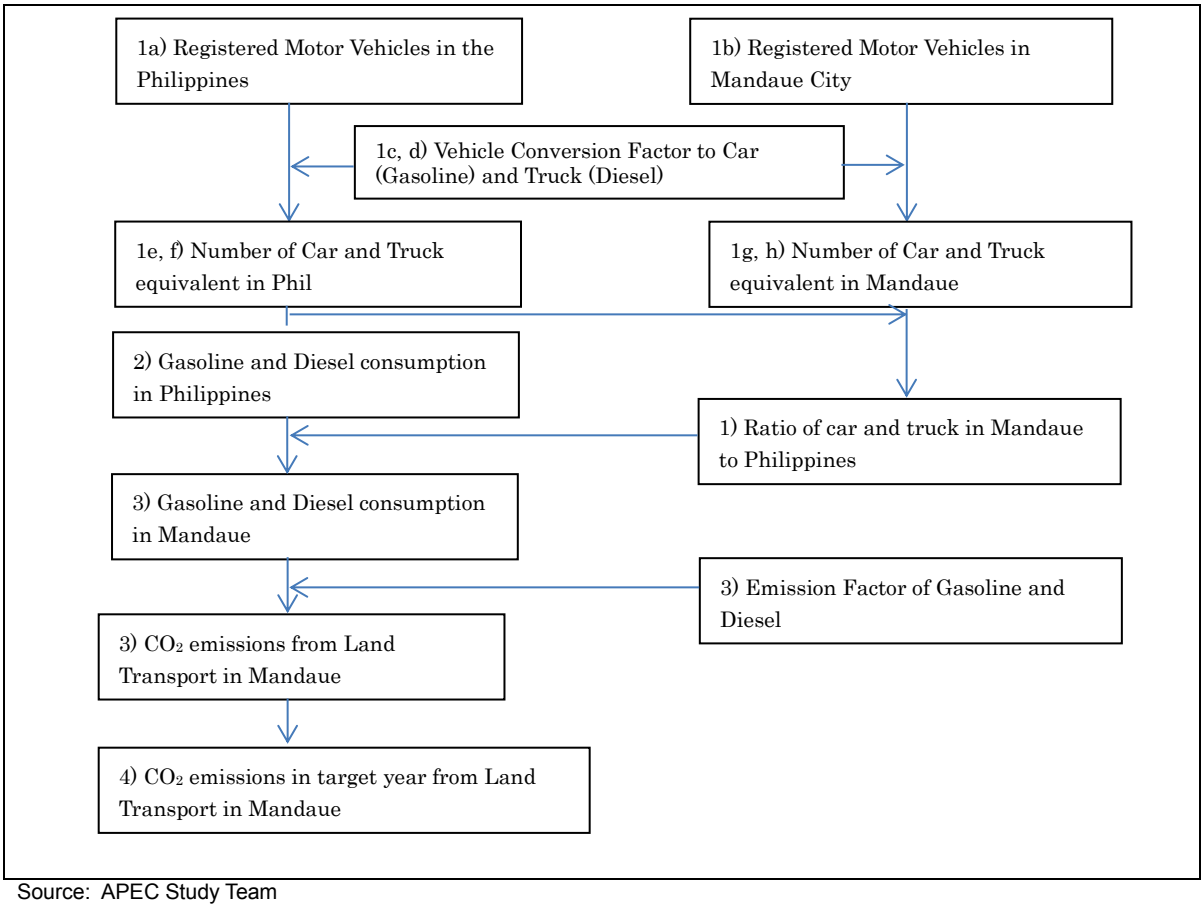
### (2) Transport Sector

Transport energy consumption is divided into “Road”, “Water”, “Air” and “Rail”. In this report the $CO_2$ emission from road transport was estimated due to limited data that was available and the feasibility of low carbon measures to be introduced.

The $CO_2$ emission baseline of the transport sector in Mandaue will be calculated based on the flowchart shown in Figure 4.3.4.

The following data are shown in Table 4.3.12

- The number of registered vehicles in the Philippines and Mandaue City;
- Vehicle conversion factor to car for gasoline combustion vehicles and truck for diesel combustion vehicles in the view of annual fuel consumption;
- The number of car and truck equivalent in the Philippines and Mandaue City; and
- The share of gasoline and diesel consumption in Mandaue against the Philippines.




Source: APEC Study Team

**Figure 4.3.4 Flowchart for the Estimation of the $CO_2$ Emission Baseline in Mandaue**

Table 4.3.13 shows the number of vehicles by category in Mandaue City for 2009-2013. Attention is placed on the trend estimation after 2013 because the data in 2010 and 2011 are incorrectly less than 2009 and 2012. Figure 4.3.5 shows the number of vehicles by category in Mandaue, Cebu, Metro Cebu and Region VII. The number of registered vehicles to Mandaue District Office is 70-80% of Cebu City Engineering Office, although the city population of Mandaue is about 38% of Cebu City.

For the estimation of fuel consumption in land transport sector, the conversion factors are introduced based on fuel consumption statistics in Japan by vehicle category and fuel type. Information are taken from the Philippines National Energy Planning Support Study, JICA, The Institute of Energy Economics of Japan and Tokyo Electric Power Company, 2008. The details are shown in Tables 4.3.14 to 4.3.16.

### Table 4.3.12 Number of Vehicles in the Philippines and in Mandaue City

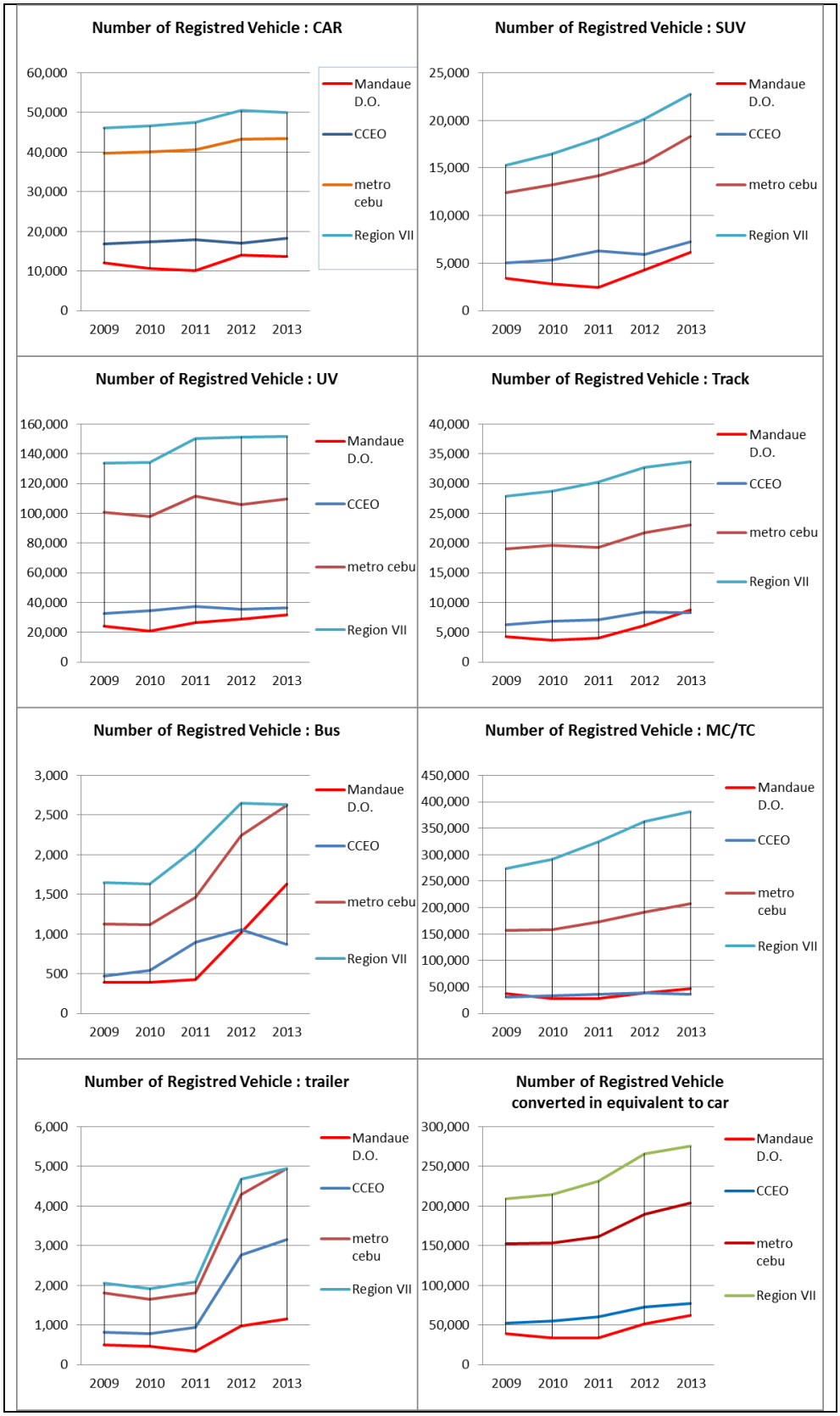
| | | | (a) | (b) | | (c) | (d) | (e) | (f) | (g) | (h) | (g)/(e) | (i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Vehicle Use | Vehicle Type | Total PH | Mandaue | (b) / (a) | conversion factor | | Total PH | | Mandaue | | Manda | |
| | | | | | | Gasoline | Diesel | Car | Truck | Car | Truck | Car | |
| 2013 | all purposes | Cars | 868148 | 13,664 | 1.6% | 1.000 | | 868,148 | | 13,664 | | 1.57% | |
| 2013 | all purposes | UV | 1794572 | 31,895 | 1.8% | | 0.111 | | 199,197 | | 3,540 | | |
| 2013 | all purposes | SUV | 346396 | 6,158 | 1.8% | 1.182 | | 409,440 | | 7,279 | | 1.78% | |
| 2013 | all purposes | Buses | 31665 | 1,634 | 5.2% | | 0.966 | | 30,588 | | 1,578 | | |
| 2013 | all purposes | Trucks | 358445 | 8,730 | 2.4% | | 1.000 | | 358,445 | | 8,730 | | |
| 2013 | all purposes | MC/TC | 4250667 | 47,018 | 1.1% | 0.185 | | 786,373 | | 8,698 | | 1.11% | |
| 2013 | all purposes | Trailers | 40,145 | 1,150 | 2.9% | | 3.400 | | 136,493 | | 3,910 | | |
| **2013** | | **Total** | **7,690,038** | **110,249** | **1.4%** | | | **2,063,961** | **724,724** | **29,641** | **17,759** | **1.44%** | |
| 2012 | all purposes | Cars | 852,255 | 13,928 | 1.6% | 1.000 | | 852,255 | | 13,928 | | 1.63% | |
| 2012 | all purposes | UV | 1,771,310 | 28,695 | 1.6% | | 0.111 | | 196,615 | | 3,185 | | |
| 2012 | all purposes | SUV | 310,521 | 4,277 | 1.4% | 1.182 | | 367,036 | | 5,055 | | 1.38% | |
| 2012 | all purposes | Buses | 33,586 | 1,015 | 3.0% | | 0.966 | | 32,444 | | 980 | | |
| 2012 | all purposes | Trucks | 341,572 | 6,157 | 1.8% | | 1.000 | | 341,572 | | 6,157 | | |
| 2012 | all purposes | MC/TC | 4,116,690 | 38,848 | 0.9% | 0.185 | | 761,588 | | 7,187 | | 0.94% | |
| 2012 | all purposes | Trailers | 37,459 | 972 | 2.6% | | 3.400 | | 127,361 | | 3,305 | | |
| **2012** | | **Total** | **7,463,393** | **93,892** | **1.3%** | | | **1,980,878** | **697,992** | **26,170** | **13,627** | **1.32%** | |
| 2011 | all purposes | Cars | 828,587 | 10,121 | 1.2% | 1.000 | | 828,587 | | 10,121 | | 1.22% | |
| 2011 | all purposes | UV | 1,748,402 | 26,293 | 1.5% | | 0.111 | | 194,073 | | 2,919 | | |
| 2011 | all purposes | SUV | 284,099 | 2,444 | 0.9% | 1.182 | | 335,805 | | 2,889 | | 0.86% | |
| 2011 | all purposes | Buses | 34,478 | 422 | 1.2% | | 0.966 | | 33,306 | | 408 | | |
| 2011 | all purposes | Trucks | 329,385 | 3,986 | 1.2% | | 1.000 | | 329,385 | | 3,986 | | |
| 2011 | all purposes | MC/TC | 3,881,460 | 28,480 | 0.7% | 0.185 | | 718,070 | | 5,269 | | 0.73% | |
| 2011 | all purposes | Trailers | 32,531 | 333 | 1.0% | | 3.400 | | 110,605 | | 1,132 | | |
| **2011** | | **Total** | **7,138,942** | **72,079** | **1.0%** | | | **1,882,462** | **667,369** | **18,279** | **8,444** | **0.97%** | |
| 2010 | all purposes | Cars | 808,583 | 10,681 | 1.3% | 1.000 | | 808,583 | | 10,681 | | 1.32% | |
| 2010 | all purposes | UV | 1,700,795 | 20,935 | 1.2% | | 0.111 | | 188,788 | | 2,324 | | |
| 2010 | all purposes | SUV | 261,213 | 2,842 | 1.1% | 1.182 | | 308,754 | | 3,359 | | 1.09% | |
| 2010 | all purposes | Buses | 34,933 | 388 | 1.1% | | 0.966 | | 33,745 | | 375 | | |
| 2010 | all purposes | Trucks | 317,903 | 3,609 | 1.1% | | 1.000 | | 317,903 | | 3,609 | | |
| 2010 | all purposes | MC/TC | 3,482,149 | 28,487 | 0.8% | 0.185 | | 644,198 | | 5,270 | | 0.82% | |
| 2010 | all purposes | Trailers | 29,279 | 455 | 1.6% | | 3.400 | | 99,549 | | 1,547 | | |
| **2010** | | **Total** | **6,634,855** | **67,397** | **1.0%** | | | **1,761,534** | **639,985** | **19,310** | **7,855** | **1.10%** | |

Source: Rail, Water, Land and Air Transportation Statistics 2003-2012, the Philippine Statistics Authority
Registered Motor Vehicles by Classification and Region, DOTC, Land Transport Office

### Table 4.3.13 Number of Vehicles by Category in Mandaue City for 2009-2013

| Year | Cars | SUV | UV | Truck | Buses | MC/TC | Trailer | Total |
|---|---|---|---|---|---|---|---|---|
| 2009 | 11,986 | 3,429 | 23,997 | 4,244 | 386 | 36,801 | 501 | 81,344 |
| 2010 | 10,681 | 2,842 | 20,935 | 3,609 | 388 | 28,487 | 455 | 67,397 |
| 2011 | 10,121 | 2,444 | 26,293 | 3,986 | 422 | 28,480 | 333 | 72,079 |
| 2012 | 13,928 | 4,277 | 28,695 | 6,157 | 1,015 | 38,848 | 972 | 93,892 |
| 2013 | 13,664 | 6,158 | 31,895 | 8,873 | 1,634 | 47,018 | 1,150 | 110,249 |

Source: Rail, Water, Land and Air Transportation Statistics 2003-2012, the Philippine Statistics Authority
Registered Motor Vehicles by Classification and Region, DOTC, Land Transport Office (Mandaue District Office)




Source: Rail, Water, Land and Air Transportation Statistics 2003-2012, the Philippine Statistics Authority
Registered Motor Vehicles by Classification and Region, DOTC, Land Transport Office

**Figure 4.3.5 Number of Vehicles by Category in Mandaue, Cebu, Metro Cebu and Region VII for 2009-2013**

**Table 4.3.14 Fuel Consumption Rate by Vehicle Category and Fuel Type**

| | Car | UV | Truck | Bus | Motorcycle |
|---|---|---|---|---|---|
| Gasoline(l) | 1,460 | 1,725 | 2,677 | 3,650 | 270 |
| Diesel(l) | 1,186 | 1,356 | 12,191 | 11,771 | - |

Source: The Philippines National Energy Planning Support Study, JICA, 2008

**Table 4.3.15 Conversion Factor to Cars and Trucks**

| | Car | UV | Truck | Bus | Motorcycle | Trailer |
|---|---|---|---|---|---|---|
| Gasoline | 1.000 | 1.182 | 1.834 | 2.50 | 0.185 | - |
| Diesel | 0.097 | 0.111 | 1.000 | 0.966 | 0.022 | 3.40 |

Source: The Philippines National Energy Planning Support Study, JICA, 2008

**Table 4.3.16 Fuel Consumption of Trucks and Trailers**

| | Truck (Light) | Truck (Medium) | Truck (Heavy) | Trailer |
|---|---|---|---|---|
| Unload (km/l) | 6.75 | 5.0 | 5.25 | 1.65 |
| Load (km/l) | 4.3 | 3.7 | 3.7 | 1.0 |
| Average(km/l) | 5.5 | 4.35 | 4.5 | 1.3 |
| Conversion Factor | 0.80 | | 1.00 | 3.40 |

Source: http://usedtrucks.blog.fc2.com/blog-entry-597.html

The shares of gasoline and diesel consumption in Mandaue against the Philippines are as follows:

| | | |
|---|---|---|
| 2010 | 1.10% (gasoline) | 1.23 %(diesel) |
| 2011 | 0.97% (gasoline) | 1.27% (diesel) |
| 2012 | 1.32% (gasoline) | 1.95% (diesel) |
| 2013 | 1.44% (gasoline) | 2.45% (diesel) |

Gasoline and Diesel Consumption in the Philippines

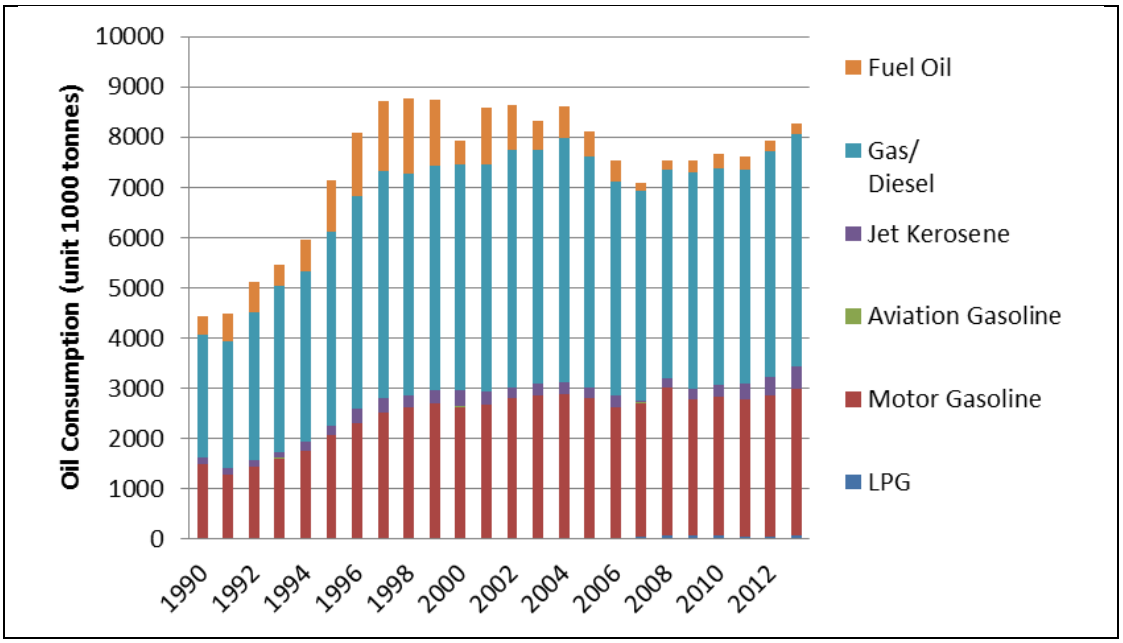
The DOE Energy Statistics shows the petroleum products consumption for 2000-2009 by sector for the entire member economy.[1] However, data on consumption by type of fuel specifically for the transport sector of the Philippines is available in the International Energy Agency (IEA) statistics as shown in Table 4.3.17. The gasoline and diesel consumption in the Philippines is stable at around 4,500 (x1000 tonnes) every year after 1997 as shown on Figure 4.3.6.

[1]Data source is http://www.doe.gov.ph/policy-planning/key-energy-statistics-2010/1234-energy-consumption2; and http://www.doe.gov.ph/downstream-oil-industry/558-fy-2015

**Table 4.3.17 Oil Consumption in the Transport Sector in the Philippines**

| Year | Volume (in 1000 tonnes) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Liquefied Petroleum Gas (LPG) | Motor Gasoline | Aviation Gasoline | Jet Kerosene | Gas/Diesel | Fuel Oil | Total |
| 1990 | 0 | 1487 | 4 | 134 | 2439 | 366 | 4430 |
| 1991 | 0 | 1282 | 3 | 116 | 2536 | 550 | 4487 |
| 1992 | 0 | 1434 | 3 | 119 | 2943 | 609 | 5108 |
| 1993 | 0 | 1602 | 3 | 125 | 3304 | 416 | 5450 |
| 1994 | 0 | 1744 | 6 | 171 | 3391 | 638 | 5950 |
| 1995 | 0 | 2053 | 4 | 192 | 3857 | 1020 | 7126 |
| 1996 | 0 | 2308 | 4 | 265 | 4249 | 1255 | 8081 |
| 1997 | 0 | 2499 | 4 | 309 | 4504 | 1390 | 8706 |
| 1998 | 0 | 2622 | 4 | 236 | 4410 | 1494 | 8766 |
| 1999 | 0 | 2702 | 4 | 240 | 4480 | 1315 | 8741 |
| 2000 | 0 | 2629 | 3 | 318 | 4496 | 490 | 7936 |
| 2001 | 0 | 2674 | 3 | 263 | 4502 | 1135 | 8577 |
| 2002 | 0 | 2791 | 3 | 225 | 4721 | 902 | 8642 |
| 2003 | 0 | 2846 | 3 | 237 | 4665 | 560 | 8311 |
| 2004 | 0 | 2876 | 3 | 232 | 4863 | 627 | 8601 |
| 2005 | 1 | 2798 | 3 | 221 | 4592 | 499 | 8114 |
| 2006 | 4 | 2613 | 3 | 225 | 4275 | 420 | 7540 |
| 2007 | 41 | 2666 | 3 | 40 | 4177 | 168 | 7095 |
| 2008 | 63 | 2952 | 4 | 172 | 4155 | 186 | 7532 |
| 2009 | 78 | 2689 | 4 | 226 | 4297 | 234 | 7528 |
| 2010 | 69 | 2766 | 4 | 233 | 4311 | 290 | 7673 |
| 2011 | 42 | 2729 | 2 | 305 | 4275 | 250 | 7603 |
| 2012 | 36 | 2813 | 7 | 364 | 4508 | 189 | 7917 |
| 2013 | 53 | 2937 | 4 | 430 | 4624 | 218 | 8266 |

Source: International Energy Agency (IEA) Statistics




Source: IEA Statistics

**Figure 4.3.6 Oil Consumption in the Transport Sector in the Philippines**

Gasoline and Diesel Consumption in Mandaue are shown in Table 4.3.20. $CO_2$ emissions from gasoline and diesel are calculated using the following formula:

$$BE_{i,y} = \sum_i \left(VFC_{i,y} \times NCV_i \times EF_i \times 10^{-6}\right)$$

| | |
|---|---|
| Where: | |
| $BE_{i,y}$ | Baseline Emission in year *y* ($tonCO_2$) |
| *VFC i, y* | Volume of fossil fuel type i consumption in year *y* (ton) |
| *NCV i* | Net calorific value of fossil fuel type *i* consumed in Mandaue (TJ/ton) |
| *EF i* | Emission factor of fossil fuel type *i* (kg/TJ) |

In this study, IPCC default value for net calorific values and $CO_2$ emission factors are applied as shown on Table 4.3.18 and Table 4.3.19.

**Table 4.3.18 Default Net Calorific Values and Uncertainty Ranges**

| Fuel Type | Net Calorific Value (TJ/Gg) | Lower | Upper |
|---|---|---|---|
| Natural Gas Liquids | 44.2 | 40.9 | 46.9 |
| Motor Gasoline | 44.3 | 42.5 | 44.8 |
| Gas/Diesel Oil | 43.0 | 41.4 | 43.3 |
| Liquefied Petroleum Gas | 47.3 | 44.8 | 52.2 |

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Energy, Chapter3 Mobile Combustion, Table 1.2

**Table 4.3.19 Road Transport Default $CO_2$ Emission Factors and Uncertainty Ranges**

| Fuel Type | Default (kg/TJ) | Lower | Upper |
|---|---|---|---|
| Motor Gasoline | 69,300 | 67,500 | 73,000 |
| Gas/Diesel Oil | 74,100 | 72,600 | 74,800 |
| Liquefied Petroleum Gas | 63,100 | 61,600 | 65,600 |
| Compressed Natural Gas | 56,100 | 54,300 | 58,300 |
| Liquefied Natural Gas | 56,100 | 54,300 | 58,300 |

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Energy, Chapter3 Mobile Combustion, Table 3.2.1

$CO_2$ Emissions from Land Transport in Mandaue (Table 4.3.20)

The $CO_2$ emission from land transport in Mandaue in 2013 is 490,000 $tCO_2$, and the annual growth rate in 2010-2013 is 23.3%. In the breakdown of 2013 emission, 74% is from diesel combustion and 26% from gasoline combustion. The 71% of $CO_2$ emission from diesel combustion is born from trucks and trailers.

Assuming the population of Mandaue in 2014 is 365,000, the $CO_2$ emission from road transport sector in Mandaue per capita is 1.34 $tCO_2$, three times more than that of the Philippines.

Total Baseline Emission

The number of vehicles during 2014-2030.is estimated based on socioeconomic indicators to be influenced to registered vehicle number.

Population of Mandaue in 2020 is forecasted 422,327 equivalent to annual growth rate 2.4%. The population density reaching 129/ha. Land use increase 53.4% for industry and 20.7% for commerce.

Average annual GDP growth rate of the Philippines is 5.1% for 2000-2015 as shown on Table 4.3.21

**Table 4.3.20 $CO_2$ Emissions from Land Transport in Mandaue**

| | Philippines | | Mandaue/Philippines | | Mandaue | | CO2 Emission(tonCO2) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Gasoline (1000ton) | Diesel (1000ton) | Gasoline (%) | Diesel (%) | Gasoline (1000ton) | Diesel (1000ton) | Gasoline | Diesel | Total |
| 2000 | 2629 | 4496 | | | | | | | |
| 2001 | 2674 | 4502 | | | | | | | |
| 2002 | 2791 | 4721 | | | | | | | |
| 2003 | 2846 | 4665 | | | | | | | |
| 2004 | 2876 | 4863 | | | | | | | |
| 2005 | 2798 | 4592 | | | | | | | |
| 2006 | 2613 | 4275 | | | | | | | |
| 2007 | 2666 | 4177 | | | | | | | |
| 2008 | 2952 | 4155 | | | | | | | |
| 2009 | 2689 | 4297 | | | | | | | |
| 2010 | 2766 | 4311 | 1.10% | 1.23% | 30.3 | 52.9 | 93,087 | 168,585 | 261,672 |
| 2011 | 2729 | 4275 | 0.97% | 1.27% | 26.5 | 54.1 | 81,350 | 172,355 | 253,705 |
| 2012 | 2813 | 4508 | 1.32% | 1.95% | 37.2 | 88.0 | 114,093 | 280,436 | 394,529 |
| 2013 | 2937 | 4624 | 1.44% | 2.45% | 42.2 | 113.3 | 129,489 | 361,032 | 490,521 |

Source: APEC Study Team

**Table 4.3.21 GDP Growth of the Philippines**

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|
| GDP(%) | 4.41 | 2.89 | 3.65 | 4.97 | 6.7 | 4.78 | 5.24 | 6.62 | 4.15 |

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | Average |
|---|---|---|---|---|---|---|---|---|
| GDP(%) | 1.15 | 7.63 | 3.66 | 6.68 | 7.06 | 6.13 | 5.81 | 5.1 |

The growth rate of registered vehicles in the Philippines and Mandaue are shown on Table 4.3.22 . In Mandaue, the increase of truck, buses and trailer is remarkable. The growth rate of MC/TC is less than the Philippines, but more for cars and SUV.

**Table 4.3.22 Growth Rate of Registered Vehicles in the Philippines and Mandaue**

| | | CARS | SUV | UV | Truck | Buses | MC/TC | Trailer | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | Mandaue D.O. | 11,986 | 3,429 | 23,997 | 4,244 | 386 | 36,801 | 501 | 81,344 |
| 2010 | Mandaue D.O. | 10,681 | 2,842 | 20,935 | 3,609 | 388 | 28,487 | 455 | 67,397 |
| 2011 | Mandaue D.O. | 10,121 | 2,444 | 26,293 | 3,986 | 422 | 28,480 | 333 | 72,079 |
| 2012 | Mandaue D.O. | 13,928 | 4,277 | 28,695 | 6,157 | 1,015 | 38,848 | 972 | 93,892 |
| 2013 | Mandaue D.O. | 13,664 | 6,158 | 31,895 | 8,730 | 1,634 | 47,018 | 1,150 | 110,249 |
| incremental (%/year) | | 6.5% | | 7.4% | 19.8% | 43.4% | 6.3% | 23.1% | 7.9% |
| | | | | | | | | | |
| 2007 | Philippines | 747,236 | | 1,788,625 | 281,128 | 30,113 | 2,647,263 | 24,319 | 5,518,684 |
| 2008 | Philippines | 759,992 | | 1,790,518 | 296,121 | 29,703 | 2,982,296 | 27,104 | 5,885,734 |
| 2009 | Philippines | 780,057 | | 1,865,575 | 311,496 | 33,006 | 3,200,961 | 28,731 | 6,219,826 |
| 2010 | Philippines | 808,416 | | 1,961,703 | 317,774 | 34,909 | 3,482,139 | 29,263 | 6,634,204 |
| 2011 | Philippines | 828,426 | | 2,032,154 | 329,309 | 34,434 | 3,881,449 | 32,518 | 7,138,290 |
| 2012 | Philippines | 852,107 | | 2,081,541 | 341,505 | 33,564 | 4,116,682 | 37,458 | 7,462,857 |
| incremental (%/year) | | 2.7% | | 3.1% | 4.0% | 2.2% | 9.2% | 9.0% | 6.2% |

Source: Land Transportation Franchising Regulatory Board (LTFRB)

Estimation of Number of Registered Vehicles in Mandaue for 2014-2030

Mandaue is small in area and high population density. It is unlikely to increase vehicles as same as before. Private cars occupy 90% of all cars and SUV in Mandaue. The number of household in Mandaue will be about 100,000 assuming the population 422,327 and household population 4.23 as same as that of in 2010. If current growth rate 6% for cars and SUV continue, the number of cars and SUV increase 42% in 2020 and 154% in 2030. The number of cars and SUV in 2030 will be 50,000 and equal to 50% of household own cars. The truck and trailer increase as per the GDP growth rate 5%.

The baseline emission in transport sector in Mandaue is shown in the following table.

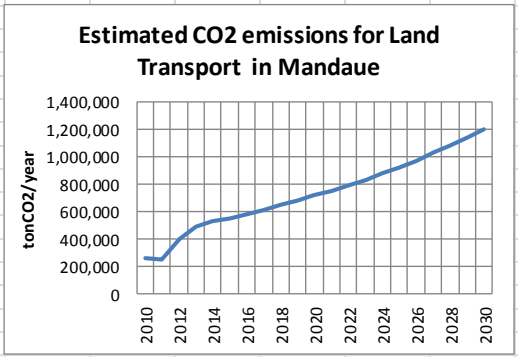
**Table 4.3.23 Baseline $CO_2$ Emissions in the Transport Sector in Mandaue**

| Fuel | Gasoline | Diesel | Gasoline | Diesel | Diesel | Gasoline | Diesel |
|---|---|---|---|---|---|---|---|
| Conversion | 1 | 0.111 | 1.182 | 0.966 | 1 | 0.185 | 3.4 |
| incrementa | 6% | 5% | 6% | 5% | 5% | 6% | 5% |

| Unit Fuel Consumption | |
|---|---|
| Gasoline | Diesel |
| 0.001458 | 0.006466 |

| | Estimated Number of vehicles 2014-2030 | | | | | | | Number Equivalent | | **Gasoline** | **Diesel** | CO2 Emission (tonCO2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cars** | **UV** | **SUV** | **Buses** | **Trucks** | **MC/TC** | **Trailers** | **Car** | **Truck** | 1000tonnes | 1000tonnes | Gasoline | Diesel | Tota |
| **2010** | 10,681 | 20,935 | 2,842 | 388 | 3,609 | 28,487 | 455 | 19,310 | 7,855 | 30.3 | 52.9 | 93,087 | 168,585 | 26 |
| **2011** | 10,121 | 26,293 | 2,444 | 422 | 3,986 | 28,480 | 333 | 18,279 | 8,444 | 26.5 | 54.1 | 81,350 | 172,355 | 25 |
| **2012** | 13,928 | 28,695 | 4,277 | 1,015 | 6,157 | 38,848 | 972 | 26,170 | 13,627 | 37.2 | 88.0 | 114,093 | 280,436 | 39 |
| **2013** | 13,664 | 31,895 | 6,158 | 1,634 | 8,730 | 47,018 | 1,150 | 29,641 | 17,759 | 42.2 | 113.3 | 129,489 | 361,032 | 49 |
| **2014** | 14,484 | 33,490 | 6,527 | 1,716 | 9,167 | 49,839 | 1,208 | 31,419 | 18,649 | 45.8 | 120.6 | 140,618 | 384,207 | 52 |
| **2015** | 15,353 | 35,165 | 6,919 | 1,802 | 9,625 | 52,829 | 1,268 | 33,305 | 19,580 | 48.6 | 126.6 | 149,059 | 403,388 | 55 |
| **2016** | 16,274 | 36,923 | 7,334 | 1,892 | 10,106 | 55,999 | 1,331 | 35,303 | 20,558 | 51.5 | 132.9 | 158,001 | 423,537 | 58 |
| **2017** | 17,250 | 38,769 | 7,774 | 1,987 | 10,611 | 59,359 | 1,398 | 37,420 | 21,587 | 54.6 | 139.6 | 167,476 | 444,736 | 61 |
| **2018** | 18,285 | 40,707 | 8,240 | 2,086 | 11,142 | 62,921 | 1,468 | 39,665 | 22,667 | 57.8 | 146.6 | 177,524 | 466,986 | 64 |
| **2019** | 19,382 | 42,742 | 8,734 | 2,190 | 11,699 | 66,696 | 1,541 | 42,044 | 23,798 | 61.3 | 153.9 | 188,171 | 490,287 | 67 |
| **2020** | 20,545 | 44,879 | 9,258 | 2,300 | 12,284 | 70,698 | 1,618 | 44,567 | 24,989 | 65.0 | 161.6 | 199,463 | 514,824 | 71 |
| **2021** | 21,778 | 47,123 | 9,813 | 2,415 | 12,898 | 74,940 | 1,699 | 47,241 | 26,238 | 68.9 | 169.7 | 211,431 | 540,556 | 75 |
| **2022** | 23,085 | 49,479 | 10,402 | 2,536 | 13,543 | 79,436 | 1,784 | 50,076 | 27,551 | 73.0 | 178.1 | 224,119 | 567,607 | 79 |
| **2023** | 24,470 | 51,953 | 11,026 | 2,663 | 14,220 | 84,202 | 1,873 | 53,080 | 28,927 | 77.4 | 187.0 | 237,563 | 595,955 | 83 |
| **2024** | 25,938 | 54,551 | 11,688 | 2,796 | 14,931 | 89,254 | 1,967 | 56,265 | 30,375 | 82.0 | 196.4 | 251,818 | 625,787 | 87 |
| **2025** | 27,494 | 57,279 | 12,389 | 2,936 | 15,678 | 94,609 | 2,065 | 59,640 | 31,893 | 86.9 | 206.2 | 266,923 | 657,061 | 92 |
| **2026** | 29,144 | 60,143 | 13,132 | 3,083 | 16,462 | 100,286 | 2,168 | 63,219 | 33,487 | 92.2 | 216.5 | 282,941 | 689,900 | 97 |
| **2027** | 30,893 | 63,150 | 13,920 | 3,237 | 17,285 | 106,303 | 2,276 | 67,012 | 35,160 | 97.7 | 227.3 | 299,917 | 724,367 | 1,02 |
| **2028** | 32,747 | 66,308 | 14,755 | 3,399 | 18,149 | 112,681 | 2,390 | 71,033 | 36,919 | 103.6 | 238.7 | 317,913 | 760,606 | 1,07 |
| **2029** | 34,712 | 69,623 | 15,640 | 3,569 | 19,056 | 119,442 | 2,510 | 75,295 | 38,766 | 109.8 | 250.7 | 336,988 | 798,658 | 1,13 |
| **2030** | 36,795 | 73,104 | 16,578 | 3,747 | 20,009 | 126,609 | 2,636 | 79,813 | 40,706 | 116.4 | 263.2 | 357,209 | 838,626 | 1,19 |

| Net Calorific Value | | Emission factor | |
|---|---|---|---|
| Gasoline | Diesel | Gasoline | Diesel |
| 44.3 | 43 | 69300 | 74100 |



### (2) Total $CO_2$ Emissions

Based on the calculation result of $CO_2$ emissions in Commercial, Residential, and Industrial sectors as well as in Transportation Sector, the total $CO_2$ emissions in Mandaue City in 2010 and 2015 are summarized in the following tables and figures.

**Table 4.3.24 $CO_2$ Emissions Estimate in 2010 in Mandaue ($tCO_2$)**

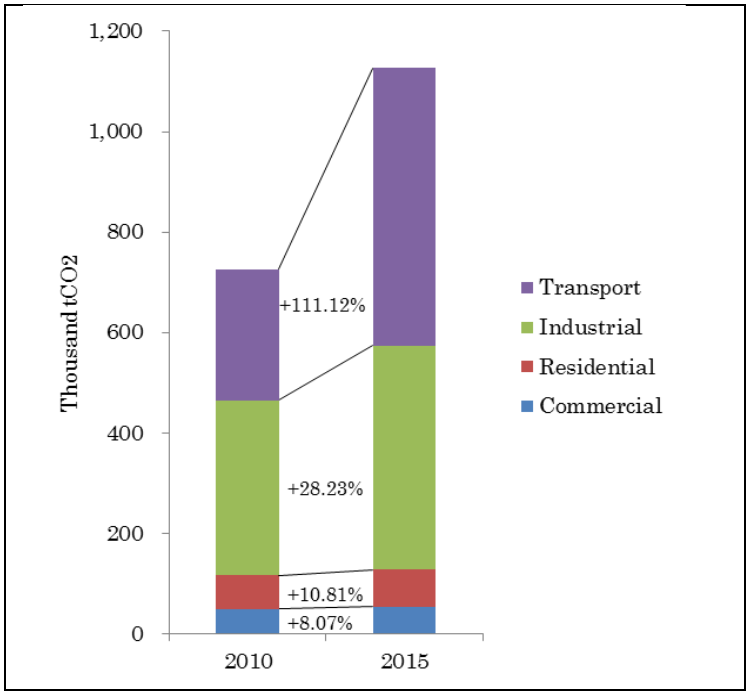
| | Commercial | Residential | Industrial | Transport | Total |
|---|---|---|---|---|---|
| Electricity | 42,541 | 55,183 | 167,090 | 0 | 264,814 |
| Gas | 0 | 0 | 0 | 93,087 | 93,087 |
| Diesel | 0 | 0 | 0 | 168,585 | 168,585 |
| LPG | 7,078 | 11,706 | 0 | 0 | 18,785 |
| Fuel Oil | 0 | 0 | 180,927 | 0 | 180,927 |
| Natural gas | 0 | 0 | 0 | 0 | 0 |
| Total | 49,619 | 66,890 | 348,017 | 261,672 | 726,198 |
| Sector Ratio (%) | 6.8 | 9.2 | 47.9 | 36.0 | 100.0 |

Source: APEC Study Team

**Table 4.3.25 $CO_2$ Emissions Estimate in 2015 in Mandaue ($tCO_2$)**

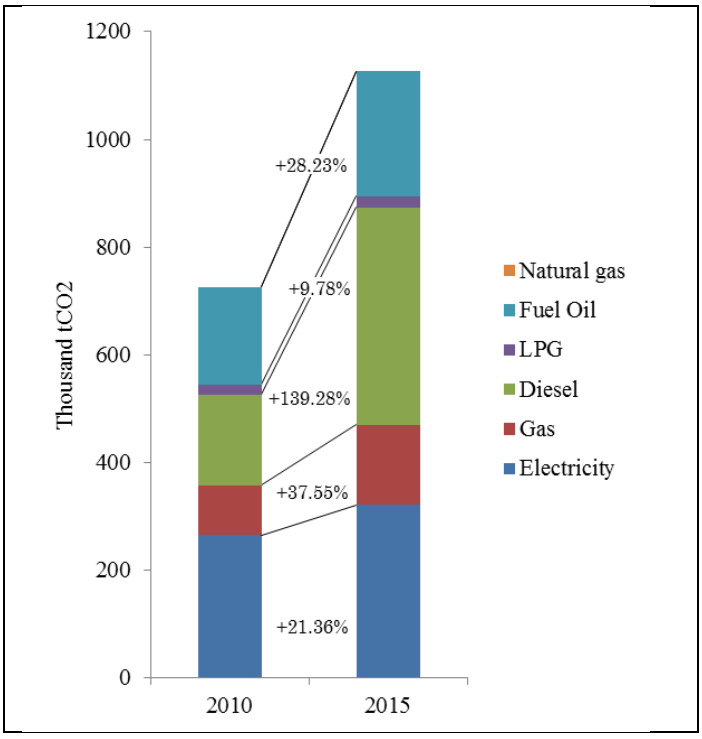
| | Commercial | Residential | Industrial | Transport | Total |
|---|---|---|---|---|---|
| Electricity | 45,976 | 61,151 | 214,259 | 0 | 321,386 |
| Gas | 0 | 0 | 0 | 149,059 | 149,059 |
| Diesel | 0 | 0 | 0 | 403,388 | 403,388 |
| LPG | 7,649 | 12,973 | 0 | 0 | 20,622 |
| Fuel Oil | 0 | 0 | 232,001 | 0 | 232,001 |
| Natural gas | 0 | 0 | 0 | 0 | 0 |
| Total | 53,625 | 74,124 | 446,261 | 552,447 | 1,126,456 |
| Sector Ratio (%) | 4.8 | 6.6 | 39.6 | 49.0 | 100.0 |

Source: APEC Study Team




Source: APEC Study Team

**Figure 4.3.7 $CO_2$ Emissions Estimates of Mandaue by Fuel Source**




Source: APEC Study Team

**Figure 4.3.8 $CO_2$ Emissions Estimates of Mandaue by Sector**

### 4.3.3 Estimation of Baseline $CO_2$ Emissions

For the estimation of baseline $CO_2$ emissions in Commercial, Residential, and Industrial sectors in target year, it is estimated that the $CO_2$ emissions in these sectors will increase corresponding to the annual growth rate of GRDP per capita of Metro Cebu. The estimate

sets annual growth rate for 2010-2020 as 6.0%, for 2020-2030 as 5.5%, for 2030-2050 as 4.5% (Table 4.3.).

This growth rate is close to $CO_2$ emission estimate from 2010 to 2015 calculated above, additionally, the National Power Development Plan 2015-2030 also adopts the use of GDP per capita for the estimation of future energy demand. Hence, for this report, GRDP per capita will be applied for emission estimate. For the transportation sector, baseline $CO_2$ emission until 2030 was calculated in Section 4.3.2.

**Table 4.3.26 GDP Growth Rate Used for Calculations**

| | Annual Growth Rate (%) | | |
|---|---|---|---|
| | 2020 / 2010 | 2030 / 2020 | 2050 / 2030 |
| GDP | 8.3 | 7.8 | 5.8 |
| GDP per capita | 6.0 | 5.5 | 4.5 |

Source: The Roadmap Study for Sustainable Urban Development in Metro Cebu, JICA, 2015

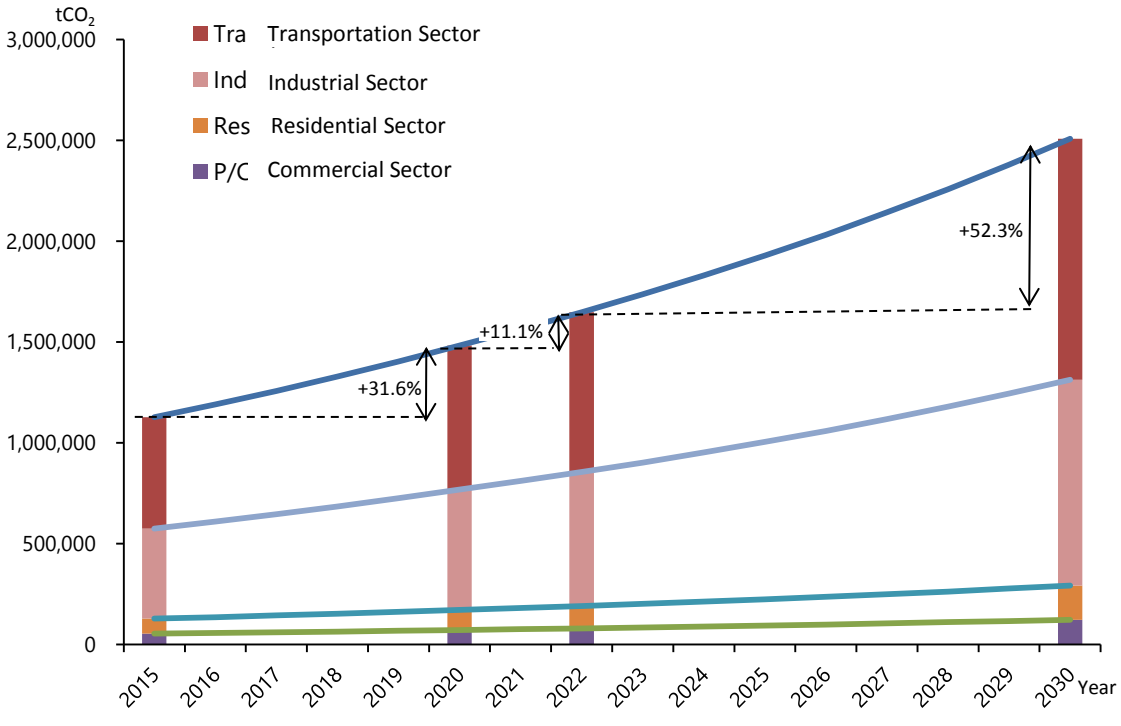
$CO_2$ emission in the base year 2015 is estimated to have a total of 1,126,456 $tCO_2$. By calculation, this is estimated to grow 31.6% in 2020 to 1,482,441 $tCO_2$, and from 2020 to 2022, 11.1% growth to 1,646,700 $tCO_2$. From 2022, it will grow 52.3% and reach 2,507,953 $tCO_2$. By sector, transport has the largest emission ratio, followed by industry. The two sectors will cover almost 90% added together, whilst the other two sectors commercial and residential will cover around 5% each of the total emission (Table 4.3.27 and Figure 4.3.9).

**Table 4.3.27 Baseline $CO_2$ Emissions Estimate ($tCO_2$)**

| | Transport | Commercial | Residential | Industrial | Total |
|---|---|---|---|---|---|
| 2010 | 261,672 | 49,619 | 66,890 | 348,017 | 726,198 |
| Ratio (%) | 36.0 | 6.8 | 9.2 | 48.0 | 100.0 |
| 2011 | 253,705 | | | | 253,705 |
| 2012 | 394,529 | | | | 394,529 |
| 2013 | 490,521 | | | | 490,521 |
| 2014 | 524,825 | | | | 524,825 |
| 2015 | 552,447 | 53,625 | 74,124 | 446,261 | 1,126,456 |
| Ratio (%) | 49.0 | 4.8 | 6.6 | 39.6 | 100.0 |
| 2016 | 581,538 | 56,842 | 78,571 | 473,036 | 1,189,988 |
| 2017 | 612,212 | 60,253 | 83,285 | 501,418 | 1,257,169 |
| 2018 | 644,510 | 63,868 | 88,283 | 531,504 | 1,328,164 |

| | Transport | Commercial | Residential | Industrial | Total |
|---|---|---|---|---|---|
| 2019 | 678,458 | 67,700 | 93,580 | 563,394 | 1,403,132 |
| 2020 | 714,287 | 71,762 | 99,194 | 597,197 | 1,482,441 |
| Ratio (%) | 48.2 | 4.8 | 6.7 | 40.3 | 100.0 |
| 2021 | 751,987 | 75,709.26 | 104,650.01 | 630,043.25 | 1,562,389.52 |
| 2022 | 791,725 | 79,873 | 110,406 | 664,696 | 1,646,700 |
| Ratio (%) | 48.1 | 4.8 | 6.7 | 40.4 | 100.0 |
| 2023 | 833,518 | 84,266 | 116,478 | 701,254 | 1,735,516 |
| 2024 | 877,605 | 88,901 | 122,884 | 739,823 | 1,829,213 |
| 2025 | 923,984 | 93,791 | 129,643 | 780,513 | 1,927,931 |
| 2026 | 972,842 | 98,949 | 136,773 | 823,441 | 2,032,005 |
| 2027 | 1,024,285 | 104,391 | 144,296 | 868,730 | 2,141,703 |
| 2028 | 1,078,520 | 110,133 | 152,232 | 916,511 | 2,257,396 |
| 2029 | 1,135,647 | 116,190 | 160,605 | 966,919 | 2,379,361 |
| 2030 | 1,195,835 | 122,580 | 169,438 | 1,020,099 | 2,507,953 |
| Ratio (%) | 47.7 | 4.9 | 6.8 | 40.6 | 100.0 |

Source: APEC Study Team



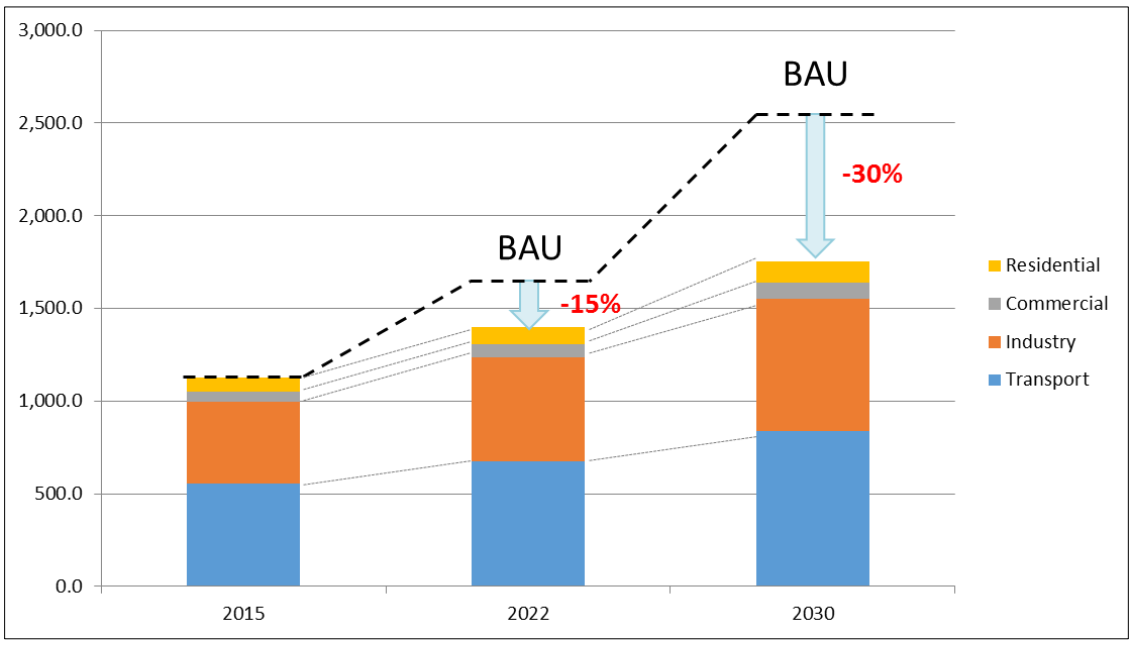

Source: APEC Study Team

**Figure 4.3.9 Estimated Baseline $CO_2$ Emissions**

## 4.4 $CO_2$ Emissions Reduction Target

The baseline scenario of $CO_2$ emissions in Mandaue City estimated in the previous section could be reduced by 15% until 2022, by 30% until 2030 and much more beyond 2031. Respective target settings are made by the following LC measures to be implemented:

- Reduction by 15% until 2022: The implementation of LC measures will focus on institutional development, capacity development and a couple of flagship projects including the AGT-CML Line and the Green Loop along Butuanon River.
- Reduction by 30% until 2030: The implementation of LC measures in the sectors of transport, energy and buildings will be intensively made for area-wide LC development at the selected 5 green growth areas.
- LC development beyond 2031: The first-hand experiences of area-wide LC development from the 5 Green Growth Areas will be expanded to other city areas




Source: APEC Study Team

**Figure 4.4.1 $CO_2$ Emissions Projections and Targets in Mandaue City**

# 5 INTEGRITY WITH APEC LOW-CARBON TOWN INDICATORS (LCT-I)

## 5.1 Introduction

APEC is developing Low-Carbon Town Indicators (LCT-I) as part of the "Concept of the Low-Carbon Town in the APEC Region" to assist city planners and developers to evaluate the progress and status of low carbon development.

In this feasibility study of APEC LCMT Phase 6 for Mandaue, the Philippines, LCT-I was applied by a study team member at the beginning of the study, and later by city officials of Mandaue, and the reliability of the evaluation obtained through the application of LCT-I and its limitations have been identified.

Valuable feedbacks by the city officials onto LCT-I have also been obtained for the future revisions and improvements of the indicator system.

## 5.2 Outlines of LCT-I

LCT-I contains both of the elements of those directly related to the reduction of greenhouse gas (GHG) emission and those indirectly related to it. It is divided into five categories at its top level, which is called Tier 1, namely, (i) demand side, (ii) supply side, (iii) demand & supply side, (iv) environment and resource, and (v) governance. The second level, which is called Tier 2, contains one to four categories under each of the sections of Tier 1, and actual indicators are defined as Tier 3, which are allocated under Tier 2.

The structure of LCT-I is illustrated in Figure 5.2.1.

## 5.3 Preliminary Adoption of LCT-I to the Current Status of Mandaue

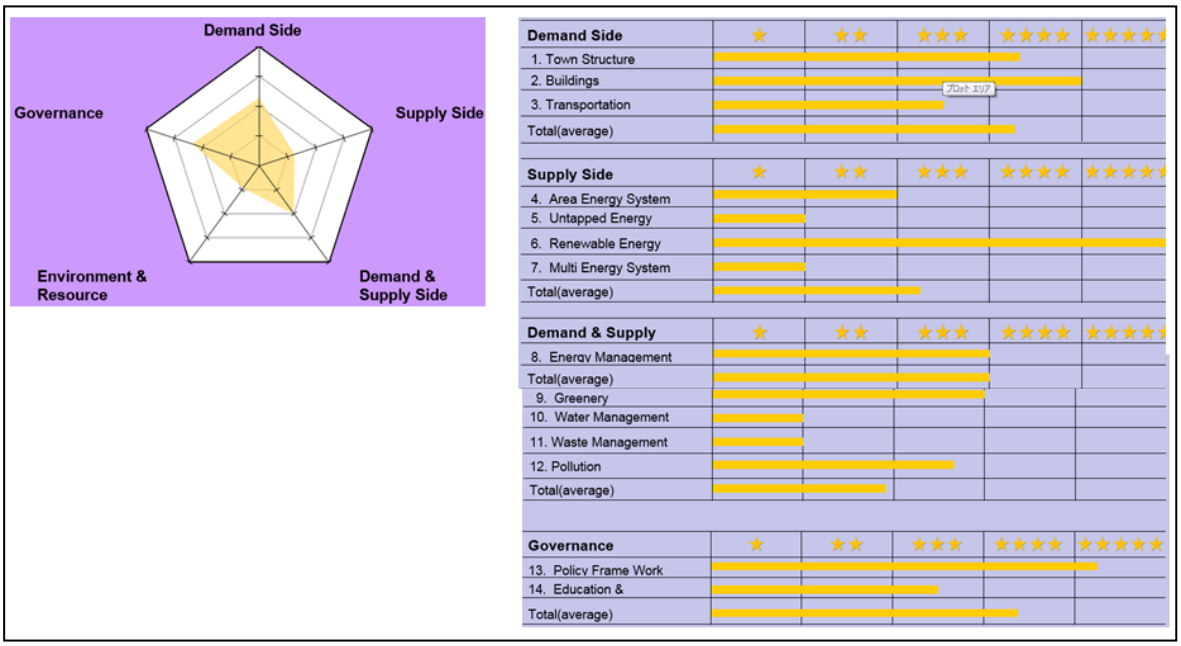
A preliminary adoption of LCT-I was carried out by a study team member to obtain an overall picture of Mandaue at the beginning of the study, based on the data obtained from the City and other related organizations during the initial discussions with the stakeholders in March 2016. The results of the LCT-1 initial evaluation by stakeholders are shown in Annex 5-1 of this report.

The summarized results of the preliminary adoption is shown in Figure 5.3.1.

| Tier 1 | Tier 2 | Tier 3 |
|---|---|---|
| Demand Side | 1. Town Structure | 1-1 Adjacent Workplace and Residence<br>1-2 Land Use<br>1-3 Transit-Oriented Development (TOD) |
| | 2. Buildings | 2-1 Energy Saving Construction<br>2-2 Green Construction |
| | 3. Transportation | 3-1 Promotion of Public Transportation<br>3-2 Improvement in Traffic Flow<br>3-3 Introduction of Low-Carbon Vehicles<br>3-4 Promotion of Effective Use |
| Supply Side | 4. Area Energy System | 4-1 Area Energy |
| | 5. Untapped Energy | 5-1 Untapped Energy |
| | 6. Renewable Energy | 6-1 Renewable Energy |
| | 7. Multi Energy System | 7-1 Multi Energy |
| Demand & Supply Side | 8. Energy Management System | 8-1 Energy Management of Buildings and Areas |
| Environment & Resource | 9. Greenery | 9-1 Securing Green Space |
| | 10. Water Management | 10-1 Water Resources |
| | 11. Waste Management | 11-1 Waste Products |
| | 12. Pollution | 12-1 Air<br>12-2 Water Quality<br>12-3 Soil |
| Governance | 13. Policy Framework | 13-1 Efforts towards a Low-Carbon Town<br>13-2 Efforts towards Sustainability |
| | 14. Education & Management | 14-1 Life-Cycle Management |

Source: APEC

**Figure 5.2.1 Structure of APEC Low-Carbon Town Indicators (LCT-I)**




Source: APEC Study Team

**Figure 5.3.1 Summary of Results of Preliminary Adoption of LCT-I**

## 5.4 Adoption of LCT-I by City Officials and Its Analysis

### 5.4.1 Adoption of LCT-I by City Officials

Adoption of LCT-I by city officials was carried out in parallel with the feasibility study and drafting the recommendations for the city. Four evaluators have been selected by the city as follows.

(a) **Evaluator A:** Senior official of City Planning & Development Office

(b) **Evaluator B:** Senior official of City Planning & Development Office (Deputy to A)

(c) **Evaluator C:** Senior official of City Environment & Natural Resources Office

(d) **Evaluator D:** A licensed environmental consultant (private contractor) working with projects in Mandaue City as well as in other areas in Metro Cebu.

Adoption of LCT-I was carried out in the following procedures.

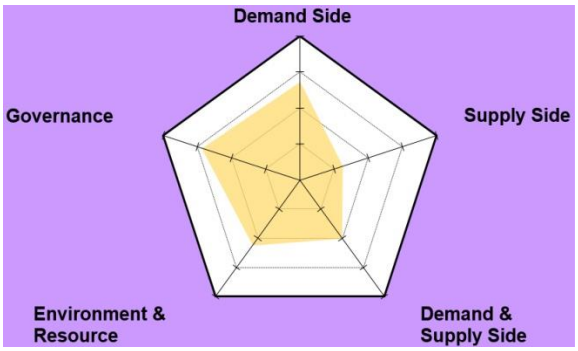
(i) Briefing of LCT-I by a study team member (2 hours);

(ii) Individual evaluation of Mandaue using LCT-I by the evaluators;

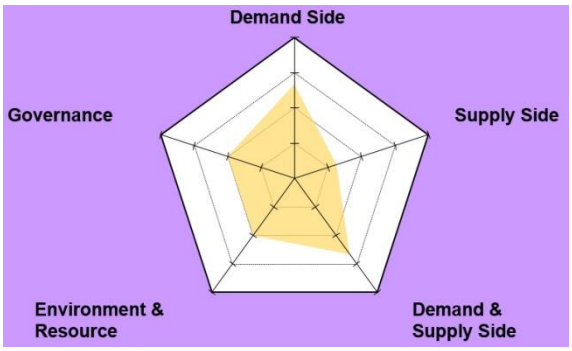
(iii) Summarization of the results; and

(iv) Review and discussion on the results by the evaluators and the team member.

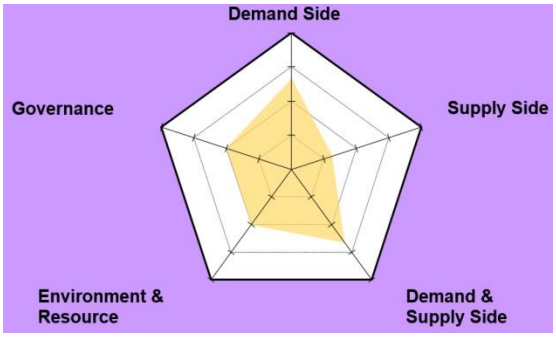
The results are shown in Figures 5.4.1 and Figure 5.4.2.



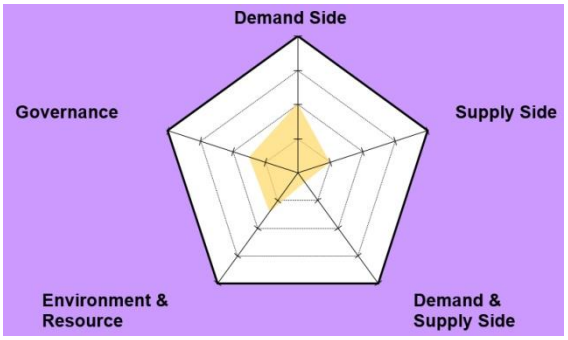

**(A) Radar Chart by Evaluator A**




**(B) Radar Chart by Evaluator B**



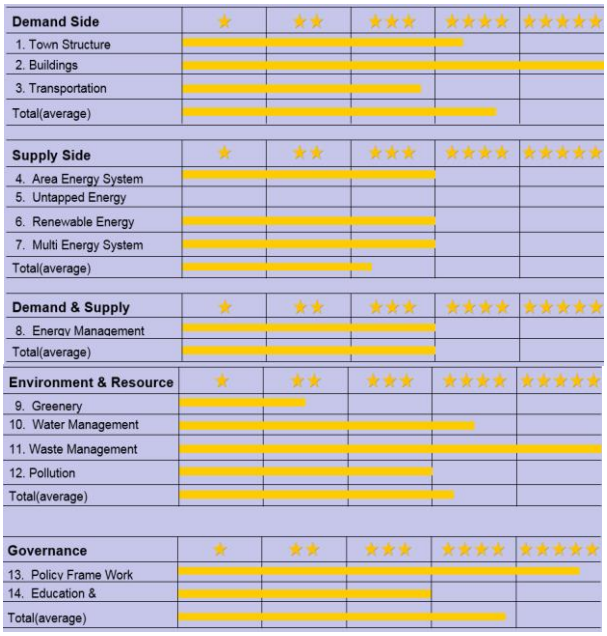

**(C) Radar Chart by Evaluator C**



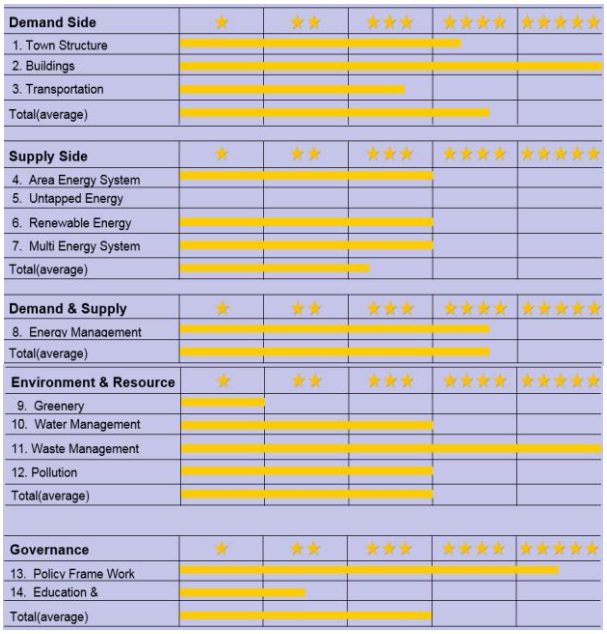

**(D) Radar Chart by Evaluator D**

Source: APEC Study Team

**Figure 5.4.1 Radar Charts Indicating the Summary of Four Evaluation**




(A) Scores of Tiers 1 & 2 by Evaluator A




(B) Scores of Tiers 1 & 2 by Evaluator B


(C) Scores of Tiers 1 & 2 by Evaluator C


(D) Scores of Tiers 1 & 2 by Evaluator D

Source: APEC Study Team

**Figure 5.4.2 Summary of Scores at Tiers 1 and 2**

### 5.4.2 Specific features of Mandaue

Specific features of Mandaue have been made clear as common trends in evaluations by the city officials and private contractor with different governmental functions.

(i) Green building code, BERDE, has been applied as mandatory, and this has been reflected in the results of evaluation as the high scores in “Demand Side – 2. Buildings”, which can be observed commonly among the evaluators.

(ii) The transportation section of “Demand Side” shows relatively low scores, which reflects the situation that Mandaue is located at the cross-section of the traffic corridors and supports the efforts of the city to improve the transportation conditions.

(iii) The city does not possess the data on greenery, which resulted in the low score in “Greenery”, but at the same time, this justifies the city’s efforts of “Green Growth Areas” as well as the preservation of the mangrove areas.

### 5.4.3 Proof of Efficacy of Evaluations

The result of the adoption of LCT-I by city officials also proved the efficacy of the system for self-diagnosis of the current status of the city/town and of finding aspects to be reinforced.

(i) As described in the previous section, the results in the buildings section, the transportation section, and the greenery section properly reflected the current situations of the city, as well as supported that the focus of recommendations in the feasibility study are in line with the needs of the city.

(ii) It is also proven that the use of LCT-I for the self-diagnosis at the beginning of the efforts of low-carbon development projects is effective in identifying the priorities of targets of development projects.

### 5.4.4 Feedbacks from the Evaluators for the Future Revision and Improvement of LCT-I

The feedbacks and comments made by the evaluators are listed below.

(i) LCT-I is good for understanding the big picture of the city.

(ii) Some of the terms are difficult to understand as the concepts and technologies described by these terms are not well spread among the developing economies.

(iii) There are cases that the city does not possess the data defined by LCT-I but does possess other data, with which the same characteristics of LCT-I can be evaluated. It is, therefore, advisable to make LCT-I more flexible so as to allow evaluators to select data available in the city. To cite an example: Mandaue City does not possess data of floor areas for evaluation of town structure such as adjacent workplace and residence. The city has embarked on developing a systematic data of “Community-Based Monitoring System” from which the ratio of the people living close to their workplaces and traveling by public transportation for work can be analyzed when it becomes available.

(iv) In the case of Mandaue, where the residential, commercial and industrial areas are mixed up, the application of LCT-I to the entire city is difficult as the evaluations differ depending on the regions within the city. LCT-I seems to be appropriate for smaller areas.

(v) The results from the city officials are similar, while the private contractor evaluated with relatively lower results. This is because the city officials understand better their policy and future directions and are confident in the implementation of the policies, while the private contractor's view is relatively conservative regarding the implementation aspects of the policies, although he/she sufficiently understands them.

It is, therefore, advisable that the future use of LCT-I for self-diagnosis should include external referees among the evaluators in case the evaluation is carried out by the local government.

(vi) The briefing by the study team member was very effective. LCT-I cannot be used without this kind of briefing, if the documents are given only in the written formats.

# 6 CONCEPT OF LOW CARBON MODEL TOWN

## 6.1 LCMT Approach

This chapter outlines the high level vision of the APEC LCMT as it applies to Mandaue City, Cebu Province, the Philippines. Mandaue City is unique among other LCMTs since the city has already prepared an updated sustainable comprehensive land use plan and has initiated green growth development actions.

In addition, Metro Cebu, consisting of 13 LGUs, including Mandaue City, has recently completed the Roadmap for Sustainable Urban Development[1] where Mandaue City's role in the metropolis is designed in its land use plan, transport network plan and other urban services provision and management plans such as storm water and sewer, water supply and solid waste. Within Metro Cebu's spatial plan, Mandaue City will be fully urbanized with industrial, residential and commercial lands. Practically more than half of the industrial lands are accumulated in the city (Refer to Figure 6.1.1). New reclamation lands will also be created facing the Opon Channel and the Cansaga Bay. Due to its location as the central connection of the metropolitan transport network, new roads and bridges, such as the Mandaue–Mactan new bridge and the second Cansaga Bay Bridge, and urban rails will be developed in the city. The first public transit rail line, in the form of an automated guideway transit (AGT), is proposed to connect the cities of Cebu, Mandaue and Lapu-Lapu.

Mandaue City has recently taken several actions which are related to a low carbon town development as follows:

(i) The Integrated Development of New Green Growth Areas, otherwise referred to as Planned Unit Developments (PUDs)

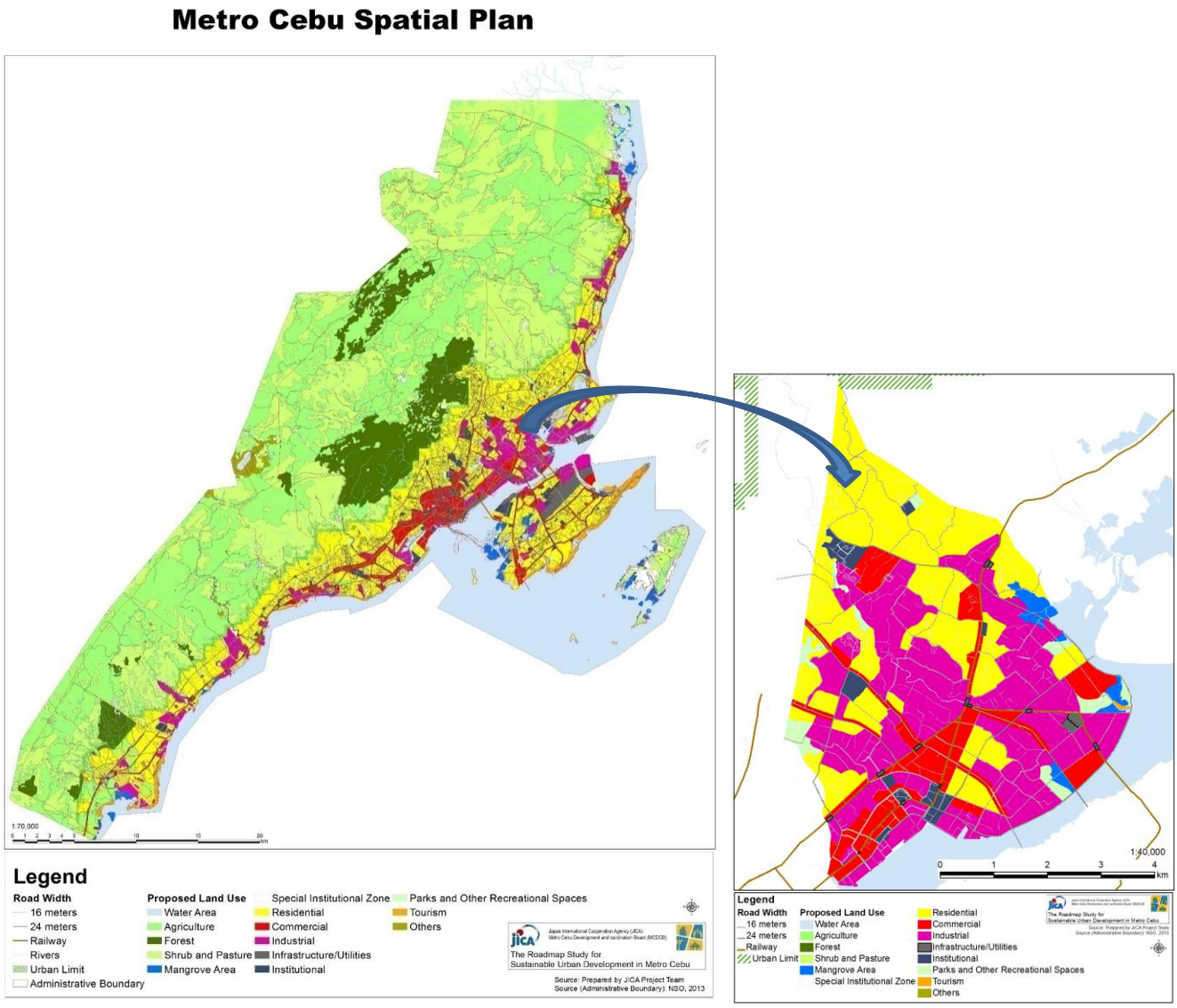
(ii) The Green Building Ordinance (Ordinance No. 13-2015-1047)

(iii) The Butuanon River Watershed Management Board (Ordinance No. 13-2014-889)

(iv) Expanded use of the old dumpsite as a sanitary landfill with a MRF at Barangay Umapad.

The low carbon model town in Mandaue City is, therefore, illustrated based on the recent spatial planning works done for Metro Cebu as well as Mandaue City.

[1] This is a JICA funded development study project between 2013 and 2015. The Metro Cebu Development and Coordination Board (MCDCB) was the counterpart agency together with the Province of Cebu and the 13 LGUs including Mandaue City.




Source: The Roadmap Study for a Sustainable Urban Development in Metro Cebu, JICA, 2015

**Figure 6.1.1 Spatial Planning Approach from Metro Cebu to Mandaue City**

## 6.2 LCMT Concept

APEC's past LCMT projects were conducted for selected cities of different urban conditions for feasibility studies (see Table 6.2.1). Since this undertaking, as Phase 6, is part of the APEC LCMT Project, the previous five FS experiences are duly noted while this phase considers further a low-carbon development plan in Mandaue to be developed in cooperation with neighboring cities in accordance to the study's TOR.

Phase 6 selects Mandaue City, the Philippines. The city is rather compact, almost totally urbanized with large industrial lands, with a gateway seaport and airport located nearby but outside of its jurisdiction. Since the city is one among the conurbation of cities making up Metro Cebu, a metropolitan solution would be more effective than a lone city undertaking in low-carbon development.

**Table 6.2.1 Previous LCMT Feasibility Studies**

| Phase | City | Study Focus | Relevant Experiences for Mandaue |
|---|---|---|---|
| Phase 1 | Yujiapu, Tianjin, China | Central Business District (CBD) | Low-carbon buildings, DHC, renewable energy, mass transit |
| Phase 2 | Samui Island, Thailand | Resort Island | NMT, low-carbon buildings, renewable energy |
| Phase 3 | Danang City, Viet Nam | Urban redevelopment | E-vehicles, mass transit, LED streetlights |
| Phase 4 | San Borja, Lima, Peru | Residential area | Low-carbon building, ITS, PV roof tops, renewable energy |
| Phase 5 | Bitung, Indonesia | Industrial area | Renewable energy, low-carbon building, NMT, TOD, mass transit |

Source: APEC Study Team.

Therefore, the LCMT concept of Mandaue is set as:

*'Sustainable Urban Life and Economic Activities in cooperation with Neighbouring Cities'*

## 6.3 Low Carbon Measures

Table 6.3.1 below outlines the low carbon (LC) measures recommended by this feasibility study. The LC measures include land use, transport, other urban services and combined measures at the designated Green Growth Areas. Each measure can be classified in terms of its impact coverage of either being of a metro-wide impact or an internal city impact.

**Table 6.3.1 List of Low Carbon Measures**

| Category | Low Carbon Measure | Impact Coverage | |
|---|---|---|---|
| | | Metro Cebu | Mandaue alone |
| Land Use | 1. Green Loop | X | |
| | 2. TOD along the stations of the AGT-CML Line | | X |
| Transport | 3. Metro-wide ITS | X | |
| | 4. Improvement of Road Public Transport Vehicles | | X |
| | 5. The AGT-CML Line | X | |
| Other Urban Services | 6. Waste to Energy | | X |
| | 7. DHC and DCS | | X |
| | 8. LED Street Lighting | | X |
| | 9. Renewable Energy | | X |
| Building | 10. Institutionalization and operationalization of Green Building Code | | X |
| Combined | 11. Green Growth Area 1 (new development and building improvement at South Reclamation Point) | X | |
| | 12. Green Growth Area 2 (reorganization of public buildings) | | X |
| | 13. Green Growth Area 3 (redevelopment of industrial area) | | X |
| | 14. Green Growth Areas 4 & 6 (new reclamation and land development at Global City) | X | |
| | 15. Green Growth Area 5 (orderly urbanization at sprawling area) | X | |

Source: APEC Study Team.

## 6.4 Interconnection between Neighboring Cities

Mandaue City is small and almost urbanized and, therefore, new development areas are limited except for reclamation lands. Even the city has urban management issues, many of which cannot be solved by the city alone. Neighboring cities also would need Mandaue

City to jointly solve their issues and vice versa. Such joint tackling of agenda may include land use, transport, other urban services as follows:

**(1) Land Use**

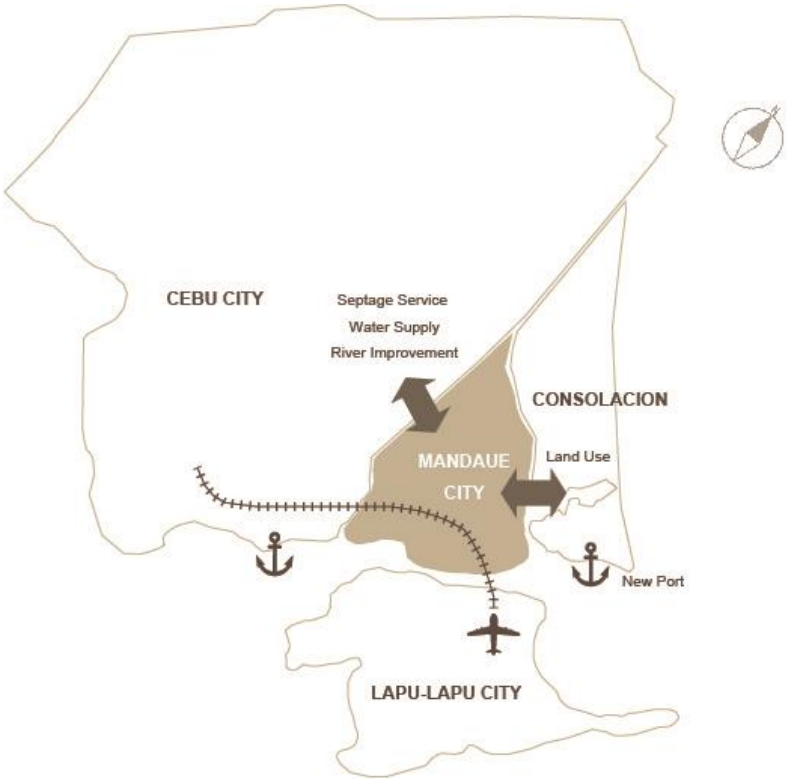
- Mandaue City has an accumulated industrial lands of 925 ha. in 2014 which accounts for 67% of all industrial lands in Metro Cebu. Being an almost urbanized city, future industrial investments may go to Consolacion, e.g., Nozomi Economic Zone (49 ha.) and other LGUs.
- A new container port is planned at Tayud, Consolacion in the form of a reclamation. Some logistics industry entities currently located at South Point, Mandaue City will be transferred to the adjoining lands of the new port. Mandaue's Global City proposed along the Opon Channel and the Cansaga Bay may meet future demands to be generated due to its strategic location between the new container port in Consolacion and the existing port in Cebu City as well as between the new container port and the airport (MCIA).

**(2) Transport**

- Within Metro Cebu, the most congested city boundary is located between Cebu City and Mandaue City, i.e., 910 thousand passengers per day in 2014, and the second congested is between Mandaue City and Lapu-Lapu City, i.e., 323 thousand passengers per day in 2014. Although accelerated infrastructure development is required, new roads (or bridge) and road widening would be costly, time consuming and environmentally unfriendly solutions. It is suggested that an urban rail be constructed to connect the three cities and to partly convert vehicular traffic to elevated rail traffic.

**(3) Other Urban Services**

- Metro Cebu Water District (MCWD) supplies tap water to Mandaue citizens. However, the water resources are largely deep wells and the Buhisan Dam located in Cebu Cities.
- Floods are serious in Mandaue City. To improve the situations, collaborated river improvement works with Cebu City are necessary since the downstream of Subangdaku River and the upper stream of Butuanon River are located within Cebu City.
- For sanitation, septage treatment service is an urgent issue. It is advisable for Mandaue City to operate a septage treatment plant with Cebu City (i.e, particularly the northern part of the city).




Source: APEC Study Team

**Figure 6.4.1 Important Interconnections of Mandaue City with the Neighboring Cities**

# 7 LAND USE PLANNING

## 7.1 Background and Issues

### 7.1.1 Geographic and Demographic Background

Mandaue City is one of the LGUs forming Metro Cebu. It has one of the smallest area measuring 32.85 square kilometers. It is bordered on its east side by Lapu-Lapu City in Mactan Island; on the south and west by the provincial capital that is Cebu City; and on the north by the Municipality of Consolacion. It is in the heart of the metropolitan area and the gateway to the airport. Thus, being at the junction of major roads going to any part of Metro Cebu, the high number of vehicles traversing the city's roads causes serious traffic congestion during most time of the day.

Mandaue City's land profile is mostly flat. It has major tributaries that is shared with other LGUs but the water quality conditions of these rivers are in really poor state. These are the Butuanon River and the Mahiga Creek/Subangdaku River. Being an industrial hub, many industries are situated along the 7-kilometer stretch of the Butuanon River. Both informal and formal residences are also located along the river. With the current poor waste management condition, both industrial and domestic wastes find their way into the river.

Moreover, being more of the lowland of the province, the city is suitable for industrial and urban development but not without the hazards of flooding and sea level rise due to climate change as well as liquefaction in the event of earthquakes.

The population of Mandaue City grew at a rate of 2.46% for the ten-year period covering 2000 to 2010 and 1.89% for the period 2010 to 2015. Recent count of the population now stands at 362,654 (2015) and the projected population for 2024 is 465,593. With a small land mass, population densities are quite high with 10 barangays (of the 27 barangays) having more than 150 persons per hectare. Another 12 barangays have more than 100 persons per hectare as of 2015. On the whole, Mandaue City had an average density of 107 persons per hectare in 2010 which increased to 118 persons per hectare in 2015. The detailed population distribution is given in Chapter 2.

The city embarked on the Mandaue Southpoint Reclamation Project (180 hectares) in the 1980s. Buildings have been constructed mainly for commercial, business and logistics use. The rest of the blocks will be developed in the near future. Similarly, the city government promotes Mandaue's Global City Project, which will create a reclamation site of 131 hectares around the Opon Channel and the Cansaga Bay.

### 7.1.2 Economic Background

Mandaue City has well-diversified economic base consisting of manufacturing, trading, and commercial activities. In 2013, there were about 13,372 commercial establishments and 1,317 manufacturing establishment located in the city. And this number continues to grow at an average of 2% per year.

Business and economic activities tend to concentrate near the urban core specifically near arterial roads. Many of the industries are situated in close proximity to the urban core and in clumps without regard to the poor road network or distance from water ways.

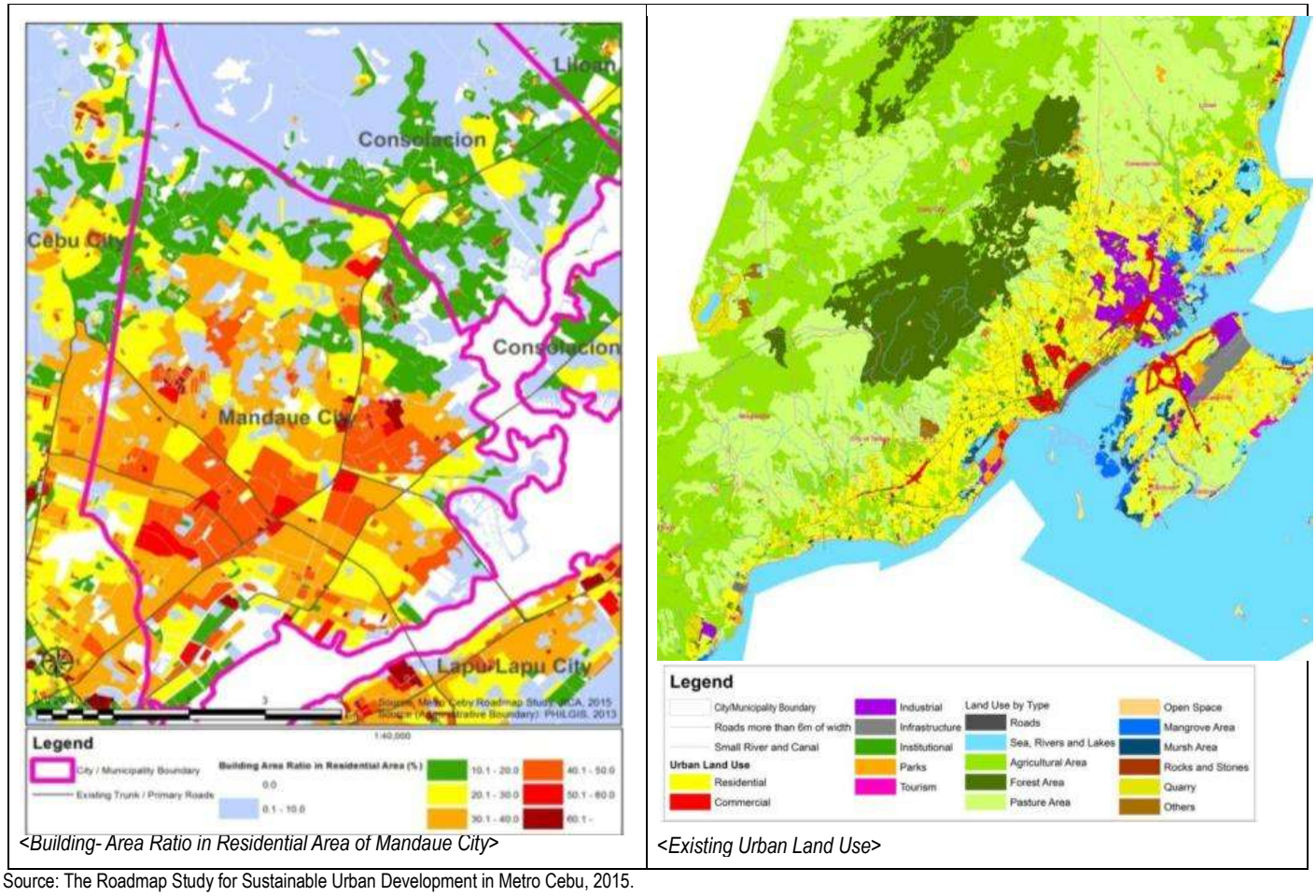
Similar to its neighboring cities, new trends and technologies are employed in the businesses and industries of Mandaue. These are the business process outsourcing (BPO), computer-related information/communications activities; and high-technology manufacturing activities.

### 7.1.3 The Land Use Plan

The city is the second smallest local government unit of the metropolitan area with a land area of only 32.85 square kilometers but is the most dense with about 118 persons per hectare as of the 2015 member economy's census. Commercial buildings and factories densely stand along the national highway (M.C. Briones–Cebu North Road). The city is historically an industrial town, having 925 hectares of industrial lands that occupy over 60% of industrial lands in Metro Cebu (see Figure 7.1.1).

As of July 2015, the city government of Mandaue updated its Comprehensive Land Use Plan (CLUP) and passed a zoning ordinance to amend its previous 1979 ordinance. The zoning ordinance sets the city into 19 base zones for its present and potential uses to maximize, regulate and guide land developments according to their CLUP. With this ordinance, regulations for each zone are established as to building density, bulk, allowable uses and building regulations (i.e., covering heights and architectural design).

The 2015 zoning ordinance intends to address the pressing urban sprawl issues facing the city in terms of the non-conforming land uses of 47% of actual land uses (per the 1979 zoning plan) and the 20% of the land that are idle lots. There is also the presence of blighted areas in built-up areas of the poblacion (urban core) and the CSSEAZ (south reclamation area).




*<Building- Area Ratio in Residential Area of Mandaue City>*

*<Existing Urban Land Use>*

Source: The Roadmap Study for Sustainable Urban Development in Metro Cebu, 2015.

**Figure 7.1.1 Development Characteristics of Mandaue City**

The city government has established Planned Unit Developments (PUDs) to spur its economic growth and bring in developments that are designed to be energy efficient and responsive to climate change. These PUD zones are land development or redevelopment areas which are required to have a Master Development Plan and compulsory Green Building Certifications with at least "3-star" BERDE rating.[1] The distinct themes in these zones are as follows:

(a) PUD-Z Block 1 is reserved as the Civic and Trade Center Development Zone. It will be a Central Business District with high density commercial, institutional and residential buildings with accompanying support uses. This will be a green growth area referred in this study as GGA1. The maximum allowable floor area ratio (FAR) is 8.

[1] The Building for Ecologically Responsive Design Excellence (BERDE) program was created by PHILBGC to address the negative environmental effects in the property sector. The BERDE rating system is a tool to measure, verify and monitor the performance of buildings beyond the existing mandatory building and environment regulations and standards. The BERDE assessment and certification is achieved through a third party certification and process conforming to international standards.

(b) PUD-Z Block 2 is the Light Industrial Park Development which assumes some consolidation of properties among lot owners for light intensity industry use that can co-exist with residential areas. This will be a green growth area or GGA2. Industrial uses shall provide a 5-meter buffer or tree and greenery lining.

(c) PUD-Z Block 3 is the Residential-Commercial Mixed-use Development intended to be a development with high-end residential condominiums and commercial establishments with structures that are terrain compatible which consider disaster risk reduction management and climate change adaptations being a coastal area. This area is referred to here in this study as GGA6.

(d) PUD-Z Block 4 is the Recreation and Tourism Development area which is proposed to be a reclamation area. Allowable uses are those devoted for recreation and tourism such as 5-star resort hotels, condominiums, theme parks, promenades, shops, banks, etc. This will be referred to as GGA4.

(e) PUD-Z Block 5 is the Medium Industrial Park Development areas identified solely for medium- to high-intensity industrial development with priority to high-value manufacturing activities. This will be GGA5.

(f) The Old Town Center Redevelopment area containing the HR-Z or Historic Zone. The existing hitorical/heritage sites and landmarks in the inner urban core will be preserved. Along the historical strip from St. Joseph Shrine to the "Bantayan sa Hari" and the "poblacion" area, facade design of establishments should conform to the historical period. This area is referred to as GGA2 where building heights are limited to 2-storeys or a height of 9 meters.

Developments that will follow the changes in landuse will have both positive as well as negative impacts on a specific area or the whole city. Two obvious and anticipated impacts are congestion due to the densification of commercial and residential lands as well as environmental degradation of the river due to industrial developments. It is in this light that the low carbon measures to address mobility, accessibility and river water quality are proposed.

## 7.2 Proposed Low Carbon Measures

### 7.2.1 Green Loop

The Green Loop Project is one low carbon project that transcends the boundary of Mandaue City as well as involves the responsibilities and functions of both national and local agencies. It holds numerous ideas of low-carbon measures that can come together for a wider impact benefitting not only Mandaue City but neighboring cities as well. This project was newly formulated and integrated in the Metro Cebu Roadmap Study.

Currently at its conceptual stage, the plan is for a green corridor loop development prioritizing non-motorized transport (NMT). The Loop traverses both the Cebu mainland and the Mactan Island and it connects the local governments of Cebu City, Mandaue City, Lapu-Lapu City, and the Municipality of Cordova in Metro Cebu. The portion of the loop in Mandaue City is further divided into the stretch along Hernan Cortes Street and the stretch along the banks of the Butuanon River (see Figure 7.2.1).


Source: The Metro Cebu Roadmap Study, JICA, 2015.

**Figure 7.2.1 Overview of the Green Loop Alignment**

The aspirations of the people of Mandaue City are high and clear for the Butuanon River to be a living and refreshed river as depicted in Figure 7.2.2. As such, the new plan of the city laid down a no-build zone of 25 meters on either side of the river (i.e., 50-meter river easement). This is shown in Figure 7.2.3. Moreover, the city government is targeting 2019 to get all firms and subdivisions along the Butuanon River to comply with environmental standards. And informal settlers along the river will also be relocated with the assistance of the National Grid Corporation of the Philippines since grid lines are to be built along the river.

A concept typical design was offered during the Metro Cebu Roadmap Study for the Green Loop only for sections where applicable (see Figure 7.2.4). The existing road section of Hernan Cortes Street, 2 or 4-lane carriageway with narrow sidewalks, will be widened to a 30m ROW where wider space is allocated for non-vehicle traffic such as for pedestrian and bicycle lanes and street trees and greenery.

The loop along the Butuanon River is designed to be a 50m ROW (see Figure 7.2.5). In addition, the existing water quality of the river is so polluted that the foul odor emitted is not conducive for any human activity close to the river. For the envisioned Green Loop

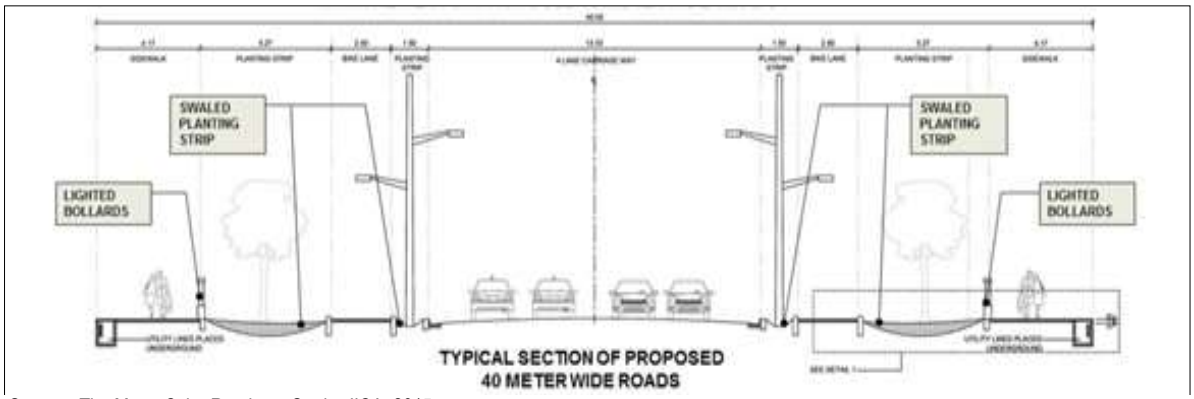
with parks, pedestrian and bicycle lanes along the riverside, a program for cleaning the river and smoothening the water flow will have to be included in the plan. It should be mentioned that improvement of the water quality of the river will tantamount to reduction, if not elimination, of methane release from the river.


Source: Mandaue City and DENR-EMB Region VII.

**Figure 7.2.2 Aspirations for Butuanon River**

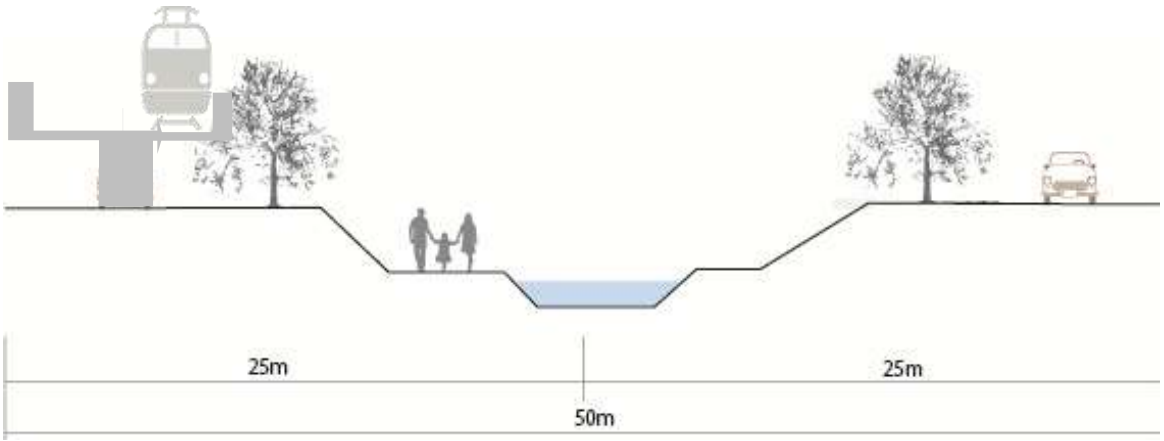

Source: Mandaue CPDO.

**Figure 7.2.3 Image of Butuanon River in Mandaue City**




Source: The Metro Cebu Roadmap Study, JICA, 2015.

**Figure 7.2.4 Green Loop Typical Design Section along Hernan Cortes Street**




Source: APEC Study Team.

**Figure 7.2.5 Green Loop Typical Design Section along the Butuanon River**

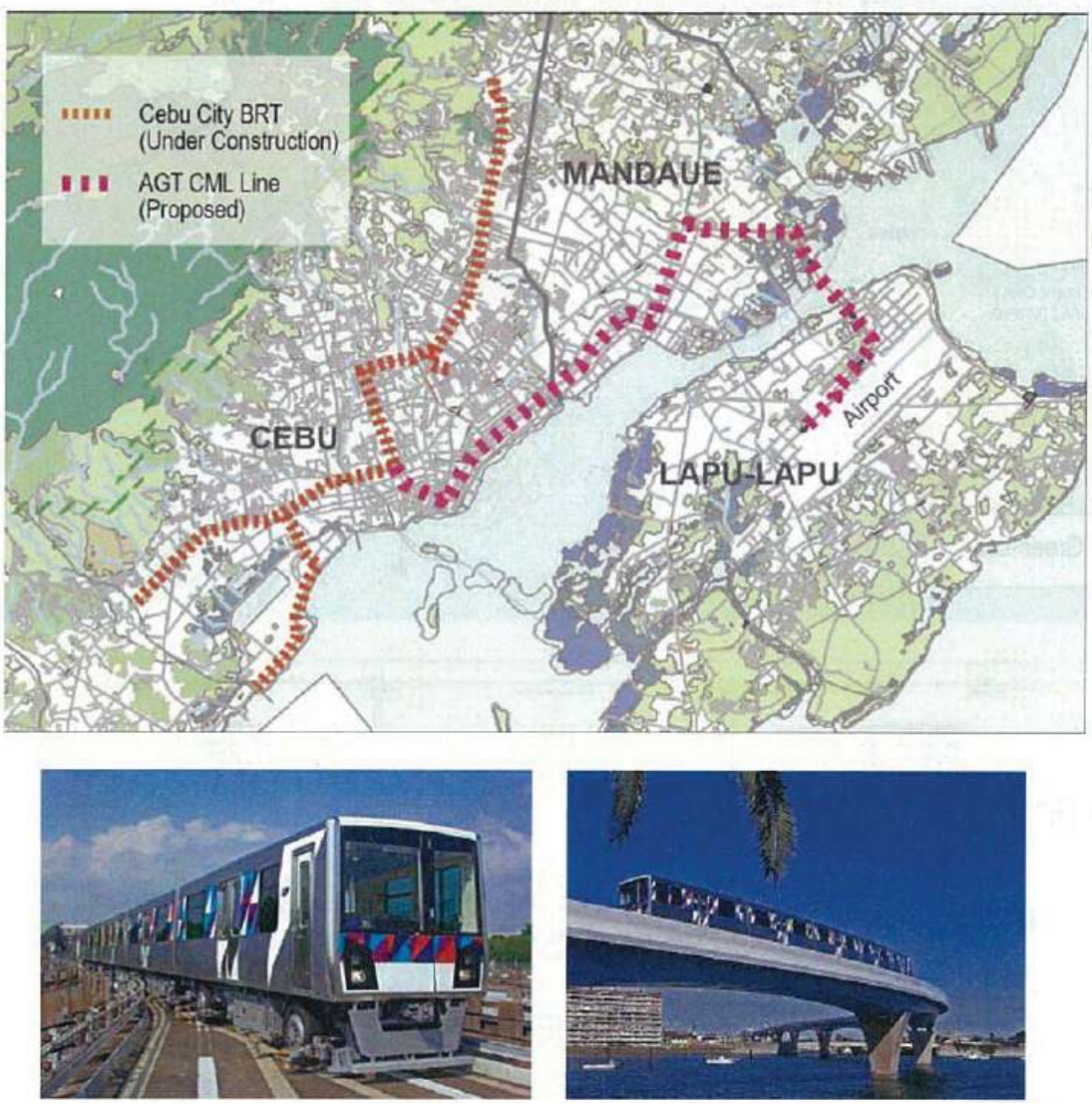
### 7.2.2 Transit-Oriented Development (TOD)

The development of the proposed mass transport system integrates and complements other low carbon measures of Mandaue City, such as the Green Loop and the Green Growth Areas. The envisioned mass transport system is the AGT-CML (Cebu-Mandaue-LapuLapu) Line, which is proposed to connect the Cebu City Central Business District, the Mandaue high growth areas, and Lapu-Lapu City with the Mactan Cebu International Airport (MCIA), which is one of the heaviest traffic corridors of Metro Cebu. The proposed alignment of the AGT Line is shown in Figure 7.2.6.

Transit-Oriented Development (TOD) is a development that encourages transit ridership thereby maximizing access to the public transport facility. It normally has a transit stop or station in the middle of a residential and commercial neighborhood with relatively higher densities. The location of a TOD is within walking distance of about half a kilometer from a transit station.

Pursuing a TOD development, among others, would benefit several groups that would have improved accessibility such as the women that go about their daily activities like

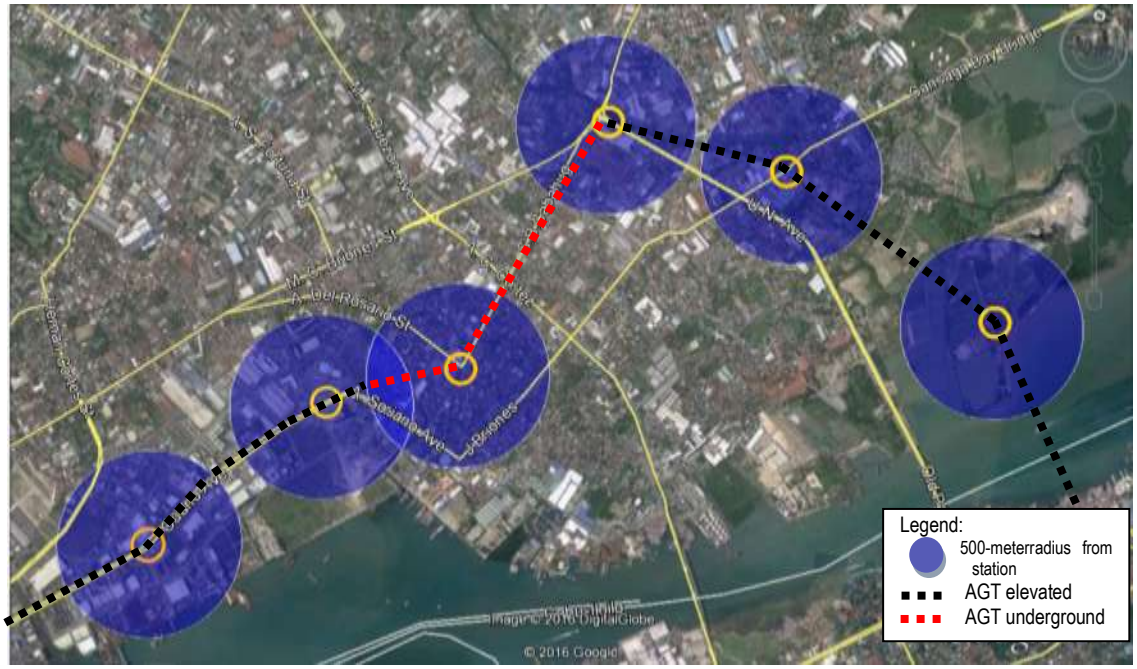
shopping, the young children going to school, and the elderly seeking medical services or even recreation. There groups are usually overlooked in improving accessibility since economics dictate efficient movement of goods and working people. However, in the case of the TOD, all groups of people are considered in the planning.




Source: The Roadmap Study for Sustainable Urban Development in Metro Cebu, JICA.

**Figure 7.2.6 AGT-CML Line Alignment and System Images**

In Mandaue City, there are six stations proposed in the AGT-CML Line Project. Adjoining land use plan and intermodal transfer facility are two conduits to realize the TOD. A TOD is planned for each station, as illustrated in Figure 7.2.8.




Source: APEC Study Team based on Metro Cebu Roadmap Study, JICA 2015.

**Figure 7.2.7 TOD along the AGT Line**

**Station 1**


| Adjoining Land Use | Intermodal Transfer Facility |
|---|---|
| Commercial and logistics buildings, sub-center development with a 16-hectare mall and entertainment area (Diana Mall), Cebu North Bus Terminal, university and tertiary hospitals. | Skywalk between the Station and, Diana Mall and Cebu North Bus Terminal. |

**Figure 7.2.8 TOD Plan for Each Station**

Cont. Figure 7.2.8

**Station 2**

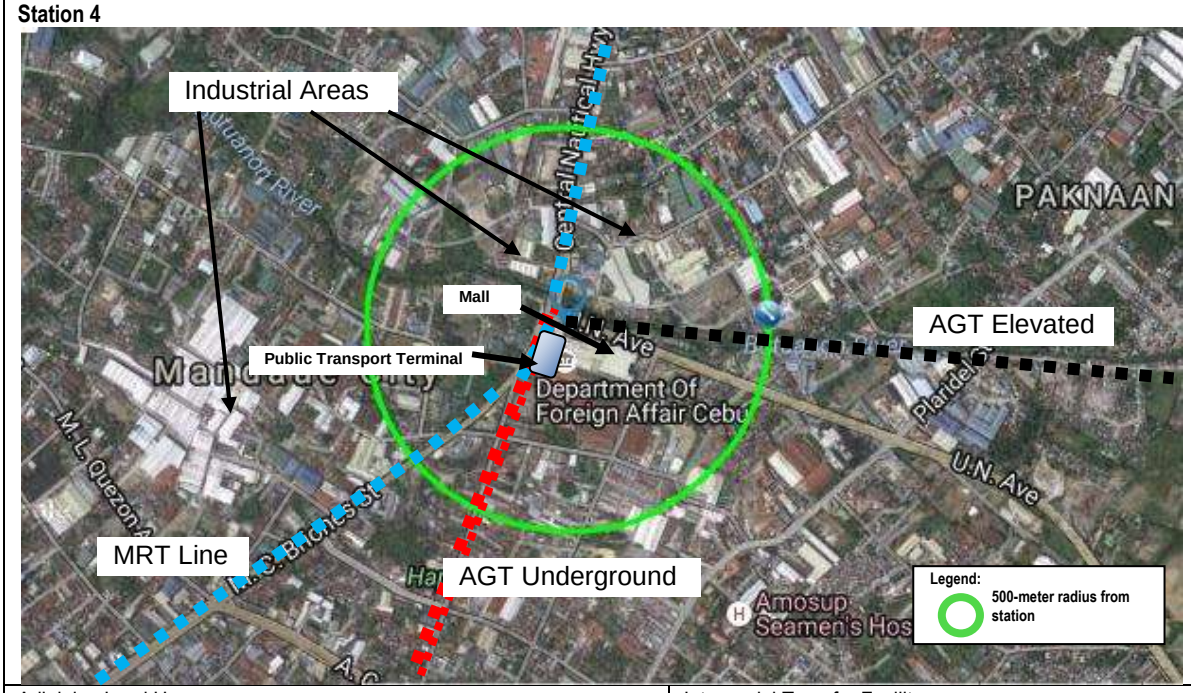

| Adjoining Land Use | Intermodal Transfer Facility |
|---|---|
| Convention Center, 5-star hotel, luxury condominiums, neighborhood malls sub-center development (Mandani Bay – 20 ha) | Public transport terminal (bus, jeepney) |

**Station 3**


| Adjoining Land Use | Intermodal Transfer Facility |
|---|---|
| Urban Core and historical strip (historical buildings) | Entrance/exit points from the underground station |

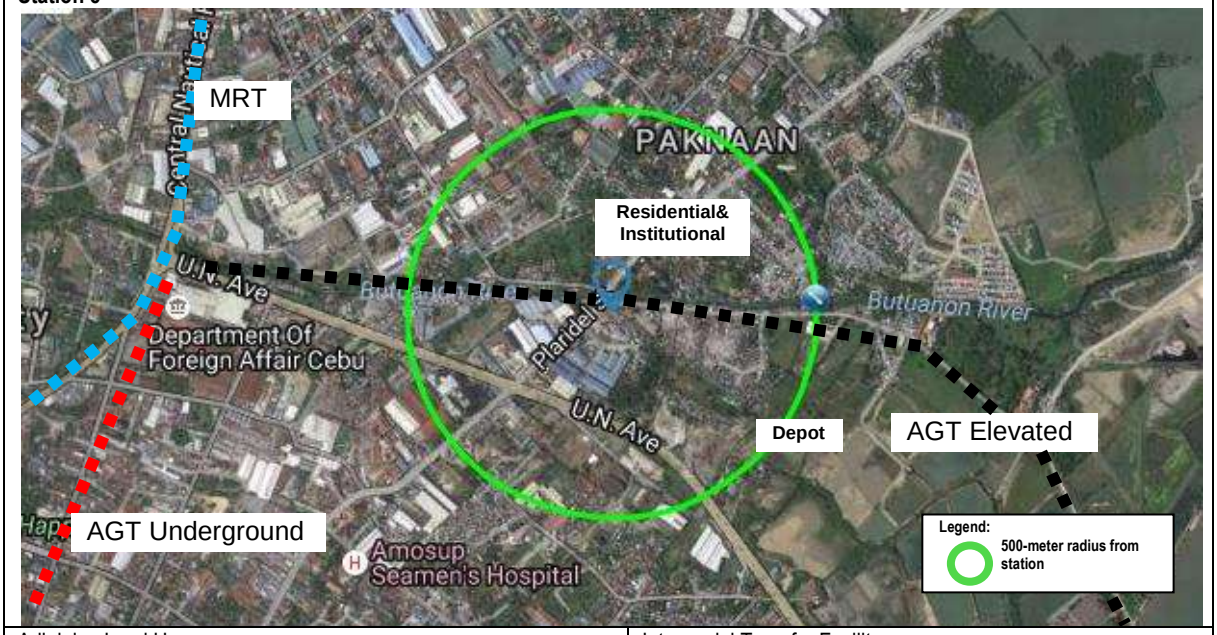
Cont. Figure 7.2.8

**Station 4**




| Adjoining Land Use | Intermodal Transfer Facility |
|---|---|
| Commercial and industrial buildings, MRT and AGT Lines | - Station transfer between MRT and AGT<br>- Large station plaza with public transport terminal |

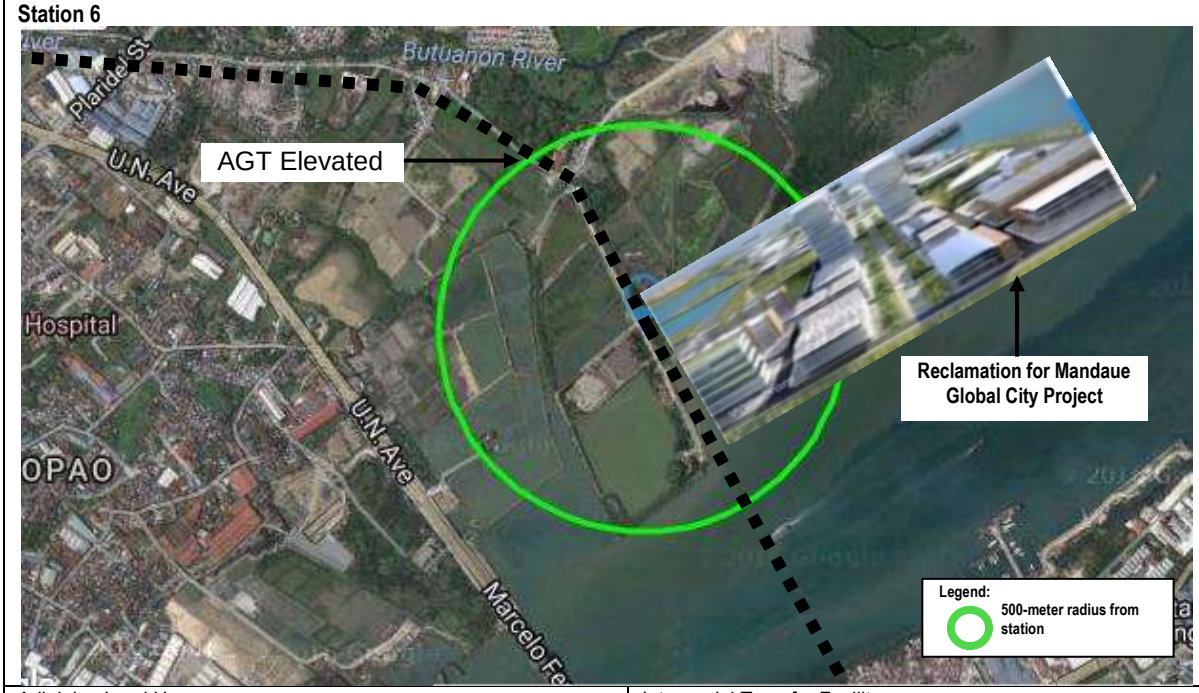
**Station 5**




| Adjoining Land Use | Intermodal Transfer Facility |
|---|---|
| Institutional and residential buildings, AGT Depot | Small station plaza |

Cont. Figure 7.2.8

**Station 6**




| Adjoining Land Use | Intermodal Transfer Facility |
|---|---|
| Commercial and high-rise condominium buildings and theme parks in a tourism zone (Mandaue Global City) | Large station plaza |

Source: APEC Study Team.

## 7.3 GHG Reduction Analysis and Cost Estimates

### 7.3.1 Examination of LCMT Measures with the Land Use Plan

A land use plan finds its effectiveness when it goes hand-in-hand with a sound transport plan to ensure the efficient movement of people and goods in an area. As Mandaue is gearing up for high density mixed use areas with lead themes for each of its PUDs, high capacity public transport corridors need to be set in place to sustain the growth of each area. The transport plan itself was already envisioned to link and serve not only the city itself but the neighboring LGUs as well on a metropolitan level. An AGT line was proposed by the Roadmap Study for a Sustainable Metro Cebu in 2015 to traverse Mandaue with stations located within or near the PUDs. This can easily set the pace for establishing peak densities around the railway stations to promote the use of railway vis-a-vis cars for getting to places as well as creating walkable communities around the stations. This is ideal for developing compact cities as a low carbon urban plan; a concept cited as well in the APEC LCMT Phase 1 Project[2] and experienced by Japanese cities.

The CLUP of Mandaue City establishes the allowable uses for the development of vacant lots and redevelopment of existing structures within each PUD and integrates said development with other LCM initiatives. It should be noted that the LCMs themselves cut

[2] APEC LCMT Project for Tianjin Yujiapu Feasibility Study, October 2011.

across several sectors (i.e., transportation, energy, social, and economy) thereby compounding the expected benefits.

### 7.3.2 Green Loop Effect and Expected $CO_2$ Reduction

The massive undertaking for the Green Loop, with its intertwined environmental measures, requires the participation of both the public and private entities. The work implies heavy challenges and changes on a long haul but carries immense positive outcomes. It will contribute to both economic and social development of the city by uplifting the environment. Taking stock from experiences of cities that persevered with their river cleaning program (e.g., Singapore), the benefits (both direct and indirect) of cleaning the environment far outweighed the investments.

The Green Loop with its components for the improvement of drainage way, clean up initiatives to increase the water quality of the river, greening of riverbanks, installation of paths for pedestrians and bicycles, and the introduction of the AGT will work together for a compounded reduction of $CO_2$ emissions. The reductions will be substantial due to the shifting of motorized trips to non-motorized trips and the elimination of pollutants including methane generation in the river.

When done properly, crowded informal dwellings along the banks of the river will be provided with improved living conditions away from a hazardous location and riverbanks will be free of settlements that discharge untreated waste into the river.

In similar manner, the industries along the river and the government sector will be made responsible to protect and improve the condition of the river. This will increase the value of land especially along the waterways.

Taking care of the river not only addresses water pollution but also reduces the incidence and intensity of flooding in Mandaue since flow at waterways become efficient (i.e., eliminating the stagnation of water). Among others, damages to property and lives caused by flooding will be also reduced.

So as not to overlap in the calculation of the $CO_2$ reduction, components directly related to the AGT will be analyzed within the purview of the transportation sector while those for the TOD are assessed in the land use subsector. Other components of $CO_2$ reduction attributable to the Green Loop that remains to be assessed are the improvement of the water quality of the river and the installation of pedestrian paths/ cycle lanes.

#### (1) Water Quality of Butuanon River

For present water quality of Butuanon River, the number of industries draining out their wastewater into the river were identified based on data collected by the DENR-EMB Region VII as shown in the table below. The water quality of the river was measured at

31.2mg/liter BOD5[3], which is far below the acceptable standard of 15mg/liter. The intensity of $CO_2$eq from the untreated wastewater in Annex III IPCC Assessment Report 5 was adopted an emission intensity of 7.5.[4]

**Table 7.3.1 Wastewater from Industries**

| No. of Dischargers | Daily Wastewater Volume (cu m/day) | Annual Wastewater Volume (cu m/yr) | BOD (g/ cu m) | $CO_2$ eq emission intensity ($tCO_2$/tBOD5) 1/ | $CO_2$ eq emission ($tCO_2$) |
|---|---|---|---|---|---|
| 46 | 12,027.70 | 3,608,310 | 250 | 7.5 | 6,766 |

Source: DENR-EMB Region VII Data for volumes.
1/ Annex III IPCC AR5

The present $CO_2$ emission intensity of the river can be reduced substantially given the following efforts and activities that are already ongoing and planned:

(i) The EMB and the local government units and other stakeholders have increased their efforts to monitor locators along the river to lower the BOD5 concentration of the river to pass the standard. Only locators upstream passed the BOD5 standards;

(ii) Installation of a wastewater treatment process by each locator or for a general area as required by EMB. Already, EMB is exerting more effort for industries to improve their wastewater treatment activities and adopt a river program for clean up;

(iii) Planned improvement of water flow of the river through desilting and revetment of riverbanks by DPWH;

(iv) Some organizations and firms are in collaboration with local government units (i.e., barangay level) to install Material Recovery Facilities (MRFs) to avoid household waste disposals at rivers especially for the informal settlers along the river;

(v) The Department of General Service of Mandaue City has enjoined informal settlers to earn by turning trash into income as well as improve their way of living (including health and sanitation).

As such, it is recommended that a consolidated wastewater treatment plant (WWTP) be installed to treat the wastewater coming from the industries located along the Butuanon River by 2020. This is in addition to the requirement of EMB to totally eliminate the GHG emission of the wastewater from industries.

**(2) Pedestrian and Bicycle Lanes along the Green Loop**

The Green Loop within Mandaue is 9 kilometers long traversing along Hernan Cortes Street and reaching Butuanon River where it continues along the riverside parallel to U.N. Avenue until it reaches the bridge that crosses to Mactan Island. With the installation of the pedestrian and cycle lanes, there will be a shift in modal use displacing private

[3] BOD5 parameter represents the amount of dissolved oxygen needed by aerobic biological organisms to break down organic materials present in the river (or body of water) at certain temperature over a given time period.
[4] The given parameter for untreated stagnant water is 5–10.

motorized vehicle use within Mandaue. For a conservative calculation of the modal shift from private vehicles to cycle and walk, the following data were collected and processed:

(i) Traffic and occupancy counts on Hernan Cortes Street and U.N. Avenue, which were captured by the 2015 screenline surveys conducted during the Roadmap Study for a Sustainable Urban Development in Metro Cebu; and

(ii) Light Duty Vehicle (LDV) emission of 136 $gCO_2$/km reported in IPCC AR5 based on EU test results in 2011. The vehicles tested have about the same specifications as those at present in Asia.

**Table 7.3.2 Modal Shift from Private Car to Cycle and Walk for Green Loop**

| Street Name and Length | No. of LDVs Reduced (Vehicles/day) in 2021 | Cumulative Modal Shifts (Vehicles; 2021– 2030) | Reduction in $CO_2$ Emission (tons; 2021–2030) |
|---|---|---|---|
| Hernan Cortes St. (4 km) | 109 | 1,137 | 223 |
| U.N.Avenue (5 km) | 245 | 2,566 | 628 |

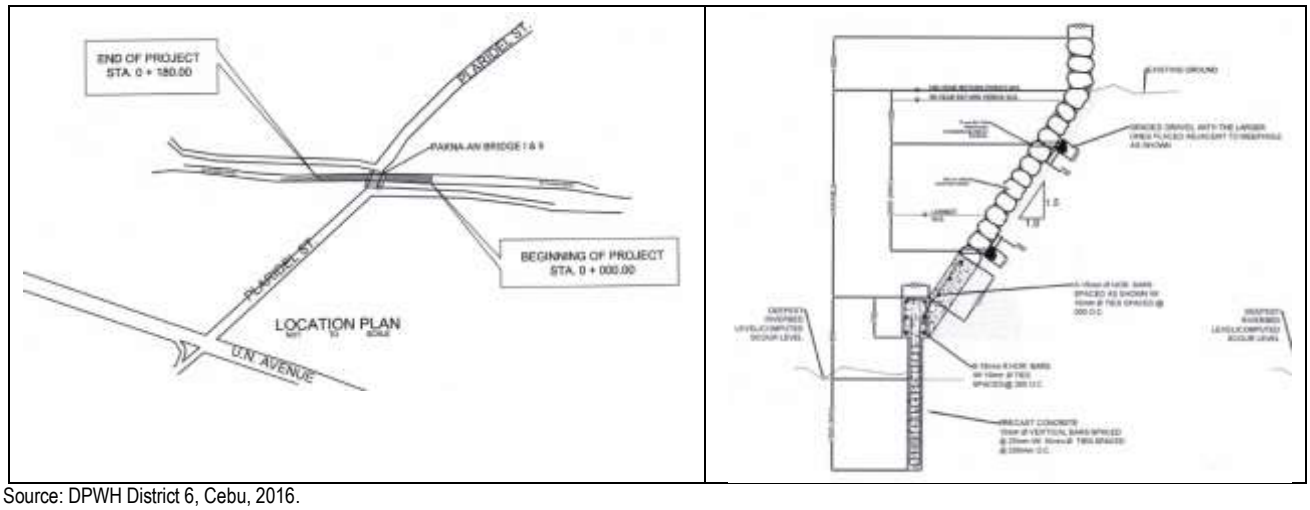
Source: APEC Study Team.

### 7.3.3 Green Loop Cost Estimate for Mandaue

On the whole, a detailed engineering design and concrete implementation plan with designated budgets and implementing bodies have not been forged to date for the entire Green Loop. However, agencies and organizations are doing their part to improve the Butuanon River and its environs toward this end.

In the absence of a complete cost, available initiatives of agencies were placed together as a first draft for an estimated cost, which is subject to further detailed study. To start with, the Department of Public Works and Highways (DPWH) is undertaking revetment works along the Butuanon River waterways (see Figure 7.3.1). This is on a limited scale with about a few hundred meters constructed per year as part of their repair and maintenance task with costs running from PHP3 million to PHP5 million. With Butuanon River stretching 7 kilometers within Mandaue, this initiative is expected to take long to complete.

Similarly, the Environment Management Bureau (EMB) of the Department of Environment and Natural Resources (DENR) is working for the improvement of the river's water quality. EMB has identified 77 dischargers (companies discharging their waste into the river) and 13 donors for the river's revitalization. A campaign is pursued by EMB to set companies to adopt their portion of the river for cleaning and preservation as well as the installation of community MRFs (at a cost of PHP225,000 per facility) and installation of basket at each outfall of industries along the river. Community parks are invariably part of the advocate of EMB.




Source: DPWH District 6, Cebu, 2016.

**Figure 7.3.1 Grouted Riprap Work on Butuanon River by DPWH**

Another study on stormwater management and drainage system in Metro Cebu[5] has designed a program on the improvement of drainage flow from the North Road to the Mactan Channel where Butuanon River drains out (see Figure 7.3.2). The program is for a 3-kilometer stretch of the river and, as such, the cost given is referenced for estimating a cost for the entire length of the river in Mandaue City. The component of the program involves ROW highway to Mactan Channel, road access North Road to Mactan Channel (5 meters each way), 6-meter high embankment, resettlement (where necessary), cleaning of silt and garbage, construction of wastewater treatment system, and lighting along the river. The total estimated cost of the designed program is PHP992 million for an implementation period spanning 5 years. Thus, the 7-kilometer length would translate to a cost of approximately PHP2,183 million for the improvement of the drainage flow of the river with selected areas for access ways.

Additionally, costs for 2.4-meter wide bikeways and pedestrian lanes are estimated to be about PHP10 million per kilometer.[6] This would mean an add-on cost of PHP50 million if it is to be implemented for the 5-kilometer stretch of the river within the loop.

For the Green Loop initiative, Mandaue City has allocated PHP13.5 million in 2015 for the design and build of the Butuanon River Rehabilitation Project. This is aimed at restoring a portion of Butuanon RIver (about 1.5 km) in terms of restoring the riverbed gradient as well as beautification and greening along the banks. It started with the clearing of informal settlers along the hazard zones of the river in 2014. Bidding for the project is yet to be conducted.

[5] A JICA-funded study on Stormwater Management and Drainage System for the Roadmap Study for Sustainable Urban Development of Metro Cebu in 2015.

[6] Cost for Pedestrian and Bicyclist Infrastructure Improvement is a resource for researchers, engineers, planners, and the general public placed together by the University of North Carolina Highway Safety Research Center. Indicative costs of USD 537,000 per mile for bikeways were localized for this study.

| No | Item | Unit | Qty | Unit Cost (PHP) | Total Cost (PHP) | Location Map |
|---|---|---|---|---|---|---|
| 1 | Right-of-Way highway to Mactan Channel | sqm | 30,000 | 10,000 | 300,000.000 |  |
| 2 | Road access North Road to Mactan Channel - 5 meters each side | sqm | 30,000 | 7,500 | 225,000,000 | |
| 3 | Embankment (3 km) –6 meters high | sqm | 36,000 | 4,500 | 162,000,000 | |
| 4 | Wastewater treatment system | cu m | 10,000 | 15,000 | 150,000,000 | |
| 5 | Environment components (5%) | Lumpsum | | | 34,350,000 | |
| 6 | Lighting along the river | M | 600 | 5,000 | 3,000,000 | |
| 7 | Relocation / disturbance fees | Lumpsum | | | 20,000,000 | |
| 8 | Desilting / cleaning | cu m | 14,400 | 500 | 7,200,000 | |
| 9 | Engineering and supervision (10%) | | | | 90,155,000 | |
| Total | | | | | 991,705,000 | |

Source: Stormwater Management and Drainage System Study, JICA, 2015

**Figure 7.3.2 Proposed Program for Improvement of Drainage Flow**

### 7.3.4 Development Effect of the TOD and Expected $CO_2$ Reduction

As witnessed in other development cities, TOD is the normal response to road congestion, climate change, better quality of life, rising energy prices, green buildings and walkable communities. Compact development around a transit station encourages shorter and non-motorized trips. Convenient intermodal transfer facility encourages modal transfer between private vehicles and transit and between road-based public vehicles and transit.

As for the benefits accrued from TODs, studies have shown that this type of development reduces traffic congestion and air pollution by about 25% to a high of 50% in comparison to the uncontrolled urban development or suburban development.[7]

$CO_2$ reduction is realized when people veer away from vehicle use causing a decrease in the vehicle-kilometer trips. The $CO_2$ calculation for TOD in this study hinges on the existing and future floor areas by use (i.e., commercial, residential, institutional and industrial). Further refinement of the calculation would have been possible through data on current trip generation and attraction rates of areas within 500 meters to 1 kilometer radius distance from public transit stations. These information are not available for Mandaue but are given for Metro Manila. Such trip generation and attraction rates are usually dependent on a variety of information like the number of dwelling units, location and size of buildings, mixed use intensities near public transit stations, and future developments.

Nonetheless, an estimate of the trips for areas at each station was determined with the assumption of densification of residential high-rise buildings, employment centers, and shopping areas within walking distance of the mixed-use areas around the AGT stations. Calculations for new buildings and ongoing developments up till year 2020 as well as calculation for future buildings[8] beyond the year 2020 was conducted based on the

[7] National League of Cities, Sustainable Cities Institute.
[8] Explanation of data processing and results are given in Chapter 11 of this report.

available data used in the calculation of buildings (see Chapter 11 of this report). Based on the 2015 transport surveys conducted in the Roadmap Study for a Sustainable Metro Cebu, total trips in Mandaue was at 1.1 million per day. The shorter travel distances were for "to shop," "to work" and "to home" trip purposes.

Table 7.3.3 and Table 7.3.4 present the derivation of the number of trips that will shift to walk and non-motorized transport (NMT) trips. With an average occupancy of cars at 2 persons per vehicle, a reduction in private vehicles on streets can, thus, be calculated. A target of 1% increase in the shifting per year is assumed. Emission of one private vehicle or light duty vehicle (LDV) was established (EU, 2011) to be 136 $gCO_2$/km. It should be noted that modal shifts will have multiplier effects for $CO_2$ reduction as an indirect impact such as traffic congestion avoidance.

The results of the calculation of the expected $CO_2$ reductions are shown in Table 7.3.5.

**Table 7.3.3 Modal Shift to Walk for Year 2020**

| | Land Use | | | | Total |
|---|---|---|---|---|---|
| | Commercial | Residential | Institutional | Industrial | |
| Additional Floor Area (2020; in sq.m.) | 1,659,679 | 441,452 | 344,597 | 433,237 | 2,878,965 |
| Modal Shift to Walk and NMT (no. of trips) | 33,194 | 18,394 | 17,230 | 12,448 | 81,265 |

Source: APEC Study Team.

**Table 7.3.4 Modal Shift to Walk for Year Beyond 2020**

| | Land Use | | | | Total |
|---|---|---|---|---|---|
| | Commercial | Residential | Institutional | Industrial | |
| Additional Floor Area (beyond 2020; in sq.m) | 3,344,289 | 623,166 | 273,984 | 636,363 | 4,877,802 |
| Modal Shift to Walk and NMT (no. of trips) | 66,886 | 25,965 | 13,699 | 11,624 | 118,174 |

Source: APEC Study Team.

**Table 7.3.5 $CO_2$ Emission Reduction for TOD Measure**

| Emission Reduction (cumulative 2021 to 2030; $tCO_2$) | Estimated Emission Reductions in 2022 (ave. $tCO_2$/year) | Average Annual Cost (USD/year) 1/ | Unit Cost of $CO_2$ Reduction (USD/tCO2/year) |
|---|---|---|---|
| 24,487 | 2,364 | 32,609 | 67 |

Source: APEC Study Team.
1/ average of 5-year cost from 2017 to 2021.

### 7.3.5 Cost Estimate for TOD Measure

The AGT is expected to be in place by 2022 with the assumption that construction starts in 2019. The cost for TOD here is in terms of its planning and promotion, which should go hand-in-hand with the AGT planning. The CLUP of the city was already approved and, as such, the cost to be imputed for TOD at this time would be for the design and planning. The city can allocate PHP1.8 million per year for design and promotional initiatives with

the private developers and non-governmental organizations. The IPCC Assessment Report 5 of 2014 places the average cost for policy design and planning strategies in the range from USD10–USD20 per $MtCO_2$. The cost assumed for Mandaue was calculated to be approximately USD14 per $MtCO_2$.

# 8 TRANSPORTATION PLANNING

## 8.1 Background and Issues

Mandaue City is located in the midst of Metro Cebu. It has the most densely developed road network (118 km long with a road density of 3.4 km/km$^2$) among the 13 member LGUs of Metro Cebu, which covers the entire territory of the city connecting it to Cebu City, Consolacion and Lapu-Lapu City. As such, it is unavoidable for Mandaue City to have a large amount of through-traffic that is characteristically with different origins and destinations outside of the city.

The city's $CO_2$ emissions profile in 2015 reveals that the transport sector accounts for 49.0% of total emissions, making it the largest emission generating sector, followed by the industry sector (39.6%). Most of the $CO_2$ emissions from the transport sector come from motor vehicles. $CO_2$ emissions from vehicles are factors of traffic volume, trip distance, driving time and emission intensity of motor vehicles. Low carbon measures to reduce the emission of motor vehicles include the following:

(a) **Reduction in vehicular traffic:** the shift to non-motorized transport modes (i.e., the use of walk and bicycle to travel) and the use of mass transit systems such as rail and BRT, which have less per capita $CO_2$ emissions than motor vehicles. To promote non-motorized trips, the Green Loop development has been proposed in the previous chapter. In this chapter, an urban rail opportunity is analyzed.

(b) **Reduction in trip distance:** through promoting a compact city which shortens the commuting distance. The city has experienced urbanization at most of its areas. Further opportunities towards a compact city structure may be brought about by urban renewal, reclamation and TOD around rail stations. The TOD opportunity has been discussed in the previous chapter.

(c) **Reduction in driving time:** by efficient and safe road space utilization without road infrastructure development where drivers are able to avoid congested points and ensure safe driving with the use of ITS. This chapter looks into such an innovative solution for the city.

(d) **Reduction in emission intensity per vehicle unit:** by introducing more fuel efficient vehicles, using eco-driving and alternative fuels. Since the DOE pursues a policy to replace tricycles with e-trikes, this chapter analyzes how to introduce small electric vehicles for public transport in the city.

## 8.2 Proposed Measures

### 8.2.1 Smart Corridor

#### 1) Existing Conditions

This project is designed to establish a synergy effect between ITS and LED lighting when using the same power source. Respective conditions are briefly described as follows:

**(1) ITS Services**

Intelligent Transport Systems (ITS) are advanced applications which aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and "smarter" use of transport networks. ITS in practice among large cities in the world are car navigation, ETC, safety driving support, traffic control center, road monitoring and traffic information, commercial vehicle management, public transport service management, pedestrian support and vehicle traffic management in emergency, etc. In recent years, smart-phone and GIS related services have been greatly improved.

In Mandaue City, the following ITS services are being practiced (see Figure 8.2.1):

(a) **Traffic Control Center (TCC):** The city government operates the center which monitors 21 major intersections and adjusts their signals depending on road traffic conditions.

(b) **Road Traffic Information through the Internet: "**Google Map" and "Waze" provide real-time road traffic information including congestion levels.

(c) **Taxi Arrangement Application:** Local people can use "Grab" and "Easytaxi" applications to arrange for taxi services. Many taxi drivers are now registered under this system, based on interviews and other qualification surveys.


*Mandaue TCC*



*Grab Application*

Source: APEC Study Team and Grab Service website photo

**Figure 8.2.1 Some ITS Services in Practice in Mandaue**

### (2) LED Street Lighting

There are some light sources for streetlights including mercury lamps, high-pressure sodium lamps, and LED lamps. In recent years, mercury and sodium lamps have been replaced with LED lamps in many cities due to the LED lamp's superiority in terms of electricity consumption and service life (see Figure 8.2.2).

According to DPWH, LED lamps are being installed along the Second Mactan Bridge while the First Bridge is now lighted by LED lamps. As of 2015, the Department of General Services (DGS) of Mandaue City manages 8,453 streetlights. They are lighted by sodium, SL, mercury, fluorescent and incandescent bulbs in descending count share. Sodium lamps have the largest share in number (39%), but their electricity consumption is not efficient. Based on the city's records, the average electricity consumption of a sodium lamp is 219W compared with fluorescent (22W), incandescent bulbs (73W), and mercury (182W).

DGS, in collaboration with VECO, prepared a replacement plan of the existing sodium lamps with LED lamps. The replacement scheme is a kind of PPP or ESCO1 in particular. There is no replacement plan for other lamps.

| | LED | Sodium | Mercury |
|---|---|---|---|
| Street Light Sources |  |  |  |
| Service Life | 60,000 hours | 24,000 hours | 12,000 hours |

Source: Yokohama City.

**Figure 8.2.2 Comparison of Streetlight Sources**

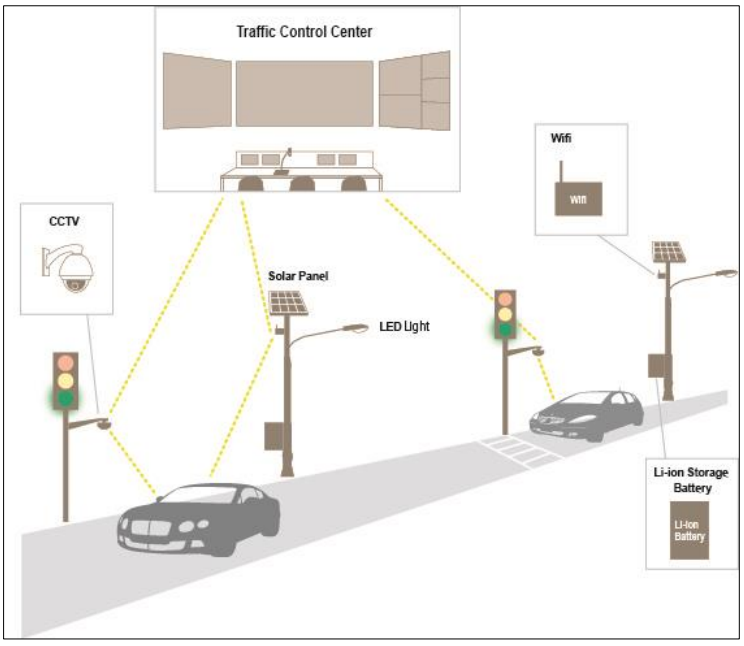
## 2) The Project

The replacement of existing streetlights provides an additional opportunity to introduce optimum lighting control through ICT. A smart streetlight system can save electricity and optimize lighting service by ICT methods such as remote control, modulation and fault detection. The system reduces not only electricity consumption but also maintenance cost. The system can be expanded to include other services such as traffic congestion mitigation and disaster-resilient urban management.

[1] An energy service company or energy savings company (ESCO) is a commercial or non-profit business providing a broad range of energy solutions including designs and implementation of energy savings projects, retrofitting, energy conservation, energy infrastructure outsourcing, power generation and energy supply, and risk management. ESCO's innovative financing methods include off-balance sheet vehicles which own a range of applicable equipment configured in such a way as to reduce the energy cost of a building. The building occupants, or landlord, then benefit from the energy savings and pay a fee to the ESCO SPV in return. At all times, the saving is guaranteed to exceed the fee.

Under the situation that Mandaue City still has a wide range of ITS options to be developed and numerous existing non-LED streetlights, the Study conceptualizes a smart corridor. It is a concept to provide street lighting service, road transport monitoring and management, road traffic information to the road user, security service and disaster management along a designated corridor (see Figure 8.2.3). To make it happen, the concept requires roadside streetlight poles, E-trike stations, and green buildings.

A streetlight pole is a strategic device to realize the smart corridor concept since a pole is equipped with efficient LED light, CCTV and traffic detector, WIFI, optic fiber, solar panel and rechargeable lithium-ion battery. A group of the proposed streetlight poles can configure a dual-band mesh network. The network becomes a potent tool not only to monitor and control street lighting, road and bridge conditions and intersection signals, but also to serve other various urban services such as garbage collection, route bus service, security management at parking lots and others, WIFI spot services, etc.




Source: APEC Study Team.

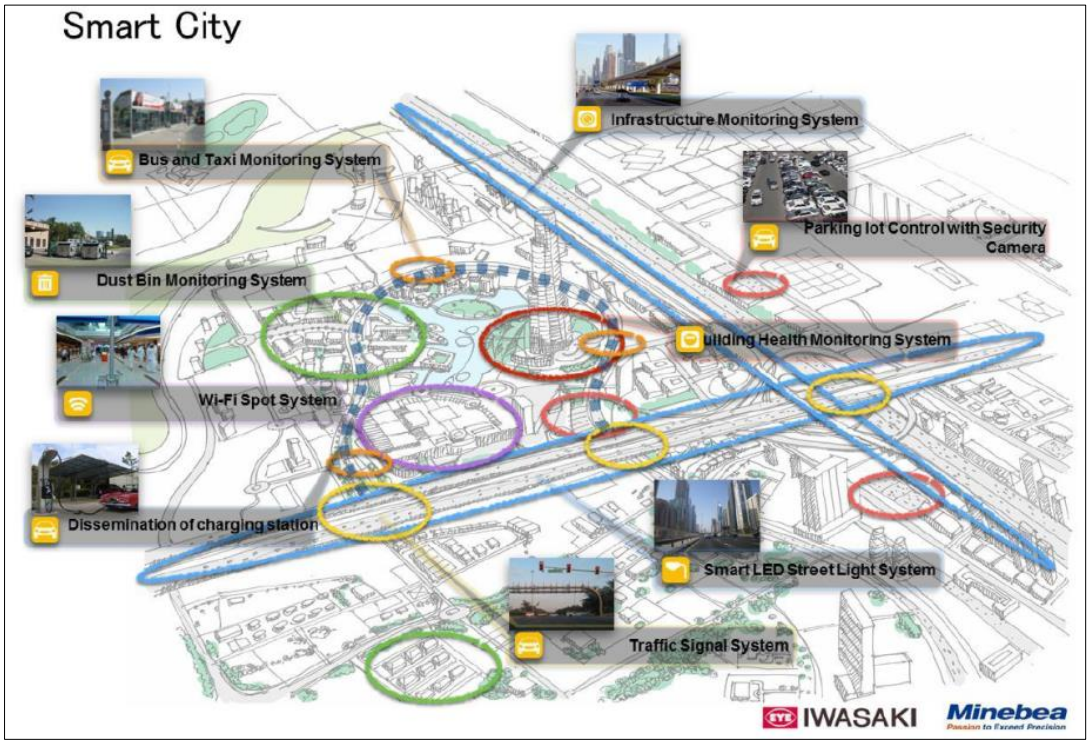
**Figure 8.2.3 Smart Corridor Concept**

The smart corridor project will initially install 4,000 LED streetlights including smart poles instead of the existing sodium and mercury lamps between 2018 and 2019 (the first batch). The second batch of another 4,000 LED streetlights will be installed to replace other existing streetlights between 2023 and 2024. The third batch of new 4,000 LED streetlights will be installed at newly urbanized areas between 2028 and 2029. At this time, the LED lamps installed during the first batch will be renewed due to expiration of their service life of 10 years.

Since all the poles work for smart urban management as a network, the project can greatly contribute to safety, security and low carbon development in Mandaue City. This

Study, therefore proposes an enhanced LED street lighting plan which is under preparation by DGS, the replacement of sodium lamps with LED under ESCO arrangement.

The concept is innovative but implementation action has already been taken in some cities in the world. It is advantageous for a city to replace obsolete streetlights with new LED streetlights in bulk over a short period of time. One city example in Cambodia is illustrated below.




Source: JCMFS Report for Efficient LED Streetlights in 2015 by Minebea.

**Figure 8.2.4 Smart City Development with LED Streetlights and Their WIFI Network**

## 8.2.2 E-Trikes

### 1) Government Policy

With the decline of the battery price, popularization of the EVs has started all over the world. In order to gain momentum, the outlook of DOE in the "Philippine Energy Plan (2012-2030)" is for the e-trike to replace tricycles nationwide (see Table 8.2.1).

**Table 8.2.1 Target Vehicles on Alternative Fuels**

| Type | No. of Vehicles | | | | | |
|---|---|---|---|---|---|---|
| | 2011 | 2015 | 2016 | 2020 | 2025 | 2030 |
| CNG Bus | 61 | 1,000 | 5,000 | 6,900 | 9,200 | 15,000 |
| CNG Taxi | | | 100 | 1,000 | 6,000 | 16,000 |
| Auto-LPG | 19,052 | 20,200 | 20,500 | 21,700 | 23,200 | 23,000 |
| E-trikes | 630 | 50,170 | 80,730 | 106,000 | 150,000 | 230,000 |

Source: The Philippine Energy Plan 2012-2030.

DOE is promoting the market transformation through Introduction of the Energy Efficient

Electric Vehicles Project or the E-Trike Project to help ensure energy security through the promotion of energy efficient and clean technologies. The project budget consists of a USD500 million loan mostly from ADB and a USD5 million grant.

In 2016, BEMAC Electric Transportation Philippines Inc. engaged the first USD30 million deal to produce 3,000 e-trikes at its factory located in Cavite Province. These units will be rolled out in Metro Manila, Region 4-A and Region 4-B. In addition, the contract includes a five-year warranty on the e-trike battery, three-year LTO registration, and three-year comprehensive insurance.

To avoid the establishment of a monopoly in the member economy for the supply of e-trikes, the project requires at least three vehicle manufacturers/assemblers that will be selected through international competitive bidding for the supply and support of the vehicles in the Philippines in accordance with ADB's Procurement Guidelines.

### 2) Local Tricycle Operators

In cooperation with the Mandaue Tricycle Operators Association, the APEC Study Team conducted a questionnaire survey in July 2016. The respondents represent 11 franchised routes and 626 operators/members (see Table 8.2.2) The survey results profile their daily business conditions as follows:

(i) Business operation hours – from 04:00 (earliest) to 22:00 (latest), transporting around 100 passengers in 12 return trips on the average;
(ii) Client segments – the largest segment from 10 to 20 years old, followed by those in their 20s and 30s;
(iii) Trip purposes – going to school, commuting and shopping;
(iv) Average trip distance – from 2 to 4 km;
(v) Daily travel distance – around 100 km;
(vi) Daily petrol consumption – from 3 to 4 liters (PHP36/liter);
(vii) Daily fare revenue – from PHP500 to 800;
(viii) Daily vehicle rental charge – PHP150 on the average;
(ix) Daily net income – from PHP300 to 400; and
(x) Replacement with e-trike – maybe difficult due to prohibitive vehicle price.

**Table 8.2.2 Tricycle Survey Respondents**

| No. | Franchise | Route of Service | No. of Operators/Members |
|---|---|---|---|
| 1 | Subangdaku to Tipolo | Subangdaku, Herman Cortes | 50 |
| 2 | Paknaan to Metro | Iskina Paknaan, Iskina Tulay | 50 |
| 3 | Suabngdaku to Cabangcalan | Herman Cortes | 50 |
| 4 | Canduman to Tintay Market | Canduman, Cabacub, Casili, Basak, Tawason | 111 |
| 5 | Bakilid to Casuntingan | Balikid, Sacris, Casuntingan | 40 |
| 6 | Bakilid to Gethemani | Bakilid, Casuntingan, Gethemani | 30 |
| 7 | Maguikay to Cabangcalan | Maguikay, Cabangcalan, Tangub | 35 |
| 8 | Banilad, Casuntingan to Marfa | P. Remedio Street, Cab 5/11 | 60 |
| 9 | Cabangcalan, Casuntingan, Sudion to Maguikay MC | Cabangcalan, Casuntingan, Maguikay MC | 50 |
| 10 | Pagsabungan | Pagsabungan, Canduman, Tabok, Tingub, Basak | 100 |
| 11 | Labogon, Paknaan, Opao,Pilapil to Umapad | Labogon, Paknaan, Opao, Umapad | 50 |

Source: APEC Study Team.
Note: Survey at Mandaue Sports Center on July 29, 2016.

At present, there are 15 e-trikes in operation in Mandaue City. They are participating in the e-trike demonstration project sponsored by Prozza, a Japanese invested local manufacturer at Consolacion. The Study Team directly interviewed one participating operator in the demonstration project. Some characteristics of the demonstrated e-trike operation are observed as follows:

(i) Prozza supplies 2 e-trike bodies on a lease contract basis (PHP180 per unit per day);
(ii) Prozza also supplies batteries on a different contract (the first 2 batteries – PHP170/day for charging and additionally PHP40/day/unit);
(iii) Prozza operates battery stations at Subangdaku and Banilad in the city;
(iv) Since one battery can run 40km, one e-trike needs 3 batteries per day;
(v) The minimum fare up to 3 km is set at PHP7;
(vi) The e-trikes can get regular clients easily because of no emission, no noise and comfortable ride; and
(vii) As a result, increased fare revenue and shorter operation hours have been realized.

The specifications of the e-trikes of BEMAC and Prozza, a Consolacion manufacturer, are illustrated in Figure 8.2.5.

| BEMAC's 68VM Specifications | |
|---|---|
| Dimensions | 3,300(L) x 1,440(W) x 1,820(H) |
| Capacity | Passenger 6+ driver 1 |
| Battery | Lithium Ion Battery (3kwh – 5kwh) |
| Motor | 5 kw AC Motor |
| Drive Range | 80km (20km/h constant drive) |
| | 50km (Free drive) |
| Max speed | 50 km/h |
| Max gradient | 16 degree |
|  |  |
| Specification of Pecolo manufactured in Consolacion | |
| Dimensions | 2,880(L) x 1,540(W) x 1,880(H) |
| Capacity | Passenger 6+ driver 1 |
| Battery | Lithium Ion Battery (48V 60Ah) |
| Motor | 4.9 kw 3phase AC Motor |
| Drive Range | 40km (constant drive) |
| Max speed | 40 km/h (constant drive) |
| Max gradient | 15 degree (constant drive) |
|  |  |

Source: Photos from suppliers' websites

**Figure 8.2.5 Comparison of BEMAC and Prozza E-Trikes**

### 3) The Project

Mandaue City has pioneering experiences in e-trike operation with the replacement of conventional tricycle operation. They show favorable results not only for the environment but also for their business, particularly client satisfaction. In order to promote e-trikes, at least three factors will have to be achieved at once, namely (1) more battery recharging stations, (2) lower e-trike body and battery prices by mass production, and (3) project finance to support (1) and (2).

The project is proposed to replace most of the existing tricycles which hold route franchises[2] up to the year 2030. It will be done by three times mass procurement deals or 600 e-trikes per deal. To enjoy the economy of scale, each e-trike procurement deal will be done by Metro Cebu. For example, one procurement deal would be for 5,000 e-trikes for Metro Cebu, 600 of which will be for Mandaue City.

On the condition that an e-trike body has a lifetime of 10 years while the e-trike battery will

[2] According to the Legal Office of Mandaue City, there are more than 2,000 tricycles which have franchises within the city.

last for 5 years, Mandaue City will procure 2,400 body units and 3,600 battery units, and install 45 battery recharging stations so as to operate 1,800 e-trikes in 2030.

**Table 8.2.3 E-Trikes Procurement Plan in Mandaue City**

| | No. of E-Trike Body | No. E-Trike Battery | Battery Station |
|---|---|---|---|
| 1st Procurement (2018-20) | 600 | 600 | 15 |
| 2nd Procurement (2023-25) | 600 | 800 | 15 |
| 3rd Procurement (2028-2030) | 1,200 | 1,800 | 15 |
| Total Procurement | 2,400 | 3,600 | 45 |
| E-Trikes in Operation in 2030 | 1,800 | | 45 |

Source: APEC Study Team.

### 8.2.3 AGT-CML Line

The 19.2-km long AGT-CML Line is proposed between the Cebu City CBD and the MCIA (see Figure 8.2.6). CML stands for the three cities of Cebu, Mandaue and Lapu-Lapu. The line will serve the heaviest inter-city traffic route (Cebu-Mandaue) and the second heaviest one (Mandaue-Lapu-Lapu).[3]

Automated Guideway Transit (AGT) is one of the LRT categorized systems. Among various LRT systems, AGT is an environment-friendly and disaster-resilient system. AGT operation generates less air pollution than jeepneys and buses as it uses electric power and generates less noise and vibration than ordinary rail due to its rubber tires. AGT has an elevated substructure and simple railcars without catenary for electricity supply. It is disaster- resilient against strong wind, heavy rain and earthquake and, thus, suitable as a seaside people mover in Metro Cebu.

Along the project alignment, the Mandaue City portion has six stations within a rail length of 9.3 km. The alignment strategically serves the city's four Green Growth Areas (i.e., 1, 2, 4 and 5) among six districts (see Chapter 11 of this report). Therefore, the AGT-CML Line will be able to not only decongest road traffic but also promote the city's envisaged urban structure particularly the development priority areas or the so-called Green Growth Areas of Mandaue City.

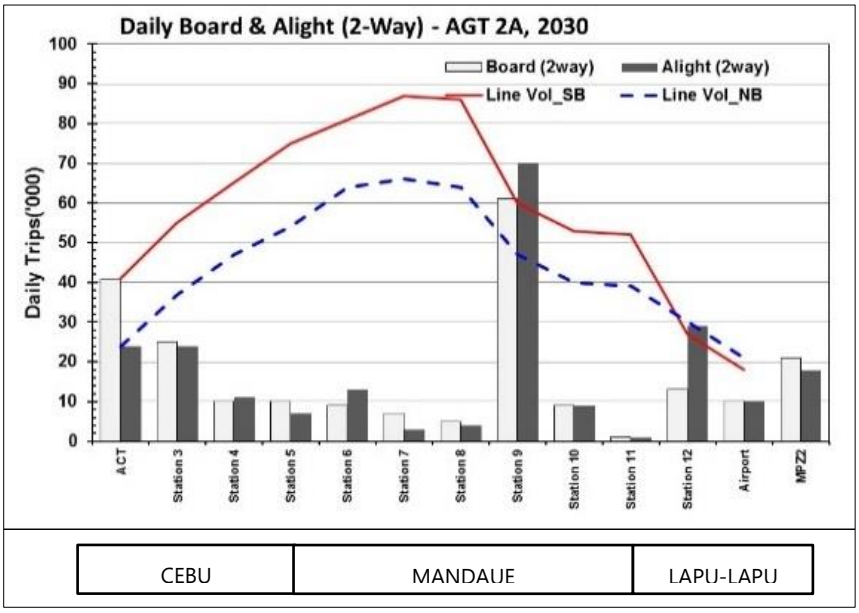
A depot, which requires a space of 6 ha, is a prerequisite facility for the project. It is planned near GGA5. A station at GGA5 will have a service line to the depot. Passenger traffic demand volumes are different between the Cebu City–Mandaue section and the Mandaue–Mactan north section. The former section is roughly three times bigger than the latter. Rail service frequency will be adjusted by the depot.

[3] The project was prepared by the JICA-funded Roadmap Study for Sustainable Urban Development in Metro Cebu in 2015. The Mandaue City Development Council decided to promote the AGT CML Line as well as the Mandaue–Mactan North Dual-mode Bridge on February 20, 2015.


Resource: Mitsubishi Heavy Industries.

**Figure 8.2.6 Depot Requirements**

The project is expected to substantially reduce road traffic since it carries more or less 200,000 passengers daily in the opening year or in the early 2020s and 222,000 passengers in 2030 (see Figure 8.2.7).




Source: The Roadmap Study for Sustainable Urban Development in Metro Cebu, 2015.

**Figure 8.2.7 Station Loadings and Line Volumes (Year 2030)**

The implementing agency is the Department of Transportation (DOTr) of the Philippines. Project implementation has not been approved by DOTr (as of September 2016). In the member economy, only Metro Manila has urban rails. LRT Line 1 and 2 are operated by LRTA, an attached agency to DOTr while MRT Line 3 is operated by a private entity under the Build-Lease-and-Transfer (BLT) scheme. Various project implementation

schemes are considerable when developing urban rails outside Metro Manila such as the AGT-CML Line project.

## 8.3 GHG Reduction Analysis and Cost Estimates

### 8.3.1 Smart Corridor

#### 1) GHG Emission Reduction

##### (1) ITS Services

Among ITS services, traffic information can contribute to $CO_2$ emission reduction through improved travel speed and reduced waiting/queuing time at intersections and others. More specifically, vehicle drivers may avoid driving through congested areas because of changing driving route and departure time if road congestion information is provided in advance or in real time. Traffic information service may bring about other benefits such as reduction in vehicle operating costs (VOC) for vehicle drivers and operators, shorter waiting time for public transport passengers, and so on.

In order to estimate $CO_2$ emissions reduction by providing road traffic information, it is assumed that vehicular travel speed will become faster by 0.1%.[4] Under the traffic assignment practices of the year 2022 situation (medium term) and the year 2030 situation (long term), reduced traffic demand and its respective $CO_2$ emissions are estimated as follows:

**Table 8.3.1 $CO_2$ Emissions Reduction by ITS Service**

| Year | Assigned Daily Traffic Volume ('000 pcu x hours) | Traffic Reduction Volume by ITS Service (pcu x hours) | Estimated Yearly $CO_2$ Emissions Reduction (tons) * |
|---|---|---|---|
| 2022 | 650,000 | 650 | 388 |
| 2030 | 877,000 | 877 | 524 |

Source: APEC Study Team.
Note: * $CO_2$ Emissions Reduction = Shorter Driving Hours x Fuel Consumption Efficiency x Energy Density x Net Calorific Value x Emission Coefficient

##### (2) LED Streetlights

Provided that all the streetlights in Mandaue City would be converted to LED lamps, the present electricity consumption could be saved by 63% (see Table 8.3.2). When 2,000 new LED streetlights replace the existing ones, $CO_2e$ emissions could be reduced by 1,633 tons per year (see Table 8.3.3 and Table 8.3.4). It is suggested that the project start lamp replacement from sodium lamps and mercury lamps taking high energy savings into account.

[4] "Road network connection reliability and the difference between user equilibrium assignment and system optimization assignment" (by Wakabayashi, Nakagawa and Iida, the Japan Civil Engineering Society Journal in 1993).

### Table 8.3.2 Electricity Saving Potentials when Introducing LED Lamps in Mandaue City

| Present Lamp Type | Fluorescent | Incandescent | Mercury | SL | Sodium | Total |
|---|---|---|---|---|---|---|
| Average wattage per lamp | 22 | 73 | 182 | 24 | 219 | 123 |
| Streetlight electricity consumption shares(A) | 2% | 2% | 19% | 7% | 70% | 100% |
| Electricity saving rates to LED (B) | 20% | 80% | 75% | 20% | 65% | |
| Electricity saving potentials (A x B) | 0.4% | 1.6% | 14.3% | 1.4% | 45.5% | 63.2% |

Source: Mandaue City and Various Sources.

### Table 8.3.3 $CO_2$ Emission Reduction from Existing Lamps to High Efficiency LED Lumps

| | | | |
|---|---|---|---|
| $E_{BL,y}$ | | kWh | 4,541,902 |
| | total wattage | W | 1,036,964 |
| | light on hours | hours/day | 12 |
| | days per year | days/year | 365 |
| | | | |
| $EF_{CO2,ELEC,y}$ | | kg-CO2/kWh | 0.512 |
| ni | | | 8453 |
| $\rho_i$ | | W | 122.67 |
| $O_i$ | | hours/year | 4380 |
| $L_y$ | | | 0.1 |
| | | | |
| BEy | tCO2/year | | 2,584 |
| PEy | tCO2/year | | 951 |
| ERy | tCO2/year | | 1,633 |

Note: No. of LED Lamps – 4,000 units.

| | | |
|---|---|---|
| Note: | The emission baseline is determined using the following equations:<br>$BE_y = E_{BL,y} \times EF_{CO2,ELEC,y}$<br>$E_{BL,y} = \sum_i (n_i \times \rho_i \times o_i)/(1 - l_y)$ | |
| | Where: | |
| | $BE_y$ | Baseline emissions in year *y* ($tCO_2e$) |
| | $E_{BL,y}$ | Energy consumption for the baseline in year *y* (kWh) |
| | $EF_{CO2,ELEC,y}$ | Electricity emissions factor. 0.512 $tCO_2$/Mwh (Second National Communication) |
| | $\Sigma_i$ | Sum over the group of i baseline equipment (e.g. 40W incandescent lamps) replaced or that would have been replaced. |
| | $n_i$ | Number of pieces of equipment of the group of i baseline equipment replaced or that would have been replaced |
| | $\rho_i$ | Electrical power demand (kW) of the group of i baseline equipment (e.g. 250W sodium lamps). In the case of a retrofit activity, electrical power demand is the weighted average of the rated power (kW) of group i baseline equipment. |
| | $O_i$ | Average annual operating hours of the group of i baseline equipment. |
| | Ly | Average annual technical grid losses (transmission and distribution) during year *y* for the grid serving the locations where the devices are installed, expressed as a fraction. |
| | PEy | Project emissions in year *y* ($tCO_2e$) |
| | ERy | Emission reductions in year y ($tCO_2e$) |

### Table 8.3.4 $CO_2$ Emissions Reduction by LED Streetlights

| Year | No. of LED Streetlights Installed | Estimated Yearly $CO_2$ Emissions Reduction (tons) |
|---|---|---|
| 2022 | 4,000 | 1,633 |
| 2030 | 12,000 | 4,899 |

Source: APEC Study Team.

### 2) Project Cost

The ITS service will rely on available car navigation tools such as "Waze" and "Google Map." But such mobility management service will be provided by the private sector. Road traffic situations will be monitored at the city's Traffic Control Center (TCC). Considerable investment will not be required to upgrade the existing facility. Therefore, the project implementation costs is assumed at USD1 million only for the PR activities and system integration. Annual operation costs will be as small as USD0.1 million, mostly for electricity consumption.

The LED streetlights will be introduced in the entire city. The number of streetlight fixtures will be 12,000 including lamps, poles, solar panels, CCTVs and communication equipment. The installation cost is estimated at PHP1,020 million or PHP85,000 per unit so as to expand a city-wide WIFI network for various urban management purposes.

## 8.3.2 E-Trikes

### 1) $CO_2$ Emission Reduction

The calculation method comes from the respective CDM methodology.[5] The baseline emissions are calculated based on the unit of service provided by the project vehicles (travel distance) times the emission factor for the baseline vehicle to provide the same unit of service. Project emissions include the electricity and fossil fuel consumption associated with the operation of project vehicles. As a result, the emissions reduction per unit is 0.681 $tCO_2$ per year (see Table 8.3.5) or a total of 408 $tCO_2$ in 2022 and 1,224 $tCO_2$ in 2030 (see Table 8.3.6).

**Table 8.3.5 $CO_2$ Emissions Reduction from Tricycles to E-Trikes**

*Baseline Emissions*

| N | Number of Project Vehicles | unit | | 1 | 1,800 |
|---|---|---|---|---|---|
| SFC | Specific Fuel Consumption | L/km | 0.03 | | |
| D | Density of fossil fuel | Kg/l | 0.7407 | | |
| NCV | Net Calorific Value | TJ/Gg | 44.3 | | |
| EF | Emission Factor of fossil fuel | $kgCO_2/TJ$ | 69,300 | | |
| IR | Technology improvement factor | | 1 | | |
| DD | Average annual Drive Distance | km/year | 30,000 | | |
| BE | Baseline Emissions | $tCO_2$ | | 2.047 | 3,685 |

*Project Emissions*

| N | Number of Project Vehicles | unit | | 1 | 1,800 |
|---|---|---|---|---|---|
| SEC | Specific Electricity Consumption | kWh/km | 0.08 | | |
| EF | Emission Factor of electricity | $kgCO_2/kwh$ | 0.512 | | |
| TDL | Technical Loss of Electricity | | 0.1 | | |
| DD | Average annual Drive Distance | km/year | 30,000 | | |
| PE | Project Emissions | $tCO_2$ | | 1.365 | 2,457 |

*Emissions Reduction*

| ER | Emissions Reduction | $tCO_2$/year | | 0.681 | 1,226 |
|---|---|---|---|---|---|

Source: APEC Study Team.

[5] CDM Small-scale Methodology AMS-III.C "Emission reductions by electric and hybrid vehicles" (Ver. 15.0).

**Table 8.3.6 $CO_2$ Emissions Reduction by E-Trikes**

| Year | No. of E-Trikes in Mandaue City | Estimated Yearly $CO_2$ Emissions Reduction (tons) |
|---|---|---|
| 2022 | 600 | 408 |
| 2030 | 1,800 | 1,224 |

Source: APEC Study Team.

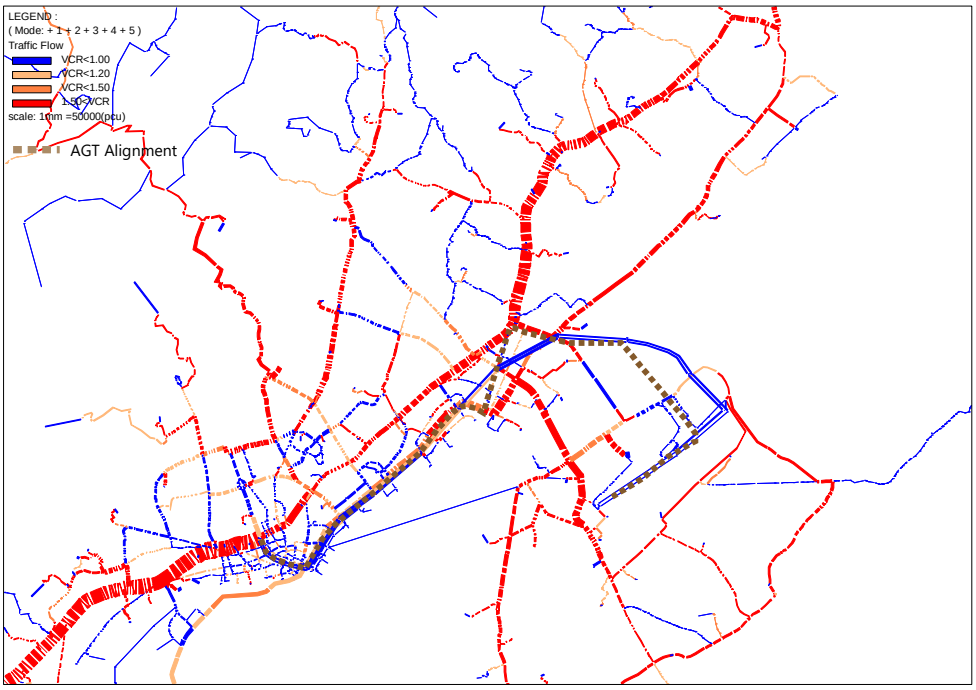
### 2) Project Cost

The project costs are estimated at USD42.4 million during the project period 2018-2030. They include e-trike bodies (USD12.0 million for 2,400 units), e-trike batteries (USD18.0 million for 3,600 units), battery stations (USD4.5 million for 45 units) and O&M costs (USD7.9 million or PHP80/unit/day). With this implementation plan, the number of e-trikes operating in Mandaue City will gradually increase up to 1,800 units in 2030.

## 8.3.3 AGT-CML Line

### 1) $CO_2$ Emissions Reduction

The project's $CO_2$ emissions reduction is calculated based on the demand forecast results of future AGT operation. The year 2030 matrices are assigned on the present road network "with" and "without" the project. As a result, the project expects to reduce road traffic volume within Mandaue City by 357,000 pcu x km or 10.8% of the city traffic per day while within Metro Cebu by 891,000 pcu x km or 4.1% (see Figure 8.3.1 and Table 8.3.7). This is the quantitative impact of the modal shift from road vehicular traffic to the AGT-CML Line. It is assumed that respective proportions of $CO_2$ emissions in the transport sector (i.e., 1.2 $MtCO_2$ in Manduae City in 2030) would be reduced.




Source: APEC Study Team.

**Figure 8.3.1 Traffic Assignment Results (year 2030 OD matrix) with the AGT-CML Line**

**Table 8.3.7 Reduction in Road Traffic with the AGT-CML Line in 2030**

| | Road Traffic without AGT (a) | Road Traffic with AGT (b) | Road Traffic Reduction | |
|---|---|---|---|---|
| | | | (a - b) | (a - b)/ (a) |
| Mandaue City | 3,292 | 2,935 | 357 | 10.8% |
| Metro Cebu | 21,562 | 20,671 | 891 | 4.1% |

Source: APEC Study Team.
Note: Road Traffic ('000 pcu x km) per day

On the other hand, the Project will produce new $CO_2$ emissions due to rail operation. It is calculated at 4,635 $tCO_2$ per year (see Table 8.3.8). As a result, the project's $CO_2$ emissions reduction is estimated at 80,871 $tCO_2$ and 124,515 $tCO_2$ in 2022 and 2030, respectively (see Table 8.3.9).

**Table 8.3.8 Project Emissions from AGT Operation**

| N | Number of Project Vehicles | Unit | 1 |
|---|---|---|---|
| SEC | Specific Electricity Consumption | kWh/km | 1.6 |
| EF | Emission Factor of electricity | $kgCO_2/kwh$ | 0.512 |
| TDL | Technical loss of electricity | | 0.1 |
| DD | Average annual Drive Distance | '000 km/year | 5,092 |
| PE | Project Emissions | $tCO_2$ | 4,635 |

Source: APEC Study Team.

**Table 8.3.9 Estimated $CO_2$ Emissions Reduction of the AGT-CLM Line Project**

($tCO_2$/year)

| | Year 2022 | Year 2030 |
|---|---|---|
| Reduction by Modal Shift (a) | 85,506 | 129,150 |
| Addition by AGT Operation (b) | 4,635 | 4,635 |
| Balance (a - b) | 80,871 | 124,515 |

Source: APEC Study Team.

**2) Project Cost**

The AGT-CML Line is estimated to cost USD819 million while its economic value is translated to USD815 million (see Table 8.3.10). When the financial cost is divided by route length and maximum transport capacity, the cost index is USD2,848. The Project will take three years to construct. Taking the necessary implementation arrangements into account, the earliest year to start operation will be in 2021.

The operating cost for the AGT was calculated based on the following assumptions that are anchored on real rail systems (see Table 8.3.11). In short, the operating cost is USD21.0 million per year during the project period.

**Table 8.3.10 Estimated Capital Cost of AGT-CML Line**

| Item No. | Particulars | Financial Cost (in USD mil) | Economic Cost (in USD mil) | |
|---|---|---|---|---|
| 1 | Civil Works | 322.1 | 341.4 | Foreign content ~30% |
| | Viaduct/a | 252.9 | 260.5 | |
| | Stations | 65.0 | 67.0 | |
| | Depot Building | 4.2 | 4.3 | |
| 2 | Rolling Stock (Trains) | 270.0b/ | 295.7 | RS=USD104m – minimum unit |
| 3 | Electromechanical System | | | Foreign content~95% |
| | Signalling & Telecommunications | 96.0 | 114.2 | |
| | Power System | 15.0 | 17.8 | |
| | Depot equipment | 5.8 | 6.9 | |
| | Other E&M | 15.2 | 18.1 | |
| 4 | AFCS (Smart card ticketing) | 5.0 | 6.0 | |
| 5 | Right-of-Way/Land | 13.4 | 13.4 | |
| 6 | Taxes | 99.6 | 0 | VAT and import taxes |
| | Total | 818.6 | 814.7 | |

a – Excludes the cost of bridge across Mactan, but include viaduct & track cost.
b – For 30 train-set of 6-car/train; Urbanismo-22

Source: Roadmap Study for Sustainable Urban Development in Metro Cebu (JICA, 2015).

**Table 8.3.11 Operating Cost Assumptions – AGT**

| Parameter | Value | Remarks |
|---|---|---|
| Power Consumption - Traction | 2.50 | Kwh per car-km |
| Power Consumption – Station | 0.78 | Million kwh/station/year |
| Power consumption - Depot | 2.30 | Million kwh/year |
| Power Cost/kwh | 8.00 | Pesos/kwh |
| Cost of Railcar | 1.50 | Million USD per car |
| Maintenance - Regular | | |
| - Track infrastructure | 0.2% | Of initial cost, every year |
| - Rolling stock | 2.0% | Of initial cost, every year |
| Maintenace – Periodic | | |
| - Track infrastructure | 1.0% | Of Initial cost, every 10 years |
| - Rolling stock | 10.0% | Of initial cost, every 8 years |
| Manpower | 585 | Headcount @ PHP460k/yr |
| Overhead & Miscellaneous | 15% | Of cash operating cost |
| Security & Janitorial | 10.0 | PHP, in millions/yr, per station |

Source: Roadmap Study for Sustainable Urban Development in Metro Cebu (JICA, 2015).

For evaluating the project's low carbon impact to Mandaue City, the city's portions of the construction and operation costs are supposed to be USD397.0 million per system and USD10.2 million per year taking into account the AGT alignment length within the city, i.e., 9.3 km long of the total length of 19.2 km.

# 9 OTHER URBAN SERVICES PLANNING

## 9.1 Background and Issues

In Mandaue City, several large scale urban development projects are planned. Supplying sufficient energy is an important subject for realizing the planned development. The usage of renewable energy and untapped energy, as well as energy conservation is necessary to be considered for the low carbon development. Furthermore, given the Philippine's expensive electricity tariff, it is important for Mandaue City to encourage usage of renewable energy and energy saving measures for its economic sustainability. This chapter outlines the measures for renewable energy, waste-to-energy, and District Heating and Cooling System as other urban services and analyzes the potential GHG emission reductions and cost of these measures.

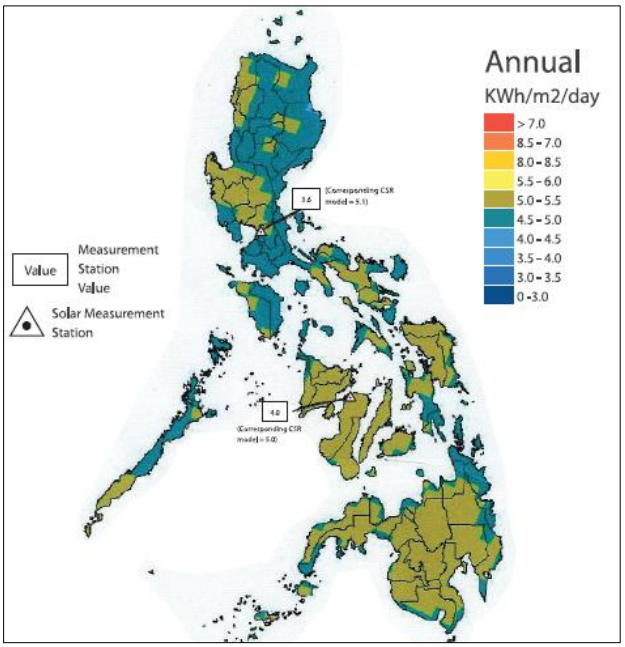
## 9.2 Proposed Measures

### 9.2.1 Renewable Energy

The solar radiation of Cebu is high at 5.0-5.5 kWh/$m^2$/day. Although the development of a solar power plant in Mandaue City is not realistic due to the high price of land, the promotion of the rooftop solar photovoltaics (PV) system is a suitable option in order to maximize the usage of the solar resource in the area. The VECO has been promoting the use of solar energy to its customers by the roof renting business model and net-metering scheme[1]. Net-metering was implemented under the Renewable Energy Act of 2008 as a non-fiscal incentive. Through the installation of solar PV panels of up to 100 kW, house owners, commercial and industrial establishments can partly satisfy their electricity demand by themselves, and the excess electricity generated can be credited through the customers' billing accounts. In June 2016, 24,454 kWh/month, which is 0.01% of total electricity purchased by VECO is from net-metering export[2]. Due to the high cost of the initial outlay, the implementation rate of this scheme is still low. Therefore, VECO has conducted workshops to explain the benefit of roof top solar PV and net-metering scheme to build awareness among the customers.

The installation of roof top solar PV systems should be prioritized in conjunction with the other policies such as those intended for the Green Growth Areas (GGAs) planned development by Mandaue City. There are a number of wide roofs of logistic warehouses, industrial and commercial buildings where the solar PV systems can be installed. Moreover, the use of solar PV system can be promoted in the GGA through BERDE application, which contains rating criteria for on-site renewable energy generation, for upcoming buildings.

[1] http://www.philstar.com/cebu-news/2014/09/13/1368606/veco-customers-install-solar-panels
[2] http://www.veco.com.ph/page.html?main=clients&sub1=your%20bill&sub2=June%202016%20Gen%20Rate




Source: Renewable Energy Plans and Programs (2011–2030), Department of Energy.

**Figure 9.2.1 Climatological Solar Radiation Model**


Source: VECO.

**Figure 9.2.2 VECO's Net Metering Program[3] and System Demonstration**

## 9.2.2 Waste-to-Energy

Waste is being identified as one of the fifteen major sources of GHG emissions, which contribute 3% share of the global GHG emissions. The disposal and treatment of waste can produce emissions of several GHGs.. The most significant GHG produced from waste is methane released during the breakdown of organic matter in landfills[4], most especially,

[3] VECO presentation, Net Metering Program, July 8, 2015.
[4] GRID Arendal, A Center Collaborating with UNEP, Climate Change and Waste- Gas emissions from waste disposal http://www.grida.no/publications/vg/waste/page/2871.aspx

when it is not captured – as in the cases of open and uncontrolled dumpsites.

While there is one private sanitary landfill (SLF) in the municipality of Consolacion, most municipalities and cities within Metro Cebu still utilized open dumpsites. However, the landfills in the cities of Cebu and Mandaue, while constructed as SLFs, were not operated and functioning as SLF but as an uncontrolled and open dumpsites, which the DENR-EMB ordered closed and rehabilitated, in accordance with the provisions of the RA 9003 (Ecological Solid Wastes Management Act).

The Mandaue City government ceremonially closed its Umapad 2-hectare landfill in 2009. For a time, it contracted the Asian Energy System Corporation's (AEC) SLF as the final disposal site for its wastes but soon resorted to using a site adjacent to the previous Umapad landfill (effectively expanding the landfill area) for the city's collected residuals.

The Umapad landfill, located at Brgy. Umapad, now occupies a total land area of 5 hectares, with only 1 hectare being utilized as a landfill cell receiving only residual wastes from different barangays of the city. The Umapad landfill and surrounding areas were mostly abandoned fishpond traversed by the Butuanon River abutting the Mactan Channel. It's the most convenient area for wastes disposal area, but were subject to various complaints from NGOs and residents (Converting Wastes, 2009).

Efforts to rehabilitate the landfill are on-going, which includes improvement of access road and circulation network within the landfill, mining of garbage in the old dumpsite, excavation for landfill cells, tree planting and landscaping, upgrading of facilities (administration and Material Recovery Facility buildings), etc. At the moment, the rehabilitation works are limited to the above-mentioned efforts and do not include works to significantly address GHG emissions (lack/ absence of introduction of methane capture technology) and leachate management (e.g. absence of lining in landfill cells and leachate treatment facility).

By the Concept of the Low-Carbon Town in the APEC Region, the usage of waste heat from the garbage incineration plant is recommended as a measure for the utilization of untapped energy. Also, the APEC Concept describes that the energy from the garbage incineration plant, which is often located near residential area, could be converted to energy supply for nearby buildings and houses, and facilitates the cyclic use of energy at a regional level.

The Umapad Landfill site is in the best location to host a Waste-to-Energy (WTE) facility, as this is strategically located to serve not only the City of Mandaue, but the surrounding localities within the Metro Cebu area, given that transport of wastes materials will be made convenient through the nearby 2nd Mactan and Cansaga Bridges, and by barging through the Mactan Channel. In addition, the current Umapad Landfill site is close to GGA4 and GGA6 where the tourism, commercial and residential buildings are planned to

be constructed in the future, therefore it is a good location to supply energy for the upcoming buildings.

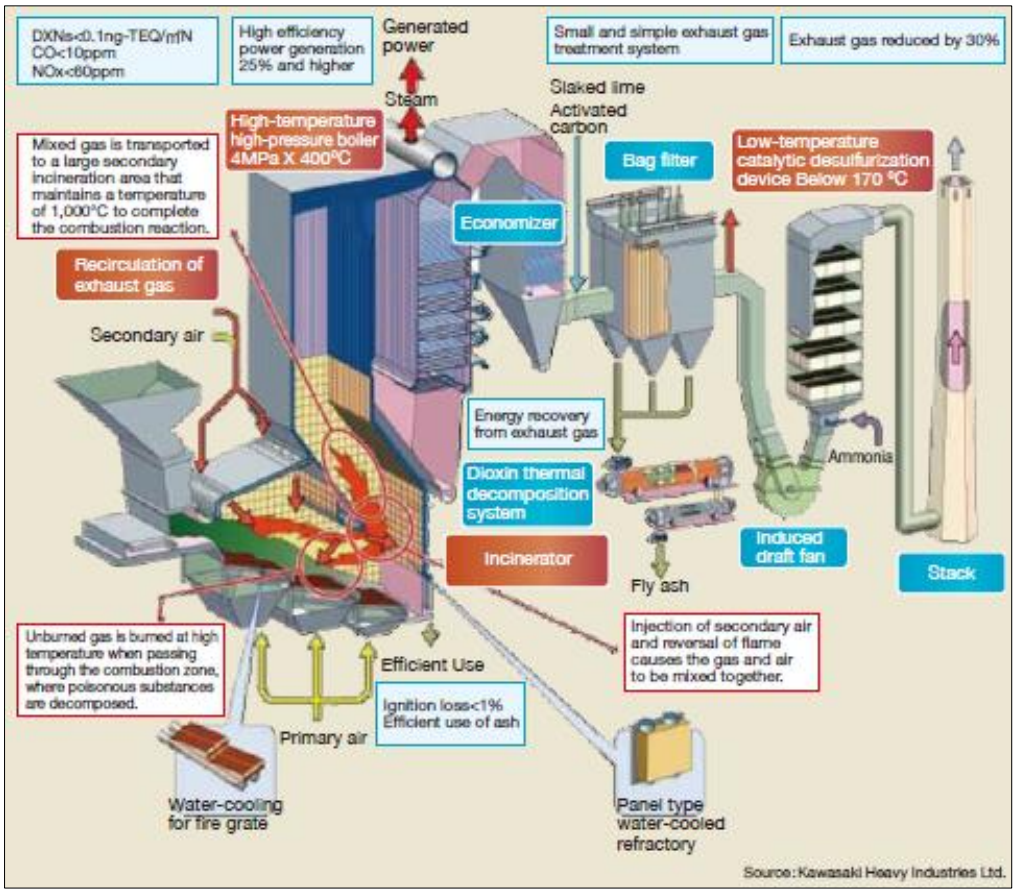

Source: APEC Study Team.

**Figure 9.2.3 Location/ Vicinity Map of Umapad Landfill**

Source: APEC Study Team.

**Figure 9.2.4 The Umapad Landfill Site at Present (taken 6/14/2016)**

Japan, leading the way for advanced high-efficiency power generation incineration facilities has been using several methods, namely: stoker furnaces, fluidized bed furnaces, and gasification fusion resource furnaces with the objective of ash recycling. Stoker furnaces account for 70% of all furnaces, and improvement of this type of furnace is progressing rapidly, which can be utilized for the type of garbage generated in the ASEAN region. In addition to the high-efficiency power generation technology, incineration plant in Japan applies high pollution prevention technology which avoids not only dioxin gas, $SO_x$, HCl, and $NO_x$.




Source: Kawasaki Heavy Industries Ltd.

**Figure 9.2.5 Advance Waste Incineration Facility Diagram**

Shibuya Incineration Plant in Tokyo is located in the center of a high-density urban district, where a large amount of waste is generated. The facility employs a high technology with a capacity of 200t/day, which cleared strict gas emission regulations for NOx, SOx, smoke, dioxin and other gases. Shibuya Incineration Plant is small compared to other waste treatment facilities in Tokyo, and it uses a swirling flow fluidized-bed incinerator.
Fluidized-bed furnaces fluidize sand layer on the floor of a tubular furnace with air to maintain high temperature, which leads to efficient incineration of waste.

Source: Ministry of the Environment

**Figure 9.2.6 Incineration Plant in Tokyo (Example)**

### 9.2.3 DHC (District Heating and Cooling) and DCS (District Cooling System)

UNEP initiated a research on and surveyed low-carbon cities worldwide to identify the key factors underlying their success in scaling up energy efficiency and renewable energy, as well as in attaining targets for zero or low greenhouse gas emissions. The UNEP report in 2015 “District Energy in Cities, Unlocking the Potential of Energy Efficiency and

Renewable Energy"[5] which defined district energy/ district energy systems as "the provision of thermal energy at a district level through district heating and/or district cooling" noted the following key benefits that a city could achieved through having a district energy systems in-place:

(i) Greenhouse gas emissions reductions;

(ii) Air pollution reductions;

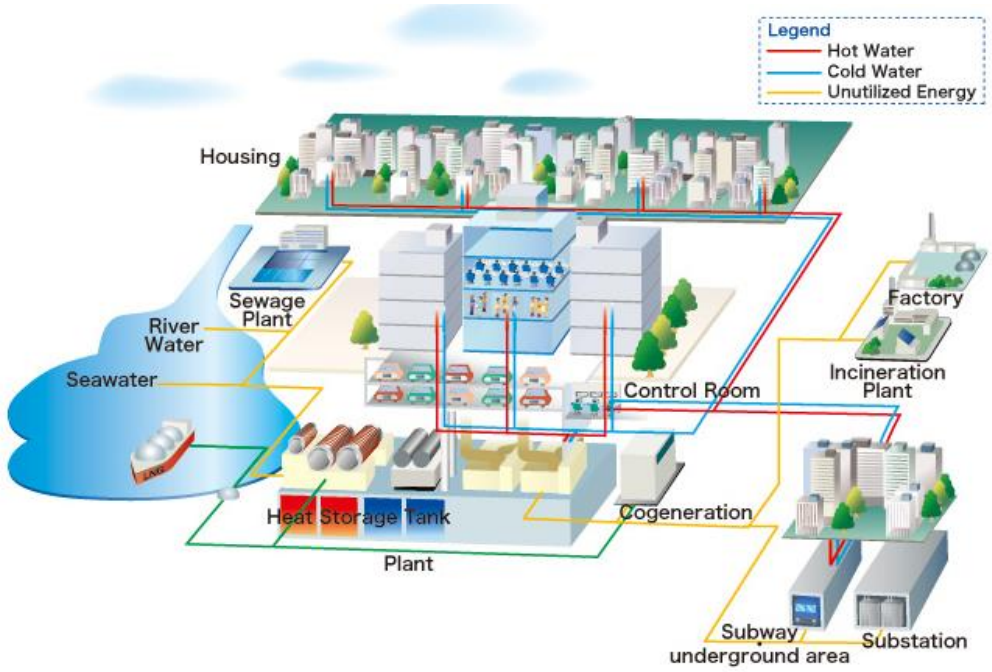
(iii) Energy efficiency improvements;

(iv) Use of local and renewable resources;

(v) Resilience and energy access; and

(vi) Green economy.

In recent years, co-generation (or CHP-combined heat and power) area energy networks supply not only heat but also electricity. DHC/DCS can create greater energy saving effects compared with individual systems by integrating a thermal storage and cogeneration. In addition to conventional energy sources, DHC/DCS can utilize various sources of waste heat energy throughout the city, such as heat from incineration plants and factories. Therefore, in Mandaue city, the proposal to establish a Waste-to-Energy facility in the present landfill facility at Barangay Umapad, Mandaue City, provides an opportunity for developing a potential heat source for DHC.




Source: Japan Heat Supply Business Association

**Figure 9.2.7 District Heating and Cooling Conceptual Diagram**

[5] http://www.unep.org/energy/portals/50177/DES_District_Energy_Report_full_02_d.pdf

## 9.3 GHG Reduction Analysis and Cost Estimates

### 9.3.1 Renewable Energy

#### 1) GHG Emission Reduction

Mandaue City is encouraging the use of natural energy through the Green Building Ordinance (GBO) which is described in the Chapter 10. Since the compliance to the ordinance and taking the green building measures are especially encouraged in GGA, the estimation of the potential GHG emission reduction by installation of roof-top solar panel is calculated based on the building area in GGA. The detail GGA Planning is explained in Chapter 11. The estimation used two assumptions (i) 50%, and (ii) 25% of all buildings install solar panels.

As a green building measure, the GBO also encouraging to have 75% of the building roof area by such as open-grid pavement system with vegetated roofing, therefore 25% is used to calculate panel area per roof area[6].

**Table 9.3.1 The Estimation of Potential Panel Installation Area**

| Land Use Name | Total GGA | | Scenario 1 | | Scenario 2 | |
|---|---|---|---|---|---|---|
| | Area ($m^2$) | Total Building Roof Area* ($m^2$) | Roof Area | Panel Area ($m^2$) | Roof Area | Panel Area ($m^2$) |
| Residential | 1,207,350 | 845,145 | 422,573 | 105,643 | 211,286 | 52,822 |
| Commercial | 2,148,292 | 1,503,804 | 751,902 | 187,976 | 375,951 | 93,988 |
| Institutional | 350,072 | 245,050 | 122,525 | 30,316 | 61,263 | 15,316 |
| Tourism | 894,250 | 625,975 | 312,988 | 78,247 | 156,494 | 39,123 |
| Industry | 2,805,575 | 1,963,903 | 981,951 | 245,488 | 490,976 | 122,744 |
| Total | 7,405,539 | 5,183,877 | 2,591,939 | 647,670 | 1,295,970 | 323,993 |

Source: APEC Study Team based on Mandaue City MISO, 2016
Note: Institutional includes schools, churches, hospitals, government offices and other community buildings
*Assumption: 70% of land area.

**Table 9.3.2 The Estimation of Potential $CO_2$ Emission Reduction by Solar PV Installation**

| Item | Value | |
|---|---|---|
| Solar radiation in Cebu (kWh/$m^2$/year) | 5.0[7] (kWh/$m^2$/day) x 365 (days)=1,825 (kWh/$m^2$/year) | |
| Module conversion efficiency (%) | 15 | |
| System efficiency (%) | 70 | |
| | Scenario 1 | Scenario 2 |
| Panel Area ($m^2$) | 647,670 | 323,993 |
| Power Generation (MWh/year) | 123,705 | 61,883 |
| $CO_2$ Emission reduction ($tCO_2$/year) | 63,337 | 31,684 |

Source: APEC Study Team

#### 2) Cost Estimates

The assumption used for the cost estimation of solar PV system installation is shown in Table 9.3.3.

[6] Based on the BERDE (Building for Ecologically Responsive Design Excellence) rating system. The BERDE rating system is applied by Mandaue GBO to evaluate the green buildings.
[7] Renewable Energy Plans and Programs (2011-2030), Department of Energy

**Table 9.3.3 The Assumption Used for the Cost Estimation of Solar PV System Installation**

| Item | Value |
|---|---|
| Installation of solar PV (PHP/W) | 170[8] |
| Output (W/$m^2$) | 150 |
| Estimated cost per panel Area (PHP/$m^2$, USD/$m^2$) | 25,500PHP/$m^2$= 550USD/$m^2$ |

Source: APEC Study Team

Therefore, the cost for the installation of solar PV system to achieve the described scenario is analyzed below.

**Table 9.3.4 The Cost Estimation for the Installation of Solar PV System**

| Item | Scenario 1 | Scenario 2 |
|---|---|---|
| Total Initial Cost (Million USD) | 356 | 178 |
| Life Cycle (Years) | 20 | 20 |
| Annual O&M cost* (Million USD/year) | 7.1 | 3.6 |
| Annual Expense (Million USD/year) | 25 | 12 |
| Total CO2 Emission Reductions ($tCO_2$/year) | 63,337 | 31,684 |
| Unit cost of $CO_2$ reduction (USD/$tCO_2$) | 394 | |

Source: APEC Study Team
* Assumption of 2% of initial cost was used.

## 9.3.2 Waste-To-Energy

### 1) GHG Emission Reduction

The solid waste generation in Mandaue City is classified as: (i) domestic, (ii) commercial (iii industrial, (iv) hospital, and (v) others. A total of 185 tons of garbage is generated each day with domestic waste accounting for almost 52% of total waste while commercial and industrial waste account for about 34%, and the rest are hospital and other waste. Of the total daily solid waste generation, only 79% is collected and the rest are presumed dumped in open pits or burned.

**Table 9.3.5 Solid Waste Generation by Sources**

| Source | Volume of Solid Waste Generated (tons/day) | Volume of Solid Waste Collected (tons/day) | Disposal Methods Treatment/ Facilities | Disposal Sites |
|---|---|---|---|---|
| Domestic | 96 | 81 | Segregation | Umpad/ Barangay Recovery Facilities |
| Commercial | 38 | 30 | | |
| Industrial | 24 | 22 | | Off site |
| Hospital | 5 | 5 | PASSI* segregation | Off site |
| Others | 22 | 8 | | |
| Total | 185 | 146 | | |

Source: Mandaue City Comprehensive Land Use Plan 2014.
* Pollution Abatement Systems Specialists, Inc.

The potential electricity generation by the waste-to-energy plant is calculated as below:

$$W= (G \times 1{,}000 \times Hu \times \eta)/3600 \times 1{,}000$$

[8] Source: Department of Energy.

**Table 9.3.6 Assumption and Calculation of Potential Electricity Generation**

| Parameter | Definition | Assumption | Source |
|---|---|---|---|
| *W* | Power Generation (MWh) | 13,505 | Calculated |
| *G* | Collected volume of waste (t/year) | 40,515 | Mandaue City Comprehensive Land Use Plan 2014<br>Collected domestic and commercial waste |
| *Hu* | Low Calorific Value of waste (kJ/kg) | 7,500 | Ministry of Environment of Japan[9] |
| *η* | Efficiency of the plant | 0.16 | Ministry of Environment of Japan[10] |

Source: APEC Study Team

It is estimated that 13,505 MWh electricity is generated by the waste-to-energy plant. GHG emission reductions by this assumed waste-to-energy plant is estimated as follows:

- By replacing grid electricity with the generated electricity: 6,914 $tCO_2$/year:
- By avoiding CH4 emissions from landfill: 0.145 (tCH4/t)[11] x 40,515 (t/year) =5,874 tCH4/year = 123,354 $tCO_2e$/year: and
- Emissions by incineration of waste: 0.33 ($kgCO_2$/t)[12] x 40,515 (t/year) x 1/1,000= 13 $tCO_2$/year.

Therefore, total emission reduction is estimated at 130,255 $tCO_2$/year.

### 2) Cost Estimates

Recently, it was announced that Hitachi Zosen is planning to build the Philippines' first waste-to-energy plant in the Metropolitan Manila area. The incineration plant has the capacity to process the waste of three million residents, with 20,000 kW power generation capacity. The estimated initial cost is 395 million USD[13].

The other study conducted for waste-to-energy project in the Philippines showed that the initial cost of stoker furnaces plant with the capacity to process 250t/day waste was USD40 million[14], and O&M cost was USD2.3 million/year.

The assumption of USD 0.2 million/ton of daily waste was used to estimate the initial cost for the propose waste-to-energy plant in Mandaue City. It is also assumed that O&M cost is 5% of initial cost.

Since the constant supply of waste is necessary to operate the waste-to-energy plant, it is important to collect waste not only from Mandaue City but also from the surrounding localities as mentioned before. The efficient collection and transportation of waste is also necessary to be considered to keep the generation capacity and also cost efficiency.

[9] http://www.env.go.jp/earth/ondanka/gel/pdf/manual201203.pdf
[10] https://www.env.go.jp/recycle/misc/he-wge_facil/ref1.pdf
[11] Ministry of Environment Japan, http://ghg-santeikohyo.env.go.jp/files/calc/itiran.pdf
[12] http://www.env.go.jp/earth/ondanka/gel/pdf/manual201203.pdf
[13] http://asia.nikkei.com/Business/Companies/Hitachi-Zosen-to-build-the Philippines-first-waste-to-energy-plant
[14] http://www.env.go.jp/recycle/circul/venous_industry/pdf/env/h26/10_1.pdf

**Table 9.3.7 Cost Estimation of Waste-to-Energy Plant**

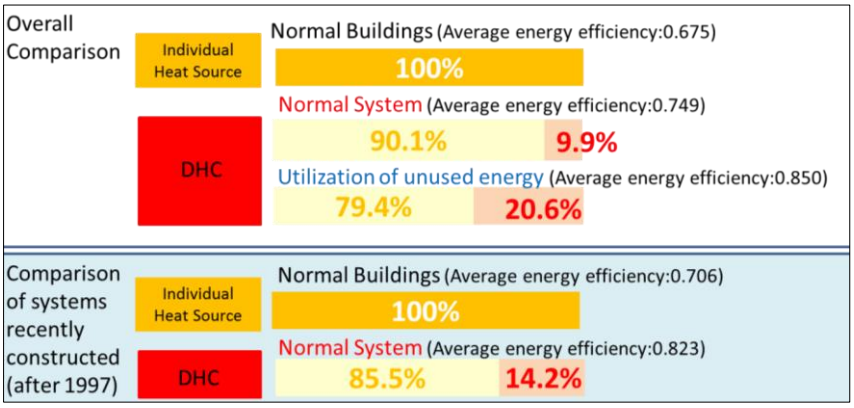
| Item | Value |
|---|---|
| Total Initial Cost (USD) | 25,000,000 |
| Life Cycle (Years) | 20 |
| Annual O&M cost (USD/year) | 1,200,000 |
| Annual Expense (USD/year) | 2,450,000 |
| Total $CO_2$ Emission Reductions ($tCO_2$/year) | 130,255 |
| Unit cost of $CO_2$ reduction (USD/$tCO_2$) | 19 |

Source: APEC Study Team

### 9.3.3 DHC and DCS

#### 1) GHG Emission Reduction

The effect of DHC is summarized in Figure 9.3.1. It was reported that the installation of normal DHC system could save 9.9% of primary energy consumption compared to the individual heat supply to the building. Furthermore, the DHC system which utilize unused energy source such as energy from waste incineration plant, waste heat from the industry, could achieve 20.6% energy saving compared to the individual heat supply. Based on the result by the systems installed after 1997, the normal DHC system could achieve 14.2% energy saving compared to the individual energy supply.




Source: Ministry of Economy, Trade and Industry, Japan.

**Figure 9.3.1 The Effect of DHC**

In the development plan, DHC with utilization of energy from the waste-to-energy facility is proposed to be installed to supply energy to commercial buildings in GGA4 and GGA6. GGA4 is the reclamation area for recreation and tourism development with hotels and condominiums planned to be constructed after 2020. GGA6 is a residential/commercial mixed used development. The expected energy consumption by these buildings in GGA4 and GGA6 is calculated based on the floor area and also energy intensity of buildings. The energy intensity data for hotels and office buildings are used for the calculation for GGA4 and GGA6, respectively, based on the study conducted by International Institute for Energy Conservation in the Philippines as given in Table 9.3.8.

**Table 9.3.8 Estimation of Energy Consumption in GGA4 and GGA6**

| Type of buildings | Floor Area ($m^2$) | Energy Intensity ($MJ/m^2 \cdot year$) | Energy Consumption (GJ) |
|---|---|---|---|
| Commercial buildings in GGA4 | 1,228,623 | 586 | 719,973 |
| Commercial buildings in GGA6 | 2,487,936 | 600 | 1,492,762 |
| Total | 3,716,559 | - | 2,212,735 |

Source: Study on the Energy Efficiency in the Philippine Commercial Sector, International Institute for Energy Conservation (IIEC), November 2010, Energy Performance Index of hotels is 163kWh/$m^2$-year=586MJ/$m^2$-year, 167kWh/ $m^2$-year=600MJ/$m^2$-year

Based on the study result in Japan (Figure 9.3.1), 14.2% energy saving is expected by the installation of normal DHC compared to the installation of individual heat source. Assuming that 14.2% of energy saving could be achieve by the installation of DHC, 314,208GJ is expected to be saved.

$$2,212,734 \times 0.142 = 314,208(GJ/year)$$

$CO_2$ emission reduction by this energy saving is estimated based on the grid emission factor. As a result,44,687 $tCO_2$ is expected to be reduced by the installation of DHC.

$$314,208 \times 1000 \times 1/3600\ (MWh/MJ) \times 0.512\ (tCO_2/MWh) = 44,687\ (tCO_2/year)$$

## 2) Cost Estimates

The initial cost and O&M cost for the installation of individual and normal DHC to the new development area where the commercial buildings with 347TJ of energy consumption per year are planned to be constructed are estimated as Table 9.3.9 according to the study in Japan.

**Table 9.3.9 Comparison of Initial Cost between Individual Heat Source and Normal DHC**

| | Individual Heat Source | Normal DHC |
|---|---|---|
| Initial Cost (USD) | 20,899,030 | 32,837,120 |
| O&M cost (USD/year) | 1,514,650 | 1,824,490 |

Source: METI, Japan http://www.meti.go.jp/meti_lib/report/2012fy/E002694.pdf
Exchange rate 1USD=100yen was applied.

Although the system assumed in Table 9.3.9 includes heating facility and also the building types are different, this cost information is used as an assumption to estimate the cost performance of DHC here due to the similarity of amount of energy requirement in the area.

**Table 9.3.10 Analysis of Cost Performance of DHC**

| | Individual Heat Source | Normal DHC |
|---|---|---|
| Annual expense (USD/year) * | 2,559,602 | 3,466,346 |
| Additional cost by DHC installation (USD/year) | - | 906,744 |
| $CO_2$ emission reduction by DHC ($tCO_2$/year) | - | 7,234 |
| Unit cost of $CO_2$ reduction (USD/$tCO_2$) | - | 125 |

Source: APEC Study Team
* Life cycle is assumed at 20 years.

# 10 GREEN BUILDING PLANNING

## 10.1 Background and Issues

In the 3rd volume of the Comprehensive Land Use Plan (CLUP) of Mandaue City, it is mentioned that the city plans to develop the urban and non-urban land use of the city from 2014 to 2024[1].The city plans to increase urban land use with an additional of 502 hectares or an increase of 21.9% over the present land use, replacing the current non-urban land use. In order to ensure the balance between economic growth and environmental sustainability, the city decided to pursue the Green Building Program. This chapter outlines the general background regarding green building development in the city, focusing on the recently issued Green Building Ordinance of Mandaue City (GBO #13-2015-1047), and the projected GHG emission reductions and cost by implementing the ordinance and proposed green building measures.

Currently, 36% of the energy used in the Philippines is from the building sector[2]. With the current economic development outlook, growth of energy consumption and GHG emissions per capita are likely to cause further increase in GHG emissions in the building sector. With Mandaue City having several large scale building development plans, a regulation was necessary to suppress further GHG emissions. The city believed that the Green Building Program can address the environmental challenges related to buildings while inviting investments for future sustainable developments in the city[3]. Therefore, the city enacted the Green Building Ordinance of Mandaue in November 2015.

### 10.1.1 The Green Building Ordinance of Mandaue City

The Green Building Ordinance of Mandaue City (GBO) was applied as the city's policy on improving the resource efficiency of buildings, contributing to the global efforts in reducing GHG emissions, and minimizing the impact of buildings on health and environment. The holistic program promotes the sustainability in the design, construction, and operation of buildings within Mandaue City[4]. The GBO applies to all buildings within the city. The city mandated green building for all public buildings, and for new private buildings located in the Planned Unit Development (PUD) areas, otherwise known as the integrated Green Growth Areas or GGA in this study. The Building for Ecologically Responsive Design Excellence (BERDE) Green Building Rating System was adopted as the tool to verify environmental performance of building projects in the city. Requirement of BERDE certificate per type of the buildings are summarized as follows:

[1] CLUP Volume 3
[2] The presentation of Mandaue City, Asia Clean Energy Forum 2016
[3] The presentation of Mandaue City, Asia Clean Energy Forum 2016
[4] Green Building Toolkit, USAID, April 2016

(a) Both public and private buildings:

- Mandatory for public buildings: Required minimum 1-Star BERDE Certification
- Voluntary for private buildings, unless otherwise indicated specific zones (PUD)

(b) New Buildings:

- Mandatory in Planned Unit Development (PUD) areas: Required minimum 3-Star BERDE Certification
- Voluntary in other areas of the City

(c) Exemptions:

- Heritage or cultural buildings:
- Post-disaster shelters and structures.

Separately from the GBO, BERDE Program was created by PHILGBC as a voluntary initiative in order to encourage building owners, construction contractors, building professionals to design and construct greener buildings. According to BERDE Program, greener buildings are (i) energy and water efficient, (ii) cheaper to operate and maintain, (iii) lesser in negative impacts to the environment, (iv) creating healthy environment for the users, (v) providing improved productivity of users, and (vi) improve the quality of life. The BERDE rating schemes have been developed for three categories, (i) new construction, (ii) retrofit and renovations, and (iii) operations, targeting commercial buildings, clustered residential development, vertical residential development, and educational institutions as summarized in the following Table 10.1.1.

**Table 10.1.1 Summary of BERDE Rating Schemes[5]**

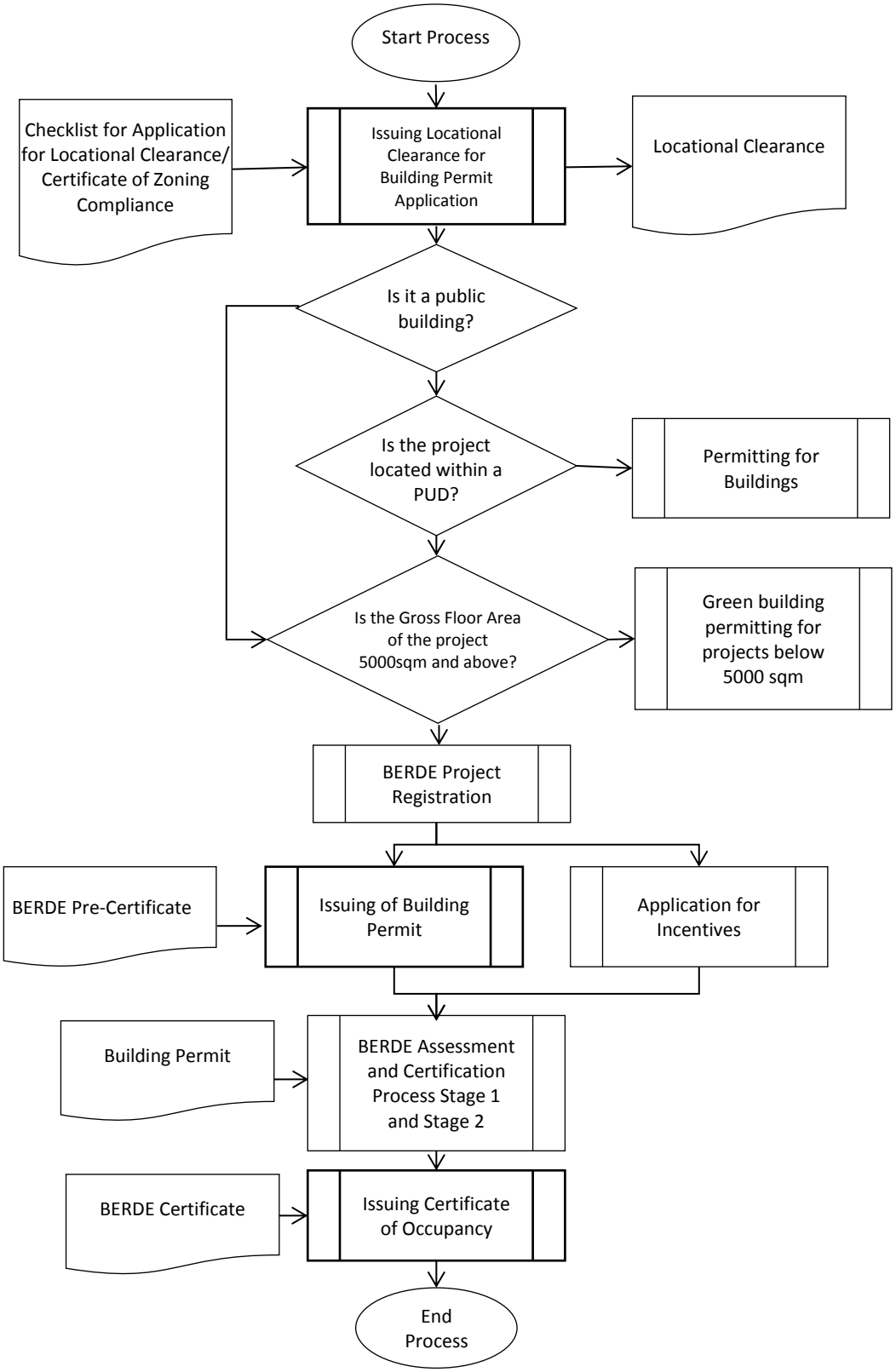
<table>
<tr><td>New Buildings</td><td colspan="2">Existing Buildings</td></tr>
<tr><td colspan="2">Building and Design</td><td>People and System</td></tr>
<tr><td>BERDE for New Construction</td><td>BERDE for Retrofits and Renovations</td><td>BERDE for Operations</td></tr>
<tr><td colspan="2">For Commercial Buildings</td><td rowspan="4">Same rating scheme for all buildings</td></tr>
<tr><td colspan="2">For Clustered Residential Development</td></tr>
<tr><td colspan="2">For Vertical Residential Development</td></tr>
<tr><td colspan="2">For Educational Institutions</td></tr>
</table>

Source: The Philippine Green Building Council

BERDE rating scheme covers 11 criteria; management, land use and ecology, water, energy, transportation, indoor environment quality, materials, emissions, waste, heritage conservation, and innovation. Each criterion is assigned a certain number of points, for a total score of 110 points. The process to incorporate the BERDE certification into the permitting process for the buildings for the project required to comply with the mandatory provisions is shown in the Green Building Toolkit which was prepared with the support from the United States Agency International Development (USAID) to complement the

[5] Smart Building and Green Standards, Christopher C. de la Cruz Chief Executive Officer, the Philippine Green Building Council, 27 November 2015

GBO. The flowchart of issuance of permits for buildings incorporating the requirement of BERDE certification is shown in Figure 10.1.1.



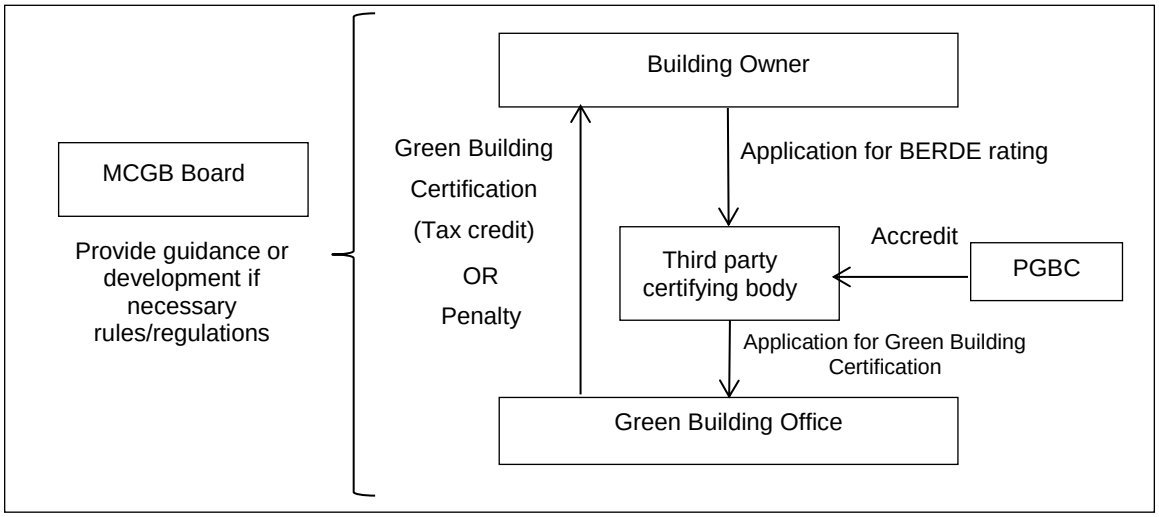

Source: Green Building Toolkit.

**Figure 10.1.1 Flowchart of Permits Issuance for Application for the Green Building Ordinance**

## 10.2 Proposed Measures

### 10.2.1 Operationalization of the Green Building Ordinance

For the implementation of GBO, the Mandaue City Green Building Board (MCGB Board) is coordinated and given the primary responsibility. It is composed of 11 members headed by the city mayor, and representatives from the city building officials, engineers, and academes. Through monthly meetings, the Board will decide on necessary and appropriate measures and matters that will enhance effective implementation of the GBO.[6] Current means of promotion are tax credit for owners of certified green building project, and penalties for violation of the GBO. The Green Building Office is administering and monitoring compliance with the ordinance.




Source: APEC study team based on Green Building Toolkit

**Figure 10.2.1 Role and Responsibilities of Relative Organizations of the GBO**

Since the promulgation of the GBO, there has been 1 project which applied for a building permit in Mandaue. This project applied for the building permit during the grace period which was between the issuance of the GBO (Nov. 26, 2015) until when the IRR was signed by the mayor (May 2016). Therefore, it was omitted from the BERDE certification requirement for its application of the occupancy permit. Also, there are several projects which have been planned and also designed their buildings before the issuance of GBO but have not applied for building permits. These projects will be affected by the GBO and will be required to secure a BERDE certificate before the issuance of a building permit. It is anticipated that these projects need to redesign the buildings to satisfy BERDE requirement resulting in additional initial cost. The implementation rule of the GBO with its process, incentives, and penalties are stated in the Green Building Toolkit. Although this toolkit was distributed to the project owners whose projects were required to receive the BERDE certificate, this should be widely distributed and published on the City's website

[6] Implementing rules and regulations are set by law and could not be easily modified unless done through another ordinance.

for instance, for all organizations and individuals who are thinking to construct new buildings in Mandaue City to prepare designing green buildings.

To operationalize the GBO, it is necessary for the city to announce the implementation rules widely to citizens, firstly. In addition, it is expected to strengthen the capacity of the organizations, especially the Green Building Office which is in charge of the permitting process, and also ensure the capability of organizations and persons in charge of BERDE certification. From the interview conducted by LCMT study team, following points should be further considered for the legitimate operation of the certification process, and enhancement of green buildings in the city.

(i) Capacity building of the city officials of the Green Building Office which is administering and monitoring compliance with the ordinance;

(ii) Ensure the quality and number of Certified BERDE Assessor and Professionals;

(iii) Promotional activities to build awareness about GBO and also the benefit of green buildings; and

(iv) Examine proper incentives to encourage the voluntary application of BERDE certification to building owners and developers .

In addition, the leading by example of public buildings which are required to be designed, built, and operated as green buildings by the GBO is important to encourage participation from the private sector. The actions to be taken by the city to satisfy the mandatory requirement, receiving a minimum of 1-star BERDE certificate for all public buildings in the city, should be planned and announced to the citizen.

BERDE was developed not only to evaluate the low-carbon buildings but also as the comprehensive rating system for green buildings covering the following indicators for energy, water, land-use, ecology and so on. In order to list and evaluate the low-carbon building measures encouraged by BERDE rating system, the measures which contribute to GHG emission reductions need to be clarified. Following sections explain the measures evaluated by the APEC indicators, and also the case in Japan.

Based on the Green Building Toolkit, below points are unclear. Rules should be set or clarified in order to avoid issues in future.

(i) Treatment of existing buildings in PUD;

(ii) Treatment of expansion of the buildings which will exceed gross floor area of 5,000 $m^2$ in total; and

(iii) Requirement of BERDE certificate for industrial buildings.

### 10.2.2 Low Carbon Measures Encouraged by BERDE Rating System

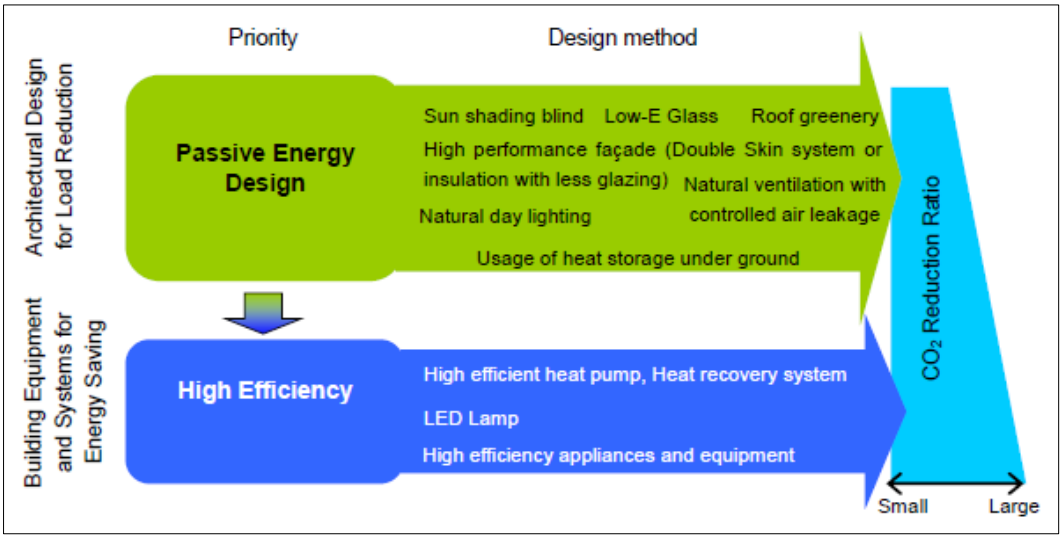
Mandaue City expects that the green buildings option can address the reduction of energy consumption through renewable energy, energy efficiency, and passive strategies[7], and thus it initiated the green building program. In order to list and evaluate the low-carbon building measures encouraged by BERDE rating system, the measures which contribute to $CO_2$ emission reductions need to be clarified. The following sections explain the low carbon building measures recommended by the APEC and also by BERDE.

#### (1) Low-Carbon Building Measures Recommended by APEC Low-Carbon Town Indicators

On the basis of APEC Low-Carbon town indicators (LCT-I), the concept of the Low-Carbon Town in the APEC Region[8] recommends to follow the steps shown in Figure 10.2.2 for more efficient and cost effective $CO_2$ reduction when evaluating the low-carbon building measures.

(a) **1st Step:** Deploy passive energy design strategies; and

(b) **2nd Step:** Improve energy efficiency.




Source: The concept of the Low-Carbon Town in the APEC Region, Fifth Edition

**Figure 10.2.2 Schematic Design Flow of Low-Carbon Building Recommended by APEC**

#### (2) Low-Carbon Measures Evaluated by BERDE

As previously mentioned, BERDE is a system to evaluate comprehensive environmental performance rather than evaluating low-carbon impact. Table 10.2.1 shows possible applicable parameters from BERDE assessment parameter "4. Energy", and "8. Emissions" which have direct impact on $CO_2$ emission reductions. Below are the example parameters and criteria for the new construction of commercial buildings to be

[7] The presentation of Mandaue City, Asia Clean Energy Forum 2016
[8] The concept of the Low-Carbon Town in the APEC Region, Fifth Edition

evaluated regarding energy:

**Table 10.2.1 Sub-Parameters and Criteria to be Assessed related to Energy**

| Parameters to be Evaluated from the Energy Perspective | Criteria |
|---|---|
| Energy Sub-Metering | Sub-metering for the following systems:<br>• Space Cooling<br>• Hot Water<br>• Fans (major)<br>• Lighting<br>• Other major energy-consuming items where appropriate (e.g. lifts, escalators) |
| Innovation Point | Building Automation System (BAS) is in place to monitor and control the chillers, air handling units & pumps, fans, and other major MVAC equipment. |
| Energy Efficient Lighting | Minimum luminous efficiency 80 lumens/watt |
| Natural Ventilation | Natural ventilation in 50% of regularly occupied ventilated spaces in total |
| Innovation Point | Conduct computational fluid dynamics (CFD) studies of naturally ventilated spaces achieving 0.6m/sec in velocity. |
| On-site Renewable Energy Generation | Offset five % of the building's total energy demand through the installation of renewable energy technologies such solar panels wind energy, etc. |
| Innovation Point | Annual energy reduction cost is greater than 15% |
| Energy Efficient Improvement | 12.5% reduction of energy consumption from a baseline 200 kWh/$m^2$ per year for commercial buildings operating 12 hours/day, or 400 kWh/$m^2$ per year for buildings operating 24 hours/day. |
| Innovation Points | 25% energy reduction, or attaining 150kWh/$m^2$ per year for buildings operating 12 hours/day, or 300kWh/$m^2$ per year for buildings operating 24 hours/day. |
| Energy Efficient Building Envelope | The Overall Thermal Transfer Value (OTTV) <45 W/$m^2$<br>Maximum Thermal transmittance Values of roofs for 50–230 kg/$m^2$ is 0.8W/$m^2$K with A/C, and 1.1 W/$m^2$K without A/C. |
| Energy Efficiency Equipment | Energy efficient A/C based on the minimum EER based on the capacity |
| Building Automation Systems | -Installation of automatic controls, performance monitoring, and electronic documentation of significant building service systems.<br>-Establishment of an electronic system indicating overall power consumption and consumption of significant loads. |

Source: The Philippine Green Building Council

Taking into account the low carbon building measures recommended by APEC Low-Carbon town indicators (LCT-I) and also measures evaluated by BERDE, the proposed measures for Mandaue City are summarized in Table 10.2.2. The table evaluates the application possibility of each measure from passive energy design, improvement of energy efficiency, and on-site renewable energy to building types in the city based on the building categories of BERDE. Passive energy design and improvement of energy efficiency measures are mostly highly applicable to new construction buildings. While for existing building retrofits, it is unlikely to apply passive design strategy measures due to the measures requiring the redesigning of the whole building.

**Table 10.2.2 Application of Measures**

| Low Carbon Building Measures | Existing Building Retrofits | New Vertical Residential Buildings | New Cluster Residential Buildings | New Commercial/ Public Buildings |
|---|---|---|---|---|
| Passive Energy Design | | | | |
| Natural ventilation systems | | ●● | ●● | ●● |
| Natural daylighting | | ●● | ●● | ●● |
| Roof greenery | ● | ●● | ● | ●● |
| Energy efficient building envelope | | ●● | ●● | ●● |
| Low E-glass | ●● | ●● | ●● | ●● |
| Improvement of Energy Efficiency of Equipment | | | | |
| Energy Efficient A/C | ●● | ●● | ●● | ●● |
| Energy efficient chiller | ●● | ●● | ●● | ●● |
| Energy efficient lighting | ●● | ●● | ●● | ●● |
| Refrigerators | ●● | ●● | ●● | ●● |
| BEMS | | ● | | ● |
| On-Site Renewable Energy | | | | |
| Solar PV system | ● | ● | ● | ● |
| Solar water heating | ● | ● | ● | ● |

Source: APEC Study Team
Unlikely to be applicable -
Possibly applicable ●
Highly applicable ●●

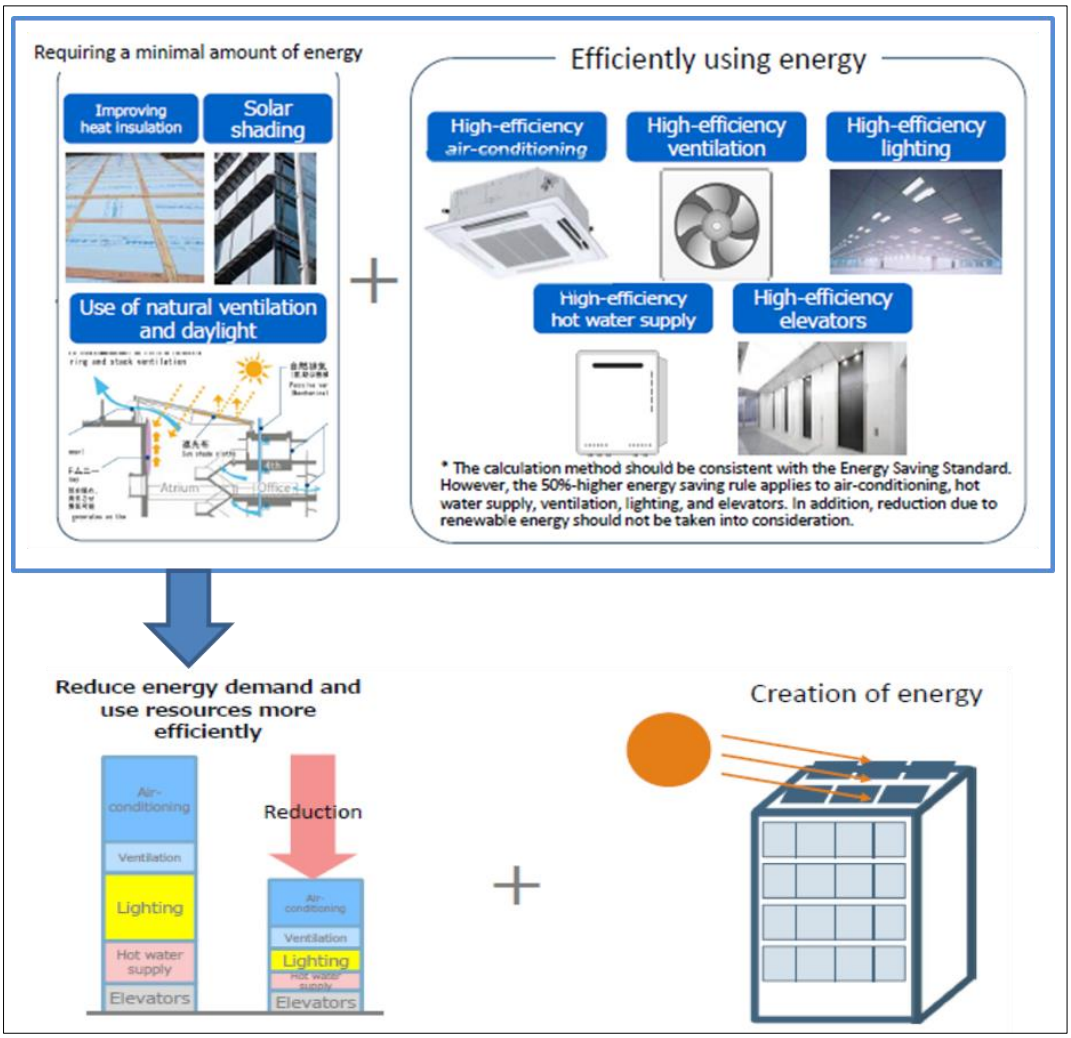
(a) **Example of Application of Low Carbon Building Measures in Japan:** Combination of passive energy design, improvement of energy efficiency, and on-site renewable energy measures

Comprehensive Assessment System for Building Environment Efficiency (CASBEE) is adopted as comprehensive assessment system for environmental performance of the buildings in Japan. For evaluating from an energy perspective, “Building Energy-efficiency Labeling System (BELS)” was established as a system to simply evaluate and indicate energy conservation performance of non-residential buildings on April 2014 by the Ministry of Land, Infrastructure, Transport and Tourism, Japan. In terms of the energy conservation of the buildings, Japan’s Strategic Energy Plan (adopted at the Cabinet Council in April 2014) established the following goals to realize and promote the Net Zero Energy Building (ZEBs):

(i) Realize ZEBs in newly constructed public buildings by 2020; and

(ii) Realize ZEBs in average by newly constructed public and private buildings by 2030.

A ZEB is a building with considerably reduced annual energy consumption by saving as much energy as possible via better heat insulation, solar shading, natural energy and high-efficiency equipment as well as creating energy (e.g., with photovoltaic power generation), while maintaining comfortable environments. In addition to the energy saving measures including passive energy design and energy efficient equipment recommended in the concept of the Low-Carbon Town in the APEC region, the combination of renewable energy utilization is proposed by the concept of ZEBs. BELS is used to simply evaluate and indicate the rate of energy conservation and promote the ZEBs.




Source: METI, Japan.

**Figure 10.2.3 Comprehensive Assessment System for Building Environment Efficiency**

## 10.3 $CO_2$ Reduction Analysis and Cost Estimates

### 10.3.1 $CO_2$ Emission Reduction Analysis

Mandaue City mandated green building for all public buildings, and for new private buildings located in GGA areas. Therefore, the GHG emission reductions are estimated based on the assumption that new buildings to be constructed after the issuance of GBO will apply the green building design to satisfy BERDE requirement and will undoubtedly achieve energy saving. Although the amount of energy saving varies depending on the combination of measures, the condition of buildings and also behavior of uses, etc., the baseline energy use intensity and average saving potential per building type shown in Table 10.3.1 are used for the estimation of energy saving in this study.

For energy use intensity ($kWh/m^2$) of residential buildings, not enough statistics data is available for Mandaue as well as for the Philippines. The information below will be used as reference, where the figures (400 $kWh/m^2$) for the baseline energy used of vertical residential was adopted from the BERDE rating schemes. Although energy use intensity

of 400kWh/$m^2$ seems quite high as a residential building, it is used as the baseline here following the BERDE rating schemes and also taking into account that the most planned residential developments in GGAs are high rise condominiums.

For the remaining building types, the energy use intensity and average saving potential based on a study conducted by the International Finance Corporation on the energy saving potential in the Philippine commercial sector in 2010 were used. The energy use intensity and average saving potential were estimated by conducting building energy survey among more than 125 commercial buildings in the economy and walk through energy audits for selected buildings. Figures adopted were of malls to commercial buildings, and 1 shift office buildings for institutional (public) buildings.

**Table 10.3.1 Energy Use Intensity of Residential Buildings**

| Building Type | Energy Use Intensity (kWh/$m^2$) | Average Savings to Total Consumption (%) | Data Source |
|---|---|---|---|
| Vertical Residential | 400 | 20 | BERDE New construction for Vertical Residential Development Version 1.1.0 (2013) |
| Malls | 230 | 20 | Study on the energy efficiency in the Philippine commercial sector, International Finance Corporation, November 2010 |
| Office Buildings (1 shift) | 279 | 19 | |
| Hotels | 163 | 23 | |

Source: Study on the energy efficiency in the Philippine commercial sector, International Finance Corporation, November 2010.

The floor area mentioned in Table 10.3.2 is the estimated overall floor area of new constructions in GGAs by 2030. This figure was applied as the GBO mandatorily requires all new buildings within GGAs to apply for BERDE certification.

Using the energy use intensity, the baseline energy consumption of each building type was calculated where estimated floor area for each building type is multiplied by the relevant energy intensity. As for the energy saving of green buildings, estimated floor areas are multiplied by the relevant energy intensity, then by the relevant average savings to total consumption.

**Table 10.3.2 Energy Consumption of Buildings in Mandaue**

| Building Type | Floor Area ($m^2$) | Baseline | | With Green Building | | Green Building Scenario |
|---|---|---|---|---|---|---|
| | | Energy Use Intensity (kWh/$m^2$) | Energy Consumption (MWh) | Energy Use Intensity (kWh/$m^2$) | Energy Consumption (MWh) | Energy Saving by Green Building (MWh) |
| Residential | 3,833,506 | 400 | 1,533,402 | 320 | 1,226,722 | 306,680 |
| Commercial | 6,267,658 | 230 | 1,441,561 | 184 | 1,153,249 | 288,312 |
| Institutional | 349,972 | 167 | 58,445 | 135 | 47,341 | 11,105 |
| Total | 10,451,136 | - | 3,033,409 | - | 2,427,312 | 606,097 |

Source: APEC Study Team

Putting the assumption that the emission reduction will be from the saving of grid electricity, the $CO_2$ emission reduction from the building sector was then calculated by multiplying the energy consumption by the grid emission factor, 0.512 ($tCO_2$/MWh). As a result, 310,322 ($tCO_2$/year) is estimated to be reduced by the applications of green buildings in 2030.

**Table 10.3.3 Emission Reduction by the Energy Saved**

| Building Type | $CO_2$emission Reduction ($tCO_2$/year) |
|---|---|
| Residential | 157,020 |
| Commercial | 147,616 |
| Institutional | 5,686 |
| Total | 310,322 |

Source: APEC Study Team

## 10.3.2 Cost Estimate

The table below summarizes average cost of selected low carbon building measures. Sources are based on international research results and reports by manufacturers. It must be mentioned that costs vary depending on several factors such as types of equipment used as technology develops daily, number and size of equipment used, etc.

**Table 10.3.4 Estimated Cost of Potential Low-Carbon Building Measures**

| Low-Carbon Building Measures | Estimated Cost | Information Source |
|---|---|---|
| Passive | | |
| Natural Ventilation Systems | | |
| Natural Day Lighting | (Natural day lighting) Light sensors and dimming controls: for a building larger than 9,290$m^2$ is estimated at USD5.92/$m^2$ | USDOE, Technical Support Document: Strategies for 50% Energy Savings in Large Office Buildings |
| Roof Greenery | USD10-25/$f^2$ | Natural Resource Defense Council https://www.nrdc.org/sites/default/files/GreenRoofsReport.pdf |
| Energy Efficient Building Envelope | Air barrier USD15.07/$m^2$ of exterior wall area | USDOE, Technical Support Document: Strategies for 50% Energy Savings in Large Office Buildings |
| Low E-Glass | USD41.80~93.70/$ft^2$ depending on type of glass | USDOE, Technical Support Document: Strategies for 50% Energy Savings in Large Office Buildings |
| Improvement of Energy Efficiency of Equipment | | |
| Energy Efficient Chiller | USD0.827M | Restructuring paper on a proposed project restructuring of PH – Chiller energy efficiency project |
| | USD1.52/$ft^2$ | USDOE, Technical Support Document: Strategies for 50% Energy Savings in Large Office Buildings |
| Energy Efficient Lighting | USD30-USD50 depending on design | Final report EE in the Phil Commercial Sector |
| | USD67.70~123.90/$m^2$ depending on lighting type, each set every 5.4~7.4$m^2$ | USDOE, Technical Support Document: Strategies for 50% Energy Savings in Large Office Buildings |
| BEMS | P5M-P15M depending on number of control points | Final report EE in the Phil Commercial Sector |
| On-site Renewable Energy | | |
| Solar PV System | USD4.00/Watt | USDOE, Technical Support Document: Strategies for 50% Energy Savings in Large Office Buildings |
| Solar Water Heating | USD1,000–USD2,000 | Final report EE in the Phil Commercial Sector |

Source: APEC Study Team culled from cited sources.

Regarding the analysis of unit cost of $CO_2$ emission reductions, the above-mentioned study conducted by IFC also estimated potential investments for energy efficiency of the buildings as shown in Table 10.3.5. The information is only available for commercial buildings.

### Table 10.3.5 The Information of Unit Cost of Energy Saving and $CO_2$ Emission Reduction

| Building Type | Unit Cost of Energy Saving (USD/MWh) | Unit Cost of $CO_2$ Emission Reduction (USD/t$CO_2$) |
|---|---|---|
| Vertical Residential | N/A | N/A |
| Malls | 277 | 541 |
| Office Buildings (1 shift) | 227 | 443 |
| Hotels | 467 | 912 |

Source: Study on the Energy Efficiency in the Philippine Commercial Sector, International Finance Corporation, November 2010.

# 11 GREEN GROWTH AREAS PLANNING

## 11.1 Existing Situation of Green Growth Areas

### 11.1.1 Existing Land Use

The aggregate total area of all designated green growth areas (GGAs) of Mandaue City is 848 hectares, which is approximately 0.26% of the city's land area of 32.85 square kilometers. The existing general land uses of each GGA are given in Table 11.1.1, while the urban land uses are given in Table 11.1.2 and shown in Figure 11.1.1. It can be noted that GGAs 1 to 3 are basically built-up with a high percentage of their areas already urbanized. GGAs 4 to 6, on the other hand, are currently much smaller in land size and are less urbanized owing to the character of the lands which are more of pasture areas, idle lands, marshlands and mangrove areas. Nevertheless, these areas are subject to planned development as GGAs since there will be land reclamation activities to increase their sizes coupled with pending large realty developments for residential, commercial, industrial and tourism purposes. The envisioned development for these latter areas is, however, expected to take a considerable amount of time compared to the developments for GGAs 1 to 3.

**Table 11.1.1 General Land Use of Green Growth Areas of Mandaue City, 2016**

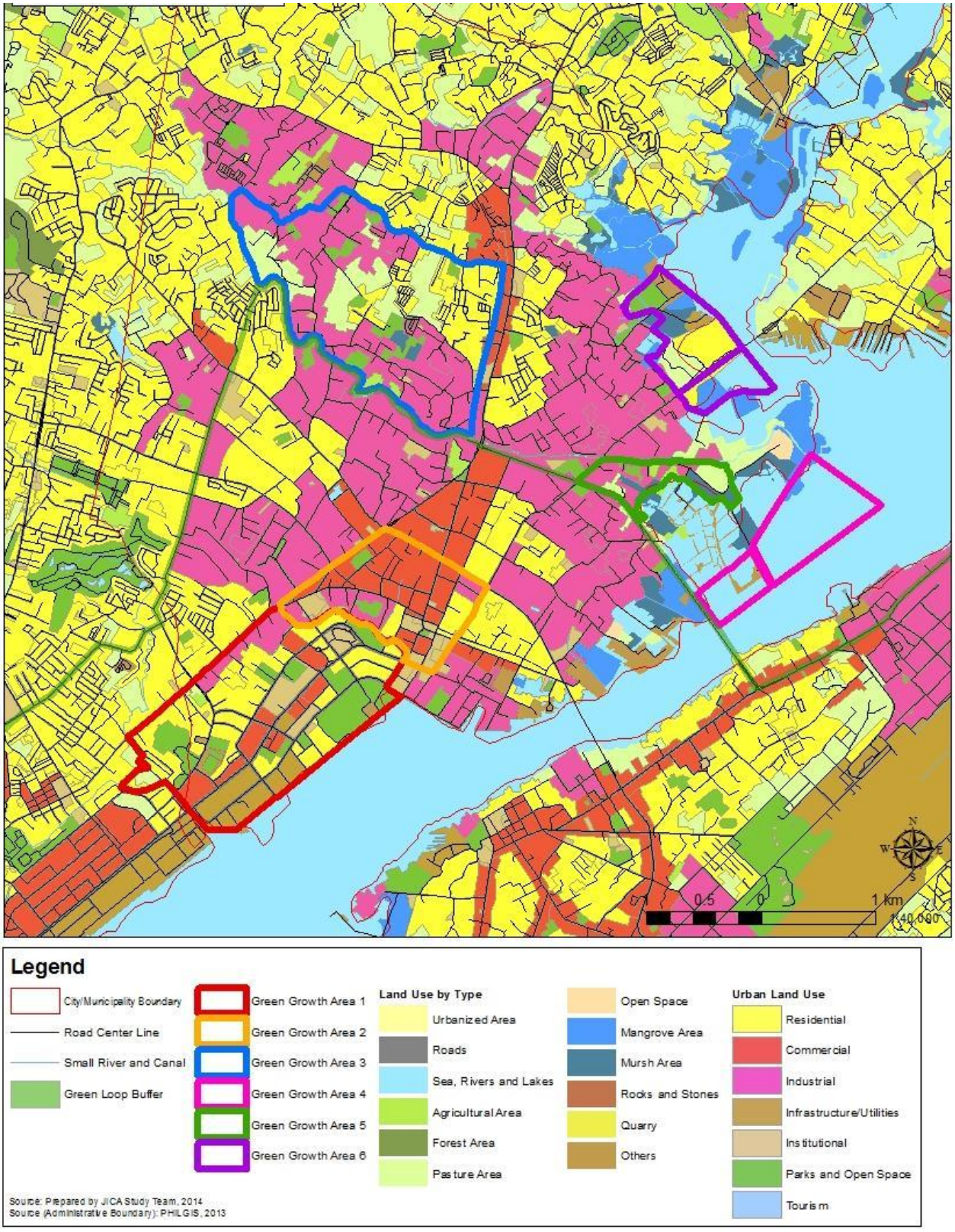
| General Land Use | GGA 1 | | GGA 2 | | GGA 3 | | GGA 4 | | GGA 5 | | GGA 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area (ha) | % of Total | Area (ha) | % of Total | Area (ha) | % of Total | Area (ha) | % of Total | Area (ha) | % of Total | Area (ha) | % of Total |
| Urbanized Area | 224.0 | 83.6 | 103.9 | 91.7 | 212.0 | 75.9 | - | - | 15.4 | 44.3 | 28.8 | 39.4 |
| Roads | 33.5 | 12.5 | 8.8 | 7.8 | 7.5 | 2.7 | - | - | 0.8 | 2.3 | 1.1 | 1.6 |
| Sea, Rivers and Lakes | 1.2 | 0.5 | 0.5 | 0.5 | 0.1 | 0.0 | 73.2 | 91.9 | 0.0 | 0.0 | 13.0 | 17.8 |
| Agricultural, Pasture, Open Space Areas | 4.4 | 1.6 | - | - | 57.1 | 20.4 | - | - | 10.5 | 30.0 | - | - |
| Mangrove Area | - | 0.0 | - | - | - | - | 3.3 | 4.2 | - | - | 9.1 | 12.5 |
| Marsh Area | - | 0.0 | - | - | 2.9 | 1.0 | 0.2 | 0.2 | 8.1 | 23.3 | 6.3 | 8.6 |
| Others | 4.9 | 1.8 | - | - | - | - | 3.0 | 3.7 | - | - | 4.8 | 6.5 |
| Total | 267.9 | | 113.2 | | 279.5 | | 79.7 | | 34.8 | | 73.1 | |

Source: APEC Study Team.

**Table 11.1.2 Urban Land Uses of Green Growth Areas of Mandaue City, 2016**

| Urban Land Use | GGA 1 | | GGA 2 | | GGA 3 | | GGA 4 | | GGA 5 | | GGA 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area (ha) | % of Total | Area (ha) | % of Total | Area (ha) | % of Total | Area (ha) | % of Total | Area (ha) | % of Total | Area (ha) | % of Total |
| Residential | 126.8 | 47.3 | 11.6 | 10.3 | 53.1 | 19.0 | 0 | 0 | - | - | 19.4 | 26.5 |
| Commercial | 0.01 | 0.0003 | 54.6 | 48.3 | 0.8 | 0.3 | 0 | 0 | - | - | - | - |
| Industrial | 15.1 | 5.7 | 18.8 | 16.6 | 139.0 | 49.7 | 0 | 0 | 14.0 | 40.1 | 1.1 | 1.5 |
| Infrastructure/Utilities | 27.1 | 10.1 | - | - | - | - | 0 | 0 | - | - | 2.1 | 2.9 |
| Institutional | 3.7 | 1.4 | 14.4 | 12.7 | 1.9 | 0.7 | 0 | 0 | - | - | - | - |
| Parks and Other Recreational Spaces | 51.2 | 19.1 | 4.4 | 3.9 | 17.2 | 6.1 | 0 | 0 | 1.5 | 4.2 | 6.2 | 8.4 |
| Tourism | 0.0 | 0.0 | - | - | - | - | 0 | 0 | - | - | - | - |
| Special Institutional Zone | 0.0 | 0.0 | - | - | - | - | 0 | 0 | - | - | - | - |
| Total Urbanized Area | 224.0 | 83.6 | 103.9 | 91.7 | 212.0 | 75.9 | - | - | 15.4 | 44.3 | 28.8 | 39.4 |

Source: APEC Study Team.




Source: APEC Study Team.

**Figure 11.1.1 Existing Land Uses of Green Growth Areas of Mandaue City, 2016**

### (1) GGA1

GGA1, otherwise called the South Point Reclamation Area since the 1980s, has a total area of 268 hectares. It has been divided into large blocks with provision of a wide road network (road/area ratio of 12.5%). Although many blocks are still vacant, land development and preparation of the entire area has been completed. In this sense, there are no non-urbanized lands (see Figure 11.1.2). In GGA1, there are 1,333 realty properties with tax declarations showing existing buildings. Majority of the current buildings is commercial in nature with 64% of total building floors utilized for commercial purposes. This is followed by 26% of floor spaces for institutional use, 6% for industrial use, and 3% for residential use. The average floor area per building is 598 sq.m., which is the largest among the GGAs.

### (2) GGA2

GGA2 measures 113 hectares and is the city core which historically developed as the first urbanized place of Mandaue City. Main land uses are commercial, industrial, institutional and residential. Typical to the era of old town centers during the Spanish regime, the roads are narrow and of close-knit grid pattern. The road area ratio is moderate at 7.8% (see Figure 11.1.3).

Currently there are 3,627 properties in the area. Based on floor space, commercial use account for the largest share at 51%, followed by 38% residential, 8% institutional, and 3% industrial. Since existing buildings are comparatively small, the average floor area per building is 167 sq.m.

### (3) GGA3

GGA3 measures 279 hectares and is mostly urbanized with industrial and residential buildings while the remaining 25% of the land is still vacant or idle (see Figure 11.1.4). The area has 2,425 buildings with 44% of the floor area occupied for industrial use, followed by 35% for residential use, 19% for commercial and 1% for institutional. The average floor area per building is moderate in size at 177 sq.m.

The remaining idle lands are attributable to the poor and incomplete road network. The existing land use problem is a mixture of residences and industries.

### (4) GGA4

Currently, GGA4 (100 hectares) consists largely of mangrove habitat areas and open wetlands, which are partly used for aquaculture industries (see Figure 11.1.5). Of the six buildings in this growth area, 59% of the floor area is for commercial use, 40% for residential, and there are no industrial or institutional buildings.

#### (5) GGA5

GGA5 is the smallest area, at 35 hectares, where urban and non-urban areas co-exist. The largest land use is open space/ idle land (29%), followed by marsh area (23%), residential (20%), and industrial (16%) (see Figure 11.1.6).

There are 107 buildings declared in GGA5, where 46% of total floor area is utilized for commercial purposes, 42% is industrial, and the rest is residential. The average building floor area is 223 sq.m.

#### (6) GGA6

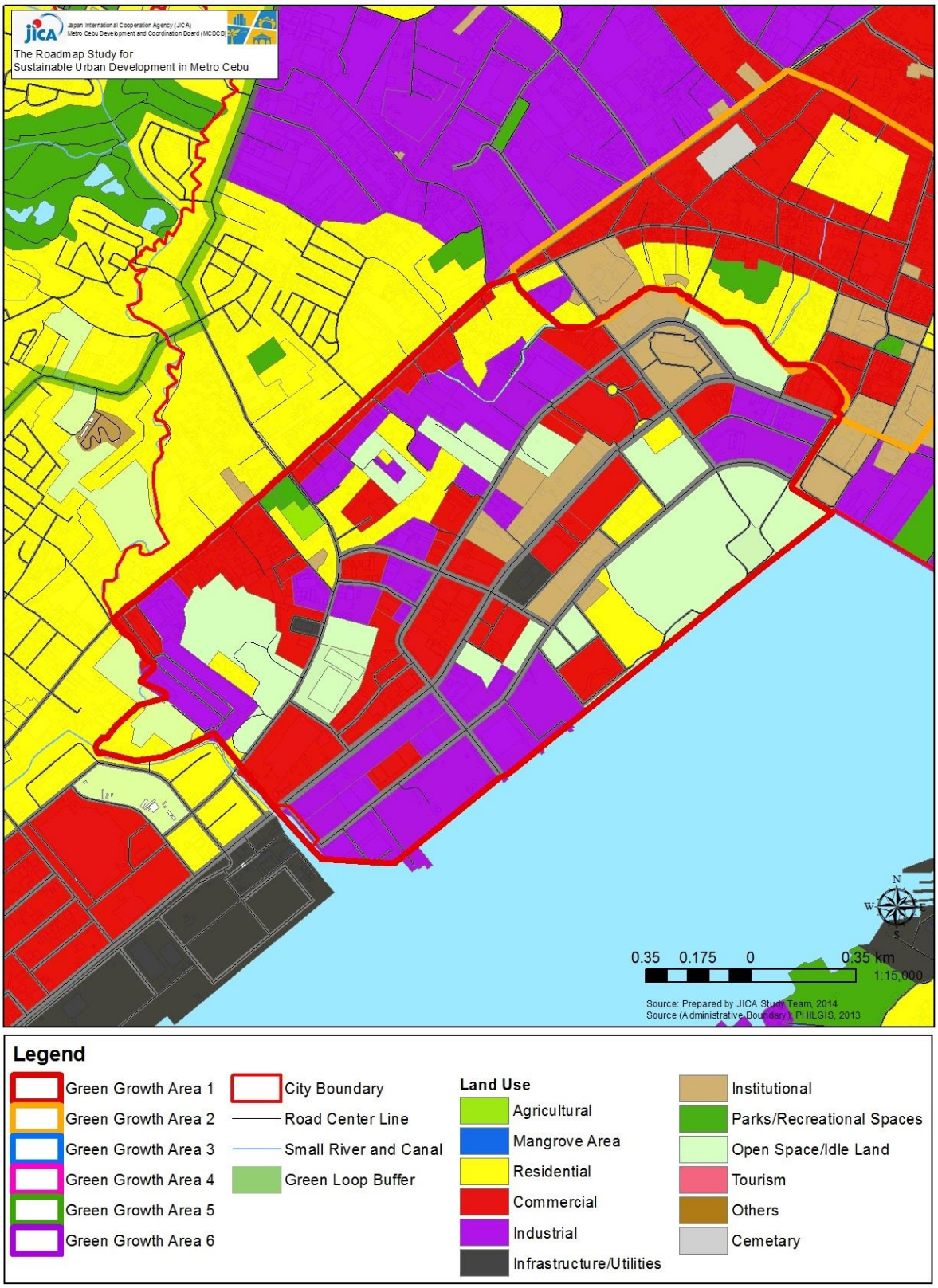
GGA6 is a 94-hectare area facing the Cansaga Bay. Currently, the area consists largely of mangrove habitats, open grasslands and a few residential units (see Figure 11.1.7). There are only 7 properties with commercial buildings.

### 11.1.2 Existing Buildings

An inventory of the buildings currently found in the GGAs were processed from the database of Mandaue City. The records of structures and their aggregated floor areas of various uses are given in Table 11.1.3.

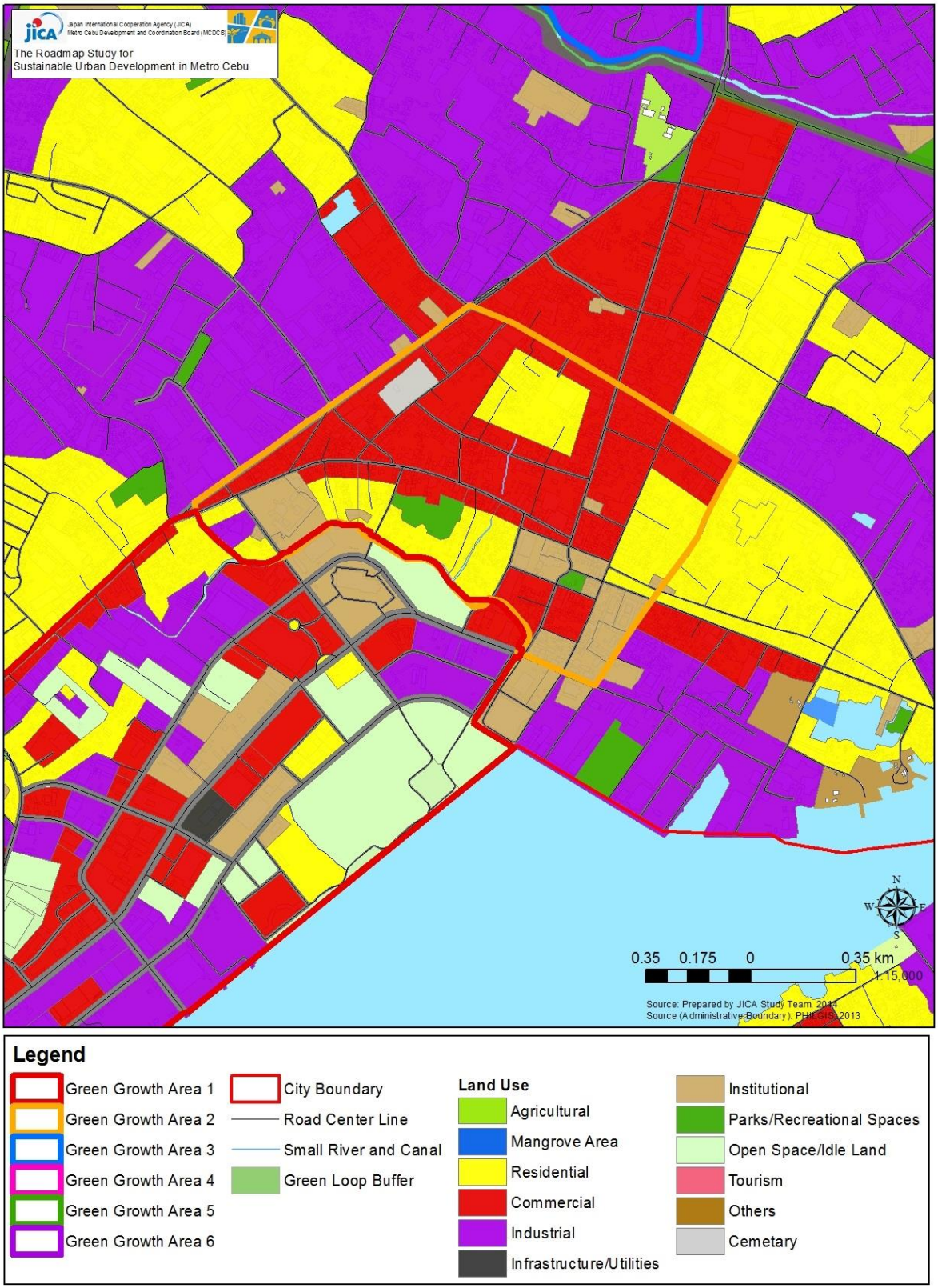
The processed data for buildings were derived from the records of the tax declaration of properties. Only those properties with declared buildings were selected for further processing. These can represent the existing buildings in Mandaue City. The information provided the use of the building and the floor areas only. The age of the buildings were based on the dates these were registered but these information were cautiously interpreted since computerization of the data only started in 2001. Hence, it was presumed that all buildings registered in 2001 could be older than 15 years. Some of those recorded in 2002 may also be a flow over of 2001 and could be older as well but, without any other means of weeding them out, these were grouped in the 14–11 year old buildings.

At a glance, it is noted that the GGA2 holds the most number of buildings, followed by GGA1 and GGA3. As the "poblacion", GGA2 is the earliest urbanized place in the city with about 64% of the buildings inventoried as old beyond the 15-year old recording of the city. There is no new building recorded to have been built within the recent 5-year period (see Table 11.1.3). On the whole, many of the buildings are for commercial and residential uses accounting for 51% and 38% of total floor area, respectively.



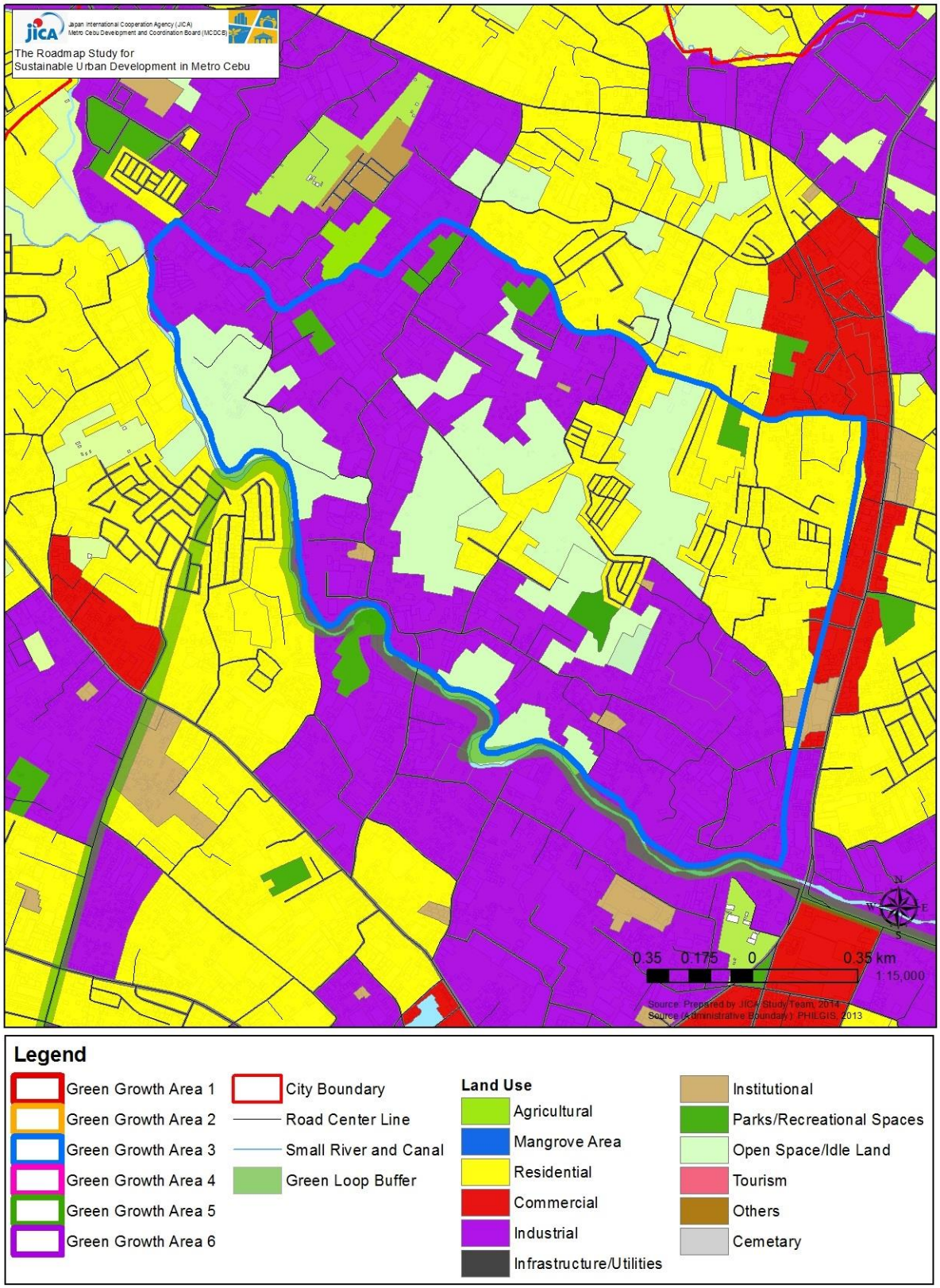

Source: APEC Study Team based on JICA study on "The Roadmap Study for Sustainable Urban Development in Metro Cebu" and discussions with Mandaue CPDO.

**Figure 11.1.2 Existing Land Use for GGA1**



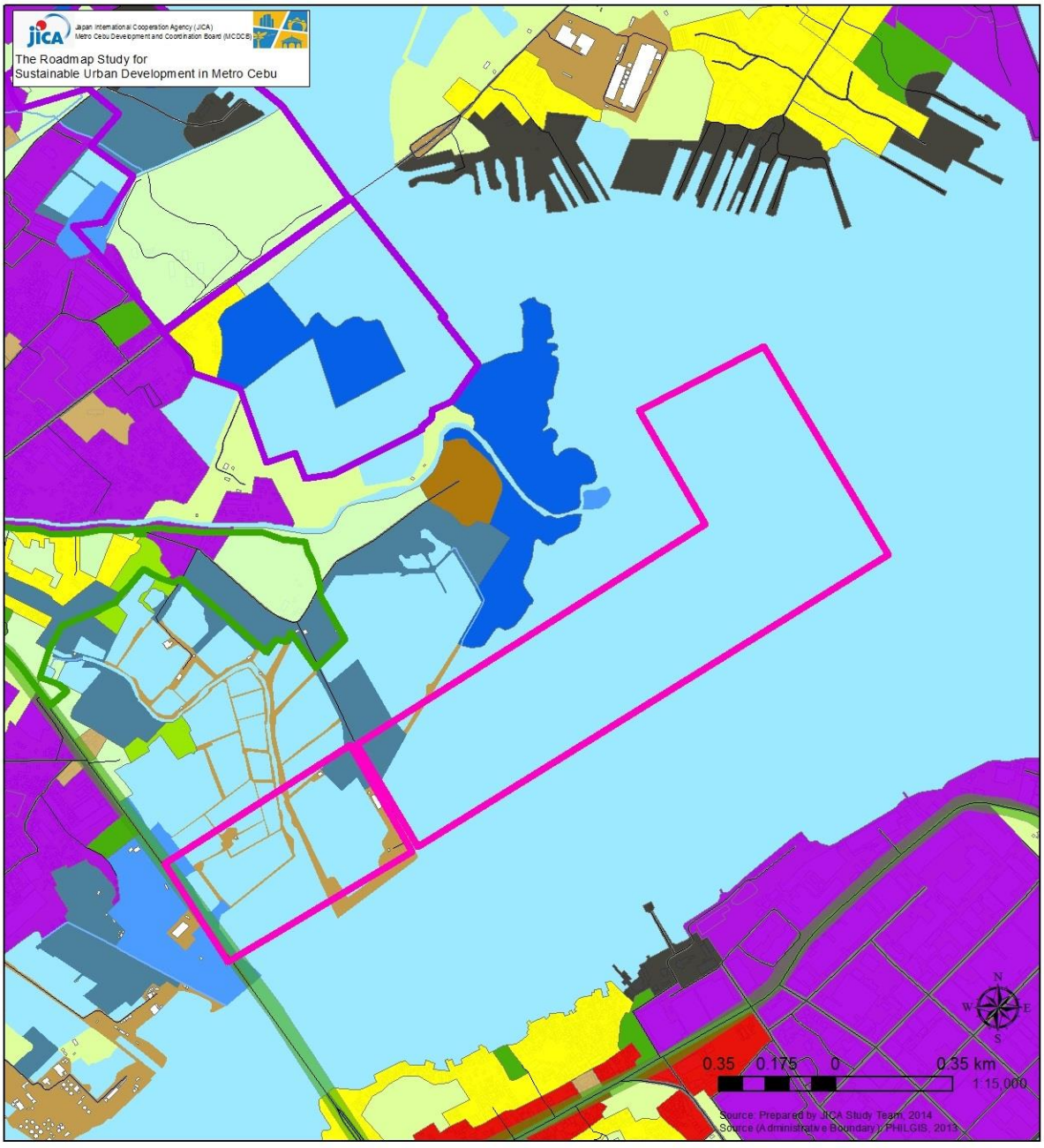

Source: APEC Study Team based on JICA study on "The Roadmap Study for Sustainable Urban Development in Metro Cebu" and discussions with Mandaue CPDO.

**Figure 11.1.3 Existing Land Use for GGA2**



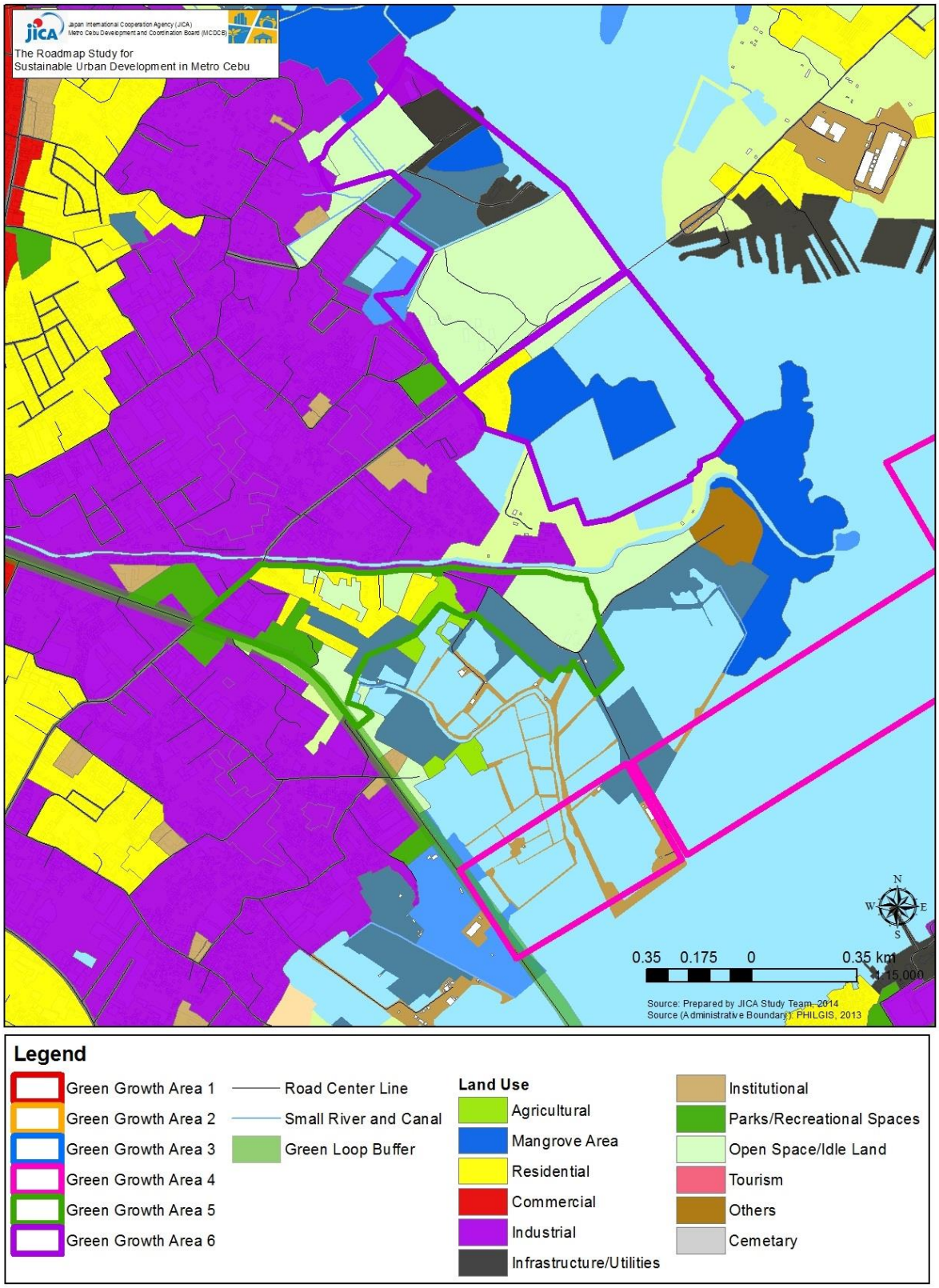

Source: APEC Study Team based on JICA study on "The Roadmap Study for Sustainable Urban Development in Metro Cebu" and discussions with Mandaue CPDO.

**Figure 11.1.4 Existing Land Use for GGA3**



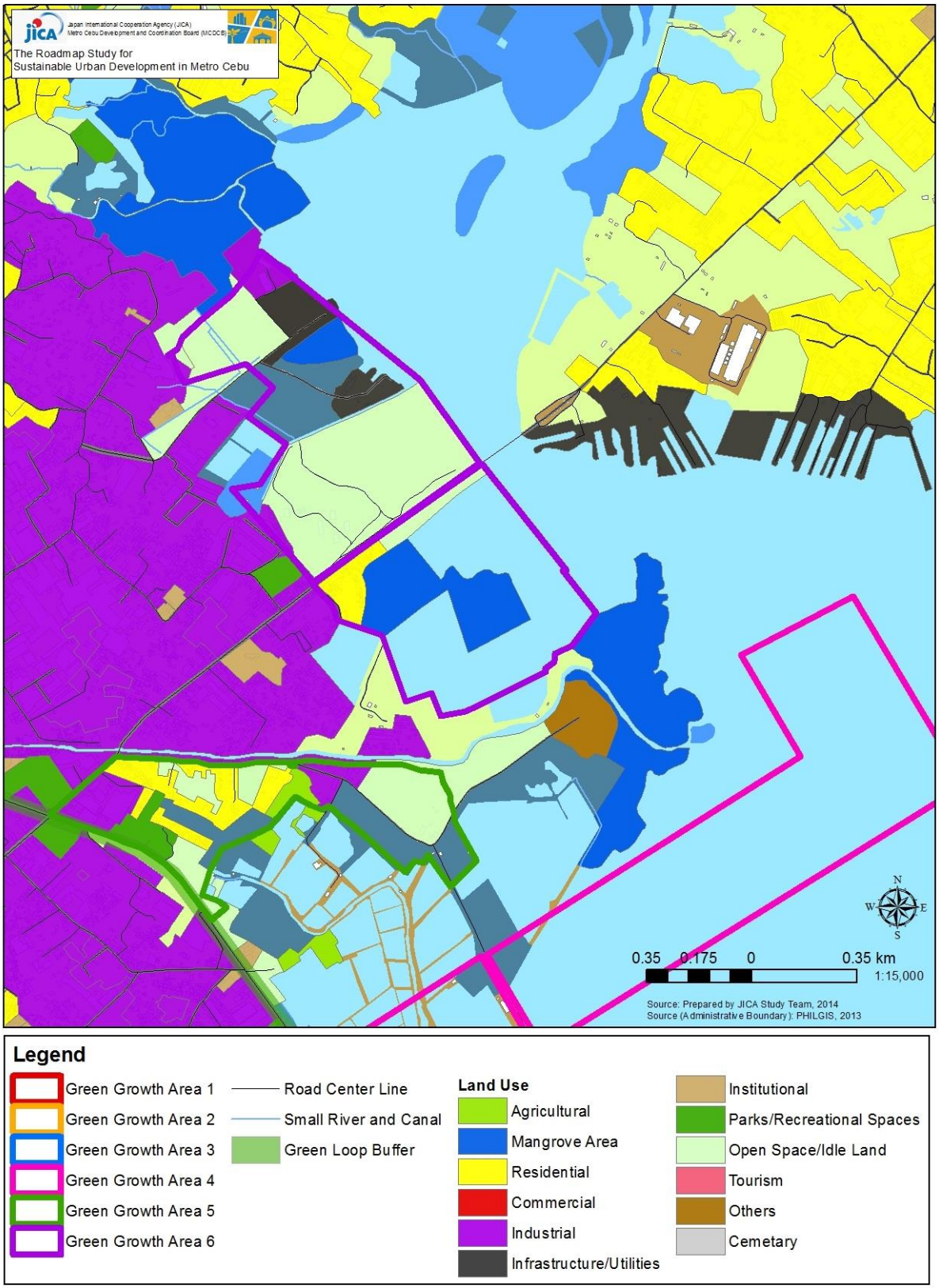

Source: APEC Study Team based on JICA study on "The Roadmap Study for Sustainable Urban Development in Metro Cebu" and discussions with Mandaue CPDO.

**Figure 11.1.5 Existing Land Use for GGA4**




Source: APEC Study Team based on JICA study on "The Roadmap Study for Sustainable Urban Development in Metro Cebu" and discussions with Mandaue CPDO.

**Figure 11.1.6 Existing Land Use for GGA5**




Source: APEC Study Team based on JICA study on "The Roadmap Study for Sustainable Urban Development in Metro Cebu" and discussions with Mandaue CPDO.

**Figure 11.1.7 Existing Land Use for GGA5**

**Table 11.1.3 Existing Building Uses in Green Growth Areas**

| Age based on Registration (years) | No. of Existing Records | Building Uses ($m^2$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Residential Total Floor Area | Commercial Total Floor Area | Industrial Total Floor Area | Institutional Total Floor Area | Grand Total | % of Total |
| GGA 1 | | | | | | | |
| 15 above | 42 | 3,446 | 5,922 | - | 43,185 | 52,595 | 6.6 |
| 14 - 11 | 1,239 | 20,524 | 445,968 | 48,641 | 55,715 | 572,087 | 71.8 |
| 5 - 10 | 52 | 770 | 59,041 | 3,102 | 108,896 | 171,860 | 21.6 |
| below 5 | - | - | - | - | - | - | |
| Total | 1,333 | 24,739 | 510,931 | 51,743 | 207,796 | 796,542 | 100.0 |
| | % of Total | 3.1 | 64.1 | 6.5 | 26.1 | 100.0 | |
| GGA 2 | | | | | | | |
| 15 above | 2,635 | 153,900 | 174,907 | 12,362 | 43,148 | 386,951 | 63.9 |
| 14 - 11 | 924 | 69,387 | 129,544 | 5,565 | 5,123 | 210,543 | 34.8 |
| 5 - 10 | 68 | 4,399 | 2,665 | 863 | - | 7,995 | 1.3 |
| below 5 | - | - | - | - | - | - | - |
| Total | 3,627 | 227,686 | 307,116 | 18,790 | 48,271 | 605,489 | 100.0 |
| | % of Total | 37.6 | 50.7 | 3.1 | 8.0 | 100.0 | |
| GGA 3 | | | | | | | |
| 15 above | 0 | - | - | - | - | - | - |
| 14 - 11 | 2404 | 146,585 | 82,009 | 188,306 | 6,271 | 425,576 | 99.2 |
| 5 - 10 | 21 | 1,633 | 880 | 869 | - | 3,403 | 0.8 |
| below 5 | 0 | - | - | - | - | | - |
| Total | 2425 | 148,219 | 82,889 | 189,175 | 6,271 | 428,979 | 100.0 |
| | % of Total | 34.6 | 19.3 | 44.1 | 1.5 | 100.0 | |
| GGA 4 | | | | | | | |
| 15 above | 0 | - | - | - | - | - | - |
| 14 - 11 | 6 | 391 | 570 | - | - | 967 | 100.0 |
| 5 - 10 | 0 | - | - | - | - | - | - |
| below 5 | 0 | - | - | - | - | - | - |
| Total | 6 | 391 | 570 | - | - | 967 | 100.0 |
| | % of Total | 40.4 | 58.9 | - | - | 100.0 | |
| GGA 5 | | | | | | | |
| 15 above | 36 | 1,091 | 289 | 4,680 | - | 6,097 | 25.6 |
| 14 - 11 | 67 | 1,658 | 10,395 | 4,880 | - | 17,000 | 71.3 |
| 5 - 10 | 4 | - | 338 | 388 | - | 730 | 3.1 |
| below 5 | - | - | - | - | - | - | - |
| Total | 107 | 2,749 | 11,023 | 9,948 | - | 23,827 | 100.0 |
| | % of Total | 11.5 | 46.3 | 41.8 | - | 100.0 | |
| GGA 6 | | | | | | | |
| 15 above | - | - | - | - | - | - | - |
| 14 - 11 | - | - | - | - | - | - | - |
| 5-Oct | 7 | - | 4,057 | - | - | 4,057 | 100.0 |
| below 5 | - | - | - | - | - | - | - |
| Total | 7 | - | 4,057 | - | - | 4,057 | 100.0 |
| | % of Total | - | 100.0 | - | - | 100.0 | |

Source: APEC Study Team based on Mandaue City MISO, 2016.
Note: Institutional includes schools, churches, hospitals, government offices and other community buildings.

In contrast, GGA1 is a new urbanized area since it is on the South-point Reclamation Area situated at the boundary of Cebu City. Commercial activities dominate the building uses, accounting for 64% of total floor area, and most buildings were built recently just

within the 11-14 year period.

GGA3, likewise, has more of its buildings within the 11–14 age bracket with industries taking up about 44% of the floor area.

Owing to its land features, GGAs 4 to 6 have far less buildings but endowed with open areas that are intended for future development.

## 11.2 Development Plan of GGAs

### 11.2.1 Future Land Use

The future land use of Mandaue City is expected to change with the intensification of uses on GGAs 1 to 3 and land altering developments on GGAs 4 to 6. The city has recently updated its CLUP, which sets the tempo for allowable changes in the GGAs as the Planned Units for Development (PUDs) as described below.

**(1) GGA1**

GGA1 is declared as one of the PUDs of the city. The theme of the area is that of a Civic and Trade Center Development where it will be treated as a CBD. It is meant primarily for high density office and residential developments on a metropolitan scale of operations with miscellaneous support uses.

Currently, there are two obvious investment patterns noted in GGA1. These are the logistics or warehouses and commercial buildings. However, the city has already informed owners of lands with special use permits (i.e., storage/warehouses and logistics use) that by 2018 said permits will no longer be valid and that they will have to comply with allowable uses for the area. Also, with the anticipated situation that a new container terminal will be developed at its neighboring town of Consolacion (i.e., Tayud), land demand for logistics will become small.

GGA1 will receive more investments for commercial, business, residential and public purposes. In particular, two sub-center development projects (Project Diana - 16.9 ha and Mandani Bay - 20 ha) will attract large investments up to year 2030. The Cebu International Convention Center (CICC), which was destroyed by earthquake and typhoon, was closed in 2013. It will be redeveloped as a multi-functional civic center. The future land use of GGA1 is shown in Figure 11.2.1 while images of the anticipated notable developments are shown in succeeding section 11.2.2.

**(2) GGA2**

The area within the "poblacion" and the stretch between the St. Joseph's Shrine and the watchtower "Bantayan sa Hari" facing the Mactan Channel is zoned as historic in GGA2. This historical tourism strip includes the existing city hall. The buildings within the strip will

be renewed to attract tourists. Social housing will be developed at Barangay Guizo where a large fire destroyed over 500 makeshift houses in early 2016. Figure 11.2.2 shows the future land use of the area.

The landscape of GGA2 is not expected to change drastically in the future with new buildings as it is built-up with relatively smaller plots of land, compared to the other growth areas, with zoning restrictions to building heights. Instead, redevelopment plans are on the drawing board to expand the open spaces and parks by tearing down selected dilapidated structures with no historical significance.

**(3) GGA3**

The existing idle lands will be developed in an orderly manner for industrial, institutional and residential uses with the BERDE system employed where applicable and incentives provided for the replacement of existing buildings and factories. This area is planned where existing residential subdivisions can coexist with the development of idle lots into a light intensity industrial use preferably of high-technology in nature but with low environmental impact. Joint ventures among several lot owners will be encouraged toward this end.

The existing road network that is narrow, circuitous and incomplete will be strengthened by means of road extensions, connections and widening as well as the implementation of the Green Loop along the Butuanon River.

The future land use plan for GGA3 is shown in Figure 11.2.3.

**(4) GGA4**

As one of the PUDs, this area is intended for recreation and tourism development. The area of GGA4 will be expanded through land reclamation. This will require a huge volume of rocks and sands. Since Mandaue City has been mostly urbanized, the materials for the reclamation will be acquired from outside areas such as Consolacion, Cebu City and other areas.

The area sits along the 2nd Mactan Bridge which is currently functioning as one of the main connections between Cebu Island and Mactan Island. The Mandaue Global City Project is proposed for this area, hence development will be undertaken through the improvement of transportation infrastructure and establishment of tourism-related places such as 5-star resort with hotels, high-end residential condominiums, sports and recreational establishments, thematic activity parks, and a mangrove eco-park. Figure 11.2.4 shows the future land use for GGA4.

The Mandaue Global City Project is intended to be a public-private partnership (PPP) undertaking. A perspective of the development is shown in the succeeding section 11.2.2.

#### (5) GGA5

GGA5 is intended for a medium industrial park development, which will prioritize high-value manufacturing activities. The area is bordered by the Butuanon River which is planned for the development of the Green Loop as a green corridor for non-motorized public transport coupled with environmentally sound amenities.

#### (6) GGA6

GGA6 is also planned as part of the Mandaue Global City with a separate reclamation area. The area is intended for residential-commercial mixed-use development creating a good mix of residential, commercial and institutional activities.

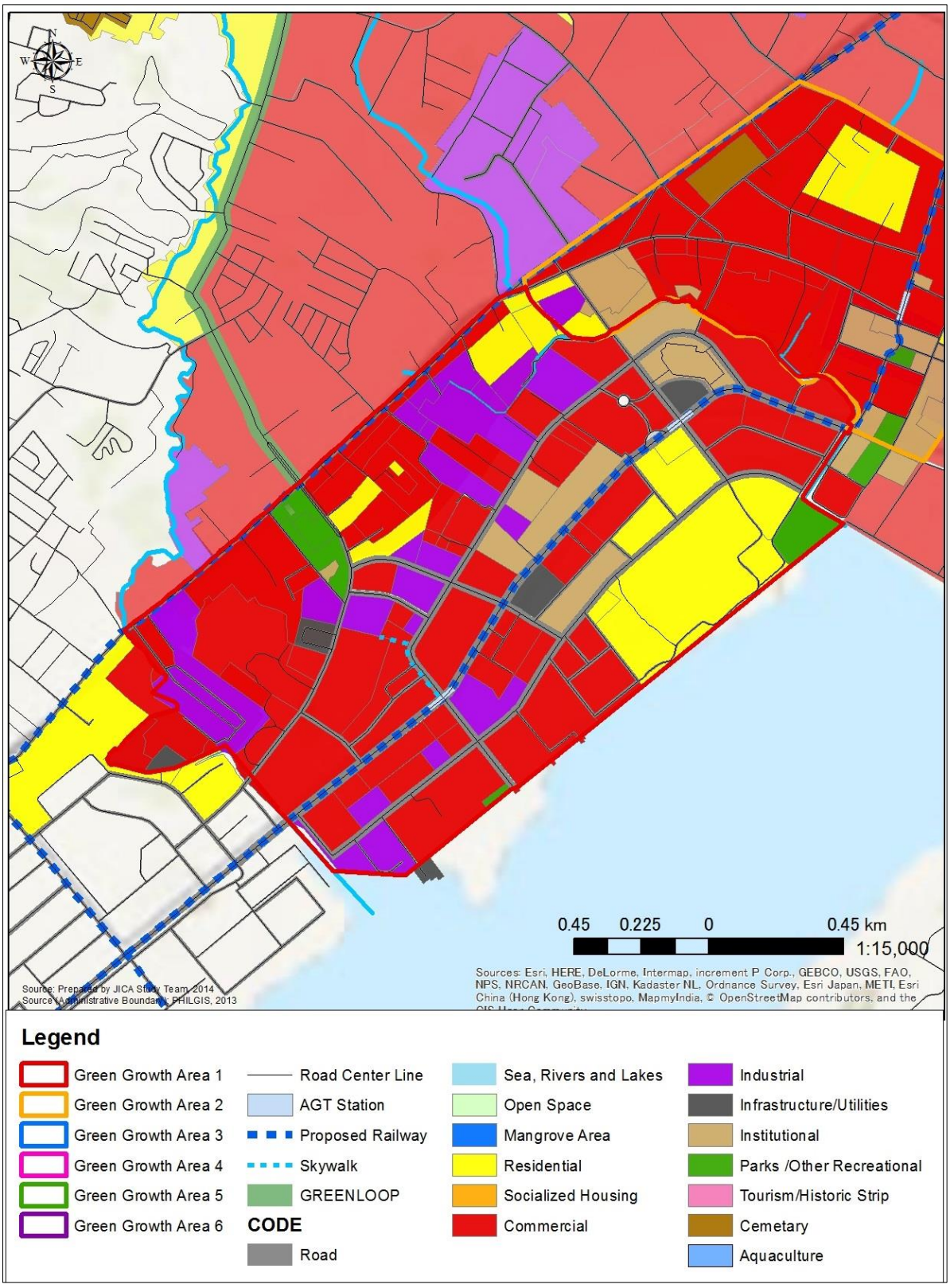
The Cansaga Bridge connecting Mandaue to Consolation runs through this development and a 2nd Cansaga Bridge is currently being planned for development. Development will entail improvement in infrastructure such as wide roads, preservation of mangroves, and construction of high-rise residential condominiums and resort hotels. Some land reclamation is intended for the southeast side of the area.

The future land use plan for GGA6 is shown in Figure 11.2.6.

### 11.2.2 Future Buildings

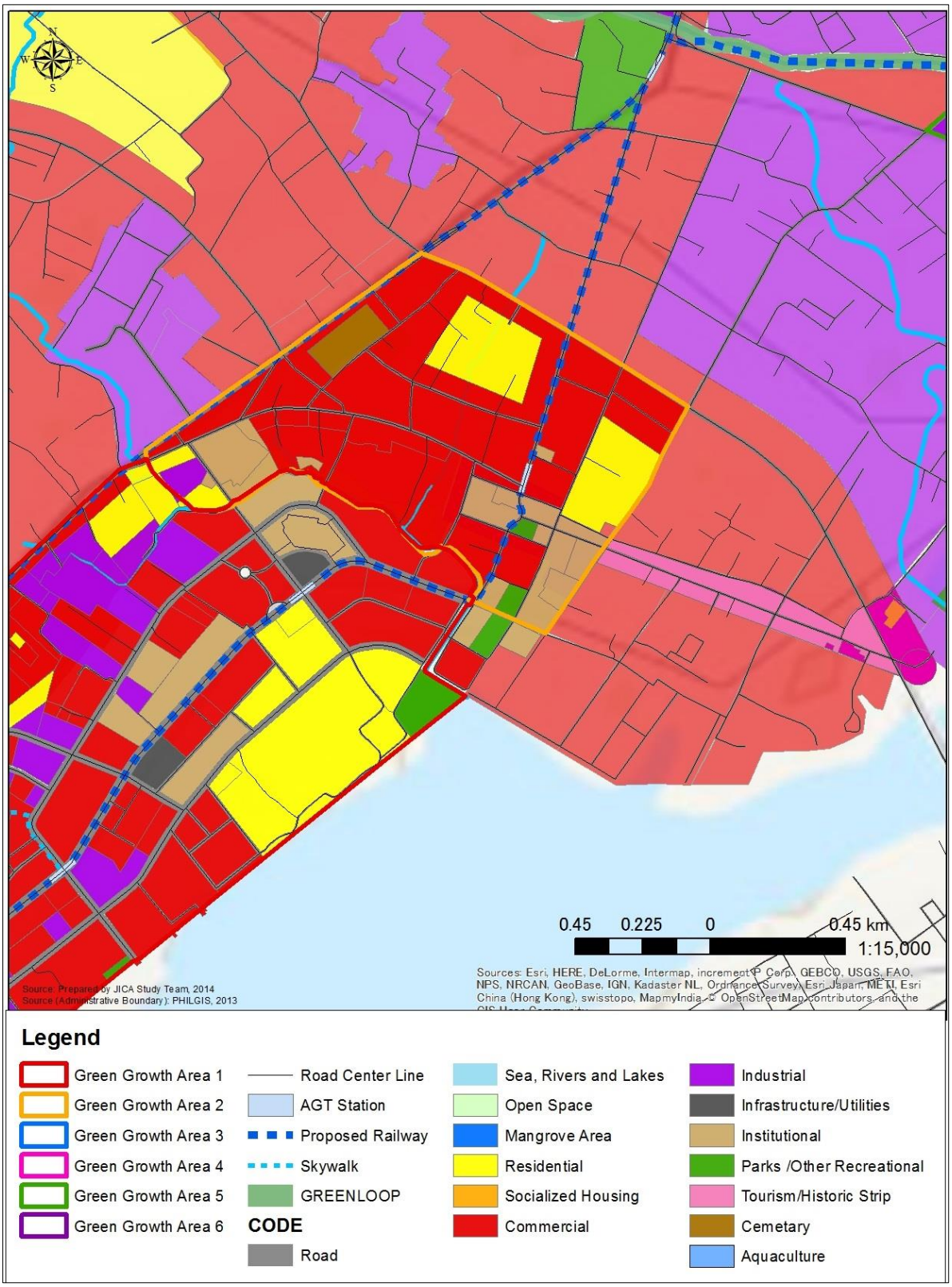
At about the same time the new CLUP was being formulated, the City of Mandaue drew up and enforced its Green Building Code whereby applications for permits to build new buildings will be mandated or required to undergo a rating for energy efficiency and conservation (i.e., BERDE or green building rating) with incentives offered for greener buildings. This will encourage the developers to employ optimal green designs and operation practices.

As Mandaue is moving towards densification in the green growth areas, it can be assumed that information submitted to DENR-EMB Region VII from large-scale developers would already be substantial (see Table 11.2.1). Images of these developments are shown in Figures 11.2.7 and 11.2.8.



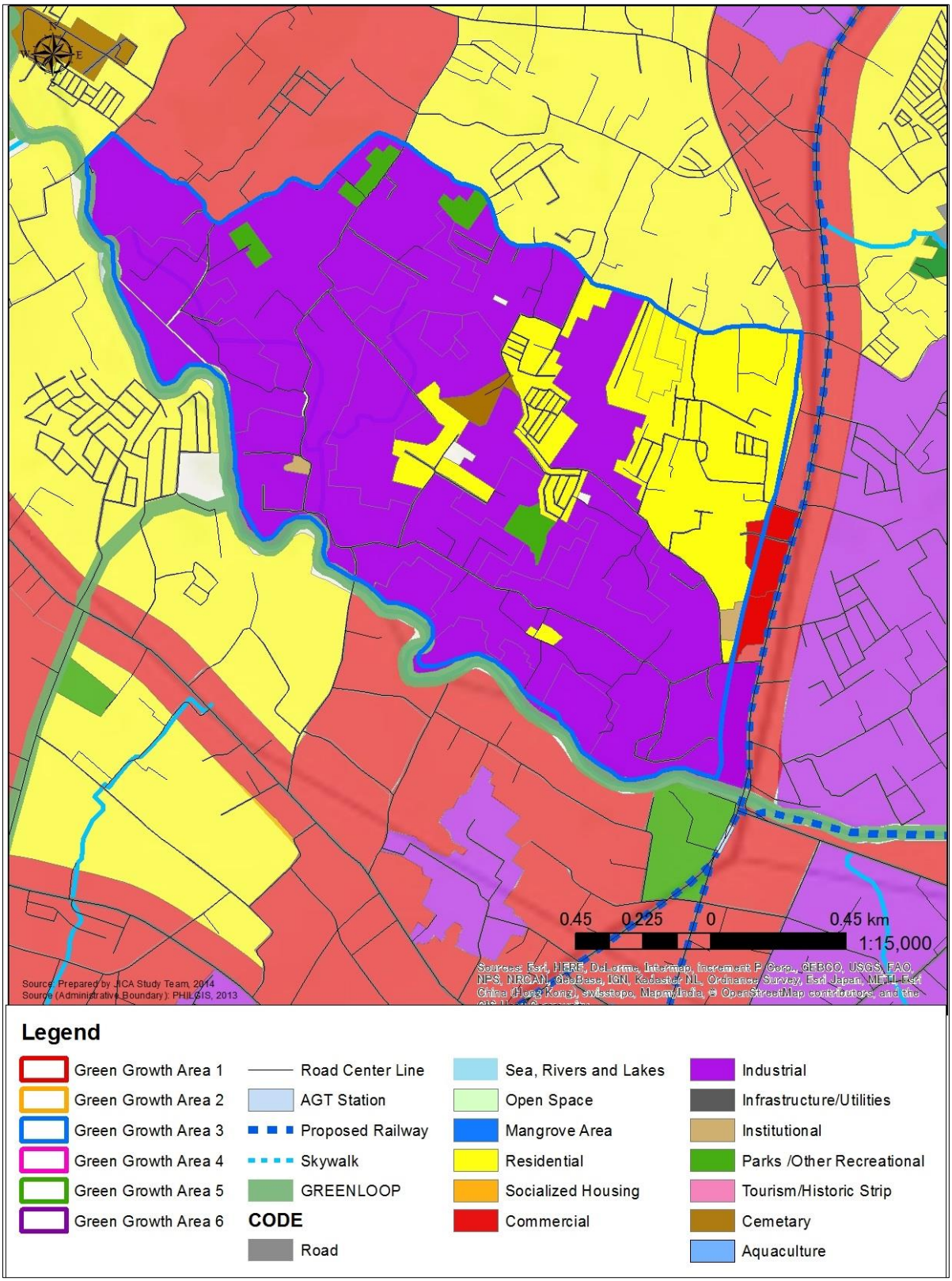

Source: APEC Study Team based on discussions with Mandaue CPDO.

**Figure 11.2.1 Future Land Use Plan for GGA1**



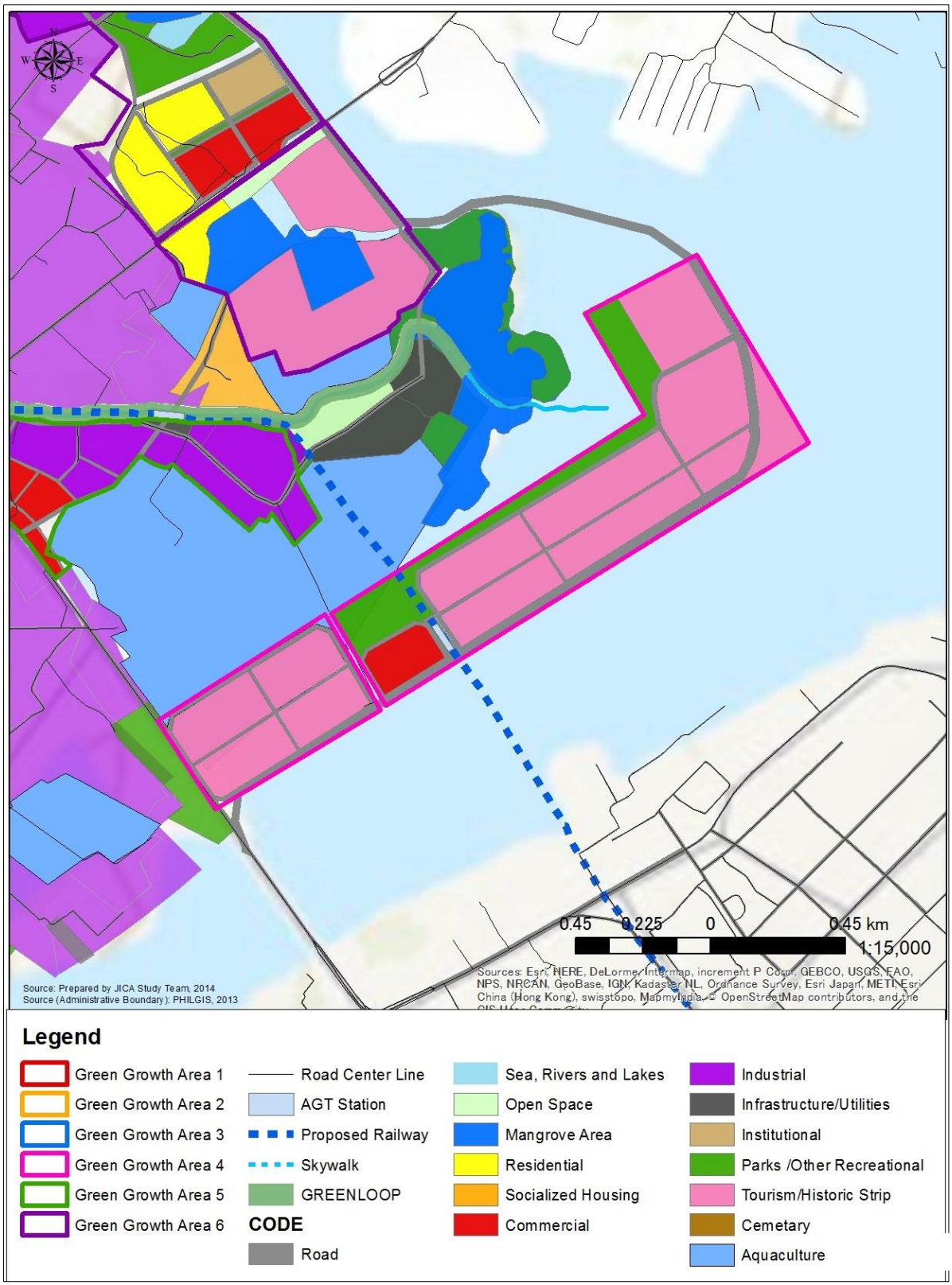

Source: APEC Study Team based on discussions with Mandaue CPDO.

**Figure 11.2.2 Future Land Use Plan for GGA2**



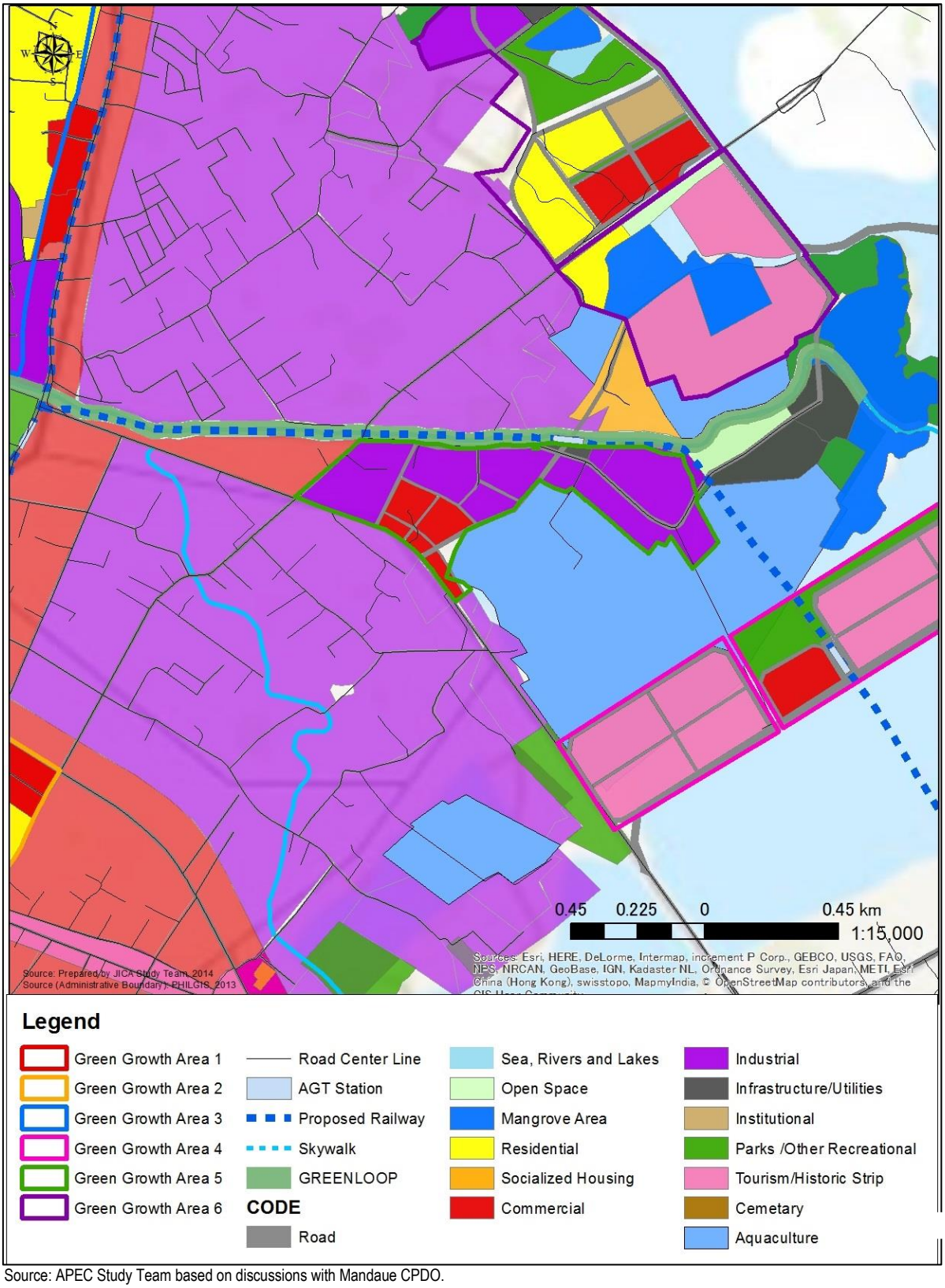

Source: APEC Study Team based on discussions with Mandaue CPDO.

**Figure 11.2.3 Future Land Use Plan for GGA3**



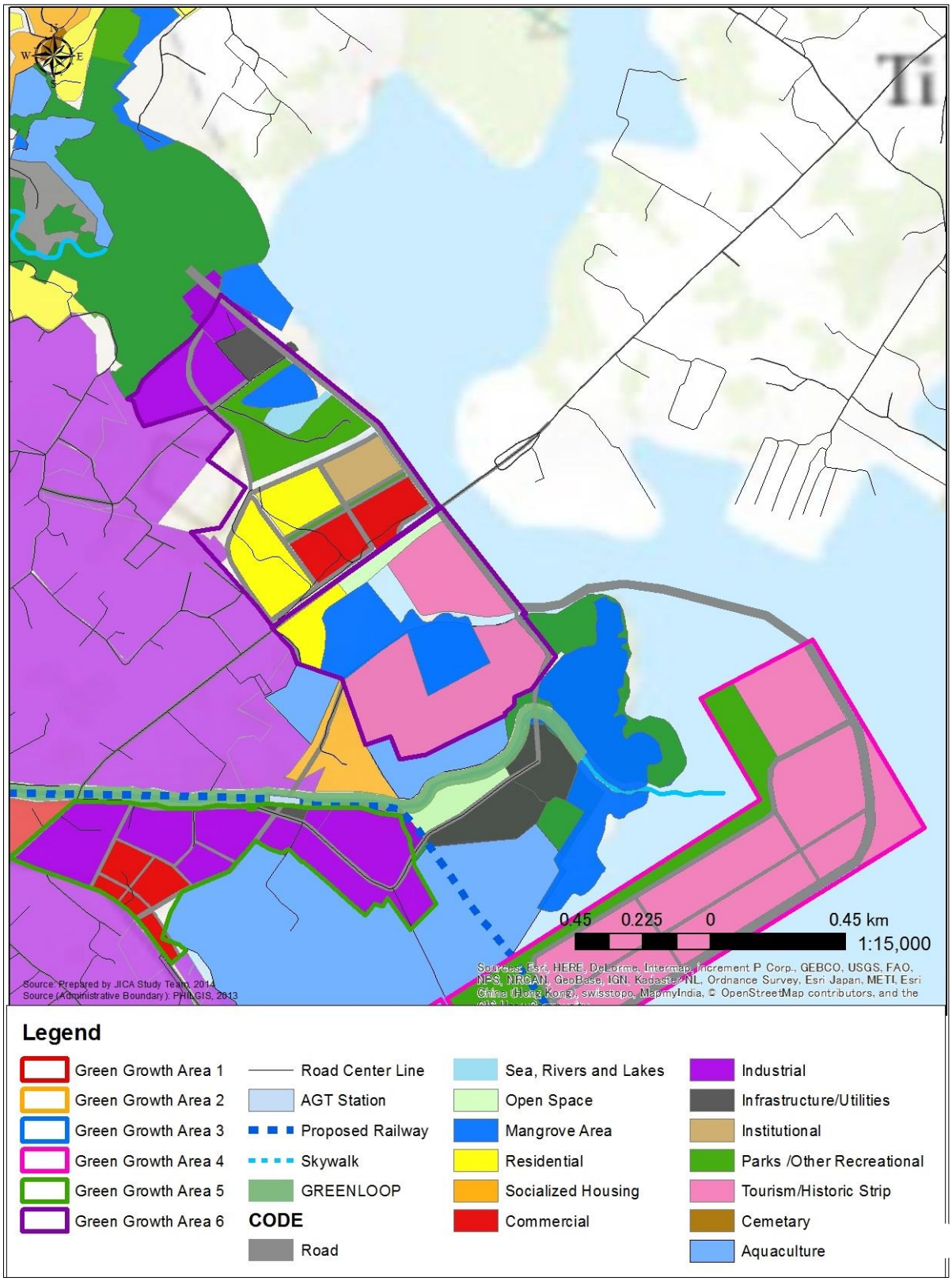

Source: APEC Study Team based on discussions with Mandaue CPDO.

**Figure 11.2.4 Future Land Use Plan for GGA4**




Source: APEC Study Team based on discussions with Mandaue CPDO.

**Figure 11.2.5 Future Land Use Plan for GGA5**




Source: APEC Study Team based on discussions with Mandaue CPDO.

**Figure 11.2.6 Future Land Use Plan for GGA6**

**Table 11.2.1 GGA1 Realty Developments Until 2020**

| Project Type | Lot Area (sq.m.) | Buildings and Areas by Use (sq.m.) | | | | |
|---|---|---|---|---|---|---|
| | | Commercial | Residential | Institutional | Open Space and Others | Total |
| Large Mall (Phase 1) | 52000 (of 169,000) | 152,907 | 0 | 0 | 3,451 | 153,064 |
| Tertiary Hospital | 15,033 | 25,488 | 0 | 21,423 | 5,050 | 51,920 |
| Medical University | 8,917 | 0 | 0 | 29,077 | 0 | 29,077 |
| High-rise Condominiums (Phase 1) | 200,000 | 51,837 | 222,065 | 0 | 61,699 | 299,582 |

Source: APEC Study Team based on EMB data and Private Realty Developer, 2016.

On the whole, drawing a scenario for future buildings in the GGAs was dependent on the following general information:

(i) Land Use Plan and Zoning Ordinance of the city as discussed in Chapter 7;

(ii) Approvals of Environmental Compliance Certificates (ECCs) from EMB for upcoming huge development projects intended for the GGAs;

(iii) Property information contained in the Tax Declaration of each lot within the GGAs; and

(iv) Actual land use conditions.

Furthermore, the methodology and assumptions for determining future buildings where floor areas were calculated by use is outlined as follows:

(i) Characteristics of all vacant lots and ownerships were identified.

(ii) It is assumed that large tracts of land will be developed with 60% of the land area allocated for open spaces, internal circulation, parking and greeneries.

(iii) About 40% of the land area is assumed for buildings to rise at a given number of floors per zoning ordinance.

(iv) GGA1, as the Civic and Trade Center, was set at a maximum allowable floor area ratio (FAR) of 8. Current land use shows a number of land utilized under special uses for storage of containers and machineries. Said special use permits will expire by 2018 and these lands will have to be developed for commercial or mixed uses. A number of large projects such as Project Diana, Mandani Bay, University of Cebu Medical Center, Chong Hua Hospital, Bai Hotel, etc. have their data available from EMB, news, promotional announcements and websites.

(v) GGA2 is zoned as the Old Town Center Redevelopment with maximum height limit of buildings set at 9 meters or equivalent of 2 storeys. Historical and heritage sites/landmarks will be preserved. The city government building will be converted to a museum and another building 20 meters from the current city hall leased out as commercial spaces is planned to be converted to a park.

| | |
|---|---|
|  | Redevelopment of Cebu International Convention Center vicinity for institutional uses. |
|   | Mix-use development of Project Diana comprised of high-rise buildings for commercial uses. |
|  | Mandani Bay 18 residential high-rise buildings with limited retail/commercial floors and 3 office buildings. |

Source: Property Developers and Mandaue CPDO.

**Figure 11.2.7 Images of Realty Developments in GGA1**

The operations and activities at the present city government buildings will be transferred to a New City Government Complex to be developed on a construction bid process. As such, information on this project is withheld at the present time.

(vi) GGA3 is zoned as a Light Industrial Area and with its current poor road structure, it is assumed future developments will have, at most, a FAR of 2.

(vii) GGA4 is a reclamation project intended for recreation and tourism development. Theme parks would be more of open spaces and low-rise structures. High-rise structures would be condominiums and hotels only but since the site is within the 2.5-kilometer radius from the airport, structures should be no higher than 36 meters above ground level. Being a coastal area, development will consider disaster-risk-reduction

management and climate change adaptations.


Source: Mandaue CPDO.

**Figure 11.2.8 Perspective of Proposed Mandaue Global City Project for GGA4**

(viii) GGA5 is a Medium Industrial Park Development. FAR is assumed at 5 for the buildable area of 40%.

(ix) GGA6 is a Residential/Commercial Mixed Use Development that is within a 3.5-kilometer radius from the airport. Residential condominiums are assumed to go no higher than 12 storeys only. The planned sports arena is assumed to be 5 storeys high. Commercial areas are of low-rise features of 2 or 3 storeys.

The resultant calculation of additional floor areas for the period covering 2016 to 2020 is given in Table 11.2.2 while that for the period beyond 2020 (or possibly up to 2030) is given in Table 11.2.3.

**Table 11.2.2 Future Development Floor Areas by Use Until 2020**

| Growth Area | Additional Floor Areas by Use by 2020 (sq.m.) | | | Institutional | Total |
|---|---|---|---|---|---|
| | Residential | Commercial | Industrial | | |
| GGA1 | 138,672 | 743,100 | 0 | 75,988 | 819,088 |
| GGA2 | 0 | 0 | 0 | 0 | - |
| GGA3 | 0 | 0 | 4,565 | 0 | 4,565 |
| Total [1/] | 138,672 | 743,100 | 4,565 | 75,988 | 823,653 |
| Share (%) | 14.4 | 77.2 | 0.5 | 7.9 | 100.0 |

Source: APEC Study Team.

[1/] GGA 4,5, and 6 were not included in the calculation since building developments are assumed to occur only after 2020.

**Table 11.2.3 Future Development Floor Areas by Use Beyond 2020**

| Growth Area | Additional Floor Areas by Use after 2020 (sq.m.) | | | Institutional | Total |
|---|---|---|---|---|---|
| | Residential | Commercial | Industrial | | |
| GGA1 | 2,000,000 | 1,644,731 | 0 | 0 | 3,644,731 |
| GGA2 | 0 | 91,890 | 0 | 0[1/] | 91,890 |
| GGA3 | 29,901 | 0 | 425,141 | 0 | 455,042 |
| GGA4[2/] | 1,142,400 | 1,228,623 | 800,000 | | 3,171,023 |
| GGA5 | 0 | 71,378 | 180,912 | 0 | 252,290 |
| GGA6 | 522,533 | 2,241,019 | 51,894 | 273,984 | 3,089,430 |
| Total | 3,694,834 | 5,524,558 | 1,457,947 | 273,984 | 10,951,323 |
| Share (%) | 33.7 | 50.5 | 13.3 | 2.5 | 100.0 |

Source: APEC Study Team.
[1/] A new city government complex is expected to be developed on a bid process. Information is withheld at this time.
[2/] Preliminary breakdown is available since planning is in the conceptual stage to date.

## 11.3 Combined Low Carbon Measures at GGAs

### 11.3.1 GGA1

GGA1 is a completed reclamation area and developed block lands with supporting road network. Based on that layout, the following low carbon measures will be added:

(i) The AGT-CML Line with 2 stations;

(ii) TOD around 2 AGT stations including a skywalk to the Project Diana site and the Cebu North Bus Terminal and a bus and e-jeepney terminal at the former CICC site;

(iii) Metro-wide ITS and LED street lighting; and

(iv) Green buildings for new private and public buildings.

As a CBD, high-density office and high-rise residential developments are planned in GGA1. Below is a sample image of green complex development with high-rise residences, commercial buildings, and parks, applying low carbon measures suggested in Chapter 6.

Source: Sankei Digital.

**Figure 11.3.1 Example of a Green High-rise Building: One Central Park in Sydney**

### 11.3.2 GGA2

GGA2 has a historical urban form with narrow roads, small lots and many public buildings to function as a city center. In accordance with Mandaue's Green Building Code, government-owned and operated buildings will be mandated to adhere to the BERDE system. Based on the area's character, the following low carbon measures will be undertaken:

(i) The AGT-CML Line with 1 station;

(ii) TOD around the existing city hall;

(iii) Metro-wide ITS and LED street lighting;

(iv) Improvement of road public transport vehicles and promotion of pedestrian zones; and

(v) Green buildings for new private and public buildings.

GGA2 includes public buildings such as the city hall, and are planned to be developed into museums, but will remain as low storey buildings. Figure 11.3.2 is an example of a green government building, which shows some green measures applicable for BERDE rating as well.

### 11.3.3 GGA3

GGA3 includes many, and rather old, factories. For a disaster-resilient and better urban environment, the area will be redeveloped especially along the Butuanon River and the road network will be improved with the following proposed low carbon measures:

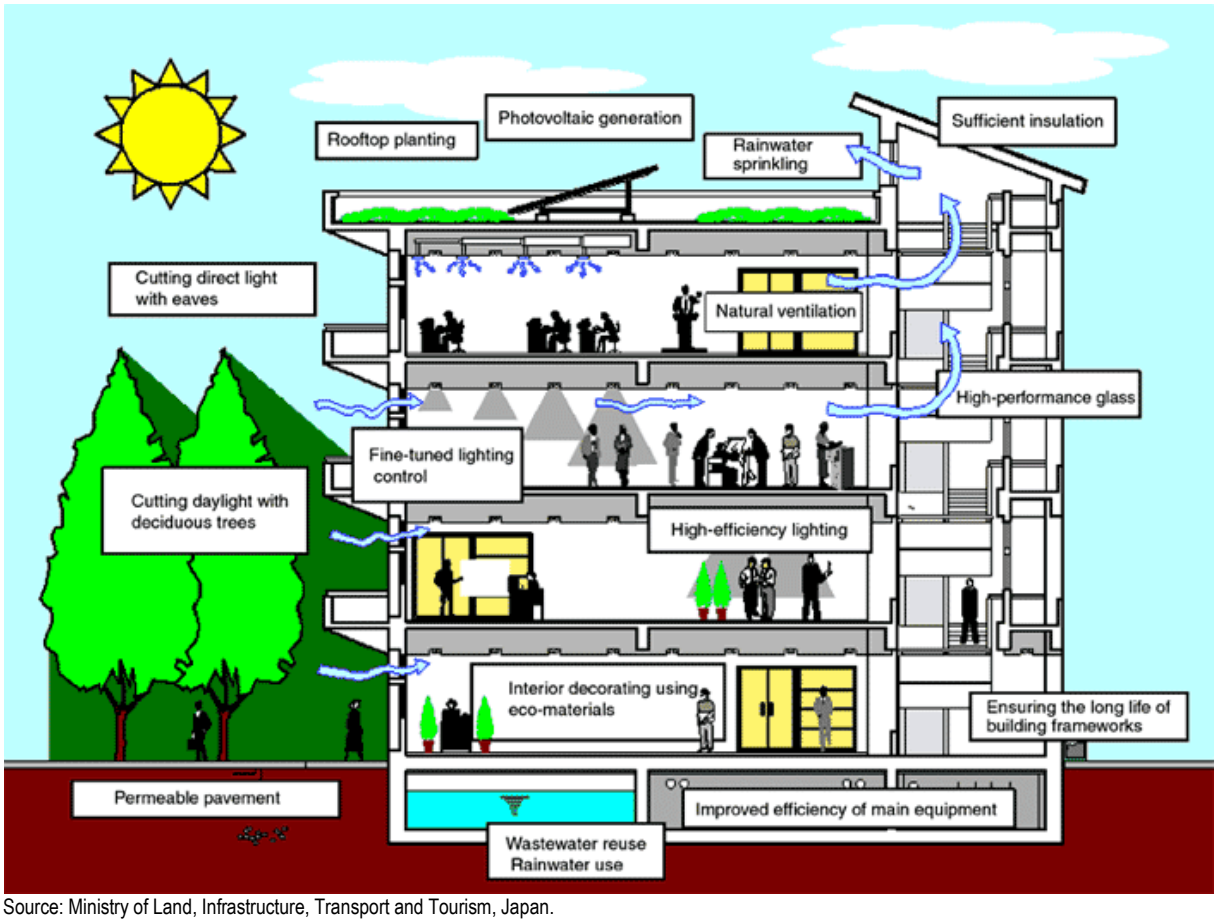
(i) Green Loop including river improvement;

(ii) Metro-wide ITS and LED street lighting;

(iii) Solar power generation; and

(iv) Green buildings mainly for industrial and commercial use.

GGA3 covers several industrial buildings where solar panels could be installed on the roof. Figure 11.3.3 shows examples of solar panel installation.




Source: Ministry of Land, Infrastructure, Transport and Tourism, Japan.

**Figure 11.3.2 Image of Sample Green Government Building**


Source: Astecss.

**Figure 11.3.3 Rooftop Solar Panels Installed on the Factory Roof and Side of a Shopping Mall**

### 11.3.4 GGA4

Mandaue City proposes an advanced urban reclamation project called "Mandaue's Global City." This area faces the Opon Channel. The following low carbon measures will be examined for adoption in this area:

(i) The AGT-CML Line with 1 station;

(ii) TOD including station plaza;

(iii) Metro-wide ITS and LED street lighting;

(iv) Improvement of road public transport vehicles;

(v) Waste-to-energy facility at the adjacent Barangay Umapad and DHC at GGA4;

(vi) Renewable energy (solar, wind); and

(vii) Green buildings for commercial and tourism use.

### 11.3.5 GGA5

The area is currently characterized as inconvenient and low utilization lands. With the following low carbon measures, the area will be reorganized as one of the green growth areas in Mandaue City:

(i) Green Loop including Butuanon River improvement;

(ii) The AGT-CML Line along the Green Loop with 1 station and 1 depot (6 ha);

(iii) Metro-wide ITS and LED street lighting; and

(iv) Green buildings for institutional use.

GGA5 includes the industrial park development. As a sample of a green building, Figure 11.3.4 are pictures of the Henry Sy Hall of De La Salle University in Manila, which has achieved a BERDE Design 2 Star rating, currently waiting for assessment to receive the construction rating.

### 11.3.6 GGA6

The area is partly existing but underutilized and some reclamation will be undertaken to expand it. The following low carbon measures are proposed for this area:

(i) Metro-wide ITS and LED lighting;

(ii) Improvement of road public transport vehicles;

(iii) Waste-to-energy at Barangay Umapad and DHC at GGA6; and

(iv) Green buildings for commercial, business, and high-rise residential buildings.

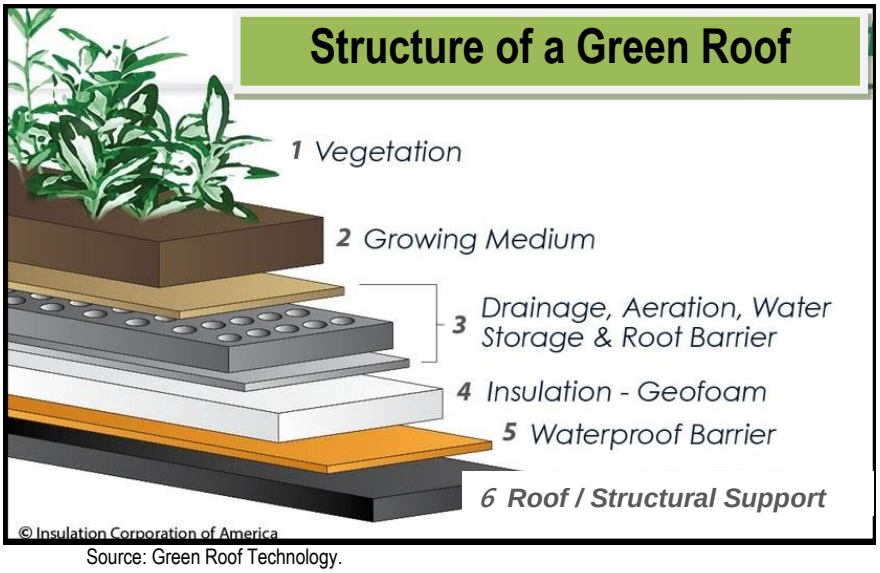
For commercial and high-rise residential buildings planned in GGA6, one possible green building measure is the green roof, as shown in Figure 11.3.5 and Figure 11.3.6.

Source: APEC Study Team

**Figure 11.3.4 Example of Natural Ventilation, Natural Lighting, and Energy Efficient Building Envelope: Henry Sy Hall, De La Salle University (BERDE Design 2 Star Building)**


Source: Insulation Corporation of America.

**Figure 11.3.5 Example of Green Roof**




Source: Green Roof Technology.

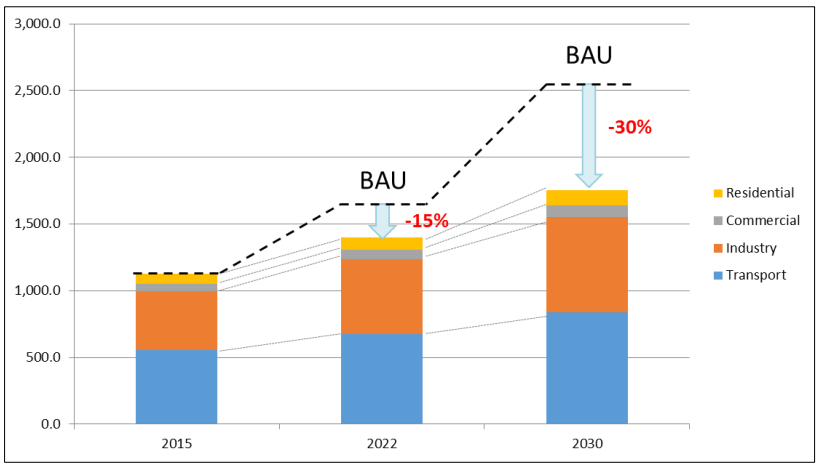
**Figure 11.3.6 Example of a Green Roof Structure**

# 12 RECOMMENDATIONS FOR LCMT IMPLEMENTATION

## 12.1 Impact of LCMT Implementation

### 12.1.1 GHG Emissions Reduction by Implementation of LC Measures

The baseline scenario of GHG or $CO_2e$ emissions in Mandaue City are estimated as shown in Chapter 4. In addition, the emissions reduction target scenario was set as 15% reduction by 2022 and 30% reduction by 2030 compared to the baseline.




Source: APEC Study Team

**Figure 12.1.1 GHG Emission Projections and Targets in Mandaue City**

**Table 12.1.1 The GHG Emission Projections by Sectors and Target in Mandaue City ($tCO_2$)**

| | 2015 | 2022 | 2030 |
|---|---|---|---|
| Residential | 74,124 | 110,406 | 169,438 |
| Commercial | 53,625 | 79,873 | 122,580 |
| Industry | 446,261 | 664,696 | 1,020,099 |
| Transport | 552,447 | 791,725 | 1,195,835 |
| BAU Total | 1,126,456 | 1,646,700 | 2,507,953 |
| Target | - | 1,399,695 | 1,755,567 |
| Reduction Target | - | 247,005 | 752,386 |

Source: APEC Study Team

Following sections will analyze the potential GHG emissions reduction by the proposed LC measures in different sectors, and see the possibility to achieve the set target and contribution of each LC measure to the total reduction.

#### 1) Land Use Sector

Table 12.1.2 shows the projected GHG emissions reduction from the proposed LC measures in the Land Use sector. The Green Loop project includes the construction of waste water treatment facility to treat the water which will be discharged to the river and also the improvement of Butuanon River as described in the Chapter 7. The estimated GHG emission reductions in Land Use including Green Loop and TOD measures are 67,731 $tCO_2$/year in 2022, and 100,086 $tCO_2$/year in 2030 compared to the BAU scenario.

**Table 12.1.2 Projected GHG Emissions Reduction in Land Use Sector**

| | GHG Emissions Reduction Projections Compared to BAU ($tCO_2$/year) | |
|---|---|---|
| | 2022 | 2030 |
| Green Loop (Waste Water Treatment Facility + River Improvement/Clean-up) | 65,367 | 97,526 |
| TOD | 2,364 | 2,560 |
| Total Emission Reduction | 67,731 | 100,086 |

Source: APEC Study Team

### 2) Transportation Sector

Table 12.1.3 shows the projected GHG emissions reduction from the proposed LC measures in other transportation sector. The transportation sector is the largest sector contributing to GHG emissions in Mandaue City. By the implementation of the combined LC measures for the transportation sector, 83,300 $tCO_2$/year in 2022, and 131,182 $tCO_2$/year in 2030 are estimated to be reduced compared to the BAU scenario, which are about 11% of GHG emissions from the sector.

**Table 12.1.3 Projected GHG Emissions Reduction in Transportation Sector**

| | GHG Emissions Reduction Projections Compared to BAU ($tCO_2$/year) | |
|---|---|---|
| | 2022 | 2030 |
| Metro-wide ITS | 388 | 524 |
| E-Trikes | 408 | 1,244 |
| The AGT-CML Line Project | 80,871 | 124,515 |
| LED Street Lighting | 1,633 | 4,899 |
| Total Emission Reduction | 83,300 | 131,182 |

Source: APEC Study Team

### 3) Other Urban Service Sector

Table 12.1.4 shows the projected GHG emissions reduction from the proposed LC measures in the other urban services sector.

**Table 12.1.4 Projected GHG Emissions Reduction in Other Urban Services Sector**

| | | GHG Emissions Reduction Projections Compared to BAU ($tCO_2$/year) | |
|---|---|---|---|
| | | 2022 | 2030 |
| Total Renewable Energy | | 31,684 | 63,337 |
| | Residential | 5,166 | 10,331 |
| | Commercial | 13,017 | 26,034 |
| | Institutional | 1,498 | 2,965 |
| | Industry | 12,003 | 24,007 |
| Waste-To-Energy | | - | 130,255 |
| DHC and DCS | | - | 44,687 |
| Total Emission Reduction | | 31,684 | 200,826 |

Source: APEC Study Team

Notes:(1) Roof-top solar panel is assumed to be installed at 25% of all buildings in GGAs by 2022, and 50% by 2030; and (2) It is assumed that Waste-To-Energy plant and DHC/DCS will not be constructed before 2022 because the buildings in GGA4 and GGA6 will be constructed only after 2020.

### 4) Green Building

Table 12.1.5 shows the projected GHG emissions reduction from the proposed LC measures by the implementation of green building program.

**Table 12.1.5 Projected GHG Emissions Reduction by Green Building LC Measures**

| | GHG Emissions Reduction Projections Compared to BAU ($tCO_2$/year) | |
|---|---|---|
| | 2022 | 2030 |
| Residential | 5,680 | 157,020 |
| Commercial | 17,501 | 147,616 |
| Institutional | 1,234 | 5,686 |
| Total Emission Reduction | 24,416 | 310,322 |

Source: APEC Study Team
Notes:(1) The data in 2022 is calculated based on the floor area constructed before 2020; and (2) The estimated emission reduction in tourism sector described in Chapter 11 is combined into commercial sector.

### 5) Total GHG Emissions Reduction

Total GHG emissions reduction expected to be achieved by the implementation of proposed LC measures is summarized in Table 12.1.6. With the listed LC measures so far, the estimated total $CO_2$ emissions are 207,131 $tCO_2$ in 2022 and 779,869 $tCO_2$ in 2030 which are 13% and 31% reduction compared to the BAU, respectively. Based on the set reduction targets of 15% in 2022 and 30% in 2030, it is expected that target emission reductions can be achieved if the proposed LC measures are successfully implemented.

**Table 12.1.6 Summary of GHG Emission Reductions**

| Sector | Item | 2015 | 2022 | 2030 |
|---|---|---|---|---|
| Residential | BAU GHG emissions/year | 74,124 | 110,406 | 169,438 |
| | Projected reductions/year by LC measures | N/A | 10,846 | 167,351 |
| | Total GHG emissions/year with LC measures | N/A | 99,560 | 2,087 |
| Commercial | BAU GHG emissions/year | 53,625 | 79,873 | 122,580 |
| | Projected reductions/year by LC measures | N/A | 30,518 | 218,337 |
| | Total GHG emissions/year with LC measures | N/A | 49,355 | -95,757 |
| Institutional | BAU GHG emissions/year | - | - | - |
| | Projected reductions/year by LC measures | N/A | 60,701 | 228,098 |
| | Total GHG emissions/year with LC measures | N/A | -60,701 | -228,098 |
| Industry | BAU GHG emissions/year | 446,261 | 664,696 | 1,020,099 |
| | Projected reductions/year by LC measures | N/A | 19,401 | 32,341 |
| | Total GHG emissions/year with LC measures | N/A | 645,295 | 987,758 |
| Transport | BAU GHG emissions/year | 552,447 | 791,725 | 1,195,835 |
| | Projected reductions/year by LC measures | N/A | 83,300 | 131,182 |
| | Total GHG emissions/year with LC measures | N/A | 708,425 | 1,064,653 |
| Land Use | BAU GHG emissions/year | - | - | - |
| | Projected reductions/year by LC measures | N/A | 2,364 | 2,560 |
| | Total GHG emissions/year with LC measures | N/A | -2,364 | -2,560 |
| Total | BAU GHG emissions/year | 1,126,456 | 1,646,700 | 2,507,953 |
| | Projected reductions/year by LC measures | N/A | 207,130 | 779,869 |
| | Total GHG emissions/year with LC measures | N/A | 1,439,570 | 1,728,084 |
| | % of GHG emission reductions compared to BAU | N/A | 13 | 31 |
| Target | Reduction Target | - | 247,005 | 752,386 |
| | Reduction Target in % | - | 15 | 30 |

Source: APEC Study Team

In order to achieve further $CO_2$ emissions reductions, the following are to be considered:

(i) Encouraging energy conservation activity in the industry sector which is the second largest emitting sector in Mandaue City by enhancing energy auditing, introduction of energy efficiency technology, waste heat utilization, etc. Achievement of 5% energy conservation in the industry sector can contribute 51,000 $tCO_2$ emission reduction in 2030.

(ii) Encouraging city-wide energy conservation activity not only in GGAs, such as encouraging the application of energy efficient electric appliances, LED lightings, and installation of roof-top solar panels on private buildings outside of GGAs.

(iii) Expanding the area of DHC/DCS application. In the above estimation, the application of DHC/DCS is only in GGA4. However, there are large-scale developments of office, commercial, and residential buildings planned in other GGAs. The expansion of DHC/DCS application in other areas can also contribute to energy conservation and GHG emission reductions. The expansion of the DHC/DCS application especially to GGA6 which has a floor area 5 times larger than GGA4 is projected to contribute approximately 36,000 $tCO_2$ emission reduction in 2030.

(iv) Promoting eco-cars including hybrid, PHV, EVs for private use by developing the infrastructure such as electric charging stations in shopping malls and providing subsidies.

(v) Tree planting in the reclamation area can also be another $CO_2$ mitigation option.

### 12.1.2 Cost Performance Analysis of LC Measures

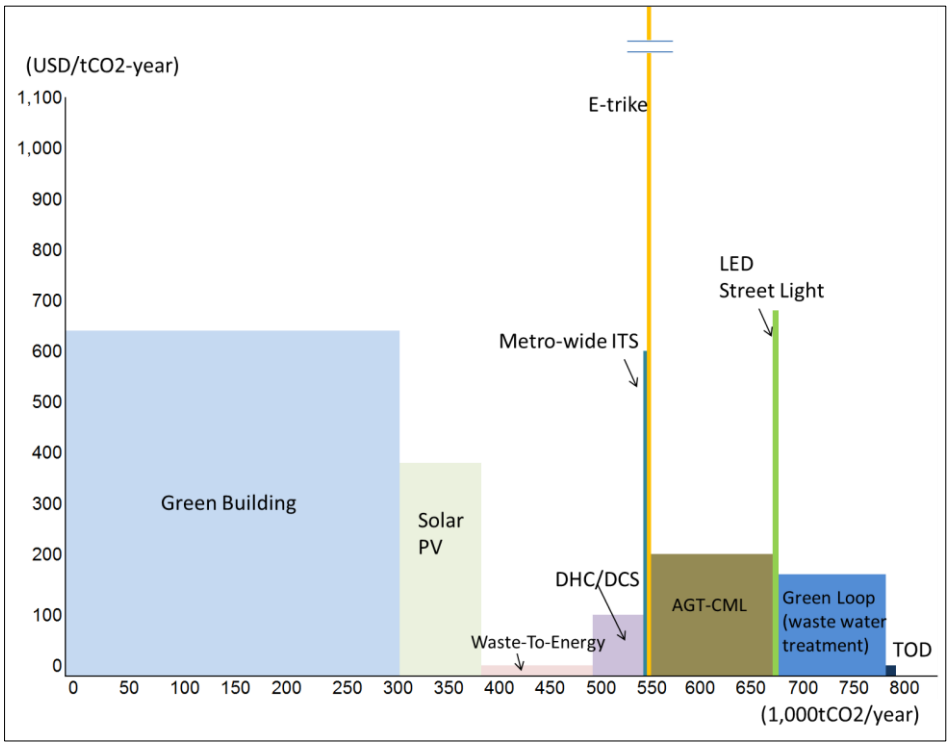
The cost performance of the proposed LC measures is summarized in the Table 12.1.7. The cost performance is analyzed based on the cost required to reduce one $tCO_2$ in USD. The cost performance varies from 15USD to 3,500USD/$tCO_2$ emission reduction.

**Table 12.1.7 Summary of Unit Cost of GHG Emission Reductions of Proposed LC Measures**

| | Average GHG Reduction/Year (at 2030) | Unit Cost (USD/$tCO_2$) |
|---|---|---|
| Green Building | 310,322 | 632 |
| Total Renewable Energy (Solar) | 63,337 | 394 |
| Waste-To-Energy | 130,255 | 19 |
| DHC and DCS | 44,687 | 125 |
| Transportation | 131,182 | - |
| Metro-wide ITS | 524 | 580 |
| E-Trikes | 1,244 | 3,495 |
| The AGT-CML Line Project | 124,515 | 192 |
| LED Street Lighting | 4,899 | 674 |
| Land Use | 100,086 | - |
| Green Loop (WWTP + River improvement) | 97,526 | 105 |
| TOD | 2,560 | 15 |
| Total Emission Reduction | 779,869 | - |

Source: APEC Study Team

The result of the cost performance analysis is shown in Figure 12.1.2. Although cost performance is one indicator to design the development process aiming for low carbon model town, it is also important to take into account the other environmental impacts as well as social impacts.




Source: APEC Study Team

**Figure 12.1.2 Cost Performances of All LC Measures**

## 12.2 LCMT Institutional and Administrative Framework Plan

### 12.2.1 Mandaue City

Mandaue City is upholding its growth vision that by year 2020, it would become " the primary source of high-quality manufactured consumer products" which is supported by its mission to "create an environment for sustainable economic growth and a liveable society through responsive governance and multi-sectoral involvement." With this in sight, the city has established their vision aligned circles (VACs) under its Performance Governance System (PGS) for the implementation of identified plans/projects (see Figure 12.2.1).

The LGU adopted the VACs Technology that subjects their plans/projects to be carried out with the participation of a group of personnel from different offices within its organization. This group would meet regularly (i.e., referred to as the Weekly Operations Review Meeting or WORM) to determine performances and delivery of outputs vis-a-vis milestones that have been set. As such, the momentum to achieve the plans/projects are maintained.

Source: Office of Strategic Management (OSM) and City Planning & Development Office (CPDO) of Mandaue City

**Figure 12.2.1 Mandaue City's Performance Governance System Roadmap**

An example of a formation of a VAC is given below

*" VAC#16 is City Core Redevelopment (Integrated Green Growth Development of GGA2) has a work group composed of members from City Planning Development Office, City Engineers' Office, Department of General Services, City Legal Office, City Treasurer's Office, Traffic Enforcement Agency of Mandaue, Barangay Centro, and City Consultant on Urban Planning."*

There is the presence of political will backed with manpower on a cross-departmental collaboration to implement the low carbon town (LCT) development plan of Mandaue, which is carried well by the city's governance structure[1]. The frontrunner of the LCT initiative is the Integrated Development of New Green Growth Areas, which are to become the economic generators of the city, supported by the green connectivity initiatives (i.e., a mass transit system and the Green Loop).

In the middle of 2016, Mandaue had a change in its leaders and a shuffle of department heads of offices. Nevertheless, the plans and projects remained in continued mode since the PGS has held the various city offices working in the same direction. This attests to the success of the PGS' engagement of employees within the city government.[2]

[1] Following the Performance Governance System with adherence to the balanced scorecard of Kaplan and Norton to monitors the implementation of all city projects.
[2] Mandaue garnered awards such as the Seal of Good Financial Housekeeping in 2014 from Department of Interior and Local Government (DILG) and PGS Proficiency Status in 2015 from Institute

There is another layer of collaboration that was formed by the city outside of its operational structure but within its political jurisdiction. This is the Multi-Sectoral Governance Council (MSGC), which engages stakeholders from the businesses and the civil society in Mandaue. The MSGC participates in the periodic monitoring, reviewing and rating of the work of VAC's. It also comes up with its own projects and activities to support the ventures of the city.

Mandaue reformed its governance structure to address various challenges of urban growth by adopting the PGS in 2013. It had its share of pitfalls but evolved into a structure that collected the synergies of its government offices, engaged its employees, formed allies of stakeholders within its various local sectors for its endeavors for a low carbon town development.

Also, the city has a working monitoring and evaluation (M&E) system that looks at each specific plan/project. It has developed an approach for assessing problems or slippages, which is referred to as "Intensive Care Unit". However, there is still room for expanding collaborative ties especially with the member economy's government agencies and other local government units for metropolitan-scale plans and projects such as the Green Loop and the mass transit lines. Since the agencies of the member economy have the tendency to proceed with projects on its own planning direction and timing, it would benefit Mandaue to provide regular inputs to and monitoring of larger (i.e., regional) plans that affect their own city projects.

In addition, capacity building of all city offices should be strengthened in anticipation with the expected and required tasks of the green initiatives installed by the city. This is especially true for the back-end of the low carbon strategy, which entails the measure, report and verify (MRV) system. The system will basically measure, report and verify: (i) the $CO_2$ emission reduction impact; (ii) the impacts on the economic, social and environment standing of the city; and (iii) the efficiency of the investment. The objective of the MRV system coupled with the monitoring and assessment system is to define the targets and key performance indicators for tracking the progress.[3] In connection with the setting of targets and key performance indicators, the city has to simplify and update the data from its operational activities (i.e., property declarations, taxes, business, transport, etc.). Such data will enable the assessments of impacts not only in terms of carbon reduction but also economic and social impacts.

### 12.2.2 Coordination with Neighboring Cities

The venue for a wider coordination with neighboring local governments, agencies of the member economy, businesses and civil society already exists for Mandaue. This is the

[3] The same process adopted by LCMT Phase 5 Project

Metro Cebu Development and Coordinating Board (MCDCB) with a growing membership profile now consisting of 14 LGUs[4], 17 agencies of the member economy, and 20 non-government organizations (including business communities and civil society organizations). This body, although with pending congressional approval, functions as the platform for planning how to implement selected projects in the context of the following metropolitan-wide growth management areas:

(i) Coordinated development planning (i.e., land use);

(ii) Transportation and traffic management;

(iii) Affordable housing;

(iv) Disaster risk reduction and environment management (flooding, water resource, solid waste, etc.);

(v) Competitiveness; and

(vi) Public finance and project financing.

The Roadmap Study for Sustainable Development in Metro Cebu, concluded in 2015, was spearheaded by the MCDCB. The resultant roadmap outlined in the study was approved by the National Economic Development Authority in 2015 and thereafter, stood as the roadmap for the development of Metro Cebu. One of the institutional recommendations of the study is the strengthening of MCDCB as reiterated for the following areas:

(i) Preparation of a Metro Cebu Long-term Development Master Plan based on the Mega Cebu 2050 Vision and the recommendations of the Roadmap Study;

(ii) Coordination of feasibility studies for various prioritized programs/ projects among LGUs and government entities of the member economy conducting the programs/ projects;

(iii) Arrangement of appropriate project financing schemes such as PPP and the like for the implementation of priority projects proposed in the Roadmap Study;

(iv) Enhancement of planning capacity for the technical team that would support facilitation of the projects' implementation;

(v) Support for the LGUs through technical advice for planning, project implementation, funding identification, and assistance to capacity building of LGUs;

(vi) Strengthen competitiveness of Cebu Province as a whole; and

(vii) Promotion of public participation to raise public awareness of Mega Cebu's development visions, strategies, and programs/projects, which need strong cooperation and involvement of the general citizenry, to foster a sense of unity and

[4] The provincial government of Cebu, the cities of Cebu, Carcar, Naga, Talisay, Mandaue, Lapu-Lapu and Danao and the municipalities of San Fernando, Minglanilla, Cordova, Consolacion, Liloan, and Compostela.

belonging to Metro Cebu.

The priority projects of Mandaue City on the Green Loop and the mass transit line (i.e., AGT) are also listed in the prioritized projects of the Roadmap Study. These projects were discussed and accepted by the neighboring LGUs but there are still a number of activities to be conducted to thresh out details (i.e., engineering design), responsibilities, timetables, funding, etc. A follow through can be taken by Mandaue with the assistance of the MCDCB.

### 12.2.3 Community Planning Council at GGAs

For ease of plan implementation, it is recommended that support from the project affected communities be engaged in the planning for project execution. The government of Mandaue has basically established a structure for planning and implementation in the form of several vision-aligned-circles (VACs) and vision-aligned partners (VAPs), which can stand as the community project council (CPC) but with the inclusion of the government officials at the barangay levels, the transport groups, the property owners, residents and civic organizations of the green growth areas (GGAs). It is noted that the women folk are particularly active at the barangay level especially when plans and projects affect their families and economic activities. It is, generally, the women that usually attend the meetings and gatherings during discussions and workshops since the men or heads of the families are at their workplaces.

For the six GGAs, these should include the leaders, residents, civic groups and businesses at the following barangays (see Figure 12.2.2):

(i) GGA1 - Subangdaku and Tipolo;

(ii) GGA2 - Centro, Mantuyong and Guizo;

(iii) GGA3 - Tingub, Tabok, and Pinagsabungan

(iv) GGA4 - Opao

(v) GGA5 - Umapad

(vi) GGA6 - Paknaan

For the identified integrated low carbon projects of Mandaue, the barangays to involve are as follows:

(i) Automated Guideway Transit - Subangdaku, Tipolo, Centro, Mantuyong, Guizo, Estancia, Maguikay, Alang-alang, and Opao.

(ii) Green Loop - Subandaku, Tipolo, Banilad, Casuntingan, Bakilid, Mantuyong, Maguikay, Tingub, Tabok, Alang-Alang, Paknaan, Umapad and Opao.

The CPC should have the following responsibilities and activities:

(i) Promote the CLUP for the GGAs and educate affected residents and property owners

regarding the plan and allowable uses;

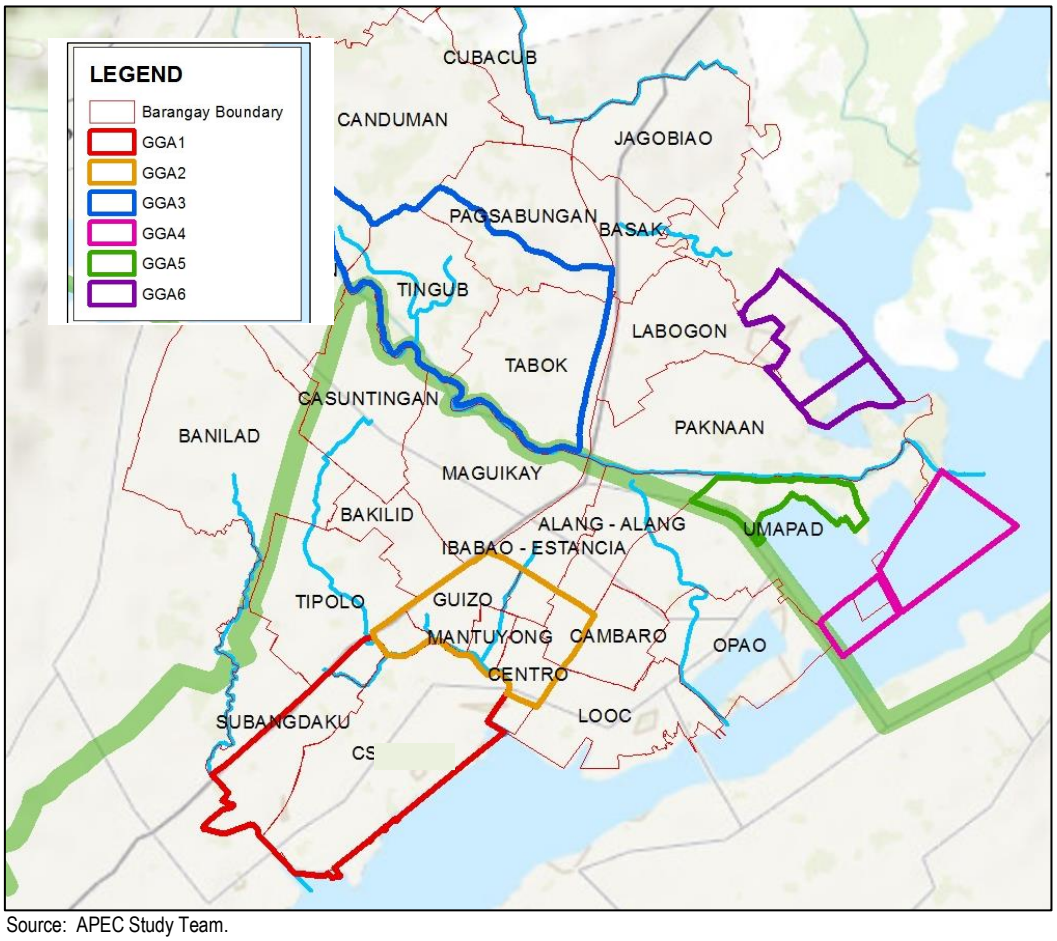
(ii) Set the $CO_2$ reduction targets of the integrated development plans for each area;

(iii) Promote low carbon measures such as waste reduction, river clean-up (especially for the Green Loop areas), building energy efficiency, etc.

(iv) Develop and exchange information and expertise from within and with other areas;

(v) Coordinate closely with the city offices; and

(vi) Manage and monitor initiatives to maintain low carbon environment.




Source: APEC Study Team.

**Figure 12.2.2 Barangay Units in GGAs**

## 12.3 LCMT Project Implementation Schemes

### 12.3.1 Land Use

Developments intended for the GGAs in terms of conforming land uses, in line with its vision, have their implementation commencing with the city's updated CLUP and zoning ordinance. City offices are already managing this in their daily operations. Likewise, land uses in support of the TOD can be attended primarily through coordination with land owners and through promotional tasks in the meantime, since the TOD is an integral part of the mass transit plan.

The Green Loop project, on the other hand, requires the involvement of the cities of Cebu, Mandaue, Lapu-Lapu and the Municipality of Cordova as well as the collaboration of agencies of the member economy (i.e., such as DOE, DENR-EMB, and DPWH), business groups and civic organizations. Implementation can be managed by each LGU both independently as well as collectively by undertaking several small tasks on phased manner to attain the objective of a Green Loop.

On a collective manner, the LGUs should first protect the alignment or right-of-way by setting ordinances for allowable or limited uses as well as defining the use of non-motorized vehicles only at the Green Loop areas. On an independent manner, Mandaue should focus its efforts on improving the 7-kilometer length of Butuanon River in its jurisdiction. It has already started this by embarking on the Butuanon River Rehabilitation Project for the first 1.5 kilometer stretch of the river. However, budgets that were allocated by both the city and DPWH are meager. These budgets should be increased to the indicative amount of about PHP250 million for the embankments, PHP7 million for river de-silting/cleaning and PHP354 million[5] for a waste water treatment facility (WWTF) to make bigger stride in project implementation. Since the cost are huge for the city to take on, an option for implementation is to apply for the project under the National Sewerage and Septage Management Program (NSSMP) of DPWH[6]. The city can then focus on the development of the pedestrian/bike lanes and the pocket of greeneries using its own resources.

The partnership option for the waste water treatment project under the NSSMP is shown in Table 12.3.1. The Philippine Clean Water Act (CWA) of 2004 requires highly urbanized cities to provide sewerage and septage service to minimize adverse impacts of waste water from households, industries and businesses on water resources of the city. Among its objectives is to enhance the ability of local implementers to build and operate waste water treatment systems for urban centers.

Mandaue City's water demand is serviced by the Metropolitan Cebu Water District (MCWD). The logical implementation partnership under the NSSMP is that the LGU(s) and the water district (i.e., MCWD) will develop, implement and manage the project for a WWTF. The project is eligible for a grant financing support from the member economy of up to 40% of the cost.

[5] A cost worked out in the Roadmap Study for Sustainable Development of Metro Cebu for a waste water treatment facility that can accommodate both the areas of Mandaue City and northern portion of Cebu City.
[6] The objective of said program is that by 2020, all LGUs will have developed their septage system.

**Table 12.3.1 NSSMP Institutional Partnership Options for Sanitation Project Development**

| Option Summary | Summary Assessment |
|---|---|
| LGU & Water District | Assuming both parties can raise the necessary finance, this is a highly viable option as each party can focus on their area of capability - the LGU on administrative matters and the Water District on operational matters. |
| LGU | The LGU can potentially manage and implement a sanitation project by itself although it will likely need to contract out the construction and operations activities to a third party. |
| Water District | It is not practical for a Water District to develop a sanitation project by itself because it will need the cooperation of the relevant LGU(s) for passage of an enabling ordinance. |
| LGU & Private Partner | The LGU can feasibly work with one or more private companies in designing, developing and operating a sanitation project and this may be the best option in circumstance where either the Water District is not interested in acting as a project partner or where the Water District does not have sufficient access to financing to become a project partner. |
| LGU, Water District & Private Partner | A tripartite agreement can be reached where one or more private firms assume responsibility for some part of the design, development and operations process with the Water District left to manage the remaining elements and the LGU handling the administrative side of things. |

Source: Support for the National Roll-out of the National Sewerage and Septage Management Program, DPWH, 2013 (Program Operations Manual

### 12.3.2 Transportation Planning

This section elaborates a doable implementation scheme of the e-trike project proposed in Section 8.2.2. Since the project is expected to enjoy the economy of scale for a discounted unit price by a mass procurement order, the synergy effect for the e-trike system will be shared between mass production and the supporting facilities such as battery recharging stations. To make it happen, the Study proposes a metropolitan approach where Mandaue City will jointly develop the e-trike system with other LGUs in Metro Cebu. During the project period up to 2030, Metro Cebu will undertake three mass procurement deals, e.g., 5,000 e-trikes for Metro Cebu with 600 of which is intended for Mandaue City under a single procurement deal.

For the first procurement deal, it is suggested that Metro Cebu make an application to the on-going E-Trike Project by DOE. The project scheme is illustrated in Figure 12.3.1.

Detailed arrangement will be done through the following procedures[7]:

(i) The participating LGUs in Metro Cebu (all 13 LGUs or some) will write to DOE to express their commitments for the requested number of e-trikes and public electric charging infrastructure;

(ii) DOE will then procure the total number of e-trikes through international competitive bidding based on the commitments from various LGUs;

(iii) ADB will directly pay suppliers;

(iv) There are two loan options when delivering e-trikes to the driver-applicants;

- LGU takes the loan, becomes the guarantor of the drivers, and assumes the credit

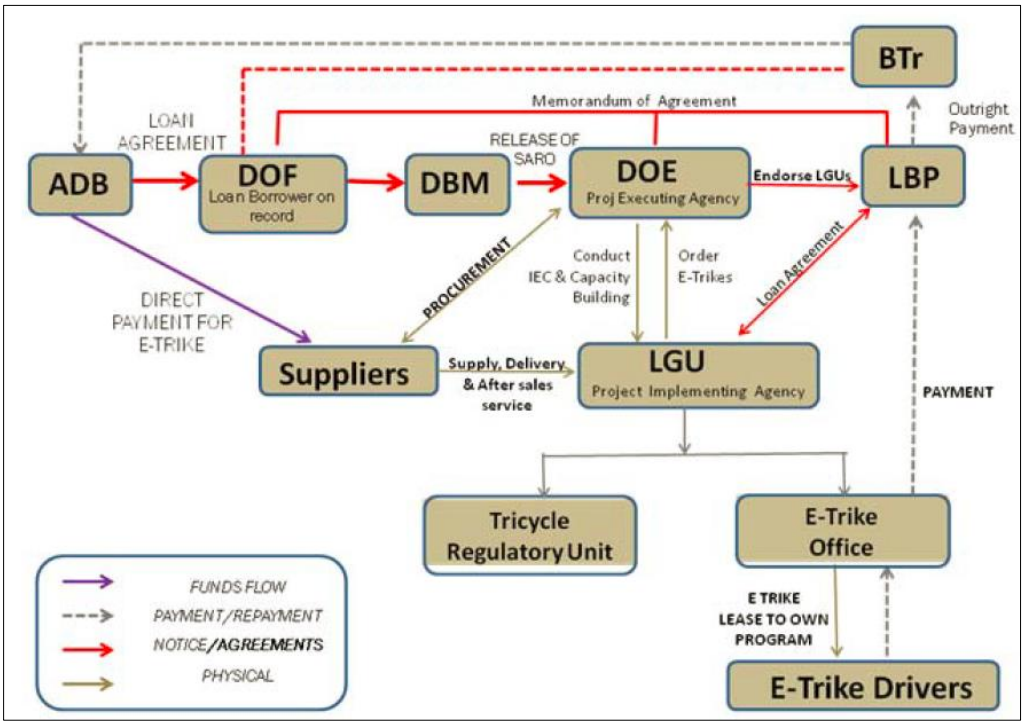
[7] According to the meeting between the Alternative Fuels and Energy Technology Division (AFETD), Energy Utilization Management Bureau of DOE and the Study Team on June 29, 2016.

risk[8]; or

- Accredited financing conduit assumes the loan and the drivers will pay the loan based on an amortization schedule to the bank;

(v) Battery charging stations of an adequate number will be constructed under the responsibility of the participating LGUs. There is a possibility for DOE to place solar battery charging station(s) for the e-trikes on a grant basis; and

(vi) The participating LGUs will pay back the Land Bank while the Land Bank will outrightly pay the member economy's treasury.




Source: Department of Energy

**Figure 12.3.1 DOE's E-Trike Project Scheme**

DOE's E-Trike Project was already launched early 2016 but there is a large possibility to modify the details of the project scheme arrangement in negotiation with the concerned LGUs to meet local needs and conditions. The first procurement deal will be concluded in 2017 and e-trikes will be produced and delivered between 2018 and 2020. The second and third deals will be done in 2022 and 2027, respectively. Metro Cebu may then assess and determine whether to use this attractive program for future occasions.

### 12.3.3 Other Urban Services Planning

**The Implementation Scheme for Waste-To-Energy and District Cooling System**

Waste-To-Energy (WTE) is a proposed measure to solve the increasing waste volumes and the limitation of landfill site in Mandaue City. The heat and electricity energy from the

[8] An interest of 9% if LGU takes the loan, which is divided into Land Bank's interest of 6% and LGU's administrative and operating expenses of 3%.

WTE facility can be utilized to supply energy to District Cooling System (DCS). Therefore, WTE and DCS are listed as the proposed measures to be applied in GGA4 and GGA6 which are close to the proposed WTE facility site near the Umapad Landfill Site. The combined implementation of DCS with WTE can further increase the efficiency of energy usage. This section describes the potential implementation scheme and financial arrangements for WTE and DCS project. Figure 12.3.2 describes the potential implementation scheme and also shows the flow of finance.

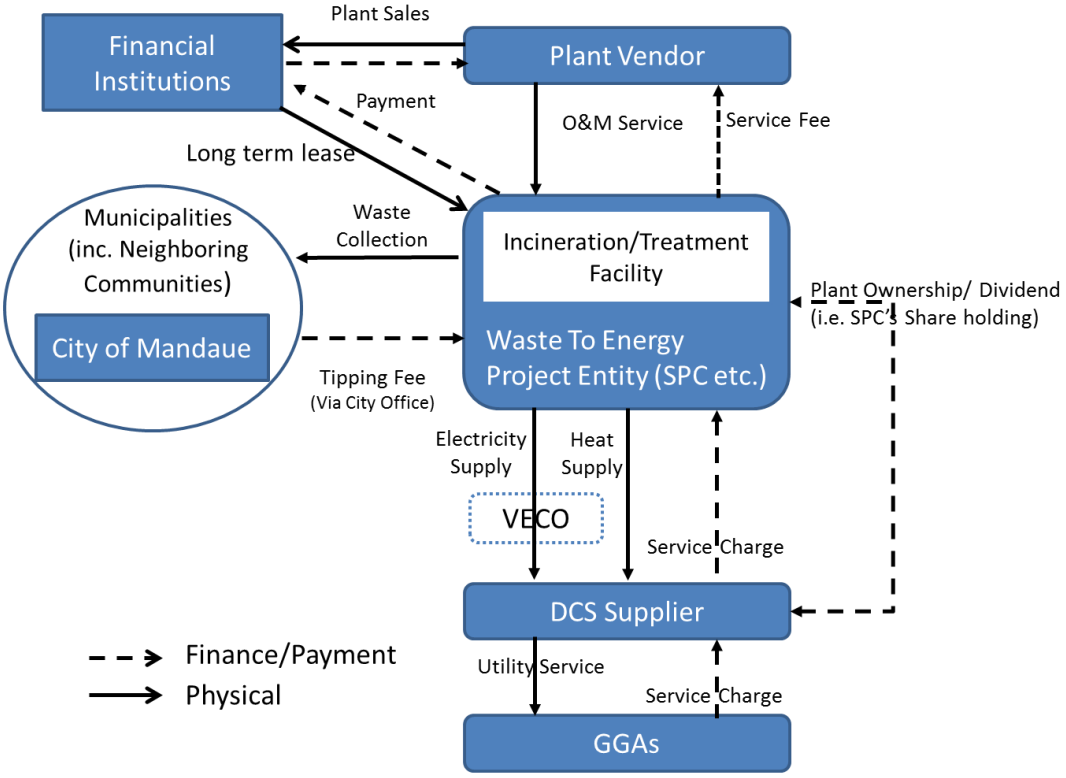



**Figure 12.3.2 Project Scheme for WTE and DCS**

Waste to energy project tends to become a costly project and investment. Facilities are often owned by the entity, i.e., special purpose company (SPC), aiming to manage the facility for asset management. The plant vendor sells the plant to a financial institution, then the plant is lent to a SPC with a lease contract. The plant vendor also provides O&M service along with the contract with SPC. SPC is aimed to avoid particular project participant to bear the investment and results in large asset proportion in particular investors' balance sheet. SPC will own the waste treatment facility during the depreciation period and then after transfer the asset with remaining asset value to either the municipalities or other entities. Project participants own share of the SPC and receive dividend to supplement. SPC's revenue consists from sales of heat and electricity.

Many waste management projects are unable to attain project feasibility only with heat and electricity sales to recover capital investment. Waste management service often

relies on service revenues from garbage collection service, called tipping fee. The project's feasibility is sometimes driven by tipping fees as income receivables of the SPC.

For DCS, the supplier purchases electricity and heat from the WTE plant and provide this to the district. The DCS supplier, in many cases, holds shares of the SPC and receives dividend from the SPC's WTE project.

## 12.4 Funding Sources for LCMT Development

### 12.4.1 International Financial Institutions

The following is a list of international financial institutions with potential interest in providing funding for low carbon projects in Mandaue City:

(a) **World Bank (Philippines):** The World Bank provides loans, credits and grants to developing countries for projects in a wide range of sectors including the projects for environmental sustainability and clean energy. For example, in 2016, the World Bank signed the Access to Sustainable Energy Project grant agreement with the LGU Guarantee Corporation (LGUGC). More than 40,000 poor families without electricity in remote areas of the member economy will benefit by having access to solar energy. In Metro Cebu, the World Bank and its Clean Technology Fund currently provides project loan for the Cebu City BRT Project (USD110 million) where co-financers are the French Development Agency (AFD, USD52 million) and the Clean Technology Fund (CTF, USD25 million).

(b) **International Finance Corporation (IFC, Philippines):** IFC is a member of the World Bank Group that provides investment and advisory services for the private sector on developing countries. Addressing climate change issue is one of its goal. In the Philippines, IFC is supporting a 180-megawatt solar-and-biomass plant investment on the island of Negros. IFC also supported Mandaue City in Metro Manila in drafting a green-building ordinance that requires new buildings to adopt environmentally friendly features.

(c) **Asian Development Bank (ADB, Philippines):** ADB assists its members, and partners, by providing loans, technical assistance, grants, and equity investments to promote social and economic development. In recent years, ADB has provided its services for environmental sustainable development and disaster recovery in the Philippines. Representative project areas are wastewater improvement, sanitation development, solid waste management, renewable energy (wind farm), air quality management, climate resilience and green growth, recovery of poor municipalities affected by Typhoon Yolanda and market transformation through energy-efficient electric vehicles (e-trikes, loan from ADB - USD300 million and CTF USD100 million and grant from CTF USD5 million).

(d) **Global Environmental Facility (GEF, Philippines):** GEF is an international partnership of institutions, civil society organizations and the private sector, including UNDP, UNEP, the World Bank and ADB to address global environmental issues. It supports a broad range of climate change projects in developing countries, focusing on the areas of renewable energy, energy efficiency, sustainable transport, land use change and management, and forestry. In the Philippines, GEF has participated in 103 projects with an aggregated grant funding of USD657 million.

(e) **Clean Technology Fund (CIF):** The USD5.6 billion Clean Technology Fund (CTF) is empowering transformation in middle income and developing countries by providing resources to scale up the demonstration, deployment, and transfer of low carbon technologies with a significant potential for long-term greenhouse gas emissions savings. The Philippines is tapping USD250 million in financing from the Clean Technology Fund (CTF) to support investments in energy efficient electric vehicles (e-Trikes), industrial energy efficiency, and renewable energy. CTF investment plan was drafted under the leadership of the Philippine government in coordination with the Asian Development Bank (ADB), members of the World Bank Group (IBRD, IFC), and key Filipino stakeholders. The plan aims to catalyze large-scale investments in low carbon technologies by demonstrating their viability and addressing key investment barriers. CTF funds are expected to leverage an additional USD2 billion to achieve transformative results.

### 12.4.2 Bilateral Donor Agencies

The following is a list of bilateral entities with potential interest in providing funding for low carbon projects in Mandaue City:

(a) **Japan International Cooperation Agency (JICA):** JICA offers a range of technical and financial assistance to developing countries including Official Development Assistance (ODA) loan, grant aid (by the Japanese government), loan and equity finance to Public-Private Partnership (PPP) projects and technical cooperation projects. JICA currently undertakes a number of projects in the Philippines. In 2015 JICA and the Philippine Government made three loan agreements amounting to JPY275.7 billion for transport infrastructure and one grant agreement of JPY1.1 billion for peace development at Mindanao. To support Metro Cebu in recent years, JICA has conducted the roadmap study for sustainable urban development and provided one sector loan for water resource development and various grant projects for solid waste management, water supply operation in emergency, septage treatment equipment and others.

(b) **United States Agency for International Development (USAID):** USAID's programs in the Philippines focus on accelerating and sustaining inclusive economic growth

through Partnership for Growth activities in the areas of governance, economic growth, and health and education, and through activities that enhance the member economy's environmental resilience and foster peace and stability in six conflict-affected areas of Mindanao. The agency's spending in the Philippines in 2015 was USD163 million with about USD20 million of which was allocated for the environmental sector.

(c) **Agence Française de Développement (AFD):** It is a financial institution and the main implementing agency for France's official development assistance to developing countries and overseas territories. In 2015, AFD achieved EUR8.3 billion of commitments for development, over 50% of its financing for projects with co-benefits for the climate with priority given to Africa. In the Philippines, AFD loan has been provided to LGUs for decentralization reforms. Technical assistance covers integrated climate change and disaster management issues. In Metro Cebu, AFD has been supporting the Cebu City BRT in collaboration with the World Bank. A new project on water supply and sanitation is under preparation with ADB.

(d) **KFW Banking Group (KFW):** KFW is a German government-owned development bank group. The KFW Development Bank provides international financing to developing countries in a range of sectors including water supply, energy, biodiversity, urban development, environment and sustainability. In 2011, the bank funded the Credit Programme to Finance Local Government Investments in Waste Management (EUR 15 million).

### 12.4.3 Other Carbon and Environment Finance Related Institutions

Carbon finance refers to investment in GHG emission reduction projects and the creation (origination) of carbon offsets that are tradable in the carbon markets. Each offset represents the reduction or removal from the atmosphere in terms of $CO_2$ MT. With the exception of transactions in the carbon markets and direct transactions between buyer and seller, the Philippines may utilize the following international institutions:

(a) **Clean Development Mechanism (CDM):** CDM is a mechanism developed by UNFCCC that allows governments/organizations to earn certified emission reduction (CER) credits for all emission-reduction projects implemented in developing countries. CERs can be traded and sold to other entities, and count towards part of the member economy's emission reduction targets under the Kyoto Protocol. In 2006, the first CDM project from the Philippine was registered by the CDM Executive Board. Now ADB supports the Philippine's E-trike Project to be registered under CDM.

(b) **Joint Crediting Mechanism (JCM):** Joint Crediting Mechanism (JCM) is a new bilateral concept proposed by the Japanese Government in order to appropriately

evaluate contributions from Japan to GHG emission reductions through the diffusion of low carbon technologies in developing countries and to use them to achieve Japan's emission reduction target. JICA and ADB established JCM funds. Some Japanese environment entities (public and private) have contacted the Province of Cebu and other LGUs in Metro Cebu for the preparation of JCM projects. The Philippines and Japan signed an aide memoire with intent to establish the JCM, and are expected to sign MOU soon to implement JCM.

### 12.4.4 Summary of Funding Sources for Mandaue LCMT Development

The Study proposes nine (9) low carbon measures to Mandaue City. Recommended funding sources are analyzed by measure as follows:

- Green Loop: DPWH is responsible for road, riverbank and riverbed. EMB of DENR is responsible for river water quality management. Due to greater $CO_2$ emission reduction impact compared with the Project's modest cost, it is recommended that the state budget prioritize the Project.
- TOD: Mandaue City will guide modal shift from road traffic to urban rail through CLUP, PUDs and related PR activities. Private investment in malls, business and residential buildings will be concentrated around stations. Pedestrian and modal transfer facilities around stations will be developed in a rail development project to attract passengers. Mandaue City will mobilize its budget to guide and promote TOD related private investments.
- Smart Corridor: A couple of internet service providers have already started real-time road traffic information in mobility management (internet free business). The city government will encourage these services by providing more and accurate information from the city's TCC. The existing streetlights of over 8,000 will be replaced with LED lamps through an ESCO business arrangement. The city government will use the money from streetlight savings to develop a city-wide smart corridor.
- E-Trike: There are 15 e-trikes operating in the city by the sponsorship of Prozza, a Japanese manufacturer in Consolacion (as of August 2016). But such a private effort is limited in scale. To enjoy bargaining power to reduce unit cost, mass procurement will be done by means of public fund. The first mass procurement of E-trikes, i.e., 5,000 units for Metro Cebu and 600 units of which are allocated for Mandue City, will be applied to the on-going ADB-DOE's E-trike Project. Best public funds will be used for further mass procurement opportunities.
- AGT-CML Line: DOTr is a responsible agency for planning and implementation. DOTr can construct the proposed AGT-CML Line as a government project or under

a PPP scheme. In the former case, DOTr developed railway system and assigned LRTA for operation such as LRT Line 1 and Line 2 in Metro Manila. LRT Line 2 was financed by JICA. The latter case, DOTr made a Build-Lease-Transfer contract with a private investor to run MRT Line 3 in Metro Manila. Therefore DOTr can arrange various project schemes with suitable funds for urban rail development.

- Renewable energy: In order to comply with the city's Green Building Ordinance (GBO), public and private building developers may decide to equip solar panels at their roof-tops. Surplus electricity to be generated and consumed in their buildings can be sold to VECO. BERDE accredited green buildings can enjoy property tax exemption for a certain period. Therefore, recommended funding source is the local commercial bank.
- Waste-to-energy (WTE): Since WTE practices are limited in the Philippines, financial viability is uncertain in the case of Mandaue Project. If the project can run at the cost equivalent to a sanitary land fill[9] or less, local development banks such as Development Bank of the Philippines (DBP) and Land Bank of the Philippines provides funds. If the project is less financially sustainable, the city may seek for advanced member economy's technology and financial assistance in plant construction and operation through JCM and CDM on the condition that the project issues CER (certified emission reduction). It is noted that a WTE project can be applied to tax exemption of imported equipment in the Renewable Act of 2008 (the Republic Act No. 9513).
- DHC or DCS: The project location is GGA4 (reclamation area) near the proposed WTE plant at Barangay Umapad. An appointed developer for GGA4 from Mandaue City will develop a DHC or DCS system connecting all buildings and transmit energy from the WTE plant to the buildings. A district system enables considerable CO2 emissions reduction. But it is expensive in the initial costs and economical in the O& M costs compared with the accumulated costs of individual building arrangements. Because the DHC/DCS project will be implemented simultaneously with the WTE project under the city's initiative, the same funding sources with the WTE project are available.
- Green Building: Mandaue City mandates green buildings for all public buildings within the city and new private buildings within PUDs or GGAs in the study. Green buildings may enhance their property value due to energy efficiency and high environmental consideration. Private building owners can enjoy property tax

[9] A private SLF operator in Consolacion charges a fee of Php 700/ton in receiving solid waste.

exemption. Since green building policy can be managed within the existing property market, no public resource is required.

**Table 12.4.1 Recommended Funding Sources by Low Carbon Measure**

| Low Carbon Measure | Estimation of Capital Cost | Implementing Body | Recommended Funding Sources |
|---|---|---|---|
| Green Loop | PHP 2,200 million | DPWH, EMB of DENR, Mandaue City, NGO | DPWH for road, riverbank and riverbed.<br>EMB of DENR for river water quality control |
| TOD | PHP 1.8 million (for only design) | Private Developers, Transit Operator and Mandaue City | Local commercial bank for station front buildings.<br>Modal transfer facilities will be built within the AGT-CML Project. |
| Smart Corridor | PHP 1,020 million | Mandaue City, Internet Information Provider, ESCO | Private investment in mobility management (internet free business) and LED street lighting (ESCO business). The city government will use the money from streetlight savings to develop a city-wide smart corridor. |
| E-Trike | USD 34.5 million | International Financial Institution, DOE, Mandaue City | The first mass procurement of E-trikes, i.e., 5,000 units for Metro Cebu and 600 units of which for Mandue City, will be applied to the on-going ADB-DOE's E-trike Project. |
| AGT-CML Line | USD 818.6 million | DOTr, Private investor | DOTr portion by IFI or DA or member economy's budget alone, Private investment (if any) by various commercial sources |
| Renewable Energy | USD 356 million | Private and public developers, DOE | Local commercial bank |
| Waste To Energy | USD 25 million | Mandaue City or its contracted operator, DOE | Local development bank, JCM |
| DCS or DACS | USD 32.8 million | Private developer appointed by Mandaue City, DOE | Local development bank, JCM |
| Green Building | USD 86.6 million | Private and public developers | Local development banks particularly for public buildings, and local commercial banks |
| TOTAL | USD 1,424 million | | |

Source: APEC Study Team

# ANNEX

# ANNEX 5-1

## Results of the Initial Evaluation of LCT-1

### Table A5-1 Preliminary Scores of Mandaue Based on the LCT-I Evaluation Principles

| APEC Low-Carbon Town Indicators | Mandaue Statistics, Policies and Measures | Score |
|---|---|---|
| Demand side | | |
| 1. Town structure | | |
| 1.1 Adjacent workplace and residence | | |
| (1) Residential use and non-residential use | Total floor area (1) residential=41%, (2) commercial=35%, (3) Industrial=24%, and the entire area is basically commercial and industrial | **5** |
| 1.2 Land use | | |
| (1) Efficient land use | No floor-area ratio defined | **NA** |
| 1.3 Transit oriented development | | |
| (1) City development centered on public transit | Development roadmap is based on the "Green Loop", including AGV and BRT. | **5** |
| 2. Buildings | | |
| 2.1 Energy saving construction | | |
| (1) Thermal insulation performance | **Note 1** | **4** |
| (2) Energy saving equipment performance | | **4** |
| (3) Natural energy | | **4** |
| 2.2 Green construction | | |
| (1) Green construction guidelines | Philippine's first municipality to apply BERDE (Building for Ecologically Responsive Design Excellence) | **4** |
| 3. Transportation | | |
| 3.1 Promotion of public transportation | | |
| (1) Easy-to-use public transportation | Buses, jeepnies and trikes are common vehicles available everywhere. | **3** |
| (2) Comprehensive transportation measures | **Note 2** | **4** |
| 3.2 Improvement in traffic flow | | |
| (1) Transportation demand management | One-way systems have been introduced in some major roads to control the flow. | **3** |
| (2) Transportation infrastructure planning | **Note 2** | **3** |
| 3.3 Introduction of low-carbon vehicles | | |
| (1) Introduction of low-carbon vehicles | While "e-trikes" are being planned, the high electricity price impedes the use of EV types of vehicles. There is no subsidy system on this. | **1** |
| 3.4 Promotion of efficient use | | |
| (1) Support for eco-driving | The maturity of economy and traffic density on the roads have not reached to the level to consider "eco-driving". | **1** |
| Supply side | | |
| 4. Area energy system | | |
| 4.1 Area energy | | |
| (1) Introduction of area energy | While the potentials are large in the "Green Growth Areas", actual plans have not been made. | **2** |
| 5. Untapped energy | | |
| 5.1 Untapped energy | | |
| (1) Introduction of untapped energy | Potentials are large in the use of waste heat from food industry, which is a major industry of the city. | **1** |
| 6. Renewable energy | | |
| 6.1 Renewable energy | | |
| (1) Introduction of renewable energy | 50% of sources of Visayan Electric Company (VECO), which supply electricity to Mandaue, is renewable, mainly hydro and small portion of geo-thermal. | **5** |
| 7. Multi energy | | |
| 7.1 Multi energy | | |
| (1) Introduction of a multi energy system | Potentials are large in a couple of the Green Growth Areas, where the neighborhood is yet to be developed. | **1** |
| Demand & supply sides | | |
| 8. Energy management | | |
| 8.1 Energy management of buildings/areas | | |
| (1) EMS (BEMS, HEMS, FEMS) | **Note 3** | **3** |
| (2) Area energy management system | | **3** |
| (3) Smart micro grids | | **3** |
| Environment and resources | | |
| 9. Greenery | | |
| 9.1 Securing green space | | |
| (1) Formation of green shades | Street-trees are planned along the new roads of the | **4** |

| APEC Low-Carbon Town Indicators | Mandaue Statistics, Policies and Measures | Score |
|---|---|---|
| | "Green Loop". Conventional roads are also treed. | |
| (2) Formation of greening | Some seashore areas of the Green Growth Areas will be preserved as Mangrove forest to maintain the eco-system. | **2** |
| 10. Water management | | |
| 10.1 Water resources | | |
| (1) Water usage | While the water issues are discussed in the water meeting of Metro Cebu Development and Coordinating Board, specific efforts on the reduction of water usage and recycling are not focused. | **1** |
| (2) Water reuse [1] Rainwater use | | **1** |
| (2) Water reuse [2] Use of recycled wastewater | | **1** |
| 11. Waste management | | |
| 11.1 Waste products | | |
| (1) Reduction of waste products | Efforts are in place to reduce solid waste, as landfill plots are limited. | **1** |
| (2) Reuse of waste products | No means can be seen in garbage separation. | **1** |
| 12. Pollution | | |
| 12.1 Air | | |
| (1) Air pollution | Comprehensive Land Use Plan (CLUP) and Green Growth Areas are aimed at the mitigation of air pollution, and Air Quality Reports are published | **4** |
| 12.2 Water quality | | |
| (1) Water pollution | "Butuanon River Rehabilitation Plan" is in place. | **3** |
| 12.3 Soil | | |
| (1) Soil contamination | No explicit plans are observed. | **1** |
| Governance | | |
| 13. Policy framework | | |
| 13.1 Efforts towards a low-carbon town | | |
| (1) Policies/business plans to create a low-carbon town | CLUP, Green Loop, and Green Growth Areas are planned. | **4** |
| (2) Budget for policies/business plans to create a low-carbon town | MCDCB functions as a promoting body of sustainable development of the region with priorities, and facilitates regulation enforcement and budget allocation. | **5** |
| 13.2 Efforts towards sustainability | | |
| (1) Business/life continuation plans | Mitigation plans are in place and being enforced against floods, which are the major cause of natural disaster of Mandaue | **4** |
| (2) Development with less influences | | **4** |
| 14. Education and management | | |
| 14.1 Life-cycle management | | |
| (1) Enlightenment and education for energy saving and a low-carbon town | No explicit information can be found in the initial data obtained. | **NA** |
| (2) Area management towards and energy-saving and low-carbon town | MCDCB is a regional community organization, comprising mayors, and is functioning effectively. | **5** |

Source: APEC Study Team

Note 1: Mandaue is the first city in the Philippines to adopt Filipino Green Building Code as its bylaw. The Green Building Code is called "Building for Ecologically Responsive Design Excellence" (BERDE), which was developed and enacted by Philippine Green Building Council. BERDE covers a broad scope of measures including building material, energy-saving equipment, and the use of natural ventilation, which are adopted by LCT-I, and these items, thus, are in place in Mandaue.

Note 2: Transportation plans should be discussed with neighboring cities, where the transportation systems in Mandaue stretch, and a comprehensive transportation plan and roadmap have been developed for the entire Metro Cebu Region, which includes Mandaue, under the subsidy of JICA. The introduction of the AGT is proposed in the roadmap, as well as the Green Loop, which links the neighboring cities, and BRT in Cebu, which is being developed with the aid of the World Bank, is planned to be extended to Mandaue.

Note 3: In one of the Green Growth Areas, which is located close to the border with Cebu City, a new neighborhood will be developed on a new filled-in land, and these energy management systems can be introduced in the new buildings and neighborhood.

The following table shows the conversion of the preliminary scores shown above into five-star ratings.

## Table A5-2 Conversion of the Preliminary Scores into Five-Star Ratings (1)

| | | | | | |
|---|---|---|---|---|---|
| **Demand Side** | | | 3.8 | | |
| 1. Town Structure | | | | 5 | |
| | 1.1 Adjacent work place and residential | | | | 5 |
| | 1.2 Land use | | | | NA |
| | 1.3 Transit-Oriented Development | | | | 5 |
| 2. Buildings | | | | | |
| | 2.1 Energy saving construction | | | 4 | |
| | | (1) Thermal insulation | | | 4 |
| | | (2) Energy saving equipment | | | 4 |
| | | (3) Natural energy | | | 4 |
| | 2.2 Green construction | | | | 4 |
| 3. Transportation | | | | 2.5 | |
| | 3.1 Promotion of public transportation | | | | |
| | | (1) Easy-to-use public transportation | | | 3 |
| | | (2) Comprehensive transportation measures | | | 4 |
| | 3.2 Improvement in traffic flow | | | | |
| | | (1) TDM | | | 3 |
| | | (2) Transportation infrastructure planning | | | 3 |
| | 3.3 Introduction of low-carbon vehicles | | | | 1 |
| | 3.4 Promotion of efficient use | | | | 1 |
| **Supply Side** | | | 2.3 | | |
| 4. Area energy system | | | | 2 | |
| 4.1 Area energy | | | | | 2 |
| 5. Untapped energy | | | | 1 | |
| 5.1 Untapped energy | | | | | 1 |
| 6. Renewable energy | | | | 5 | |
| 6.1 Renewable energy | | | | | 5 |
| 7. Multi energy | | | | 1 | 1 |
| **Demand and Supply Sides** | | | | | |
| 8. Energy management | | | 3 | | |
| 8.1 Energy management of buildings/areas | | | | 3 | |
| | | (1) EMS | | | 3 |
| | | (2) Area energy management system | | | 3 |
| | | (3) Smart micro grid | | | 3 |
| **Environment and Resources** | | | 1.9 | | |
| 9. Greenery | | | | 3 | |
| 9.1 Securing green space | | | | | |
| | | (1) Formation of green shades | | | 4 |
| | | (2) Formation of greening | | | 2 |
| 10. Water management | | | | 1 | |
| 10.1 Water resources | | | | | |
| | | (1) Water usage | | | 1 |
| | | (2) Water reuse [1] | | | 1 |
| | | (3) Water reuse [2] | | | 1 |
| 11. Waste management | | | | 1 | |
| 11.1 Waste products | | | | | |
| | | (1) Reduction of waste products | | | 1 |
| | | (2) Reuse of waste products | | | 1 |
| 12. Pollution | | | | 2.7 | |
| 12.1 Air | | | | | 4 |
| 12.2 Water quality | | | | | 3 |
| 12.3 Soil | | | | | 1 |

| | | | | |
|---|---|---|---|---|
| **Governance** | | 4.6 | | |
| 13. Policy framework | | | 4.3 | |
| 13.1 Efforts towards a low-carbon town | | | | |
| | (1) Policies/business plans | | | 4 |
| | (2) Budget for policies/business plans | | | 5 |
| 13.2 Efforts towards sustainability | | | | |
| | (1) Business/life continuation plans | | | 4 |
| | (2) Development with less influences | | | 4 |
| 14. Education and management | | | 5 | |
| 14.1 Life-cycle management | | | | |
| | (1) Enlightenment and education | | | NA |
| | (2) Area management | | | 5 |

Source: APEC Study Team