

Chapter 1

Data Collection

1. Climate of Brunei Darussalam and Temburong District

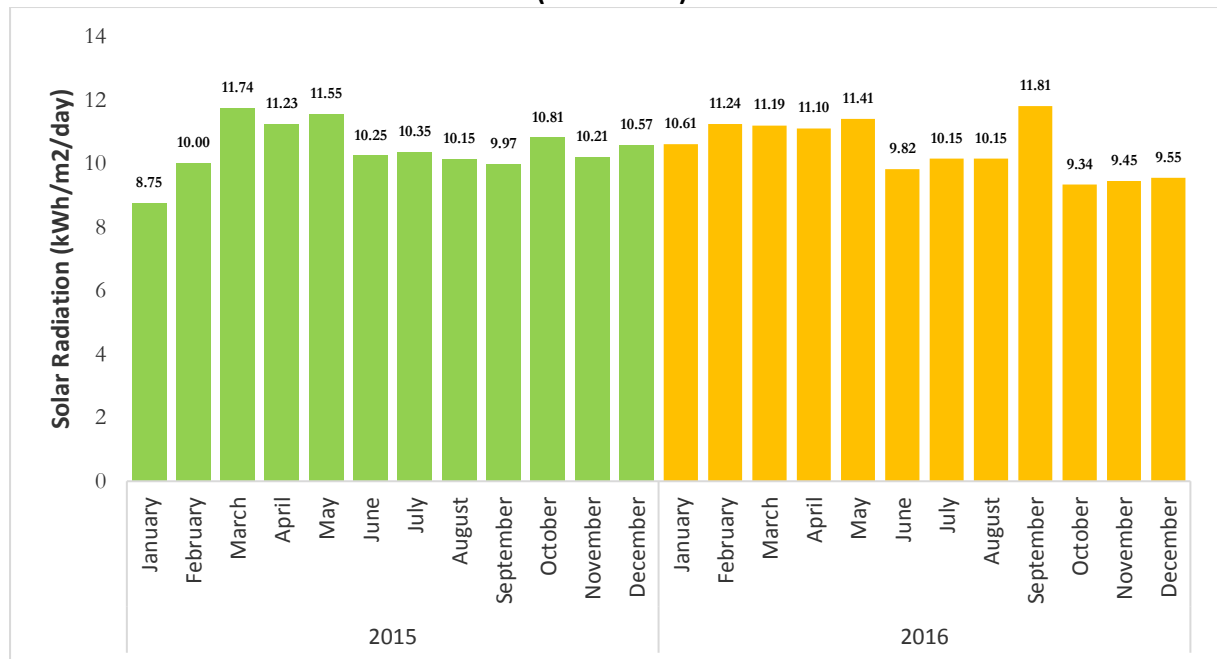
Situated at around four degrees north of the Equator, Brunei Darussalam enjoys an equatorial climate with an abundance of sunshine, high temperatures, and rainfall all year round. These parameters influence the development of the solar research programme, which may include solar photovoltaic (PV) modelling. In Brunei Darussalam, only three meteorological stations are available, the Brunei International Airport (BIA) meteorological station being the main one. In this chapter, data on solar radiation and rainfall will be examined and analysed.

1.1. Climate and Weather of Brunei Darussalam

1.1.1. Solar Radiation

Solar radiation data for years 2015 and 2016 were obtained from the Brunei Darussalam Meteorological Department (BDMD), a government agency under the Ministry of Communications. BDMD records the solar radiation data at the BIA meteorological station, which is the only station that has the capability to measure solar radiation and bright sunshine hours. The station utilises an Eppley black and white pyranometer and a Campbell–Stokes recorder, and is fully automatic.

Figure 1.1. Monthly Average Daily Solar Radiation in Brunei Darussalam (2015–2016)

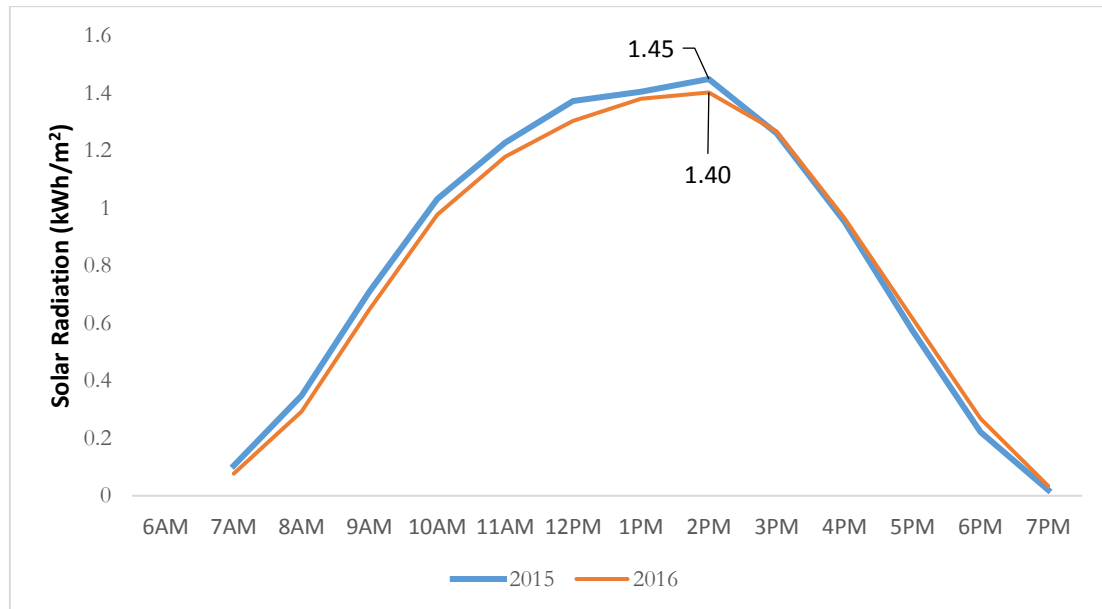


kWh = kilowatt-hour, m² = square metre.

Source: Brunei Darussalam Meteorological Department (2017).

Figure 1.1 shows that the monthly average daily solar radiation ranged from 8.75 kilowatt- hours per square metre per day (kWh/m²/day) in January 2015 to 11.81 kWh/m²/day in September 2016. The country received relatively low solar radiation in January 2015, October 2016, November 2016, and December 2016, which could be due to the presence of clouds or the occurrence of rain.

Figure 1.2. Annual Average Hourly Solar Radiation for 2015 and 2016



kWh = kilowatt-hour, m² = square metre.

Source: Brunei Darussalam Meteorological Department (2017).

Figure 1.2 shows the average hourly solar radiation for 2015 and 2016. The curves follow each other closely and exhibit an approximate symmetrical shape at noon (between 12:00 noon and 2:00 p.m.), with the radiation being highest at around 2:00 p.m. at 1.45 kWh/m² in 2015 and 1.40 kWh/m² in 2016.

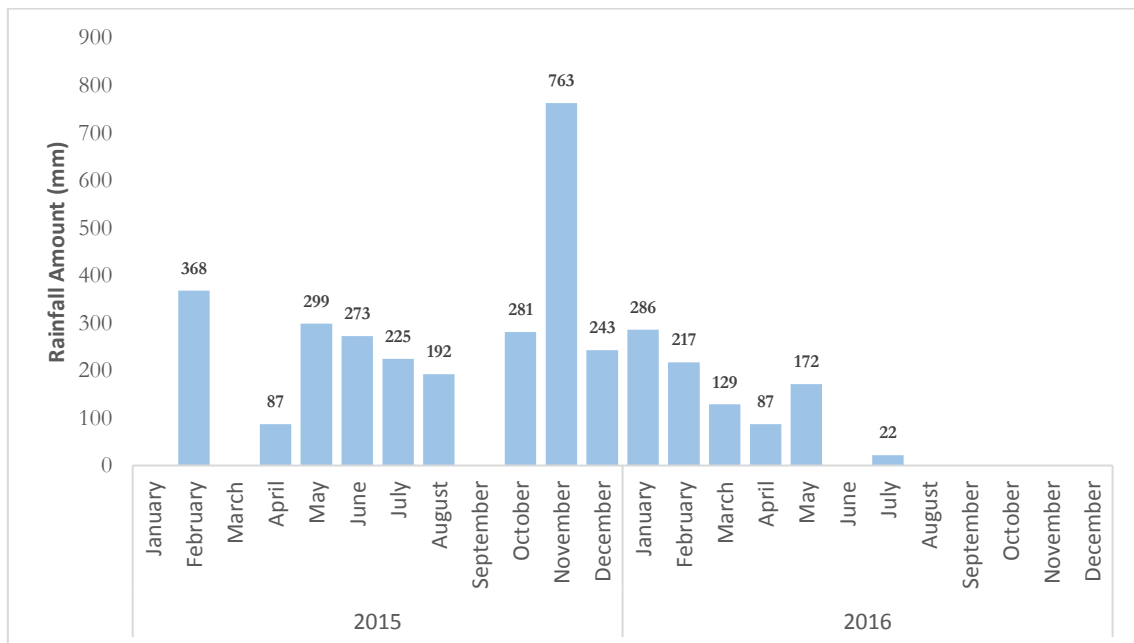
It should be noted that the solar radiation data cited above were measured only within the Brunei Muara District where the BIA meteorological station is situated. However, since the latitudes and longitudes of all the districts are close to each other, these solar radiation values can be assumed to be similar (Malik and Abdullah, 1996).

1.1.2. Rainfall

BDMD also provided the rainfall data but based in Bangar area, Temburong District, unlike data on solar radiation that was not measured locally in the district. Between 1984 and 2013, the country's average rainfall amounted to about 2,976 millimetres (mm), with an increase of 26.16 mm per year (Pg. Ali Hasan, Ratnayake, and Shams, 2015).

Figure 1.3 shows that November 2015 had the highest rainfall amount of about 763 mm, coinciding with the wet season, which usually occurs between October and February. July 2016 had the lowest with 22 mm. Missing data in most of the months are attributed to technical problems in measurements at Bangar station, according to BDMD. This makes it difficult to properly understand rainfall trends in the area.

**Figure 1.3. Rainfall Data in Bangar, Temburong District
(2015 and 2016)**



mm = millimetre.

Source: Brunei Darussalam Meteorological Department (2017).

1.2. Temburong District

1.2.1. Overview

Temburong District is located at the eastern edge of Brunei but is separated from the remainder of the country by the Malaysian state of Sarawak and the South China Sea to the north. The district is home to the country's most extensive forest area, of which 500 square kilometres in the south is still pristine (Hadi et al., 2011). The district comprises five provinces: Bangar, Bokok, Amo, Batu Apoi, and Labu. Bangar is the urban centre within the district as it contains Bangar town, which is the capital town with the most significant development. Temburong is largely underdeveloped, especially in certain areas in the central and southern parts, which are characterised by mountainous terrain and river catchments. The northern region is mostly low-lying, which makes it prone to tidal flooding. The district's development has therefore concentrated around central Temburong, which has access to river valleys and the main road system.

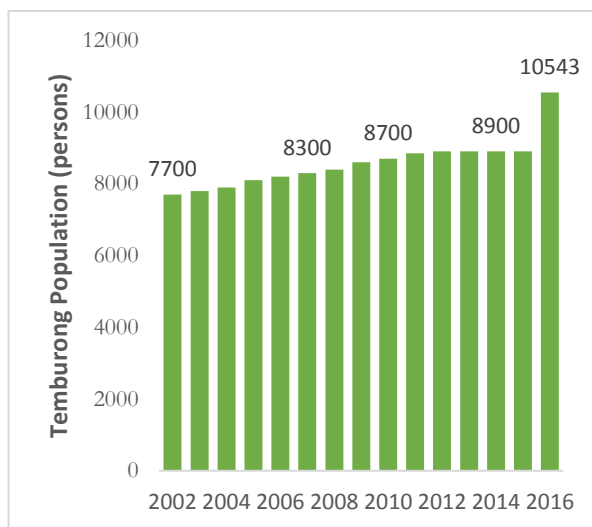
1.2.2. Temburong District Plan 2006–2025

In August 2010, Town and Country Planning Department, Ministry of Development established the Temburong District Plan 2006–2025, with the purpose of guiding and managing potential developments to meet key environmental, social, economic, and rural and urban land use objectives up to 2025. Sustaining the district's community is one of the core strategies in the district plan through providing adequate community facilities while preserving the richness of its forestry, biodiversity, and other natural resources.

1.2.3. Population

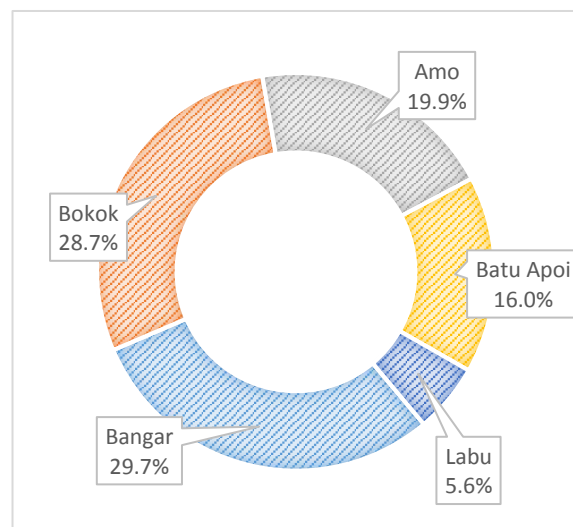
Although Temburong is the second largest district within Brunei Darussalam, it is sparsely populated with only 10,543 inhabitants in 2016, which is about 2.5% of the whole population of Brunei Darussalam (Department of Economic Planning and Development, 2016). Figure 1.4 illustrates that population had been growing at an annual rate of 1.12% from 2002 to 2015, with the population peaking at 8,900 between 2012 and 2015. However, there was a significant rise in population in 2016 at 10,543, with an increase of 18.5%. This may be due to the settlement of new residents through the Rataie National Housing Scheme.

Figure 1.4. Overall Population in Temburong (2002–2016)



Source: Department of Economic Planning and Development (2016).

Figure 1.5. Share of Population in Temburong by Mukim



Source: Department of Economic Planning and Development (2001).

Based on the 2001 Report on the Population Census, the majority of the Temburong population lives within Mukim¹ Bangar, corresponding to approximately 29.7%. This is evident since Bangar town is located within the mukim. About 28.7% reside in Mukim Bokok, followed by Mukim Amo at 19.9%, Mukim Batu Apoi at 16%, and Mukim Labu at 5.6% (Figure 1.5).

The population in Temburong is forecast to grow rapidly since a 30-kilometre-long mega bridge connecting Bandar Seri Begawan and Temburong is due to be completed in 2019. Since more economic activities are expected to bloom in the district, demand for housing lands will increase. Although the demand for energy in Temburong is the least among all the districts, the energy demand’s annual growth will double from the current 3% rate, hence the importance of maintaining energy security, as well as its usage, in a sustainable manner within the district.

¹ County, ward, or parish are the closest English translations for *mukim*.

1.2.4. Bangar Urban Growth Expansion

As shown in Figure 1.6, Bangar is the only town and main service centre within the district. The current infrastructure and development within the town is constrained by Temburong River, the route of the highway between, and the edge of the Biang Ridge to the south of the town. The centre hub is located on each bank of the river to the north of the Temburong River Bridge. Government offices and Pengiran Isteri Hajjah Mariam Hospital are located on the east and west bank of the river, while commercial entities are focused on the east bank. Residential lots are found on the west bank and to the north.

Figure 1.6. Bangar Town

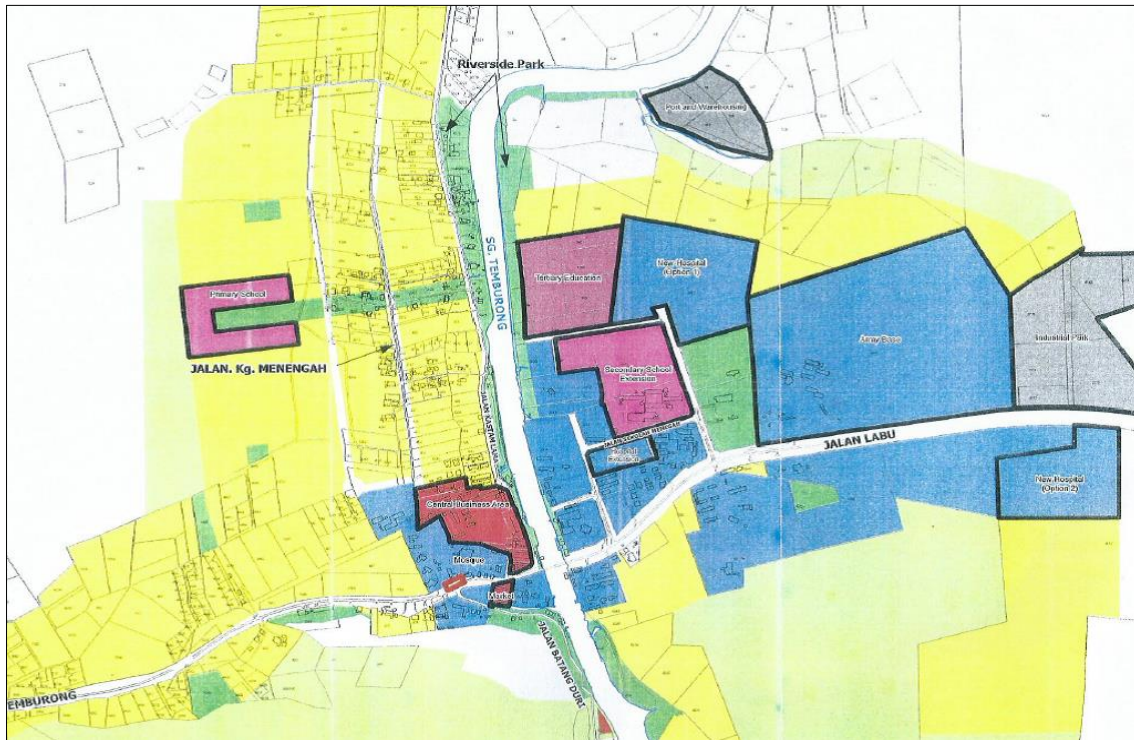


Source: Google Map (2018).

Under the Temburong district plan (Figure 1.7), the following are the key elements of the Bangar urban growth expansion:

- Expansion of the current commercial area, with an allocation of 3.2 hectares (ha) of additional land. This area will also include tourist accommodation (hotel);
- Allocation of 2 ha of land for the expansion of Temburong Industrial Estate to support agricultural and fisheries activities, as well as small service-related industrial activities;
- Allocation of some land for expansion of new government activities in the south of Jalan Labu;
- Allocation of at least 10 ha of land for a new hospital complex, or expansion of the existing Pengiran Isteri Hajjah Mariam Hospital;
- Allocation of some 10 ha of land for the development of tertiary education, i.e. university;
- Allocation of 6 ha of land for a modern port facility, fronting Temburong River to the north east of Bangar;
- Allocation of a new green space to the south of Bangar town; and
- Creation of a new riverside park along the Temburong River.

Figure 1.7. Bangar Proposed Land Use



Source: Town and Country Planning Department (2006).