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Brunei Darussalam's Way to the Future through Modern Mapping

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Abstract

In 2008, a new street directory was published in Brunei, to replace the book from 1996. This paper considers issues that were involved in producing the updated book, especially the advances in technology that have transformed the process of map-making in the intervening fourteen years. It also considers the perception of students at UBD, and how the existence of modern maps and enhanced geographical knowledge might influence their traditional spatial awareness.

Introduction

In 2008, work was completed on a new street directory for Brunei Darussalam (Becek, 2008). It represented a much-needed update on the existing street directory (BSM, 1996), in particular showing the many new roads and buildings that had been constructed in the intervening years.

One issue of interest since the publication of the earlier volume is how recent advances in technology have changed the ways we do cartography, especially in the use of technology. Some of these changes are described in this paper. Then there will be a discussion of the spatial perception among students at UBD, summarising some of the results from a comparative study of students in Brunei and Poland (Bac-Bronowicz & Becek, 2009). Finally, there will be a consideration of the extent to which modern maps have influenced the spatial perceptions of Bruneians over the past decades, and what impact they may have in the future.

Defining a Map and Mapping Needs

Over many centuries, countless attempts have been made to define a map, but most of them do not attempt to explain what elements constitute a map (Kraak & Ormeling, 2002, Pickles, 2003). Here is my attempted definition of a map. It includes not only what a map is made of, but also its function:

> A map is a collection of spatially related data presented for use by the human visual perception system in order to extract information.

A street directory is one type of map. It shows data concerning the transportation infrastructure in the area it covers, so streets form the main fabric of the map, and they are labelled with their official names. In addition, some traffic arrangements, such as one-way roads and no entry signs, may also be found.

Besides streets, some additional information is also found in street directories in order to make them useful to a range of users and applications. This may include the location of schools, hospitals, and other public facilities such as emergency services and petrol stations. Some administrative information in the form of village names is provided as well. Occasionally, transportation routes or other facilities that are projected or under construction are also shown. The textual part of a street directory always includes an index of objects found in the maps, particularly the street names.

Normally, a street directory does not indicate short-term information such as road closures or the location of temporary facilities because of the incidental nature of these features. They usually

exist for much less time than the life cycle of the street directory (the time lapse between the old and new editions).

A map is an important factual document used by the public at large. It is therefore crucial that the author of a map take all the necessary steps to ensure that the document is, as far as possible, free of mistakes and omissions. The quality of a map is assessed by its spatial accuracy, the correctness of the annotations, and the currency of the data shown. For an average user of a street directory, the most important are the last two characteristics, because a street directory is mainly used for obtaining qualitative information, such as how the landmarks are located in relation to each other, rather than how far are they apart. However, because of the enormous complexity of the process of producing maps, from data acquisition through editing to the final printing, it is inevitably subject to some omissions and other errors. One must accept that a map with no mistakes is just a pleasant dream of cartographers.

A new map is usually a compilation of an old map together with new data, and the changes between the old and the new are partly due to natural processes as well as the activities of humans. In the case of a street directory, towns and cities usually offer much work for cartographers. For example, in recent years the city of Gold Coast in Queensland, Australia, where there are 400,000 people living in houses along about 5,500 streets, has been growing at the staggering rate of about 250 new streets per year (during the period from 1995 to 2005). Such a substantial increase in the number of streets requires a well organised data flow from land developers to the cartographer who is responsible for updating the local maps. In the example of Queensland, the Department of Environment and Resource Management (http://www.derm.qld.gov.au/mapping/index.html) is in charge of the smooth flow of geographic data from the field to the cartographers and finally to the users of the maps.

The development of a transportation infrastructure is always followed by the building of many other components of an urban system, such as human dwellings, commercial precincts and recreational facilities. All these newly-created facilities demand a proper representation in the street directory so that they can easily be located by users of the document.

In a traditional society such as that of Brunei, the word-of-mouth method has in the past been effective in allowing people to find out where things are. However, this oral transmission of information is not available to everyone, especially to tourists and other temporary residents in the country. In addition, the growing complexity of an urban organism gradually makes it less practical for the word-of-mouth method to communicate spatial information efficiently. Finally, a crucial argument justifying the need for a new street directory is the fact that no revised document had been published for about twelve years (since 1996), despite a substantial urbanisation of the country. Put simply, the existing document was out of date.

Modernisation of Map-Making Technologies

Since the publication of the original street directory in Brunei (BSM, 1996), there have been many technological innovations that have influenced the map-making process. Three will be discussed here: the development of GPS technology; the popularisation of satellite and aerial imagery; and the Internet.

For many professionals, including cartographers, GPS is currently the most important spatial data acquisition system. Although it has been around since 1995, the surge in its popularity only began in 2000 when the American military, which owned the system, turned off the accuracy degradation system. In that instant, the accuracy to determine position improved from about 100 m to about 7 m. With that level of accuracy provided by an over-the-counter GPS device, many types of maps could easily be drawn. The map-making task has been even further facilitated by mobile phones and digital cameras which can be equipped with positioning sensors. Moreover, it would not

be difficult to identify some other devices which most likely will be equipped with GPS sensors in the not too distant future.

The growing importance of the positioning, timing, and navigation data in countless branches of sciences and day-to-day life was quickly recognised not just by Americans. Similar positioning systems are already operational, near-operational, or planned, including the Russian GLONASS and the European GALILEO systems. All these systems, present and future, are collectively referred to as Global Navigation Satellite Systems, or GNSS. The latest state-of-the-art positioning sensors are already GNSS-enabled, which means that they use signals from more than one of the systems to determine position, and this increases the reliability and accuracy of the positioning data.

However, easy access to positioning data does not mean that cartography has become an obsolete profession, for positional coordinates are merely the starting point for producing a good map. A glimpse at any map can enable one to realise that many of its components cannot be captured using GPS. Street names, for example, are attributes assigned by humans without reference to natural properties or geographical objects. And delving further into the art and science of map-making, one may appreciate that it is not a trivial task to reduce and project 3D space onto a flat surface while minimising unavoidable distortions in the final 2D scale model of reality. Even though two centuries of research on reducing the 3D real world to 2D maps has resulted in a comprehensive, mathematically-sound theory of map projections (Snyder, 1997), nonetheless the mathematical formulas are often too complex to deal with, even for many geoscientists.

Furthermore, an essential skill of map-making is the ability to draw aesthetically pleasing maps, something that can only be mastered by means of the long-term study of maps as a work of art. Critics argue that this part of the map-making process can be resolved by preparing templates for every type of map, which would mean that cartographers are no longer required to develop this skill. But it is worth remembering that similar debates arose both after the invention of photography suggested painting might become redundant and the development of moving pictures similarly threatened the art of acting.

The second technological development that has significantly influenced the map-making process is the use of high-resolution satellite and aerial images. Unlike GPS, images provide not only the location information or coordinates, but also attributes of geographic objects such as shape, colour and the spatial relationships between the object and its surrounding. Access to such data was restricted for a long time, and it still is in many countries around the world including Brunei Darussalam. An existing, obsolete law is to blame for this situation. Nevertheless, the data is becoming more widely available nowadays.

One major advantage of satellite imagery is that it is available at different detail levels or resolution, ranging from about 0.5 m for local needs, up to a few hundred metres for global applications. Another important characteristic of the images is that they are pre-processed, or ‘ortorectified’, before they are released to users. Ortorectification is a digital process of removing distortions from images caused by the roughness of the terrain and the photographic process (Robinson *et al*, 1995). The ortorectified image can then be overlaid with existing maps and GNSS readings.

Finally, we have the popularisation of the Internet. There is a constant enrichment of the availability of valuable, user-friendly applications, which is ensuring the accessibility to spatial data not only for entertainment purposes, but also for map-making. In fact the Internet not only influences the map-making process, but it also facilitates much easier dissemination of maps to a wide range of users.

At first glance, the technological innovations might all seem beneficial for map-making. Inevitably, however, there are some drawbacks. For example, many maps can be found in cyberspace which do not maintain basic cartographic standards, because it is nowadays easy for anybody to draw a map and upload it onto the web. Quite apart from deliberate distortions for various reasons, maps available on the Internet can reflect a distorted model of reality as a result of

a range of accidental problems such as: errors and omissions, inconsistent scales, misleading legends, lack of information on data sources used, confusing colour schemes, inappropriate size of annotations, and wrong projections chosen. Such issues can lead to serious consequences for the users of such dubious maps, but a proper disclaimer suggesting caution while using them is seldom provided for Internet maps.

For example, GoogleEarth® is a widely-used portal and it is generally considered reliable. However, discrepancies can be found in the location of its data. Figure 1 in the left pane shows an image from the Mehrabad International Airport, Teheran, Iran, and it appears to indicate that the runway is not entirely straight. This is presumably a distortion, as it is highly unlikely that any airport in the world really does have a crooked runway. Another obvious error is shown in the right pane. The snapshot shows an area in Brunei Darussalam. In the centre of the picture, a discontinued major road is clearly visible. Note also a 'ghost' object in the right-hand corner of the snapshot.

Figure 1. The GoogleEarth® image of the runway 11L at the Mehrabad International Airport, Teheran, Iran (left pane). A discontinued major road in highly populated Brunei Muara District of Brunei Darussalam. Note also a 'ghost' object in the upper left corner of the image (right pane). These snapshots have been captured in March, 2011.

Anyone using web-based material such as this should consider the potential risk (Potere, 2008) in depending on spatial data and maps without prior knowledge about their quality. If in doubt, professional advice should be sought. Every map is an important document showing a collection of facts or objects located in space at a particular point in time, and verification of the accuracy of the data is an important task of the map-making expert.

The Role of the Survey Department

Every country has a survey department which is responsible for providing spatial services to the government, including the maintenance of a database of objects located in the country. Objects of interest include land parcels, rivers and lakes, forests, buildings and roads. In fact, everything that occupies space is of interest to the survey department.

Each object is characterised by a number of attributes. For example, a parcel of land is usually described by such things as the location of its corners, the land area, the name of the owner, and the legal status of the land. The type of attribute used to describe a particular type of object is determined by particular needs. The fire and rescue department, for example, is interested in details which are essential for their activities, such as the number of residents, the type of roof, and the location of the closest hydrant. In contrast, a marketing company needs other attributes of the land parcel, such as the monthly income of residents, their buying power, and the number of car owners.

The role of survey departments is mainly to capture the location data and some basic attributes for all the various types of object in the country. A building hosting many shops is identified by surveyors just as a commercial facility, and no further details about the number of shops or their nature are usually collected or stored by the survey department. It is the job of the interested agencies to collect the particular attributes that are of interest to them.

The preparation of new and the maintenance of existing maps is the responsibility of the survey department. However, these maps are prepared to satisfy the needs of the government's departments. Some mapping services are also available to the public, but they are limited to land related matters and the supply of standard and existing maps.

Therefore, in every country there is a niche in the map market for the production and distribution of a wide range of different types of maps, such as street directories, tourist maps, ecological maps, goods distribution maps, and maps showing the location of hydrants and water bodies available to the fire and rescue services. These are all specific maps which show the attributes of objects required for particular needs.

A starting point for these specialised maps are those produced by the survey department, such as topographic maps at various scales (such as 1:1,000 and 1:10,000,.), which show not only the location of objects, but also the irregularities of the terrain.

In some countries, access to spatial data including aerial photography, satellite imagery and topographic maps is restricted by local security regulations, and permission must be obtained from the relevant department to gain access to the large-scale topographic maps. In Brunei Darussalam, the survey department handles this issue.

The recent surge of Internet-based mapping applications such as GoogleEarth® has resulted in substantial pressure on legislators towards relaxing obsolete security restrictions related to maps. While many countries have modified their security legislation, there are some other places where this has yet to happen. In the case of Brunei Darussalam, restrictions on access to spatial data are enforced by the Official Secrets Act which was enacted on 1 February 1940 and which, with some minor changes in 1988 and 2005, is still in effect (AGC, 2010). However, many of the restrictions associated with the law have to a certain extent been softened in the sense that many spatial data matters are under the discretion of the Surveyor General who seems to be reasonably flexible in relaxing in this respect.

Restricted access to digital and mapping data is, of course, a source of disappointment among professionals, and sometimes actions to acquire data may be in direct violation of the Copyright Order (AGC, 2010). In fact, such desperate measures can result in harm to people or property because of limited knowledge about the quality and reliability of the source, especially when a map is copied without permission and without any supplementary metadata. Similar dangers can occur with attempts to utilise the GoogleEarth® imagery for technical or navigation purposes (Becek and Ibrahim, 2010).

Layers of Data

The time lapse between the publication of the two street directories for Brunei Darussalam has witnessed a complete overhaul of mapmaking technology from manual drafting to a digital process. Currently, modern mapmaking software packages allow for the construction of maps by the selecting layers of data which are required on the map. A good example of this custom-driven approach to map construction would be the GoogleEarth® web application. A user is able to add predefined layers of information, such as places of interest, population centres, and many more options, and then send such a map to a peer by email or printed hard copy. The GoogleEarth® application also allows for adding custom information. All of these layers of information are projected on the extremely rich details of the high-resolution satellite imagery. However, it must be

remembered that only a limited accuracy and currency of data is delivered through the original service.

The biggest bottleneck of mapmaking is the currency and availability of data. It is clear that some components of our world change much slower than the life cycle of maps. The topography is a good example of that. At the opposite extreme, the current position of all public buses may be provided. Other examples of fast-changing phenomena requiring nearly real-time updated maps are rainfall maps, and maps dealing with road accidents, traffic congestion, and natural disasters. These examples illustrate the scale and complexity of the task of data acquisition and update faced by cartographers.

An ultimate goal of cartographers is to provide services, and some of these are described in the geosciences as *ad-hoc* maps—maps that are prepared instantly based on the requirements of a client. For example, the nine-eleven catastrophe required the delivery of *ad-hoc* maps to facilitate the effective management of the disaster, and similar needs occur when dealing with a forest fire. The most advanced countries, in terms of the rapidness of services provided by survey departments, have already reached a point where an *ad-hoc* map can be produced and delivered instantly.

The acquisition of data to develop a map involves considerable costs. It is, therefore, reasonable for owners to share the data sets and thereby reduce costs by avoiding duplication of effort. Unfortunately, this paradigm is not universally accepted and observed, for reasons that do not always have any rational justification. In Brunei, the survey department is currently striving to resolve this obstacle, but there has only been limited progress to date. Consequently, the multi-million dollar investment in the Brunei Spatial Data Infrastructure (BSDI) has not yet produced the expected results (BSDI, 2010).

Compiling the Brunei Street Directory

The preparation of the latest street directory for Brunei required about two years of part-time work by a skilled person. This included the following activities:

1. Collection of existing maps and conversion of them into raster images.
2. Building up a database of vectors extracted from various sources, such as collected and digitised maps supplied by the survey department and the Brunei Shell Geomatics Department.
3. A field check, which involved visiting every street. During this procedure, a GPS track was recorded. The street name, as spelled out on the street sign, was also manually recorded.
4. The GPS data were downloaded and overlaid on to the existing maps.
5. Comparison of street centrelines were extracted from existing maps with corresponding centrelines acquired from GPS survey, and discrepancies were resolved.
6. Labelling street lines and other objects, such as school names.
7. Cutting the map into individual sheets.
8. Preparation of a street index.
9. Field check performed by the team from the survey department.
10. Proofreading the whole document. Double-check field visits are frequent.
11. Collaboration with the printing house.

The above summary of the activities involved in the preparation of the street directory clearly show that a dream of many that maps can be prepared by selecting the desired layers of information remains a dream. A well-trained and skilled cartographer still plays a vitally important role in the map-making process.

An example of the final output, together with a comparison with the data in the original book of maps, is shown in Figure 2.

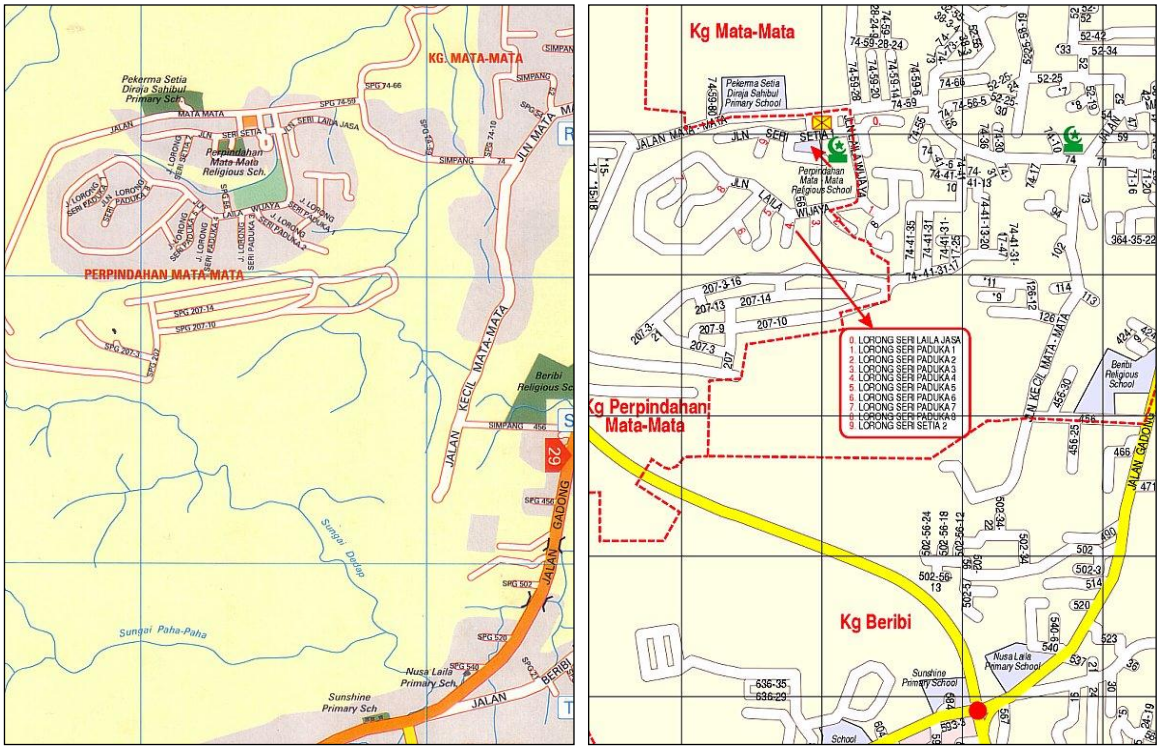

Figure 2. Fragments of the Brunei Darussalam street directories showing the same area of Brunei Muara district. The left pane is from the 1994 edition, and the right pane is from the 2008 edition. A significant increase in the number of new streets is clearly visable.

The Way to the Future through Modern Mapping

The development of a country generally involves a gradual improvement in living conditions in many dimensions across the entire society, including the modernisation and expansion of the existing physical infrastructure. The development of transportation, housing, education and cultural facilities, hospitals, commercial and industrial areas, and sport and recreational objects all require careful spatial planning.

The major objective of spatial planning is to achieve the desired aims under two constraints: minimising the use of land; and minimising the overall costs of construction of the required infrastructure. Spatial planning is very complex and time consuming. One of the fundamental requirements for a project of any form and extent is the availability of a current, accurate, and comprehensive inventory of voxels (or spatial cubes) that are being considered as potential locations for the concerned project. Such an inventory covers a detailed survey of the topography and objects found in the voxels of interests (VOI). Surveyors are trained to perform such inventories and render them in the form of maps.

For the past 25 years or so, growing sectors of the spatial sciences include geographic information systems or GIS. The adjective ‘geographic’ does not mean that GIS is a device used just by geographers. Instead, it should be understood as ‘spatial’, so spatial information systems (or SIS) is an alternative term that is frequently used. GIS (or SIS) is an information system about space, or a computerised database of our knowledge about space, so in a narrow sense, it may be considered a form of map. The superiority of GIS over traditional printed maps is indisputable, especially if one considers that the most important function of GIS is to provide a decision support system to its user. It is important to realise that not only are ad-hoc maps a GIS product, but GIS

also provides an optimal means for conducting highly complex spatial inquiries which help with the process of making decisions concerning developments in space.

Today, GIS is a tool of the trade, not only for spatial planners, but it also for all other specialists who do their business in space. It is hard to find any profession which would not consider space as a prime domain. In summary, there are no alternative means to effectively develop a country without maps and GIS. This, of course, applies to Brunei.

The development of a country is done by humans and for humans, and it is a reaction of the land administrator on pressure exerted by an expanding population. This is the point where the specific participation of the population in the development of the country takes place. As has already been mentioned, the development takes place in space, which is commonly substituted by land as a two dimensional proxy of the 3-D space.

A functional market on land transactions where an administrative process of buying and selling land takes just a couple of weeks to complete is one of the fundamental requirements to warrant effective participation of a society in the development of the country. The relevance of the relationship between land ownership and the functional market on land transactions has been recognised in Southeast Asia since at least 50 years ago when some countries embarked on national programs of land reform. An end result of land reforms is always a cadastral system, which includes a cadastral map (showing the ownership and dimensions of property). The whole society benefits from land reform because it provides a transparent confirmation of individual rights to land parcels. The authority of the government is in the issuing of these rights. A major effect of this is that the certificate of ownership becomes a legal document which may be used as a negotiating instrument with financial institutions to allow an owner to obtain loans. There is plenty of evidence of substantial benefits for societies which successfully complete cadastral reforms.

It is likely that cadastral reform might stimulate the enhancement of spatial awareness in a population, for the possibility of owning a land parcel wakens an urge to explore space for a dreamed price of land. An unavoidable companion of this exploration is always a need for a spatial guide—a current map and the skills to read it.

Preparations toward cadastral reform are well underway in Brunei Darussalam. It is hoped that the technical issues involved in the data flow and management from field to office will soon be followed by the necessary political reforms regarding land reform. These are necessary, as mentioned above, to open the land market for the benefit of all citizens of this great country. It may also happen that deficiencies in spatial awareness of young Bruneians will be gradually overcome as one of the benefits of cadastral and land reforms in Brunei. These deficiencies are discussed in the next section.

Environmentally based Perception of Space

The way of life along riverbanks, which flourished in the not too distant past among many Borneo tribes, was sustainable in all aspects, as the abundance of food on the banks of the rivers and in the rivers themselves provided no urge to explore the impenetrable Borneo forest. Separation from rainforest creatures was maintained by a stretch of water between the land and the longhouses. A constant flow of water in the river maintained waste removal from the dwellings, and an over-the-river breeze provided much needed cooling. In addition, rainfall, which was equally distributed throughout the year, provided a reliable source of fresh water. Flat topography without visible landmarks from the level of the river did not stimulate a curiosity to penetrate the island. All of this clearly points to the conclusion that living over the river in long houses was comfortable, safe, and in all respects optimal under these environmental conditions.

Life on Borneo rivers exclusively offered directions of movement up and down the river. Such an arrangement stimulated development of a one-dimensional spatial awareness among the people: you can go forwards or backwards, but there is less need to navigate on a two-dimensional basis,

and this environmentally based one-dimensional perception of space may be reflected to some extent in contemporary arrangements of urban and social developments in Brunei. For example, even though the transport system in Brunei has been transformed in recent years, with a modern road system and one of the highest rates of car ownership in the world, it seems that many aspects of the roads in Brunei are actually rather similar to a network of rivers. This may be noted in most residential areas, as short side roads (known as *simpangs*) occur off the main trunk roads. In addition, the life of contemporary Bruneians tends to concentrate on indoor activities. This can be clearly recognised by limited local tourism, few pedestrian paths, and a general lack of interest in discovering and exploring new places in the country.

These remarks were confirmed by Bac-Bronowicz and Becek (2009) in their study of the spatial awareness among young Bruneians. They compared the perceptions and knowledge of 66 geography undergraduates at UBD with 40 similar students at Wroclaw in Poland, and they found that the Bruneians had substantially less awareness of such things as the location of their university in relation to well-known landmarks, and they were less capable at labelling nearby places correctly, but they were better at naming the major rivers in their country. These observations regarding 1-D perceptions of space, which are still present in the minds of the younger generation of Bruneians, may lead to the conclusion that some sort of education programme should be introduced to address this unusual deficiency of the population. The major aim of such a programme would be to stimulate the suppressed human ability to perceive 3-D space.

Ingold (2008) claims that maps are a cognitive universal for contemporary civilisation, which means that they are an unavoidable device which are essential for humans to effectively organise their life in space. It seems that young Bruneians would benefit from some additional training in this respect.

Conclusions

The main aim of this paper is to present a few remarks regarding maps and mapping activities in Brunei Darussalam. A triggering event for the decision to embark on this project was the publication of the Brunei Darussalam 2008 Street Directory—the second of this type of map in the history of the country. A comprehensive overview of the circumstances leading to the development of the maps was provided. Some of the technical aspects of contemporary map-making were outlined, to provide some background for the local constraints involved in mapping in Brunei.

A leading motif of the considerations is an observation that the young section of the population suffers from a low level of spatial awareness. It is suspected that these deficiencies are implicit consequences of the river-based way of life of many tribes in Borneo, particularly the one-dimensional nature of transportation along the rivers.

It has been also noticed that the degree of spatial awareness may be caused by the lack of development in the land market, which might be partly responsible for the lack of interest among the local population in exploring and discovering space.

What effect might the updated book of maps have on the spatial awareness of Bruneians? Only time will tell; but experience in teaching basic geographical concepts to undergraduates at UBD suggests that it is an uphill battle. The increasing use of mobile phones and the Internet means that young people do not actually need to go out to interact with their friends, and this phenomenon might interfere even more with the development of spatial awareness. All forms of spatial education in Brunei would be valuable to secure a coherent advancement of the country on all levels of social interaction, from the individual to the entire society. In addition, the previously mentioned land reforms would certainly contribute in a positive way to the increase of the level of spatial awareness.

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