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DEVELOPING THE SOCIO-ECONOMIC ATLAS

The Socio-Economic Atlas of Myanmar emerged through many years of trusted cooperation between German and Myanmar colleagues. The work involved experts from academics, government and planning practice from the natural and social sciences including diverse disciplines such as physical and human geography, architecture and landscape planning, civil engineering and zoology.

The Atlas aims to present and evaluate key spatial developments in the current transformation process of Myanmar. The focus is on social-economic developments and their uneven manifestation in the states and regions of the country. These development processes are observed in relationship to administrative structures and their dependence on the characteristics of the landscape, natural resources and existing infrastructure. The meticulous spatial analyses aim to increase the state of knowledge about Myanmar both within the country and abroad, and to support decision-making on spatial development policy. In order to ensure wide accessibility the Socio-Economic Atlas is published in print and as an open-access document.

In international publications and media reports it is often said that little is known about Myanmar. Although this may appear true from an outside perspective, it requires qualification if not revision when the situation within the country is considered. In Myanmar there is a significant body of scarcely tapped knowledge that has attracted very little international attention. In the universities and administrations, especially on the local and regional levels, there is a great deal of knowledge – historical, regional, ecological and social – about Myanmar, its sub-regions and local, ethnic and religious communities. Numerous PhD and Master theses (albeit of varying quality, originality and depth of analysis) represent a notable body of knowledge, even if it is scattered over local libraries and hard to access, particularly as some of the work is written in the Myanmar language. Many unpublished investigations, reports and research papers have been bound by the institutes concerned and are not generally known of or catalogued. Furthermore, there is an enormous body of reflected, usually unwritten knowledge and experience. This large pool of different forms of knowledge is practically unknown or is not regarded as a serious resource, especially abroad but also domestically where it has not been systematically compiled and is not discussed among experts and decision-makers. Academic exchange with Myanmar colleagues makes clear that in the concrete social context of Myanmar apparently ‘objective’ knowledge is very differently assessed, weighted and judged from different ‘internal’ perspectives. The use of mixed teams of authors for the joint analyses and interpretations of the Atlas was a targeted attempt to take this into account.

THE CURRENT PROCESS OF TRANSFORMATION IN MYANMAR

References to the numerous basic publications in the academic literature on Myanmar are provided here with no further detailed discussion. The historical and political processes of the last two decades are the focus of the in-depth analyses by Carey (1997), Steinberg (2001), Thant Myint-U (2001, 2011), Kyaw Yin Hlaing/Taylor/Tin Maung Maung Than (2005), Charney (2009), Taylor (2009), Steinberg (2010), Than Tun (2010), Holliday (2011), Aung-

The reports focus on the central challenges related to the transformation process and possible development approaches. They largely agree on the development characteristics and problems of the country but vary in their policy recommendations, development approaches and proposed solutions.

The major challenges for the country can be summarised as follows. To date the rich potential of the landscape and natural resources has only been partially tapped. Agriculture provides employment and thus the economic basis for a large proportion of the population. The many political and economic reforms passed after 1988 and particularly after 2010 aim to improve countrywide infrastructure, promote the private sector and attract direct foreign investment. They promote decentralisation of the administration and institutional transformation, the eradication of price controls and subsidies, the modernisation of the tax and customs system, the diversification of the export sector, the improvement of import and export procedures, and the restructuring of wages and prices. They also provide increased freedom of choice for farmers in terms of the crops they cultivate and the processing, transport and trading of those products (MNPED 1995: 33, Mya Than/Tan 1990). However, these measures have not yet overcome state capitalism to a significant extent.

The greatest obstacles to the mobilisation of direct foreign investment are related to the ongoing problems of macro-economic stability, extensive bureaucracy, widespread infrastructural deficits, economic diversification, the ensuring of long-term guarantees, a lack of openness of the financial sector to foreign competition, and restrictions on the transfer of foreign capital and profits. However, the privatisation measures of recent years have led to the emergence of numerous manufacturing, trading and services companies that supplement the large, efficient, state-owned enterprises with their export trade. In addition to growing numbers of companies involved in textile, garment and food production there are more and more service enterprises (especially in the tourism sector). Foreign investment is particularly over-concentrated in the metropolitan areas of Yangon and Mandalay.

THEMATIC FOCUSES OF THE ATLAS

Against the background of the far-reaching socio-economic changes of recent years and the frequently heard call for decision-making to correct inequalities in regional development, the Socio-Economic Atlas focuses on the analysis and evaluation of current regional differences in geographical conditions, infrastructure and socio-economic development. Neither historical developments nor Myanmar’s international relationships – for instance within the ASEAN or with neighbouring countries – have been included so as to keep the subject manageable.

Considerable conceptual input was drawn from the existing thematic atlases of neighbouring countries. Thus the Atlas of Cambodia (SCW 2006) focuses on natural resources and issues of poverty, while the impressive thematic atlases of Vietnam (Vu/Taillard 1993), Laos (Bounthavy/Taillard 2000 and Messerli et
al. 2008) and Thailand (Kermel-Torrès 2004) concentrate particularly on socio-economic developments.

For Myanmar itself, the Ministry of Forestry in cooperation with the Department of Geography of the University of Yangon has produced topographic maps displaying the states and divisions of the country (MoF 2004). Insights into resources and agriculture are provided by the Atlas of the Mineral Regions of the ESCAP Region, which analyses the geology and mineral resources of Myanmar (UN 1996), and the Agricultural Atlas of the Union of Myanmar (FAO 2005). Numerous thematic maps of Myanmar are included in the KTAM Report (1953) and the comprehensive fundamental work produced by Hla Tun Aung (2003). Overviews of infrastructure and socio-economic developments are found in the maps included in the regional study by Storz (1967). However, none of these maps are georeferenced and many are either too generalised or not up-to-date.

A number of possible maps could not be produced because of a lack of reliable, consistent or plausible data:

- Thus despite the enormous relevance of questions of ethnicity, especially in the process of national reconciliation (for in-depth analysis see Skidmore 2005, James 2006, Gravers 2007, Ganesan/Kyaw Yin Hlaing 2007, Kipgen 2015), it was not possible to include a map of the regional distribution of ethnic or ethnolinguistic population groups. There are a number of spatial representations of the distribution of ethnic or ethnolinguistic population groups, at least of the groups most dominant in the individual areas (e.g. Smith 1993, Smith/Allsebrook 1994: 51, Lintner 1994: 77, Steinberg 2001: xvii, Gravers 2007: xx, South 2008: xii, Gravers/Ytzen 2014: 156). However, there is a lack of detailed regional data and no spatially differentiated cartographical representation of the great ethnic/ethnolinguistic diversity of Myanmar. The most accurate mapping to date is the large-scale key map by Moseley/Asher (1994: Map 49), but even here, for example, only four of the many ethnic and ethnolinguistic groups found in Chin State (Min Naing 2000) have been recorded. In the absence of more accurate data, cartographic representations are often copied from one another with minimal changes; several display the title ‘main ethnic groups’ but then inconsistently mix ethnic and religious groups in the actual maps (e.g. Smith/Allsebrook 1994: 51).

- On the controversial issue of regional concentrations of foreign population groups (particularly Chinese, Indian, Nepalese/Gurkha and ‘western’ foreigners) there are practically no detailed regional data and few studies (Cernea 2007, Chang 2014, Maung Aung Myoe 2014).

- Due to political sensitivity, detailed data from the 2014 census concerning the various religious and belief groups – Buddhists, Christians, Moslems, Hindus, Animists etc – have only been released on a national scale and the scale of the states and regions (MoLIP 2016c). Regional and local developments and the interfaith-networks of the religious groups have been subject to little investigation. Research has focused particularly on the development of individual religious groups (see e.g.: Chakravarti 1971, Yegar 1972, Berlie 2008), different perspectives on the religious problems (Gravers 2013, Charles Maung Bo 2015, David Thang Moe 2017) and current issues of reconciliation (Schissler/Walton/Phyu Phyu Thi 2017, Chit Win/Kean 2017).

- Interpretations and statistics on the highly charged and controversial so-called Rohingya issue vary greatly (Leider 2012 and 2014, Kipgen 2013, Gibson/James/Falvey 2016, Ibrahim 2016); it is impossible to produce reliable cartographic representations of this topic.

- Even for less controversial issues, cartographic representations of regional differences in distributions or developments are either impossible or unhelpful. Thus the mapping of numbers of tourists is presently unadvisable due to the unreliability and inconsistency of data – the published tourism
statistics include the numerous business travellers and people who are visiting relatives, leading to the recorded numbers of tourists entering the country being greatly inflated (Kraas/Häusler 2016). A cartographic representation of numbers of alleged tourists would be correspondingly misleading and could result in false conclusions being drawn.

DATA SOURCES AND CARTOGRAPHY

Drawing on topographical maps and satellite data, a Geographical Information System was created as a basis for the cartography, and linked to the statistical data and thematic contents. Great care was taken to ensure precise cartographical representations and meticulous checking of all the cartographic and data sources.

There are undoubtedly severe problems with the availability, quality and reliability of data, especially of statistics: ‘Under decades of authoritarian rule, data sensitivity was a political culture ... it is now time for Myanmar to move towards improving the quality, accuracy, credibility, timeliness and availability of economic and social statistical data and information as a first step in building a modern developed nation’ (Myint 2010, quoted in Than Tun Sein et al. 2014: 185). Against a background of very varied data quality and reliability, the temptation to create visualisations without quality control was resisted and a number of maps have not been produced that may otherwise have been possible.

The findings of the 2014 census and data from various ministries were vital sources for the Atlas. Many of the themes also drew on a synthesis of different academic sources, even when numerous very different sources had to be brought together and much work was necessary to accurately localise non-georeferenced information. Regionally detailed findings from the 2014 census have been published on population development, agriculture, education and health, allowing good and very accurate presentations of these topics. There are, in contrast, as yet limited data on industrialisation and flows of transport, trade and finance. The information on GDP, for instance, is incomplete simply because the informal sector is not included due to an understandable lack of data. There are to date no data available on the richly diverse crafts, the importance of which has scarcely been addressed, either in terms of cultural heritage or as a traditional source of local income.

Frauke Kraas, Aye Aye Myint and Regine Spohner

Agriculture between Lashio and Pyin Oo Lwin
The core idea of producing a reliable and spatially detailed Socio-Economic Atlas of Myanmar could only be realized in a targeted manner with the help of a Geographic Information System (GIS) and the available source data. Visualisation of most of the thematic contents is carried out on the basis of the 330 townships, the administrative units of Level 3. All point and line elements of the Atlas geo-database were recorded with great positional accuracy and stored at an appropriate level of generalisation for the mapping scale of 1:7,850,000 in an A4 print format. The accuracy of contents and the consistency of the data, some of which were drawn from many different sources, were ensured by an elaborate plausibility assessment. A combination of close communication with Myanmar colleagues and knowledge of the country enabled the meticulous examination of outliers and spatial anomalies and thus the administration of a reliable database.

The geo-database was compiled using administrative and topographic vector data or remote sensing raster data with the help of the Geographical Information System ArcGIS 10.2. The satellite data provided the basis for recording new or correcting existing geo-data and were processed using ENVI5.0. The final cartographic design of the maps was produced in Adobe Illustrator (Adobe CC 2015/2016). The add-on MaPublisher 9.6 (Avenza) installed in Illustrator proved to be indispensable when operationalizing the workflow between GIS-based data processing and cartographic visualisation in Illustrator. This software allowed the spatially fixed and to-scale import of the GIS data layers and their further attribute-based graphic processing. The combination of Illustrator and MaPublisher permitted the optimal construction of the maps through the establishment of the spatial data layers from the GIS. It furthermore allowed the use of very elaborate cartographic symbols and visualisations of the diverse topics, something that would not have been possible in GIS due to its considerably more limited graphical sophistication. In cooperation with the designers Luebbeke Naumann Thoben (Cologne), the ambitious overall layout was achieved using Adobe Indesign.

The fundamental coordinate system for the national data is a geographical coordinate system (GCS_WGS_1984 / Date: D_WGS_1984). For the regional maps of the urban area of Yangon the Universal Transvers Mercator-System was selected (UTM Zone 47 / WGS84). There was a lack of standards in the various source statistics/data in terms of the coding of the 330 administrative units and the Romanisation of the township names. This meant that the 330 spatial units were only linked after the adjustment of the township names in the statistics in line with the naming convention from MIMU (Myanmar Information Management Unit).

When preparing the thematic maps various steps were required, as follows:

- The basic topographic data were produced using a digital ground model (Shuttle Radar Topography Mission, SRTM 90m vers. 4.1) in combination with Landsat 8 OLI archive data (USGS, Earthexplorer). For Myanmar, a regularly updated archive of Landsat 8 OLI scenes is available to the project. An image sharpening process is used to calculate the Landsat 8 RGB images (channel combination 4, 3, 2) at 15 m; these images serve as the spatial base reference for both the national key maps and the regional maps. The rich objective image data and the accuracy of the ‘objects’ visible in the images is higher in the Landsat data
than in the available topographic maps. Landsat 8 was used as a basis for the digitalisation of the water network, the updating and correction of the street network and railway lines, the localisation of hydropower plants and the updating of the position of towns. VHR-satellite data serve as the spatial reference for Yangon (WorldView2, GeoEye), supplemented by time periods from Google Earth image data. The topographic names and toponyms for landscapes, mountainous areas, rivers and mountains are derived from the topographic maps of Myanmar at the scale of 1:250,000 and 1:50,000, from the literature and from internet research.

The relevant dataset of the geo-data made available by MIMU (Myanmar Information Management Unit) was used as the administrative base data (download in August 2014). The data were digitized by MIMU on the basis of the topographic map 1:250,000. As this dataset includes flawed polygon data (gaps and sliver) and for certain regions is too generalized or too roughly digitized, the MIMU dataset was considerably reworked and refined in the Institute of Geography of the University of Cologne with the help of topographic maps and, especially, on the basis of the Landsat 8 image data. This applies particularly to the adjustment of borders where they follow the course of rivers, mountain ridges or roads. Furthermore, in Cologne a line and polygon dataset was created for the geo-data base of the Atlas using the administrative codes and assigned names from the MIMU dataset (PCode-list, MIMU/GAUL/DCW and translation of the GAD names). The very differing Romanisation of the township names by the different authorities or ministries represented a major problem, especially as the statistics and geo-data provided had to be linked to these names. A correct ‘fit’ could only be achieved by very elaborate linking procedures and checking the assignment of every individual data sequence to each township. All datasets in the Atlas are affected by this problem.

The individual thematic maps were subject to further conceptual deliberation, as described in the following. The workflow of GIS-based data processing in ArcGIS and cartographic finalisation in Illustrator applied to all maps.

- **Topography and topographic profiles:** For this map freely accessible datasets of heights were available (SRTM vers. 4.1). However, a water-network based on the Landsat 8 data and adjusted to the scale of the map was newly created. The corrected MIMU dataset was used as administrative data. Representative cross-sections were selected and calculated in ArcGIS.

- **Land use / land cover:** For the map the freely accessible datasets from NASA WorldView, MODIS and GlobCover 2009 v2.3 were straightforwardly transferred to ArcGIS, the exemplary districts were representatively selected and were fed into the final cartographic process (Photoshop and Illustrator).

- **Population:** Data from the 2014 Census were used for total population, population density, sex ratio and urban-rural population. The census statistics were prepared so as to match the GIS dataset of the towns. In light of the problems concerning the Romanisation of the census data it was necessary to ensure the fitting of the data.

- **Modeled population density:** The modeled Myanmar dataset of the licensed LandScan 2013 data was procured for the spatial visualisation of population density.

- **Climate:** The precipitation and temperature data were derived from the ‘Agricultural Atlas of Myanmar’ (FAO 2006); new digitisation of the map of precipitation and temperature distributions allowed for adjustments appropriate to the design of this Atlas. The base data of the diagrams of the selected regional locations come from the ‘Climate Change Knowledge Portal’ of the World Bank Group; they were consistently re-visualized in Illustrator in graphic form.

- **Natural Risks:** This map is a compilation of freely available digital data. Firstly, the time
series of all earthquake events with magnitudes over 4.0 of the last 200 years were drawn from the web archive of the USGS-National Earthquake Information Center. Secondly, the ground model data from SRTM 4.1 for the land and from ETOPO1 for the seabed were used. These data were overlaid with the modeled population (LandScan 2013) and supplemented with the fault lines and seismic zones from the literature (tectonic map of Myanmar - www.sagaingfault.info).

- National conservation area: The map was created on the basis of a content comparison of a combination of four primary sources (see sources listed in the map). The spatial assignment was mainly based on Beffasti/Galanti (2011), as here detailed maps showing the extent of the protected areas are available. The visualisation was completed using the Ministry map. The classification of the protected areas is based on the usual IUCN categories.

- Fuel minerals, metallic minerals, precious stones etc.: The Ministry of Mines provided data for these maps. Due to positional errors, omissions and inconsistencies the data needed to be supplemented. An accurate basis was provided by a publication with geological maps of Myanmar (UN 1996). Extensive research was necessary to create the basis for the supplementary contents included in the map on fuel minerals; the presentation of the coal basins and the oil and gas blocks was drawn from various scientific sources (sources cited in the map).

- Urban system of Myanmar: A list made available by the Ministry of Construction provided the basis for identifying the towns and cities. This shows the towns and cities in 2015, categorized in five classes according to urban population (Census 2014) and administrative status. The position of the towns was in some cases corrected using Landsat 8 images.

- Road network, railway lines, towns, harbours and airports (transportation networks and towns) – detailed overviews in four parts: The basis of the maps was provided by comprehensive maps of each state or region from the Ministry of Construction. In some cases no accurate information was available on the year in which the individual road sections were constructed. The course of the roads was sometimes very generalized or visualized as a simple link between towns, so that the exact course of the road could not be determined from the maps. The data provided by MIMU are in some cases more accurate, but the positions and connections of roads are also often incorrect. It was therefore necessary to refer to the current Landsat 8 image data as a basis for interpreting the exact course of roads; additional information from Google Earth images was used for more narrow roads or the course of roads through wooded areas. Interpretation was aided by maps from the Myanmar Transportation Masterplan. A comparison with detailed GIS maps (such as those that exist for the eastern Shan State) was not possible. New road links, for instance between Paletwa and Matupi via Samee, were added based on Landsat images and newspaper reports on the opening of the streets. All the streets were first captured in GIS and later combined with the other map layers in the overall layout of the infrastructure maps. The data on the railway network was provided by the Ministry of Rail Transportation in the form of network plans showing all stops but not their accurate positions. The railway network was also checked using Landsat 8 data and, as far as visible, ‘sections under construction’ were also digitized. The aim of the infrastructure map is to visualize all 367 towns as connected with the street network. This goal was not fully achieved as the network of paths linking very remote small towns was not accurately visible in either the Landsat 8 or the Google Earth images. The information on airports came primarily from the UNECE platform. Local interview partners and media reports augmented the information on the operational status of the airport, for instance whether it is used seasonally. In addition, research of Google Earth images was help-
ful in recognizing whether the airport was actually in operation: some of the airports listed as 'domestic' by MIMU or UNECE (with the note: no detailed information) could be excluded from the mapping (sometimes a defunct runway could be recognized). The ports were mapped with the help of information from the DLCA platform, which allowed a distinction to be made between 'international exporting sea port' and 'sea port with domestic coastal traffic'. Presentations from the Ministry of Construction, and information from newspaper reports served for the designation of planned or already implemented Deep Sea Port projects. The background data on topography and vegetation (generalized) are freely available.

- Power plants: This map required some of the most extensive research of all the mapping projects of the Atlas. First, all the hydropower plants shown in the MoEP map (2015a, in addition 2015b) had to be pinpointed in their correct positions in GIS – here the Landsat 8 images and Google Earth or Google Earth time series were consulted. They were given attribute data (status, installed/proposed capacity). This literature-based information (especially Snider 2012) on the ‘Hydropower Plant’ and ‘Thermal Power Plant’ locations and attributes was compared with information on the status of the projects from burmariversnetwork.org, internationalrivers.org and newspaper reports. Capacity, type and status of the power plants were precisely cartographically visualized. The catchment areas of the large rivers were included as additional information. Furthermore, a summarized visualisation of the total capacities per Region/State according to type and status is included as a bar graph.

- Telecommunication: Data on the location of the towers (MPT, Ooredoo and Telenor) were transferred from the Excel tables to GIS point data. The number of towers was linked with data on availability of mobile phones per household per township from the individual Region/State data tables of the Census. The visualisation takes the percentage shares into consideration. This allowed a content-rich map to be produced.

- GDP main and per sector, economic classification of townships based on GDP 2015: Very good raw data was available for this map. Information on the main sectors and their sub-sectors was provided in the form of a table for each of the 330 townships. These tables were then manually reprocessed in a meticulous and time-consuming procedure to produce a GIS-compatible table. The attributes of each township were originally arranged in rows in 330 separate tables and had to be transferred to columns to enable linking. After the overall table had been produced with information on volumes of GDP in Kyat per sector/sub-sector and their percentages for each township, an additional link to the population was created in order to calculate GDP per capita. In the overall table the percentages per sector/sub-sector were then classified in 25% steps, an ‘outlier-category’ was identified and the result was visualized in four maps (1: % of the three main sectors, 2-4: % of the sub-sectors in the three main sectors). The visualisation of the percentages could only be undertaken semi-automatically. The workflow from the GIS-based data processing could be carried out specifically for the complicated semi-automatic assignment of the graphic attributes in Illustrator. The townships were classified according to their percentage share of the main sectors and their resulting position in a ternary plot. 16 categories with information on the percentage distribution of the sectors and the number of townships per category reflect the economic structure of Myanmar. Overall, the data preparation and semi-automatic visualisation were thus very complex and time-consuming. However, the depiction has decided advantages over a classic proportional circle map or a mono-thematic choropleth map, as the interaction of the main sectors/sub-sectors is effectively presented.

- Rain and summer paddy: The Ministry for Agriculture and Irrigation provided de-
tailed data for this map, in some cases in temporal resolution for harvested area (ha) and yields (Tinn). From this data the distribution maps for rain paddy (absolute production, annual yield and change over time of both) and summer paddy (absolute production and annual yield, without time series data) were produced. The combination of absolute production and proportion of rain or summer paddy was depicted in color-graded classified symbols, allowing both variables to be effectively portrayed (as already used in the presentation of the percentage share of urban population in the total population of a township, and later again applied to the topics of health and the availability of mobile phones).

• Agricultural regions: The map represents a substantive combination of the regional distribution of the geographical characteristics of topography, climatic conditions and land cover/land use. It was decided not to carry out automated GIS analyses, for instance according to threshold values on the individual data layers. Instead the eight agricultural regions were identified as a synthesis of the factors considered (on the basis of freely available data layers).

• Aquaculture: The map is based on, consistent datasets from the Ministry of Livestock and Fishery (MoLF). Both the datasets on shrimp and fish farming could be summarized in one map. It should be noted that data were missing from the dataset for many townships, e.g. in Shan State (although there are fish farming projects).

• Yangon garment factories: The map is based on two very detailed datasets from the Myanmar Garment Manufacturers Association (MGMA) that include almost 300 locations of garment-industry enterprises, primarily situated in Yangon, with information on addresses, investment type, type of factory, number of workers and product specifications. The pinpointing of the location of the almost 300 enterprises was undertaken by hand using the addresses of the individual industrial zones in the separate townships in Yangon (designation of the industrial zones according to information from Myanmar Industries Association, YCDC 2009, Tractus 2015b). Enterprises outside the industrial zones were grouped per township or per zone outside Yangon. The enterprise-specific data were transformed into township-summarized data that could then be processed in GIS and transferred to Illustrator for cartographic visualisation. The complex cartography visualizes the number of employees in proportional circles and the proportions of types of enterprise and investment. The current built area of Yangon, the industrial zones and the administrative structure are added as background information.

• Tourism map: in this map elements of tourism infrastructure (street/railway network, airports, selected towns and cities of the urban system of Myanmar) and tourism potential (protected area, world heritage sites) are visualized from existing data layers of the Atlas geo-database and combined with a classification in primary and emerging travel destinations.

• Electricity for lighting, availability of mobile phones: The map is based on data from the 2014 Census. It contains a combination of the variables ‘Number of households per township’ and the percentage share of ‘Township-households with mobile phones’. Color-graded symbols of different sizes were again selected. The proportion of households per township with access to electricity for lighting was added as background information. The preparation of the census statistics for the GIS dataset of the townships was subject to the problems of Romanisation.

• Health (regional health centers, sub-regional health centers; doctors, hospitals, midwives): The data were available in pdf format and contained comprehensive information on the number of hospitals, regional health centers, sub-regional health centers (all three variables: Ministry of Health, May 2015) and the number of hospitals, doctors, nurses and midwives (all
four variables: Ministry of National Planning and Economic Development MNPED, Aug. 2015). After the initial conversion/adjustment/linking process to the township object data in GIS the dataset could be directly used for the visualisation process. The Ministry of Health datasets also contain information on the number of beds per hospital and township, although these deviate strongly from the MNPED data (Ministry of Health: total number of hospitals in Myanmar: 1,083; MNPED: total number of hospitals in Myanmar: 1,001); in some townships the data concur, in others they vary widely. For the map the MNPED data on the number of doctors per hospital per township were used as these data were available in a coherent dataset. It is, however, unclear whether these data are more reliable. The datasets could not be mixed, which prevented information on hospital beds per 1,000 persons being provided. The three variables are presented using a color graduation in symbols classified according to size. The size classification was selected in order to permit a better visualisation of the 330 object data; the proportion of urban population was added as background information. The development of an operational workflow between GIS and the Desktop Publishing System was necessary for this so as to guarantee the error-free assignment of the color classes to each symbol – the aim was to minimize errors in the manual submitting of the graphic attributes; the graphic attributes were assigned through layer management.

- Higher education, location and students: The three maps are based on data from the Ministry of Education on the 169 (as of 2016) locations of institutes of higher education in Myanmar; this includes universities, degree colleges and colleges. Interviews with colleagues helped in assigning the institutes to disciplinary categories. The locational data was linked to the towns in GIS. The resulting maps show a) the locations of the higher education institutions with their subject area classified by city, b) the number of students per city plus the proportion of students in each discipline. Furthermore, c) the number of students in each higher education institution and subject area is linked with the student-teacher ratio and recorded in a comprehensive list of higher education locations.

Overall, the automatic processing of the maps in GIS was hindered by the problems caused by the very varied Romanisation of the Myanmar names, which prevented automatic linking. This necessitated the very complex and time-consuming preparation of the statistical data for the 330 townships. Many of the datasets made available (maps and statistics) are characterized by inaccuracies and incoherency; in some cases they are incomplete. Little can be said about data reliability, as few verification or plausibility investigations have been documented, even in the academic literature. Experience from fieldwork shows that data from the lowest administrative levels are the most precise and reliable; the village-tract and ward-level data and data from the individual institutions are usually the most accurate. Often data were only available on the district level and were thus not suitable for use at the scale of the administrative basis of the 330 townships.

Regine Spohner and Frauke Kraas
The census was conducted by the Myanmar Ministry of Immigration and Population (MoIP) in accordance with international standards and with technical support from the United Nations Population Fund (UNFPA) and financial aid from international donor institutions. In total, the census cost about 58.5 million USD, the Myanmar government provided more than 15 million dollars (UNFPA 2013).

More than 100,000 specially trained enumerators – mostly administrative personnel and teachers – visited almost 11 million households in the 15 states and regions of the country, reaching almost 98% of the total population. The official “census night” was the night of 29 March 2014, i.e. every person was counted in the place where they spent that night. Effectively however, as is usual with censuses elsewhere, the count period extended over two weeks. This was especially necessary because of the inaccessibility of villages in the countryside and mountain regions. Every individual was counted, regardless of nationality, religion or age. Not included were an estimated 1.2 million people in the regions of Rakhine, Kachin and Kayin State affected by ethnic conflict, which were not surveyed for security reasons (UNFPA 2015).

The households were visited personally by the enumerators between 7 a.m. and 6 p.m. As well as normal family households the population in institutions – e.g. hotels, monasteries and military barracks – as well as special groups (e.g. construction and port workers in provisional housing or people living on the streets) were counted. All persons present, i.e. not just those on the official Household Registration List, were counted.

The population had been thoroughly well informed of the reason for the census – the collection of statistics to plan the reform process –, the process of enumeration, the census questions and the extent of data collection, via television, radio, posters, flyers and the internet. The information material was available in Myanmar and English as well as numerous ethnic languages (e.g. Kachin or Chin-Laizo).

A Census Law passed in July 2013 protects the confidentiality of the personal data collected. Furthermore, there was explicit reassurance that the census information would not be used for the purpose of taxation, registrations, verification or detention (the latter in the context
of the requirement that de jure every individual on the Household Registration List has to register; but migrant workers in particular often fail to meet this requirement).

Demographic and socio-economic data were collected, including: age, sex, family composition, marital status, religion, ethnic identity, migration status, education, employment, births, deaths and handicaps as well as housing standards (house type, ownership status, electricity and water supply, communications, sanitary facilities, building materials and the means of transport available).

PREVIOUS CENSUSES AND POPULATION ESTIMATES

Since 1872 twelve censuses have been carried out in Myanmar: in 1872 and 1881 (both only in Lower Myanmar), 1891, 1901, 1911, 1921, 1931, 1941, 1953-55 (in three incomplete enumerations), 1973, 1983 and 2014. The total population of Myanmar grew from 22.9 million (1963) through 28.9 million (1973) to 35.3 million in 1983 (the second most recent census; MoHRA 1984, Than Than Thwe 2004, Spoorenberg 2013: 310, Kraas/Spohner 2015). In 1997, the country’s population was about 46.4 million.

Before the census of 2014, Myanmar’s population was estimated at about 60.5 or 60.98 million on the basis of growth projections. The census of 2014 recorded the considerably lower – but not really surprising – figure of 51.486,253 inhabitants. The miscalculation was due to the use of too high a growth factor of about 2.0% (Spoorenberg 2013: 310 and 2014), based on the forward projection of earlier fertility rates and an assumed increase in life expectancy from 60.4 to 66.8 years (1983 to 2003). Also, international migration was not taken into account (Spoorenberg 2013: 312).

While migration occurred from the late 1980s due to civil war, famine, landlessness and unemployment as well as in response to political persecution, labour migration rates rose in the last ten years, particularly because of the possibility of achieving higher earnings in the neighbouring states of Thailand and Malaysia. As well as about one million labour migrants, more than 400,000 refugees fled the country in 2009, so that the number of Myanmar citizens living abroad was estimated at up to 1.5 million (2010).

RESULTS OF THE 2014 CENSUS

The most important results of the census can be summarised as follows (MoIP 2015a, MoIP 2015b, UNFPA 2015, Kraas/Spohner 2015, MoLIP 2016a, band c):

- The total population figure of 51,486,253 includes estimated (not enumerated) figures of 1.09 million in Rakhine State, 69,753 in Kayin State and 46.600 in Kachin State.
- In rural regions the natural growth rates are often twice as high as the national average, with simultaneously increasing migration rates.
- Overall Myanmar, with an average population growth rate of 0.89%, is demographically relatively stable compared to other developing countries. In comparison with the 1970s the population growth rate has more than halved.
- About 50% of the population is under 27 years of age, although the proportion of children is falling.
- Nationwide there are 100 women to 93 men, reflecting men’s lower life expectancy and the markedly higher foreign migration rate for male workers. Currently, life expectancy is 60.2 years for males and 69.3 years for females (MoLIP 2016a: xii).
- "Some States/Regions had far lower fertility than others; Chin State had the highest TFR (5.0 births per woman), which was no less than 3.2 births higher than in Yangon Region. The level of fertility is also influenced by the high proportion of females who remain never married: some 12 per cent of women aged 50-54 have never married. The 2014 Census showed that the marital status of a woman is closely related to her educational attainment. The higher a
woman’s level of education, the higher the probability of her remaining never married. However, while there is a clear correlation between fertility and women’s level of education, education is not the single cause of low fertility in the country, there are other contributing factors. It is important to state that education for women is essential for the future development of Myanmar.” (MoLIP 2016a: xi).

- Particularly in urban regions, falling fertility rates (births per woman) are slowing down natural increase: the average number of births per woman has fallen from 4.7 (1983) to 2.3 (2014), which is equivalent to stabilising the current population figures.

- Life expectancy at birth has risen to an average of 66.8 years (men: 63.9, women: 69.9 years) and is among the lowest in Southeast Asia. Average life expectancy in urban regions is 72.1, in rural areas it is 65.5 years.

- Child mortality (under 5 years) and infant mortality at 62% and 72% respectively per 1000 live births is almost twice as high as the average for Southeast Asia. “The lifetime risk of maternal death is 7.3 per 1,000 women, which means that one in every 137 women dies as a result of pregnancy or childbirth. Maternal mortality is the most preventable of all causes of death for women and is determined by the social and economic status of the mother” (MoLIP 2016a: xi-xii).

- The number of households has risen to 10.87 million, with the highest increases since 1983 in Shan State (119%), Kayin State (116%) and the Yangon Region (108%).

- Household size has fallen to an average of 4.4 persons per household. 70.2% of households have between two and five members; the largest average household sizes are to be found in Kachin State (5.1 persons/household), the lowest in the Ayeyarwady Region, Magway Region and Nay Pyi Taw (4.1 persons/household).

- In addition to Nay Pyi Taw, “there are other States/Regions in which high levels of recent in-migration were reported; these include Kachin, Kayah and Kayin. These States are all located on the border with Thailand or China and appear to have an economic dynamism that comes from the large amount of cross-border trade that occurs through these States. Policies designed to increase the number of cross-border entry points will likely provide increased opportunities for employment, and therefore migration” (MoLIP 2016b: xii-xiii).

- Detailed information on the migration of Myanmar citizens to other countries had not previously been published. The 2014 census results cite an overall figure of 2.02 million Myanmar citizens living abroad, 61% of whom are men and ca. 83% between 15 and 39 years of age. Most of the migrants come from Mon State (427,000), Kayin State (323,000) and Shan State (236,000 individuals). 70% work in Thailand, 15% in Malaysia. “Through backward projection methods, the current study estimates that in 2014, a total of 4.25 million persons who were born in Myanmar were living abroad at the time of the Census. International migration is clearly dominated by men. The sex ratio among such migrants is 156.3 men per 100 women” (MoLIP 2016: xii).

- In total, 58,859 foreigners reside in Myanmar in 2014, among them 23,812 Chinese, 23,903 Indians, 2,286 Pakistanis, 755 Bangladeshis and 8,103 others.

- In 2014, 89.8% (87.9%) of the population were Buddhists, 6.3% (6.2%) Christians, 2.3% (4.3%) Moslems, 0.5% (0.5%) Hindus
CONCEPTION AND DATA OF THE SOCIO-ECONOMIC ATLAS

Population pyramid of the Union of Myanmar - total, urban, rural (MoIP 2015a)

Population pyramids of regions and states with total population (thousands) and female/male share (%) (MoIP 2015a)
and 0.8% (0.8%) Animists; 0.2% (0.2%) were of other religions and 0.1% (0.1%) mentioned no religion (MoPF 2016: 22).

- Almost 90% of adults countrywide are literate, but in some regions the figures are considerably lower (e.g. 64.6% in Shan State). Male literacy rates are slightly higher than female rates; the greatest divergence between the sexes is 16.6% difference (in Chin State).

- The demographic transition has "changed the position of women, as it gives them an opportunity to play a more active role in the labour market and in community life. In Myanmar, female education has improved impressively over the last three decades. Inequality no longer exists between young males and females in terms of illiteracy. In fact, more females than males now hold higher diplomas" (MoLIP 2016a: xiii).

- 85.2% of adult males but only 50.5% of women are in gainful employment; 4% were registered as unemployed. The unemployment rate among 15-29-year-olds is almost twice as high at 7.7%.

- The population projection shows that "because of the demographic momentum up until 2050, many more young people will enter the labour market than old people will leave. In 2020, some 265,000 new jobs will be needed, a further 188,000 in 2035 and 57,000 in 2050" (MoLIP 2016a: xiv).

- More than 86% of households own their home, 7% rent, and 3% of homes are provided by the government. 79% of houses are built of wood or bamboo.

- A third of households (32.4%) have electric light. However, there is a huge difference between urban (77.5%) and rural areas (14.9%) in the use of electricity as the main source of lighting. The proportion of households using battery, generator and solar systems as the main source of lighting is considerable' (MoIP 2015c: 33).

- A third of households have mobile phones: 31.9% in the Union, 63.5 in urban and 21.0 in rural areas (MoIP 2015c: 35). Half of households have a television: 49.5% in the Union, 75.8% in urban and 39.2% in rural areas (MoIP 2015c: 35).

- 86% of rural households use firewood for cooking, even in urban areas 52% of households cook with firewood or charcoal.

- Drinking water for 31% of households comes from wells, 18.9% from springs and 9% of households have piped water. 31% of urban households use water purifiers or buy bottled drinking water.

- Countrywide more than 70% of households have improved water supplies and sanitary facilities; regional values are often lower. Only 14.4% of households have no toilet facilities.

- 38.7% of households own a motorbike and 36% a bicycle – 70% of all rural households – and 3.1% have a motor car, a van or a truck.

At township level, regional developmental differences and disparities are very pronounced. Such disparities are to be found between rural and urban regions, and between the central lowlands and the frequently mountainous periphery. There are also marked differences in development potential associated with the ex-
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Number and percentage of persons by religion (MoPF 2016: 21, based on the 2014 Myanmar Population and Housing Census)

Estimated non-enumerated population: 1, 1,206,353, 2, 46,600, 3, 69,753, 4, 1,090,000