Chapter I

THE PHYSICAL INFRASTRUCTURE DEFICIENCY AND DEVELOPMENT FUNDING GAP

This chapter examines, both at the individual infrastructure and aggregate levels, the physical deficiencies in power supply, water supply and waste treatment, telecommunications and transport infrastructure and the investment resources required to address that deficiency through to the year 2000.

A. METHODOLOGY FOR ESTIMATING DEFICIENCIES

From the Commission's directive, the secretariat identified the primary areas to be investigated in the study as the magnitude of the deficiency in physical infrastructure facilities to the end of the century, the resources required for addressing that deficiency, and ways of providing those resources needed to address the deficiency, including approaches to improving the efficiency of existing infrastructure thereby reducing the shortfall, and measures needed to attract domestic and foreign private investment.

1. The intended approach

It was recognized that the first task in the study was to identify the increment in infrastructure required between a base year and the target year. In principle, that could be done by estimating the existing capital infrastructure and the demand for the corresponding facilities in a base year, projecting the demand through to the target year and converting this demand into the required capital. The difference between the capital in the base and target year would represent the required increment in capital. The second task was to deduct from that increment projects underway or committed. The remainder would represent the deficiency or 'gap' in infrastructure facilities. Whilst this methodology has a number of shortcomings, it does provide an indication of the magnitude of the deficiency in physical infrastructure facilities.

To obtain the data necessary for the study, a plan was devised consisting of a questionnaire sent to the 36 member countries of ESCAP, special focus country studies (to be undertaken by nominees of member countries on a consultancy basis), and back-up desk studies at the secretariat. In the event, fourteen questionnaires were returned, of which only three contained sufficient data for further processing, and severe cuts at the United Nations in funding for travel and recruitment of consultants meant that the planned country studies did not proceed. A key item in the questionnaires covered details on countries' forward plans and estimated infrastructure requirements. The inability of most countries to be able to supply data on basic infrastructure and forward needs provides some reflection on the inadequacy of national information systems and the level of infrastructure planning.\textsuperscript{1}

2. The approach used

In the face of the lack of data from member countries, the secretariat developed deficiency and gap estimates based mainly on desk research using data available within the secretariat.

Where adequate and relevant time series data were available for infrastructure, sector projections were made of demand to the year 2000 taking into account growth rates in the period 1980-1990, projected population growth rates over the period 1990-2000, and sector specific indicators such as increases in power consumption per capita, telephone lines per capita and decreases in population per kilometre of road length. In the process of converting demand into capacity required, efficiency improvements were also taken into account where possible (for example, reductions in transmission losses, improvements in rail productivity and improvements in cargo handling productivity at seaports). This approach was broadly used for the power, water supply, telecommunications, rail, road, and seaport (container) sectors.

In the absence of information on the urban transport and airport sectors reliance was necessarily based on literature searches to identify

\textsuperscript{1} The five-year plans of many countries provide some data on resources allocated to the infrastructure subsectors. On average, countries are half way through the current plan and consequently these data only go through until 1995. In addition, they show the allocation of resources from a finite budget, not the need for infrastructure.
major projects in the planning or proposal stage and to use these known projects to estimate funding requirements.

3. Limitations of the methodology

It is considered that the methodology utilized results in significant underestimation of the regional infrastructure deficiency and resource requirements for a number of reasons:

(a) The estimates concentrate exclusively on infrastructure increments required over and above existing assets without any regard for the status or condition of those existing assets. In many countries in the region the existing infrastructure is severely depleted or outdated and comprehensive rehabilitation programmes are required. A fuller investigation would be needed to determine the extent of this deficiency and the resources required to address it;

(b) Where a country either did not have a particular infrastructure (for example, there are no railways in the Lao People’s Democratic Republic) or the secretariat did not have detailed information on it (for example, railways of the Central Asian republics) the methodology does not recognize a deficiency or provide for infrastructure development resources;

(c) Estimates of future demand for infrastructure have in many cases been based on historical growth, whereas for some countries accelerated growth is anticipated for the 1990s and therefore underestimates of demand arise. Such underestimation could be substantial for countries with a large population, such as China, or for countries at a low development base, such as Viet Nam. Of course, where growth rates decline overestimates would have occurred;

(d) In measuring the funding gap for some infrastructure subsectors, for example, roads, it was necessary to assume that government funding would continue to be forthcoming to support projections of past growth in road lengths.

4. Country level analysis

Rather than concentrating on specific countries, the report aims to examine the level of the deficiency in infrastructure, in aggregate and by sector, across the region as a whole and estimate the resources required to redress that deficiency. Where appropriate brief discussions focus on specific country needs.

B. THE PHYSICAL INFRASTRUCTURE DEFICIENCY AND RESOURCE GAP IN SUMMARY

Table 1.1 below shows the estimated increment in physical infrastructure facilities required between a base period of 1990-92 and the year 2000 for ESCAP member countries excluding Australia, Japan and New Zealand (airports and urban public transport were estimated on a financial basis only and consequently are not shown). Table 1.2 provides an estimate of the financial resources required for those infrastructure facilities over the same period and table 1.3 shows the investment requirement by subregion.

The estimated total funding required to the year 2000 for identified additional infrastructure is approximately $1,400 billion, of which up to $500 billion was identified as available or already committed. The financial resource gap therefore amounts to $900 billion. To put this in perspective, the combined lending in 1992 of the World Bank and the Asian Development Bank (ADB) was around $27 billion, of which $7.5 billion was on transport, telecommunications, energy, urbanization and water supply and sanitation. If similar amounts were lent each year for the next eight years to the year 2000 it would amount to a total of $60 billion or 3.7 per cent of the identified additional financial resource requirement.

The sector placing by far the highest demand on funds, in terms of additional financial resources, is the power sector with a requirement for $472 billion, followed by water with $149 billion and telecommunications with $110. Railways, roads and urban public transport have a requirement for between $43 and $57 billion each, while the requirements for the remaining two sectors are $40 billion for airports and $7 billion for seaports.
Table 1.1 Estimated required increment in selected physical infrastructure facilities

<table>
<thead>
<tr>
<th>Infrastructure type</th>
<th>Existing 1990/92</th>
<th>Required 2000</th>
<th>Increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- generating capacity (gigawatts)</td>
<td>350</td>
<td>680 to 740</td>
<td>330 to 390</td>
</tr>
<tr>
<td>Telecommunications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- main telephone lines (thousands)</td>
<td>48,200</td>
<td>136,700</td>
<td>88,500</td>
</tr>
<tr>
<td>Railways</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- track length (kilometres)</td>
<td>222,800</td>
<td>264,000</td>
<td>41,200</td>
</tr>
<tr>
<td>- locomotives (number)</td>
<td>23,300</td>
<td>30,200</td>
<td>6,900</td>
</tr>
<tr>
<td>- freight wagons (number)</td>
<td>737,600</td>
<td>833,000</td>
<td>95,400</td>
</tr>
<tr>
<td>- passenger cars (number)</td>
<td>76,000</td>
<td>105,400</td>
<td>29,400</td>
</tr>
<tr>
<td>Roads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- length (thousands of kilometres)</td>
<td>4,850</td>
<td>6,860</td>
<td>2,010</td>
</tr>
<tr>
<td>Seaports</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- container berths (number)</td>
<td>233</td>
<td>374</td>
<td>141</td>
</tr>
</tbody>
</table>

Source: ESCAP secretariat estimates.

Note: 1. The figures include container berth requirements in developed member countries.

---

Table 1.2 Investment resources required for infrastructure development to the year 2000
(billions of US dollars)

<table>
<thead>
<tr>
<th>Infrastructure type</th>
<th>Investment required</th>
<th>Investment gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>575 to 634</td>
<td>401 to 472</td>
</tr>
<tr>
<td>Water supply and waste treatment</td>
<td>258 to 298</td>
<td>129 to 149</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>133</td>
<td>110</td>
</tr>
<tr>
<td>Railways</td>
<td>78</td>
<td>43</td>
</tr>
<tr>
<td>Roads</td>
<td>162</td>
<td>45</td>
</tr>
<tr>
<td>Urban transport</td>
<td>68</td>
<td>57</td>
</tr>
<tr>
<td>Airports</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>Seaports</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>1,346 to 1,444</td>
<td>832 to 923</td>
</tr>
</tbody>
</table>

Source: ESCAP secretariat estimates.
Table 1.3 Total investment resources required for infrastructure development to the year 2000, by subregion  
(billions of US dollars)

<table>
<thead>
<tr>
<th>Infrastructure type</th>
<th>Central Asia</th>
<th>South Asia</th>
<th>South-East Asia</th>
<th>East Asia</th>
<th>Pacific islands</th>
<th>Asia and the Pacific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>80</td>
<td>136</td>
<td>83</td>
<td>334</td>
<td>1</td>
<td>634</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>8</td>
<td>37</td>
<td>32</td>
<td>55</td>
<td>0</td>
<td>132</td>
</tr>
<tr>
<td>Railways</td>
<td>1</td>
<td>15</td>
<td>1</td>
<td>61</td>
<td>0</td>
<td>78</td>
</tr>
<tr>
<td>Roads</td>
<td>5</td>
<td>47</td>
<td>64</td>
<td>45</td>
<td>1</td>
<td>162</td>
</tr>
<tr>
<td>Urban transport</td>
<td>0</td>
<td>3</td>
<td>13</td>
<td>52</td>
<td>0</td>
<td>68</td>
</tr>
<tr>
<td>Airports</td>
<td>0</td>
<td>1</td>
<td>15</td>
<td>29</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>Seaports</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>15</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Water supply and waste</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>260</td>
</tr>
<tr>
<td>treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>243</td>
<td>214</td>
<td>591</td>
<td>2</td>
<td>1,144</td>
</tr>
</tbody>
</table>

Source: ESCAP secretariat estimates.

Note: There are slight differences in the totals in tables 1.2 and 1.3 because of rounding.

Resource requirements on a country basis show, perhaps not unexpectedly, that the region's most populous countries, namely China and India have the largest funding requirements. In the power sector, for example, it is estimated that China requires an additional 124,000 megawatts (MW) and India an additional 74,000 MW of capacity. Together these countries represent 57 per cent of the ESCAP region's incremental investment requirement. Similarly, almost half of the additional road infrastructure requirements are in India. In urban public transport, the metro projects of the Republic of Korea dominate the sector with a massive requirement for $31 billion. For airports, 57 per cent of the required funding is in five of the region's seven major hubs of Bangkok, Hong Kong, Singapore, Seoul-Kimpo, and Taipei.

Analysis shows that $25 billion, of the incremental investment required in transport and communications (i.e. excluding the power and water sectors) through to the year 2000 will be made in the least developed countries and disadvantaged economies in transition (although the above note on the limitations of the methodology should be especially taken into account for those economies).

C. ELECTRICAL POWER SUPPLY

For the period 1980-1990 the growth in electricity consumption has risen by an average annual rate of 8.5 per cent. For developing countries of the ESCAP region elasticities of electricity consumption with respect to gross domestic product (GDP) growth are in the range of 1.5 to 3.0. These high growth rates which are expected to be sustained in future years have caused planning problems: a 9 per cent growth rate means a doubling time of only 8 years, which is less than the lead times (including the feasibility studies, loan negotiations, design, engineering, construction and commissioning) for most power projects, with the exception of gas-fired power plants.

1. Regional electricity consumption

Electricity consumption in the developing economies of the ESCAP region for 1990 was 382 kilowatt hour (kWh) per capita compared with the 6,900 kWh per capita consumed annually in...
Organisation for Economic Cooperation and Development (OECD) countries. However, there is significant variation between countries in the region on per capita consumption. A small number of developing economies, while below the OECD demand level, still have high per capita consumption compared to other economies in the region. Such economies include Guam (9,122 kWh), Singapore (5,247 kWh), Hong Kong (4,575 kWh), and Republic of Korea (2,202 kWh). These economies only cover 1.9 per cent of the regional population but account for 13.1 per cent of regional electricity consumption.

At the lower end, per capita consumption in Afghanistan, Bangladesh, Cambodia, Lao People's Democratic Republic, Myanmar and Nepal was less than 50 kWh. Additionally these countries are among the lowest in terms of population access to electricity. According to ADB, in 1990 electricity was only available to 6 per cent of the population in Afghanistan, 6 per cent in Myanmar, and 9 per cent in Nepal. Comparative figures for some other countries and areas are 24 per cent for Indonesia, 37 per cent for Pakistan, 61 per cent for the Philippines, 71 per cent for Thailand, 80 per cent for India, and 100 per cent for both Hong Kong and Singapore⁴.

On a region-wide basis 61 per cent of electricity is consumed in the industrial sector and only 18 per cent in the household sector. In terms of the number of subscribers, however, 77 per cent are households and only 2.8 per cent are industries.

2. Regional generating capacity and power generation

The total installed generating capacity in the developing economies (excluding the Central Asian republics) in 1990 was around 320,000 MW. The developing countries rely mainly, to the extent of about 70 per cent, on coal as a source of power generation. Hydropower plants are a distant second, and oil comes third. This is because the two countries with the largest generating capacity, China and India, have large coal reserves which they use for power generation. The other developing economies of the region have much less access to their own coal resources and, in the absence of hydro-potential, have to rely on imported fuel, usually oil, because of its convenience, lower handling costs and availability. If natural gas is domestically available, then it automatically becomes the first choice as fuel for power generation. Besides being a clean fuel, it is convenient to handle, quick to install and can be used in a wide range of power plants (anywhere from 10 to 1500 MW).

For economies with large power systems, such as larger than 10,000 MW with the largest unit greater than 300 MW, coal is the cheapest fuel for power generation and is readily available in the international market. For smaller power systems with units in the range of 50 - 200 MW, oil is the preferred fuel because of its availability, convenience and lower handling costs. Hydropower and geothermal power plants are available only at specific sites. There is considerable hydropower potential still unutilized, but its exploitation is meeting increasing environmental concerns.

Total electricity generated in the developing ESCAP region in 1990 was around 1,337,000 gigawatt hour (GWh), of which 78 per cent was sold to consumers.⁶ The balance of production is accounted for mainly by internal usage within generating stations (5.8 per cent of generation) and by transmission and distribution (T and D) loss (estimated to be around 10.8 per cent over all developing economies in the ESCAP region). The estimated growth rate in electricity generation in those countries during the 1980s was 9.0 per cent a year, which may be compared with the calculated annual growth rate in electricity generation for the developing member countries (DMCs)⁵ of ADB at 8.5 per cent a year for the same period.

⁴ Asian Development Bank, Electric Utilities Data Book for the Asian and Pacific Region, (Manila, January 1993). Further consultations with ADB were undertaken in preparing this study.

⁵ See footnote 3 for definition of ESCAP developing economies.

⁶ Nuclear power could only be contemplated in units higher than 400 MW. Because of its much higher capital costs (even though its fuel costs are much lower), nuclear power could be competitive with coal only if a series of power plants were built. If only one plant were built it could not be competitive against coal.

⁷ Gross generation was 1,337,046.0 GWh and consumption (sales) was 1,336,672.8 GWh, whereas transmission and distribution (T and D) losses and other use was 144,275 GWh. Auxiliary use was 77,527 GWh. As noted under footnote 3, these figures for 1990 do not include the Central Asian republics. If these economies were included the corresponding figures for 1990 would have been installed capacity of about 350,000 MW generating 1,532 terawatt hour (TWh). The corresponding ADB figures (from publication in footnote 5) for ADB developing member countries are 300,299 MW and 1,502 TWh.

⁸ The main difference in regional coverage between ADB and ESCAP is that ADB does not encompass the Islamic Republic of Iran and the Central Asian republics.
The extent to which the generating capacity of any country is adequate to meet the production requirements will be dependent on a number of factors, including the successful implementation of programmes and plans for additional capacity, the efficiency of the generation, transmission and distribution machinery and equipment, and the spatial and time distribution of power demand. Most countries, however, are facing a situation of suppressed demand, arising out of their utilities' inability to meet all of the demand adequately. Fluctuations in the daily load may be high because of uneven demand. In addition, in some countries lack of maintenance or merely the ageing of generating machinery has resulted in a reduction of the effective operating capacity. Additionally, hydroelectric power stations may not be used to full capacity consistently over the year because of seasonal conditions and may be severely restricted in times of drought. Transmission and distribution losses are high: out of 26 countries submitting 1990 data on transmission and distribution losses and own use (T & D loss + own use), 12 countries showed less than 10 per cent and only 4 countries experienced between 15 and 15 per cent. However, 4 countries were in the 15 to 20 per cent category, 3 countries were in the 20 to 25 per cent category and 3 countries had higher than 25 per cent loss.

3. Year 2000 power generation requirements

Projections of required capacity based on historical data of electricity consumption along with estimates of future transmission and distribution losses, as well as own use, are in the range of 879 - 735 GW (3,000 - 3,230 TWh) for the Asian and Pacific developing economies. This would meet an energy demand of 2,580 - 2,800 TWh.

It may be noted, however, that this projection is likely to be in the lower range of the expected "real" requirements, because of more favourable developments in economic reforms and economic restructuring in East Asia, South-East Asia, Central Asia, and South Asia.

It is to be noted that the projections may be compared with the ADB projected figure of 538.336 MW and 2,192.5 TWh by 2000 for its developing member countries; also with a previous World Bank study for the decade 1989-1999 (for Asian developing countries) which gave 493 GW and 2,900 TWh (generation + net imports) by 1999.

Table 1.4 below shows the projected year 2000 power generation requirements of the developing economies of the ESCAP region, including the Central Asian republics. Overall there would need to be an increase of about 96 - 111 per cent in electricity generated regionally, from 1,532 terawatt hour (TWh) in 1990 to 3,000-3,230 TWh in 2000.

4. Capacity development and investment implications

The cost of developing power infrastructure varies significantly depending on the energy source, manufacturing technology, labour costs, site conditions etc. Thermal power station based development costs are of the order of $1 million per MW for plants using imported equipment. The costs of thermal plants with mostly endogenously manufactured equipment would be less, of the order of $600,000 - 800,000 per MW. Hydroelectric schemes are site-specific and could be significantly more capital intensive but incur lower long-term operating costs because of the absence of fuel costs. For the purposes of this study the average cost of the supply of electrical power generation and supporting transmission and distribution infrastructure has been estimated at $1.75 million per megawatt at 1992 prices. However, country specific figures have been used in the estimation of the investment requirement. This compares with a 1990 World Bank costing of $1.94 million per megawatt and a 1993 ADB figure of $2.12 million.

On this basis it is estimated that $576 - 674 billion will be required for the supply of electrical power infrastructure in the developing economies of the ESCAP region between 1990 and 2000. This figure compares with a recent ADB estimate of investment requirement of $500 billion for power supply infrastructure over the same period for its DMCs. The ADB estimate assumes a fall-off in annual power generation growth to between 5 and 5 per cent in 1990-2000 from the 8.5 per cent experienced in 1980-1990. This may be compared with the ESCAP assumption of 6.3 - 7.2 per cent demand growth for the region, falling only slightly from 8.0 per cent during the period 1980-1990. It should be noted that ADB in making their estimates assumed a higher unit cost per MW.


10 Asian Development Bank, op. cit.
Table 1.4 Electricity consumption and capacity scenarios to the year 2000

<table>
<thead>
<tr>
<th></th>
<th>Consumption (gigawatt hour)</th>
<th>Capacity (megawatt)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1980</td>
<td>1990</td>
</tr>
<tr>
<td>East Asia</td>
<td>358,016</td>
<td>776,027</td>
</tr>
<tr>
<td>South-East Asia</td>
<td>51,077</td>
<td>132,179</td>
</tr>
<tr>
<td>South Asia</td>
<td>109,325</td>
<td>268,299</td>
</tr>
<tr>
<td>Central Asia</td>
<td>124,315</td>
<td>215,287</td>
</tr>
<tr>
<td>Pacific islands</td>
<td>750</td>
<td>1,149</td>
</tr>
<tr>
<td>ESCAP region</td>
<td>643,483</td>
<td>1,392,941</td>
</tr>
</tbody>
</table>

Source: ESCAP secretariat estimates.

Note: (1) and (2) refer to low and high scenarios.

The three largest contributors to the ESCAP estimate are China ($143 - 181 billion for 102,000 - 129,000 MW), India ($83 - 92 billion for 55,000 - 61,000 MW), and the Republic of Korea ($42 - 46 billion for 22,000 - 24,000 MW). These three countries account for nearly 50 per cent of the total investment requirement.

No comprehensive or reliable information is available on the total level of funding already committed or utilized in the region since the beginning of the decade. However, it is estimated that $173 - 202 billion has already been committed or utilized and that $401 - 472 billion still has to be found between 1994 and 2000.

5. Selected countries: power planning and projects

In a number of countries within the region in recent years, imbalances have emerged between electricity supply and demand, thereby resulting in power shortages and disruption to both industry and other consumers. In some cases rapid economic growth has simply seen demand outstrip supply. In other cases the poor performance of existing infrastructure has been a critical factor.

India and the Philippines are two countries where such power problems have arisen.

The Philippines has experienced power shortages since 1989, and in 1992 daily brown-outs of up to 12 hours duration were experienced in the peak demand summer months. The power shortfall has been attributed to the impact of below average rainfall on hydroelectric reserves, frequent breakdowns in existing facilities and slowness in the development of new projects largely owing to environmental concerns.12

The latest Philippines Five-year Plan (1993-1998) has set targets of eliminating daily "brown-outs" by the end of 1993 and totally by the end of 1995. These objectives would be achieved with the installation of 5,914 MW of additional generating capacity. At the same time distribution losses would be reduced from 28.8 per cent to 17.8 per cent, introduction of a single new power grid would also provide greater flexibility in power distribution, and 17 existing power plants with a total capacity of 1,685 MW would be rehabilitated. Total expenditure in excess of $8.4 billion is envisaged.

The Indian Government Planning Commission's Eighth Five-year Plan covering the period 1992 to 1998 envisaged the introduction of 25,000 MW of new generating capacity. The Planning Commission has reportedly announced that even with an increase in generating capacity of 30,500 MW over the five years to March 1997 (an increase of 45 per cent over the 1990 installed capacity) there would be no change in the current position where power demand exceeds supply by 20 per cent at peak demand times.

12 One striking example relates to the nuclear power plant project which was completed in 1986 but has never been operated. Attempts to bring it to the commissioning stage have not succeeded thus far. The removal of a 600 MW unit from the Luzon grid in 1986 resulted in an instantaneous shortfall of 600 MW from which the National Power Corporation is only now recovering.
The Government of India is currently examining a range of 41 power projects proposed by the private sector which would collectively add 20,000 MW to the country’s generating capacity at a cost of $16.5 billion.

D. WATER SUPPLY AND WASTE TREATMENT

Although most countries of the Asian and Pacific region seem to have ample water resources to meet rising demand, adequate quantities may not be readily available in the places where it is needed, nor at the time of greatest demand. It has been estimated that at the beginning of the 1990s the total annual water abstraction in the ESCAP region was in the order of 1,560 billion cubic metres. In all countries of the region, except Singapore, the bulk of water is withdrawn for agriculture. The share of water abstracted for agriculture varied from about 95 per cent in the still predominantly agricultural economies of Bangladesh, Cambodia, Nepal and Pakistan to around 54 per cent in the more industrialized economy of the Republic of Korea. In China and India, agricultural use takes about 83 to 85 per cent of the total water supply. At the beginning of the 1990s it was estimated that 85 per cent of the volume of water abstracted for the region as a whole was for the agriculture sector. Domestic and industrial uses were estimated as 7 and 8 per cent respectively.

1. Regional water consumption

Present annual rates of total water abstraction for domestic, industrial and agricultural purposes are estimated as 105, 120, and 1,275 billion cubic meters respectively. In urban households with piped water, daily use typically ranges from 100 to 400 litres per day. In rural areas of the developing countries, the per capita use averages from 40 to 60 litres per day, while in some less developed and small island countries the level of water usage may be close to the biological minimum (from 2 to 5 litres per person per day) during the dry season.

According to the report on the achievements of the International Drinking Water Supply and Sanitation Decade (1981-1990), July 1990, by the Economic and Social Council, it is estimated that out of 1.347 million people globally who, for the first time, received adequate water supply services during the Decade, 60 per cent lived in Asia and the Pacific - 890 million in rural areas and 185 million in urban areas. Of the global access to sanitation services the population of the ESCAP region represents 68 per cent of the total.

2. Trends in water demand

In recent years, there has been growing pressure on water resources in many countries of the region, with increasing demand from the agricultural, domestic and industrial sectors. Table 1.5 presents changes in the volumes of water used by these sectors over the years with projected estimates for the year 2000.

Although agriculture is by far the largest water consumer in the majority of countries in the region, agricultural water usage is normally accorded a lower government priority than domestic/industrial usage. At times of water shortage, for example, agricultural water supplies are cut to ensure adequate supplies to domestic/industrial usage.

3. Projecting year 2000 water supply requirements

According to available estimates, the number of people in urban areas of the ESCAP region served with water supplies in 1990 was 586.11 million, and the total urban population is expected to reach 1,085.56 million by the year 2000. Similarly, the number served in rural areas was 1,408.60 million in 1990, and the total rural population is expected to reach 2,320.79 million by the year 2000. The number of potential additional recipients of urban water supply services between 1990 and 2000 is, therefore, 499.45 million while for rural areas the estimate is 914.18 million persons.13

Agenda 21, in its chapter 18 on freshwater resources, part E, states that:

“18.58 All States, according to their capacity and available resources, and through bilateral or multilateral cooperation, including the United Nations and other relevant organizations as appropriate, could set the following targets:

(a) By the year 2000, to have ensured that all urban residents have access to at least 40 litres per capita per day of safe water and that 75 per cent of the urban population are provided with on-site or community facilities for sanitation;

### Table 1.5 Selected countries of the ESCAP region: water usage and projections for the year 2000

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>354</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(other)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>380</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic</td>
<td>12.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>18.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>57.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>87.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>0.94</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>18.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viet Nam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic</td>
<td>1.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>1.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>35.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>37.86</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sources:** See notes below.

**Notes:**

4. *Japan's National Comprehensive Water Plan (Water Plan 2000)*.
(b) By the year 2000, to have established and applied quantitative and qualitative discharge standards for municipal and industrial effluents;

(c) By the year 2000, to have ensured that 75 per cent of solid waste generated in urban areas is collected and recycled or disposed of in an environmentally safe way."

In the review of the achievements of the Decade, it was declared that in Asia and the Pacific the percentage of people provided with water supply in 1990 was 77 per cent of the total urban population (up from 73 per cent in 1980) and 67 per cent of the total rural population (up from 28 per cent in 1980).

According to the projections made in the review, if the physical rate of supply connection achieved in the decade 1980-1990 was maintained up to the year 2000, then coverage rates at the year 2000, after taking population growth into account, would be of the order of 71 per cent of the urban population and 99 per cent of the rural population.

For the purposes of this study it has been decided to set targets of 85 per cent coverage in both urban and rural populations of the region for the year 2000. The setting of targets at this level reflects the level of development required to achieve full coverage in 2025 given that the region is already well on the way to meeting the Agenda 21 coverage objective of 75 per cent for the year 2000.

In 1990, the sanitation coverage was 65 per cent in urban areas and 54 per cent in rural areas. In order to provide 75 per cent service coverage in both urban and rural areas, it would be necessary to serve 319.4 million additional persons in urban areas and 606.91 million additional persons in rural areas between the year 1990 and 2000.

Owing to the uneven growth of industries within the region and to the variations in specific water requirements, the projections for the water demand by the industrial sector is rather difficult. For instance in a few highly industrialized countries in the region, the demand for water by industry has reached a plateau mainly because of higher efficiency in production processes as well as increased rates of water recycling and reuse. However, in some developing countries water demand for power production, manufacturing, mining and material processing are rising in conformity with the industrialization path. Therefore, a safe estimate for growth of demand for industrial water supply would be in the order of 5-10 per cent annually over the period 1990-2000 equating to 6-12 billion cubic meters of water a year.

According to the Food and Agriculture Organization of the United Nations (FAO) sources, the average annual growth rate of irrigated areas in Asia and the Pacific region was in the order of 1.1 per cent during the period 1980-1990. It is expected that this rate will continue until the year 2000. Further increases in yields and production in the region are expected to come from increased efficiency and more rational use of water on existing irrigated land, achieved particularly through rehabilitation of degraded and debilitated irrigation systems. It is estimated that in most irrigation schemes only about 40 per cent of water taken into major canals reaches the fields. It is estimated that about 16 million hectares of newly irrigated area could be developed and 35 million hectares rehabilitated during the period 1990-2000.

4. Investment requirements

According to available data in 1995 prices, the unit per capita cost of urban house connection varied from $34 in the Philippines to $170 in Sri Lanka. It was reported to be as high as $200 in Papua New Guinea and $320 in Samoa. Similarly, unit per capita cost of standpipe type urban water supply varied from $1 in the Philippines to $90 in Sri Lanka and $100 in the Maldives.

The unit per capita cost of rural water supply systems varied from $2 in Bangladesh to $40 in the Republic of Korea. The cost varied from $26 to $160 in various schemes in Malaysia. In Samoa, it reached $180.

From above it can be estimated that for the period up to year 2000, the unit per capita cost for urban house connections would be in the order of $120, and for standpipes $80. The unit cost for rural water supply is estimated as $50.

Assuming that of the $36.62 billion to be served in urban areas between 1990 and 2000, 90 per cent will have house connections and 10 per cent will be served by standpipes, the total cost reaches approximately $43 billion. Similarly, the total cost for the provision of rural water supply for 565.07 million persons would be in the order of $28 billion.

These are the estimates at 65 per cent service coverage levels. Full coverage would cost much more and it would not be realistic that full coverage levels could be achieved by the year 2000, at the current development rates.

From the available information, it is estimated that sewer connections in urban areas could cost $140 per capita and $60 for other type of sanitation facilities. The unit cost of rural sanitation is estimated at $40 per capita. Assuming that half of the urban population provided with services during the period 1990-2000 will use sewer connections, the total cost of urban sanitation reaches $32 billion at 75 per cent service level. Similarly, the total cost for rural sanitation at the same service level will be $24 billion.

According to the available data, the cost of production of water (in 1985 dollars) varied from $0.02/m³ in China and $0.08/m³ in India to $0.21/m³ in Thailand and $0.25/m³ in Myanmar and Sri Lanka. In the island countries, the water production costs were much higher, varying from $0.09/m³ in Samoa to $0.55/m³ in Papua New Guinea and $0.50/m³ in Tonga.

Accepting an estimate of $0.30/m³ for average water production costs, the total requirements for industrial water supply would be between $18-36 billion for the period 1990-2000 in Asia and the Pacific to meet 5-12 billion cubic meters of annual water demand increase.

Industrial waste treatment costs could be about 25 per cent higher than the cost of water supply, requiring $22-44 billion for the period 1990-2000.

The cost of water development for irrigation in the 1980s varied from $2,000 per hectare in China and $3,000 per hectare in Indonesia. Therefore, for the period 1990-2000, an average cost of $3,500 per hectare would be a realistic figure. A total of $56 billion would thus be required for the expansion of irrigated areas at the rate of 1.6 million hectares a year between 1990 and 2000. The average cost for upgrading and rehabilitation could be about $1,000 per hectare. Accordingly, the total cost for upgrading and rehabilitation of water supplies for debilitated schemes totalling 35 million hectares could be estimated as $35 billion.

The total expenditure on water supply and sanitation service coverage increases, between 1980 and 1990 in Asia and the Pacific, in both urban and rural areas is estimated at $56 billion. The estimates for the period 1990-2000 can be summarized as:

(a) Water supply and sanitation: 127 billion dollars

(b) Industrial water supply and waste treatment: 40-60 billion dollars

(c) Irrigated agriculture: 91 billion dollars

Total: 258-268 billion dollars

In addition to the above, about $1.5 billion a year would be required for the operation and maintenance costs.

E. TELECOMMUNICATIONS

1. Telecommunications media

For the purposes of examining the status of telecommunications in the region this study focused on main domestic telephone lines. While facilities such as mobile phones, international lines and the level of technology of telephone services are all an integral and essential part of modern telecommunications the relative number of main telephone lines provides perhaps the best indicator of the level of any country's telecommunications development.

The telephone main line information used in this study has for the most part been drawn from publications of the United Nations specialized agency for telecommunications, the International Telecommunication Union (ITU).

2. Telephone supply in the region

As at the end of 1991 the density of main telephone lines in the ESCAP region, excluding developed countries, was 1.5 main lines per hundred of population. This compares with a density of around 0.6 in 1982 (excluding the Central Asian republics for which no 1982 information was available). By comparison Australia, Japan and New Zealand had densities in 1991 of 48.4, 45.4 and 44.2 respectively.

Within the region the developing economies with the highest densities in 1991 were Hong Kong (45.9), Singapore (39.9), Republic of Korea (33.7) and Brunei Darussalam (14). With the exception of Malaysia (9.9) and the Central Asian republics (8.2 as a whole), no other country with a significant population size exceeded 5.0 main lines per hundred population.

There has been significant growth in the number of main lines installed in recent years. Between 1982 and 1991 the number of lines in the region (excluding the Central Asian republics) increased by 12.1 per cent a year. Among the larger countries with high growth rates were China (15.3 per cent), the Republic of Korea (15.2 per cent), and Thailand (15.2 per cent). Smaller countries/areas with high growth rates included the Maldives (16.1 per cent), Nepal (18.4 per cent), and Macau (21.3 per cent). Of the 19.9 million main lines installed in the region (excluding the Central Asian republics) between 1982 and 1991, China, India, and the Republic of Korea, collectively accounted for 72 per cent, with the Republic of Korea alone, with only 1.5 per cent of the population accounting for over 37 per cent.

Despite the relatively high line densities of the Central Asian republics in 1991 (6.2 compared to 1.6 for the region as a whole) the rate of growth in those countries since 1982 has not matched the rest of the region with Azerbaijan experiencing 4.1 per cent, Kazakhstan 6.7 per cent, Kyrgyzstan 5.0 per cent, Tajikistan 3.4 per cent, Turkmenistan 4.5 per cent, and Uzbekistan 4.8 per cent a year.

3. Telephone demand in the region

Notwithstanding the high rate of installation of main lines in recent years the number of unmet applications for telephone lines has been rising steadily. Excluding the Central Asian republics, the number of unmet applications rose between 1982 and 1991 from 3.7 to 6.5 million. This represents an annual rate of increase of 6.7 per cent. This figure would be much higher if it were not for the efforts of the Republic of Korea which over the same period reduced its unmet applications from 427,000 to 192. Excluding the Republic of Korea and the Central Asian republics, unmet applications in the region rose at an annual rate of 12.0 per cent.

Countries where the rate of increase of unmet demand was high included the Philippines where the number of unmet applications rose from 132,000 in 1982 to 705,045 in 1991 (an annual rate of increase of 20.5 per cent) and Thailand where unmet applications rose from 387,000 to 1,299,000 over the same period (a 14.4 per cent annual rate of increase).

Information on unmet demand for the Central Asian republics is only available from 1991. Between 1987 and 1991 the number of unmet applications for telephones increased from 1,455,000 to 1,634,000.

4. Year 2000 main line requirements

For the purpose of estimating the demand for lines in the year 2000, projections have been made on the basis of the growth in supply and an assessment of unmet demand, and demand being taken to represent total demand. This approach was followed rather than projecting total demand because of the unavailability of base year unmet demand data.

Projections for growth in supply were made using growth rates between 1982 and 1991. The results of projections using this methodology appear in Table I.6. It has been estimated that total demand in the year 2000 will amount to 136.7 million main lines with the demand for 27.1 million lines being unmet on current supply rates. At the same time telephone density in the region will rise from 1.64 per 100 of population in 1991 to 3.14 and 3.92 if total demand is met.

Nearly 40 per cent of the estimated 88.5 million additional telephone lines that would need to be installed to meet demand by the year 2000 would be in China (25.2 million), India (15.8 million) and Thailand (6.4 million).

In assessing total demand increases in telephone density (main lines per 100 persons), trends in unmet applications were taken into account. For example, in the case of the Republic of Korea there was virtually no backlog in unmet applications.

The accuracy of the above projection estimates will be dependent on the rate of economic growth.
between 1991 and 2000. It could be expected that any acceleration in economic growth would see an increase in unmet demand unless there was a commensurate increase in supply.

5. Investment requirements

ITU has estimated the cost of supplying telephones lines at $1,500 per line. On that basis the investment requirement to maintain supply growth rates in the region up to the year 2000 would be $132.8 billion. Countries accounting for significant portions of this amount would be China ($37.8 billion), India ($23.8 billion) and Thailand ($12.5 billion). Assuming funding has been secured for projects until the end of 1994 the value of funding already committed or secured would be of the order of $22.8 billion. Table 1.6 shows details of the funding requirement by subregion.

ITU has also undertaken estimates of the level of investment required in the region, excluding the Central Asian republics, in providing telephone lines up to the year 2000 and arrived at a figure of $108.6 billion. Their estimation approach assumes a 15 per cent a year compound growth rate for lower income economies and 5 per cent for higher income economies. If the same approach is extended to the Central Asian republics using 5 per cent annual growth the ITU approach yields a regional investment requirement of $112.0 billion.

6. Selected countries telecommunications planning and projects

Advice received from a number of countries suggests that the above secretariat estimates, even though they exceed ITU estimates, are conservative rather than an overestimate of the investment requirements.

Bhutan has indicated it expects to have 11,780 lines by the year 2000 and would need 14,850 to satisfy demand (secretariat estimate 4,400). Malaysia has indicated plans to have 7.4 million lines by the year 2000 (secretariat estimate 5.8 million). The Philippines 1992-97 economic plan aims to achieve a telephone density of 4 lines per 100 people by the end of 1997 (compared with the secretariat estimate of 6 lines per 100 people by the year 2000). The Republic of Korea has indicated it needs and will have 26.6 million lines in the year 2000 (secretariat estimate 22.6 million). Thailand has indicated objectives of 6 million lines by 1996 and 11 million by the year 2000 (secretariat estimate 9.9 million). Viet Nam aims to increase its number of main lines to 1.5 million in the year 2000 (secretariat estimate 0.9 million).

China is the country with the greatest potential for accelerated growth. The Vice-Minister for Posts and Telecommunications is reported[17] to have told an Asia Telecom trade show in mid-1993 that China is looking to install about 70 million new lines by the year 2000 (secretariat estimate is around 25 million new lines).

Table 1.6 shows a selection of projects being implemented or examined in the region and provides a guide to the dimensions and costs of telecommunications projects.

---

**Table 1.6 Telecommunications, growth projections and investment requirement to the year 2000**

<table>
<thead>
<tr>
<th>Region</th>
<th>Main line supply (thousands)</th>
<th>Unmet demand (thousands)</th>
<th>Total demand (thousands)</th>
<th>Funding required (millions of dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Asia</td>
<td>7,765</td>
<td>2,273</td>
<td>10,038</td>
<td>7,821</td>
</tr>
<tr>
<td>South Asia</td>
<td>23,493</td>
<td>11,328</td>
<td>34,821</td>
<td>37,426</td>
</tr>
<tr>
<td>South-East Asia</td>
<td>17,945</td>
<td>10,241</td>
<td>28,186</td>
<td>32,344</td>
</tr>
<tr>
<td>East Asia</td>
<td>59,959</td>
<td>3,255</td>
<td>63,214</td>
<td>54,830</td>
</tr>
<tr>
<td>Pacific islands</td>
<td>435</td>
<td>37</td>
<td>472</td>
<td>384</td>
</tr>
<tr>
<td>ESCAP region</td>
<td>109,597</td>
<td>27,134</td>
<td>136,731</td>
<td>122,605</td>
</tr>
</tbody>
</table>

Source: ESCAP secretariat estimates.

---

*[17] "Investors: Move as Asians get on the phone". Bangkok Post (14 June 1993).*
Table 1.7 Selected telecommunications projects in the ESCAP region, 30 June 1993

<table>
<thead>
<tr>
<th>Country</th>
<th>Project</th>
<th>Main lines installed (thousands)</th>
<th>Capital Cost (millions of dollars)</th>
<th>Status</th>
<th>Commissioning year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei Darussalam¹</td>
<td>Ten switch exchanges</td>
<td>n.a.</td>
<td>20</td>
<td>Contracted</td>
<td>n.a.</td>
</tr>
<tr>
<td>Malaysia ¹</td>
<td>Digital switching equipment</td>
<td>750</td>
<td>730</td>
<td>Contracted</td>
<td>n.a.</td>
</tr>
<tr>
<td>Philippines ²</td>
<td>National telephone programme phase 1 tranche 1-3</td>
<td>29</td>
<td>172</td>
<td>Planned</td>
<td></td>
</tr>
<tr>
<td>Thailand ³</td>
<td>Rural line expansion</td>
<td>1,000</td>
<td>1,600</td>
<td>Underway</td>
<td>1997</td>
</tr>
<tr>
<td></td>
<td>Bangkok line expansion</td>
<td>2,000</td>
<td>3,400</td>
<td>Underway</td>
<td>n.a.</td>
</tr>
<tr>
<td>Uzbekistan ⁷</td>
<td>Urban line expansion</td>
<td>70</td>
<td>n.a.</td>
<td>Planned</td>
<td>n.a.</td>
</tr>
</tbody>
</table>


example, bridges), and signalling equipment. These projects are usually intended to increase the freight and passenger handling capacity of railway systems, or to reduce unit operating costs, or to achieve both of these objectives. In order to achieve this, railway route development projects need to allow for investment in the upgrading or expansion of motive power and rolling stock fleets where required.

The rehabilitation of route infrastructure in situations where track conditions have deteriorated as a result of the deferral or neglect of maintenance over many years, provides a major focus for infrastructure expenditure by many of the region's railway systems, but this type of expenditure had to be excluded from the study owing to difficulties of estimation and to the fact that it is often undertaken and identified as "maintenance", rather than investment.

1. Current railway infrastructure

Table 1.8 below shows a summary of the regional railway infrastructure in 1992 for countries for which information was available. Subregional data has not been presented in recognition of the absence of information in a number of countries with significant railway systems such as the Democratic People's Republic of Korea and most Central Asian republics. To the extent that most major railway systems in the region are included, the available information provides a reasonable basis for estimating physical resource requirements and funding on railways until the year 2000 at a regional level.

Within the region the largest railway systems by far are accounted for by China and India who between them account for around two thirds of all track length in the region and commensurate shares of rolling stock.

Table 1.8 Initial railway infrastructure and requirement for year 2000

<table>
<thead>
<tr>
<th></th>
<th>1992</th>
<th>Based on historic growth</th>
<th>2000</th>
<th>Based on productivity improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track length (kilometres)</td>
<td>222,795</td>
<td>233,118</td>
<td>263,974</td>
<td></td>
</tr>
<tr>
<td>Locomotive (number)</td>
<td>23,284</td>
<td>28,616</td>
<td>30,200</td>
<td></td>
</tr>
<tr>
<td>Freight wagons (number)</td>
<td>737,623</td>
<td>623,004</td>
<td>683,009</td>
<td></td>
</tr>
<tr>
<td>Passenger cars (number)</td>
<td>76,002</td>
<td>104,223</td>
<td>105,449</td>
<td></td>
</tr>
</tbody>
</table>

Source: Governments and rail systems, statistical yearbooks and ESCAP secretariat estimates.
Note: Section 2 outlines further the basis for the year 2000 projections.
2. Projecting growth in railway physical asset stock

The measurement in this study of railway infrastructure investment to the year 2000 was based on forecasts of growth in railway physical assets, including permanent way (track, signalling, and other railway route infrastructure), motive power (locomotives), freight wagons and passenger cars. In addition, supplementary estimates were made of investment in electrification and railway gauge standardization projects.

For each of the above asset categories, two estimates were made: first, a baseline projection of the growth in the current (1992) physical asset base likely to be achieved between 1993 and the end of 2000 on recent past trends; and, second, a projection of growth in the asset base in line with the likely growth in the railway traffic task and productivity improvements over the same period. The latter projection was based on trends in the following indicators:

<table>
<thead>
<tr>
<th>Asset category</th>
<th>Load indicator</th>
<th>Productivity indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track</td>
<td>Gross tonne kilometres (GTK)ⁱ²</td>
<td>GTK per track kilometre</td>
</tr>
<tr>
<td>Locomotives</td>
<td>GTK</td>
<td>GTK per locomotive unit</td>
</tr>
<tr>
<td>Freight wagons</td>
<td>Net tonne kilometres (NTK)ⁱ³</td>
<td>NTK per wagon</td>
</tr>
<tr>
<td>Passenger cars</td>
<td>Passenger kilometres (PK)ⁱ⁴</td>
<td>PK per vehicle</td>
</tr>
</tbody>
</table>

¹² Gross tonne kilometres, or GTK, is a commonly used measure of the railway output or traffic task. It represents the sum of the total weight (including freight and passengers) multiplied by distance run of all trains passing over the tracks of a railway system in a given year.

¹³ Net tonne kilometres, or NTK, is a commonly used measure of the freight carrying output, or traffic task, of a railway system. It represents the sum of the freight payload, or net load, multiplied by distance run, of all freight trains operating on a railway system in a given year.

¹⁴ Passenger kilometres, or PK, is a commonly used measure of the passenger carrying output, or traffic task, of a railway system. It represents the sum of the number of passengers multiplied by distance travelled of all passenger trains operating on a railway system in a given year.

The projections of the growth in the physical asset base were then costed at representative unit values (see below), in order to obtain estimates of probable and maximum investment levels. The funding deficiency was then identified as the difference between these two estimates.

3. Estimates of unit costs of railway assets

Within the region, the costs of track construction, per kilometre, appear to range from as much as $1.3 million, (for an electrified line in the Republic of Korea) to as little as $312,000 (for a non-electrified line in India). Track construction unit costs were obtained for Bangladesh, China, India, Indonesia, Malaysia, the Republic of Korea, Sri Lanka, and Thailand. These data were used to calculate representative unit costs for various groups of countries which are relatively homogeneous in terms of labour cost and the labour intensity of their track construction activity.

For locomotives, freight and passenger vehicles, the range of unit values for different countries is narrower than for track. For diesel electric locomotives, unit purchase costs tend to range between $2.0 million and $2.5 million; for pure electric traction, unit costs are typically between $3.0 million and $3.5 million; and typical unit costs of freight wagons and passenger vehicles range between $405,000 and $600,000, and between $250,000 and $500,000, respectively. For track electrification, costs per track kilometre ranging between $170,000 (for India) and $560,000 (for the Republic of Korea) were used. For gauge standardization projects in India (the only country of the region committed to large-scale projects of this type), a cost of $170,000 per track kilometre was used.

4. Estimates of investment requirements to the year 2000

Summary estimates of the investment required in railways to the year 2000 are shown in table 1.9.

These estimates may be compared with the cost of projects identified at the time of writing as either underway or committed. The latter were projects identified from the trade press or from questionnaire...
Table 1.9 Railways: Estimate of infrastructure expenditure requirement to the year 2000

<table>
<thead>
<tr>
<th>Railway asset category</th>
<th>Probable commitment of investment funds to the year 2000 (1)</th>
<th>Estimated maximum investment requirement (2)</th>
<th>Probable funding deficiency (3) = (2)−(1)</th>
<th>Cost of projects identified as committed or underway (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent way - New construction</td>
<td>9,350</td>
<td>45,724</td>
<td>36,374</td>
<td>30,907</td>
</tr>
<tr>
<td>Permanent way - Electrification</td>
<td>4,157</td>
<td>6,432</td>
<td>2,275</td>
<td>2,167</td>
</tr>
<tr>
<td>Permanent way - Gauge standardization</td>
<td>813</td>
<td>1,525</td>
<td>712</td>
<td>1,367</td>
</tr>
<tr>
<td>Locomotives</td>
<td>10,885</td>
<td>14,081</td>
<td>3,216</td>
<td>Not identified</td>
</tr>
<tr>
<td>Freight wagons</td>
<td>2,912</td>
<td>3,416</td>
<td>504</td>
<td></td>
</tr>
<tr>
<td>Passenger vehicles</td>
<td>6,377</td>
<td>6,746</td>
<td>369</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>34,474</strong></td>
<td><strong>77,924</strong></td>
<td><strong>43,450</strong></td>
<td><strong>34,441</strong></td>
</tr>
</tbody>
</table>

Source: ESCAP secretariat estimates, see also footnote 21.

This comparison suggests that the estimates both of the maximum investment required by the year 2000 and of the probable level of funding are likely to be realistic.

In terms of the investment likely to be required in additional track, it is estimated that China will account for by far the largest amount, $42,193 million, or 52 per cent of the total. In recent years China has experienced a severe shortage of railway route capacity, as is suggested by the very high track productivity results for its railway system. This shortage of route capacity is now being addressed with major new line construction projects and with projects designed to expand the capacity of existing routes, for example, through double tracking, track electrification and re-signalling. Examples of capacity expansion projects already committed are the construction at an estimated cost of $2.960 million of a fourth east-west trunk route for a total of 520 kms from Dongshen (Inner Mongolia) to the port of Huanghua in Hebei Province, as well as the construction of a new electrified line of 245 kms from Xian to Ankang at an estimated cost of $870 million.

Similarly, China is expected to account for a dominant share (65 per cent) of the investment estimated to be required in motive power by the year 2000. The majority of this investment will be in electric traction. India is also expected to account for a large share (32 per cent) of the forecast investment in locomotives, and in the case of India, the estimates are based on an assumption that a significant improvement in locomotive productivity will be possible with the introduction of more powerful electric locomotives into the fleet.

In the case of freight wagons, the fleets of most systems have been contracting at a time of moderate growth in rail freight traffic. This has been achieved by significant improvements in the management of the wagon fleets of many of the region's railway systems, as well as by the introduction of operational initiatives, such as the increased running of block trains, designed to improve wagon utilization. Notwithstanding these improvements, China is estimated to require a substantial investment ($3,344 million), in order to satisfy rapid growth in freight traffic during the period 1990-2000.

21 Sources include various issues of Railway Gazette International and International Railway Journal, as well as questionnaire responses for the Review of Developments in Transport and Communications in the ESCAP Region 1993 (S7/ESCAP/1333).
The forecast investment requirement in passenger rolling stock is expected to be concentrated in India, with an estimated funding requirement of $4,096 million, out of a total for the region of $6,746 million by the year 2000. This requirement was estimated on the assumption that the Indian Railways would achieve a significant improvement in the utilization and productivity of its passenger stock, but the size of the funding requirement is influenced by an expectation of a continuing strong growth (5.5 per cent a year) in passenger traffic.

G. ROADS AND HIGHWAYS

In the roads infrastructure sector, expenditures are typically incurred for:

(a) Construction of new roads of various types and bridges;
(b) Road/bridge improvement or upgrading, including paving, widening, lane expansion, reconstruction to accept heavier wheel loadings and/or permit higher speeds;
(c) Routine preventative or corrective maintenance (for example, repair of cracked or deformed pavements).

In the majority of the developing countries of the region, these activities have been, and will continue to be, funded by Governments, although in a small number of cases Governments have recently approved private sector participation in the funding, management and operation of new road projects. Without exception, these approvals relate to very large projects, involving outlays of around $500 million and upwards.

A difficulty often associated with analysis of the funding of road construction and maintenance programmes is that, in many countries, the upgrading or improvement of roads is funded out of the Government's road maintenance budget, and thus cannot be distinguished in government accounts from activities properly described as "road maintenance" activities. It is not inconceivable that in some countries of the region new road construction projects, particularly those involving the construction of minor roads, are also funded as "road maintenance", thereby adding to the problem of correctly identifying expenditure on road system improvement projects.

For the purposes of this theme study road system improvement should ideally be addressed as well as new road construction. However, because of the limitations of the available road statistics and the problem of isolating the "improvement" component of total road expenditures, the physical deficiency and resource gap analysis has been restricted to growth in the region's road stock and the costing of that growth. The resulting estimates of the maximum and likely levels of road infrastructure funding must therefore be treated as "lower bound" estimates only, given that there is substantial demand for major road improvement projects, such as those involving road paving and reconstruction in the region.

1. Road stock and growth trends

The available data indicate that in 1992 the length of all categories of roads in the developing countries of the region amounted to approximately 4,800,000 route kilometres (insufficient information is currently available on the number of lane kilometres, which would have provided a superior measure of the roads for planning purposes). Table 1.10 provides further details by subregion.

The growth of regional roads averaged about 2 per cent a year during the period 1985-1992, the fastest growth (3.9 per cent a year) being achieved in South Asia, and the slowest growth in the Pacific islands (estimated at 1.0 per cent a year) and East Asia (1.7 per cent a year). The trend information is derived from multiple data sources, as there is no single source which provides a comprehensive, continuous, accurate and time series related to the construction, maintenance and usage of the region's road networks.

However, the comparatively rapid increase of roads in South Asia masks the fact that this subregion contains two countries, Bangladesh and Sri Lanka, in which population growth has significantly outstripped road system growth, and also Nepal, which after Hong Kong, has the densest concentration of population per kilometre of road, of any developing country in the region.

The growth of roads in South-East Asia averaged 3.5 per cent a year between 1985 and 1992. Indonesia, with its road network growing at an average annual rate of 6.5 per cent during this period, achieved the fastest growth of any of the region's developing countries. This result was almost matched by that of Malaysia, with a growth in its road stock of 5.8 per cent a year. Thailand, with 4.2 per cent, also achieved growth in its road network in excess of the average for the subregion.
By contrast, road system growth in Myanmar (0.4 per cent a year), the Philippines (-0.1 per cent a year) and the Lao People’s Democratic Republic (1.2 per cent a year) fell well short of population growth in those countries. No time series data were available for Viet Nam, but it is believed that the national road network in that country has been static in recent years.

Among the countries of East Asia, road system growth in China (1.6 per cent a year) has barely kept pace with population growth, whilst in Mongolia the road system grew at a rate (1.3 per cent a year) which was only about half the rate of increase in the national population. The apparent underprovision of roads in China is probably a reflection of the priority given to the development of railways and inland waterways in the past.

2. Projecting growth in the road network

Two estimates have been made: a baseline projection of the road system growth from 1993 up to and including the year 2000, reflecting historic growth; and a projection of road system growth during the same period, at accelerated rates reflecting increased demand from faster social and economic development in certain countries.

The baseline projection is an extrapolation of average annual rates of growth in the road stock, in route kilometres, achieved during the period 1985-1992 (the actual range of years within this period for which data are available vary considerably from country to country). This projection assumes that the Governments of the region will have at least the capacity to fund road infrastructure growth at its historical rate of increase.

The second projection is based on an extrapolation of trends during the period 1985-1992, in the ratio of population to road route length. In the case of countries where the trends are “positive” road construction has lagged behind population growth. For these countries it has been assumed that during the forecast period, 1993-2000, road stock growth would occur at such a level so as to maintain the population/road length ratio at about its current level. In countries where there have been “declining” trends, it reflects growth in the road stock at faster rates than those of national populations. In such cases, where it is known that the pace of road system development has historically fallen short of socio-economic development goals, but has nevertheless exceeded the rate of population growth, it has been assumed that the population/road length ratio would decline during the forecast period at a faster rate than previously experienced.

The two projections produced by the method outlined above appear in table 1.10. A continuation of historical growth will result in an increase of 1,450,000 kilometres in the region’s road network by the end of the year 2000. This is the baseline forecast used to calculate the most likely level of commitment of investment funds to the roads sector within the study time-frame.

By contrast the forecast of growth in the road network in line with a declining ratio of population to road length suggests a need to add as much as 2,010,000 kilometres to the region’s network within this time-frame. This is the upper limit to road infrastructure growth, on the basis of which the gross increment in investment funds required by the roads sector is calculated.

| Road length projections and funding requirements |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
|                     | Road length (kilometre) | Funding required (millions of US dollars) |
|                     | 1990 | 2000 | Historic | Road density | 1990 | 2000 | Historic | Road density |
| Central Asia        | 347,900 | 347,900 | 405,719 |               | -    | 5,373 |
| South Asia          | 2,492,620 | 3,394,191 | 3,638,930 |               | 35,161 | 45,605 |
| South-East Asia     | 855,492 | 1,147,594 | 1,221,440 |               | 57,438 | 63,936 |
| East Asia           | 1,121,483 | 1,278,523 | 1,555,236 |               | 23,981 | 44,450 |
| Pacific islands     | 27,624 | 29,249 | 34,151 |               | 325  | 1,305 |
| ESCAP region        | 4,845,129 | 6,197,456 | 6,855,488 |               | 116,906 | 161,670 |

Source: Statistical Yearbooks, questionnaires and ESCAP secretariat estimates.
3. Investment requirements in roads

Within the region, the costs of road construction per kilometre appear to range from as much as $42 million for the second stage (elevated) Bangkok expressway system in Thailand, to as little as $11,300 for a gravel standard rural road in India. In all countries of South Asia, in China and in some countries of South-East Asia, the average cost of road construction will be affected significantly by the length and cost of rural or minor provincial roads, which in these countries comprise a large proportion of the total road network. In India, for example, rural roads account for about 84 per cent of the national road network measured in route kilometres. In Viet Nam and Thailand, rural roads account for two thirds of the national road network, but the rural road networks of these countries are not comparable in terms of quality (the Thai system having a significantly higher proportion of paved roads than the Vietnamese system).

The cost data available for India, Thailand and Viet Nam were used as a basis for estimating the expected and required road investment in these countries and in other countries considered to have a similar mix of road types and to be at a similar stage of development. In the case of China, the average road construction cost used was the average reflected in outlays under the 7th Five-Year Plan (1986-1990).

Application of unit road construction costs, as outlined above, resulted in the following average costs per kilometre for each subregion:

(a) Central Asia $93,000
(b) South Asia $41,000
(c) South-East Asia $175,000
(d) East Asia $103,000
(e) Pacific islands $200,000

Using these unit costs the dollar investments associated with each of the two road growth projection forecasts are calculated respectively at $118.91 billion and $161.67 billion. As the first figure represents a level of growth which has been funded by Governments in the past, the difference of $44.76 billion is considered to represent the likely funding deficiency.

4. Significant areas of growth and funding

Of the additional 2 million kilometres of roads estimated to be required in the region in the second forecast, India is estimated to require 941,000 kilometres, or 47 per cent. However, India's road construction programme is likely to be focused on the construction of rural roads, as it has been in the recent past. Consequently, India is estimated to require only 23 per cent ($38.69 billion) of the road sector investment funds estimated (in the second forecast) to be required throughout the region prior to the end of the year 2000.

Next in order of magnitude, in terms of the physical requirement, is China which is estimated in the second forecast to require an additional 434,000 kilometres of road up to the end of the year 2000, representing 21 per cent of the region's estimated requirement. China's road requirement, however, was costed at only $17.73 billion, or just 11 per cent of the region's estimated investment need.

Although ranking third in terms of physical requirement, South-East Asia, is estimated to require the highest level of roads investment of any subregion, $63.94 billion, or nearly 40 per cent of the regional total. Indonesia, with the fastest rate of road system growth in the region during the period 1985-1992, is expected to account for almost half of this amount. The concentration of road investment needs in South-East Asia is explained both by the higher standard of road development and the higher unit cost of road construction in this subregion, as compared with South and East Asia.

5. Comparisons with other estimates

The estimates in this study were cross-checked with those from independent sources. In particular, comparisons were made against estimates of road infrastructure funding needs in China, India, and Thailand.

China

The physical road construction requirement to the year 2000 was recently estimated at 400,000 to 600,000 kilometres of new road, bringing the total road length to 1.3 - 1.5 million kilometres. The theme study second forecast estimated a road

construction requirement for China of approximately 420,000 kilometres between now and the year 2000, resulting in a growth in the road stock of 1.48 million kilometres. Thus, the physical growth forecast of the theme paper study is considered to be realistic. Similarly, the forecast of the likely commitment of government funds for road construction ($8.25 billion) does not appear to be unrealistic, given an expenditure on road system development under the 7th Five-year Plan (1986-1990) of 20 billion yuan renminbi ($3.64 billion).

The estimated large ($11.48 billion) funding deficiency, however, suggests an increased reliance on non-government funding sources in future.

India

Two recent studies were reviewed. In one, it was observed that more than 50 per cent of villages in India were as yet unconnected with all-weather roads. In this study, it was estimated that an amount of $54.27 billion would need to be expended over 15 years between 1998 and 2003, in order to bring the total road system up to a satisfactory standard. Of this amount, it was estimated that $30.49 billion would be required for upgrading and expanding the existing road system (the latter involving only the construction of 1.1 million kilometres of new rural roads, whilst $23.78 billion would be required for road system maintenance. If the improvement component of this estimated expenditure is adjusted to reflect a funding requirement over the time-frame adopted for the theme paper (8 years), rather than the 15-year period on which this study was based, the total investment requirement would amount to only $16.26 billion, as compared with $36.69 billion for the theme paper study). However, this calculation takes no account of the inflation of road construction costs since 1988, which could easily have increased this amount to $20 billion (reflecting an annual 5 per cent cost inflation, between 1988 and 1992). Additionally, this estimate conflicts, to some extent, with that of another recent study.

In the second study, it was estimated that $24.19 billion would be required, between 1991 and the year 2000, for the upgrading and expansion of the national highway system of India alone. This estimate allows for a doubling of the present length (about 33,000 kilometres) of the national highways system and is justified on the basis that whilst the national highway system has been growing at an annual rate of only 0.5 per cent, as compared with 4 per cent for the total road system in India, it now carries an estimated 40 per cent of the nation's passenger and freight traffic, and is fast becoming inadequate to cope with further growth in this task.

If the amount estimated in the first study to be required for rural road construction ($12.87 billion) is adjusted to an 8-year time-frame, inflated to 1992 values and then added to the above estimate of $24.19 billion for national highway system improvement, the resulting estimate of total road system investment needs in India to the year 2000 amounts to approximately $33 billion, which is not very far from the theme study estimate.

Some difficulty arises, however, with the first forecast of the theme study (i.e., the estimate of the likely commitment of investment funds), since the total amount allocated for road work under the current Eighth Five-year Plan for India is $4.99 billion. If this allocation is inflated and adjusted to the theme paper timescale, it is difficult to forecast a government allocation of more than about $12 billion for all road work in India between now and the year 2000. This would result in a much wider funding deficiency than that estimated by the method described above, perhaps reflecting the extent to which funding sources outside the government budget might need to be tapped, in order to close the gap.

Thailand

In the current Seventh Plan, covering the period 1992-1996, an amount of $6.02 billion has been committed for highway development. Of this amount $5.44 billion has been allocated for investment projects and $1.39 billion for road maintenance.

The Department of Highways is responsible for only 28 per cent of the total length of roads in Thailand, and its allocation of investment funds more than doubled in real terms between the Sixth and

Seventh Plans. Therefore, the theme paper estimate of $14.78 billion for the likely commitment of investment funds for roads in Thailand up until the year 2000 is likely to be realistic.

H. URBAN PUBLIC TRANSPORT

The approach used for the purposes of this study was to identify planned and committed investments in urban public transport projects by means of a search of the relevant trade literature. The literature search yielded the following information:

(a) The investment in specific urban public transport projects, either currently underway, currently committed, or planned for commencement, throughout the developing countries of the region, between now and the year 2000;

(b) Of the total investment in (a) above, the investment for which funds have already been allocated.

The aggregate of investment across all urban public transport projects was regarded for the purposes of this study as representing the investment requirement in this sector. The difference between (a) and (b) above was similarly regarded as being the probable funding deficiency which would need to be covered between now and the year 2000.

1. What constitutes urban public transport?

For the purposes of this study, "urban public transport" includes all facilities offering common user passenger transport services in urban areas, except urban roads (including expressways and tollways). Included under this heading are the following urban public transport modes:

(a) Metro, or urban mass transit, systems, which are high speed, high capacity (up to 80,000 passenger journeys per direction per hour) guided transport systems operating on their own dedicated permanent way, either underground, or on the surface on above-ground structures;

(b) Light rail, or LRT, systems, which are similar to metro systems in that they are guided systems operating on their own dedicated right of way, but are of lighter track and vehicle construction,

and provide a lower people movement capacity (typically no more than 25,000 - 30,000 passenger journeys per direction per hour);

(c) Suburban heavy rail, involving the operation of urban passenger trains on the urban portion of the established general railway system, which, in general, they share with long distance passenger and freight trains;

(d) Monorail systems, which are based on the operation of passenger carrying vehicles on specialized single rail elevated structures. The passenger carrying capacity of monorails is considerably less than that of LRT systems;

(e) Tramways, which are guided transport systems operating on that part of the urban road network equipped with rails and an overhead electric power supply. Unlike metro and LRT systems, trams do not always operate in multiple units, and have a considerably lower passenger carrying capacity;

(f) Guided busways (sometimes called "O-Bahn" systems), involving the operation of rubber tyred buses equipped with guide wheels along guideways constructed along major roads. These buses may also operate conventionally on the urban road network;

(g) Trolley buses, or conventionally steered rubber tyred passenger carrying vehicles, operating on the urban road system, but powered by electric traction motors, for which electric power is transmitted via overhead wires;

(h) Buses, or rubber tyred passenger carrying vehicles, powered by internal combustion engines, and operating freely on the urban road system;

(i) Ferries, or passenger carrying vessels operating on riverine and harbour services within urban areas.

In practice, the current focus of urban public transport investment programmes is on the construction of high capacity, segregated and specialized systems of the metro or LRT type. Some of the above-listed modes, such as trams
and trolley buses, are no longer favoured, owing to their relatively low passenger carrying capacity and operational inflexibility.

2. Identified investment requirement

The consolidated data obtained by means of the literature search (see table 1.11) indicate a total investment requirement, for the period 1993-2000, of $67.79 billion, of which only $10.87 billion was clearly identified as committed, leaving a deficiency of $56.91 billion still in need of funding by the year 2000. The distribution of this investment by subregion, when reviewed against the distribution of the region's urban population, shows a substantial imbalance in the case of South Asia.

In spite of the fact that South Asia contains more than one-third of the developing ESCAP region's urban population, and is expected to experience a faster rate of urban population growth during the period 1990-2010 (4.0 per cent a year, as compared with an annual average of 3.7 per cent for the region's developing countries), only 5 per cent of the urban public transport investment forecast for the region during the period to the year 2000 is likely to be expended in South Asia. Calcutta is the only South Asian city with a high capacity urban mass transit system, although a metro system is currently under construction in Teheran, whilst another for New Delhi has been in the detailed planning stages for some five years.

Of the total investment of $51.82 billion identified for East Asia, planned investment in subway systems in seven cities of the Republic of Korea is expected to account for $31.0 billion. Similarly, a small number of projects is projected to dominate expenditure on urban public transport infrastructure in South-East Asia, with three urban mass transit projects in Bangkok possibly accounting for $5.36 billion, out of a total for the subregion of $12.61 billion.

New construction and extension of metro systems may be expected to absorb $55.76, or 92 per cent, of the total urban public transport investment forecast for the region, with the development of light rail transit (LRT) systems absorbing another $7.64 billion (11 per cent).

Some of the investment projects included in table 1.11 must be classified as uncertain. For example, in Bangkok, of three urban mass transit projects approved by the Government of Thailand in 1990 only one (a project combining suburban rail, an LRT and a tollway, to be developed by Hopewell Holdings under a 30-year build-operate-transfer (BOT) concession) has actually proceeded to the construction stage.

Similarly, announcements have been made at the political level of proposals to develop urban mass transit projects in Jakarta,25 involving initially a 56-kilometre extension of the existing suburban rail network, followed by the construction of an LRT system. Feasibility studies of these proposals were completed three years ago, yet it does not appear that their implementation is imminent.

I. AIRPORTS

A search of the relevant trade literature was undertaken in order to identify:

(a) The current position and development in airport and aviation equipment either currently underway, committed, or planned for commencement.

| Table 1.11 Urban public transport investment and urban population, by subregion |
|---------------------------------|----------------|----------------|
|                                 | Required investment to the year 2000 | Share of urban population, ESCAP developing countries (percentage) |
|                                 | $US billion | Share | ESCAP developing countries |  |
| South Asia                      | 3.36       | 5.0   | 36.7                      |
| South-East Asia                 | 12.61      | 18.6  | 48.3                      |
| East Asia                       | 51.82      | 76.4  |                           |
| ESCAP region                    | 67.79      | 100.0 | 100.0                     |

Source: ESCAP secretariat estimates.

* Based on country composition of ESCAP and urban population in 1990. (Source for latter, United Nations, Urbanization Trends, 1990.)

throughout the developing countries of the region, between now and the year 2000;
(b) Of the total investment identified in (a) above, the investment for which funds have already been allocated;
(c) The difference between (a) and (b), being the probable funding deficiency, which would need to be covered between now and the year 2000.

1. The level of regional air traffic

During the period 1980-1990, the air passenger traffic of the Asian and Pacific region (measured in terms of passenger-kilometres) grew at an average annual rate of 8.0 per cent, compared with a growth rate of 5.7 per cent a year for the world and 5.8 per cent for the next fastest growing region, North America.\(^{26}\)

The Asian and Pacific region also experienced the fastest rate of growth in scheduled air freight traffic of any region in the world, with 11.3 per cent annual growth during the period reviewed, compared with 7.3 per cent for the world and 6.4 per cent for the next fastest growing region, Europe. The International Civil Aviation Organization (ICAO) has predicted a continuation of these growth trends during the period 1990-2001.\(^{27}\)

Certain developing countries of the region have experienced growth in air passenger and freight traffic at much higher rates than those of the region as a whole. In the Republic of Korea, air passenger traffic grew from 9.83 million in 1988 (3.66 million international traffic) to 16.94 million in 1992 (5.13 was international traffic). This reflects an average annual growth of 17.8 per cent for total passenger traffic and 8.8 per cent for international passenger traffic. Similarly, air passenger traffic in Malaysia and Sri Lanka grew at double digit rates during this period (13.5 per cent for total traffic and 10.2 per cent for international traffic in the case of Malaysia; and 10.8 per cent for total traffic, all international, in the case of Sri Lanka).

2. Current status of major regional airports

Seven major "hub" airports: Taipei-Chiangkai-shhek, Hong Kong-Kai Tak, Tokyo-Narita, Osaka-Itami, Seoul-Kimpo, Singapore-Changi, and Bangkok-Don Muang - handle some 68 per cent of all passenger trips between Asia and Europe, and 86 per cent of all trans-Pacific trips to and from Asia.\(^{28}\) In addition, these airports are estimated to handle more than 75 per cent of all intraregional passenger traffic.

Passenger handling capacity is under pressure at all of these airports, with the exception of Singapore, where major terminal expansion projects recently have been, and are currently being, undertaken. At some of these hubs, notably Hong Kong and Seoul, capacity shortages are becoming critical, as passenger traffic continues to grow at rates in excess of 10 per cent a year.

Problems associated with airport capacity shortages are by no means confined to the hub airports of the region. The following description of the demand/capacity problems at selected airports in the developing countries of the region, and the measures being taken to relieve them, provides a clear indication of the scale of the overall problem.

Taipei - Chiangkai-shhek

The number of passengers handled at this airport in 1991 was more than 10 million, as compared with the theoretical capacity of the airport to handle 12 million passengers a year. The second phase expansion project currently underway involves the construction of two new runways and a second terminal to handle 12 million passengers a year. Following completion of this project, the airport will have sufficient capacity to handle the projected level of traffic up until the year 2000, although a capacity shortage will begin to re-emerge at that time, given projections of an increase in passenger volume to 41.5 million by 2010.\(^{29}\)


\(^{27}\) ibid.


\(^{29}\) Asian Aviation (May 1992).
Hong Kong - Kai Tak

Aircraft movements and passenger traffic through Kai Tak Airport are expected to reach their annual capacity levels of 134,000 and 24 million respectively, by the end of 1993. Land reclamation for the new airport at Chep Lap Kok is currently underway, with the total cost of the airport project (including the supporting land transport infrastructure) now estimated at $10 billion. The new airport is designed to provide a passenger handling capacity of 87 million passengers a year and it is scheduled for completion by mid-1997. It is probable that $2.3 billion will have to be provided through commercial borrowings.\(^\text{30}\)

Kuala Lumpur - Subang

This airport handled 5.94 million passengers in 1990/91, and passenger volume is estimated to be growing at 18-20 per cent a year. By the end of the decade, Subang is expected to be handling up to 12 million passengers and 110,000 aircraft movements a year. Apron parking space is now severely limited and the domestic traffic has been transferred to a small temporary terminal. The fact that the airport is surrounded by housing and is shared with military operations has restricted the scope for its further expansion and limited construction of additional aircraft parking bays and terminal upgrading. Consequently, the Government of Malaysia has approved the construction of a new international airport at Sepang, 50 kilometres to the south of Kuala Lumpur. The first phase of this project, to be completed by 1997, will provide capacity to handle 25 million passengers a year, with subsequent development up to 100 million passengers a year.\(^\text{31}\)

Manila - Ninoy Aquino

The international terminal at this airport is designed to handle 5 million passengers a year, and is currently estimated to be handling something close to this number. Plans call for the construction, by 1996, of a new cargo handling facility and a second international passenger terminal, designed to handle 7 million passengers a year. A third international terminal is in its early planning stages, but it has not yet been determined whether this terminal will be constructed in Manila, or at the former United States Clark Air Force Base, which is being considered as the site for a new international airport.\(^\text{32}\)

Seoul - Kimpo

Seoul's Kimpo International Airport is estimated to have a capacity to handle 24 million passengers a year.\(^\text{33}\) Provisional figures for 1992 show that the airport handled 21.23 million passengers (88 per cent of theoretical capacity), and if growth in passenger traffic continues at about the rate of increase experienced between 1991 and 1992 (11.7 per cent), the airport will have reached saturation point by the end of 1994. The new Seoul International Metropolitan Airport (NSMA) project was launched in late 1992. This project involves the construction of an entirely new airport on reclaimed land near Inchon, at an estimated cost of $12.7 billion, some $6 billion of which will be expended prior to the year 2000. However, the first phase of this project will not be completed before 1997, and only then will the new airport be able to absorb the international traffic currently handled through Kimpo.\(^\text{34}\)

Bangkok - Don Muang

In 1992, the total number of passengers handled at Don Muang was 14.86 million, of which approximately 11 million were international passengers. The international terminal has the capacity to handle 16 million passengers a year. Thus, international passenger traffic has reached nearly 70 per cent of theoretical capacity. If the strong growth evident prior to 1992 (about 17 per cent a year) were to re-occur, the existing international terminal would reach saturation point by 1995. The Airports Authority of Thailand has launched the Bangkok International Development Plan (1991-1997), under which the passenger handling facilities and the number of aircraft parking bays at the international terminal will be increased (allowing an expansion of passenger handling capacity to 25 million per year), a new domestic terminal will be constructed, and car parking and cargo handling facilities will be expanded, at an estimated cost of $272 million. In addition, land acquisition for the construction of a new Bangkok International Airport at Nong Ngu Hao, 34 kilometres east of Bangkok, is currently underway. This project has an estimated total cost of $8 billion and will proceed in four phases. The first phase will


\(^{31}\) Aircraft Support (October 1991).

\(^{32}\) Airports International, (March 1993) and Bangkok Post (Shipping Post Supplement), (15 October 1993).

\(^{33}\) Asian Aviation (November 1992).
involve the construction, by the year 2000 at a cost of approximately $1.20 billion of a 3,700-metre runway and a terminal building, having capacity for 25 million passengers per year.

3. Airports, Investment requirement

The literature search approach was used to provide a guide to the investment requirement of the sector. The data obtained by this means (see Table 1.12) indicate a total investment requirement, for the period 1993-2000, of $44.7 billion, of which only $4.9 billion was clearly identified as committed, leaving a deficiency of $39.8 billion still in need of funding by the year 2000.

Of the total investment requirement identified, $29.00 billion, or nearly 65 per cent, is expected to be spent in East Asia, with two new airport development projects, in Hong Kong and the Republic of Korea, alone accounting for $15.6 billion of this amount. The countries of South-East Asia are expected to have the next largest requirement for investment funds, with an estimated $14.57 billion, or 33 per cent of the regional total, being required by the year 2000. Of this amount, $10.70 billion is estimated to be needed for the new airport at Kuala Lumpur (Sepang).

An investment of $39.36 billion will be required for 15 new airport construction projects throughout the region, representing 88 per cent of the total investment requirement. The balance, of $5.38 billion will be needed for the expansion and or improvement of existing airport/airways facilities.

J. SEAPORTS

While ports in general are becoming more specialized, the introduction and growth of containerization has and will continue to have the greatest impact on port infrastructure development through and beyond the end of the century. Already the ESCAP region is the home of the world's largest container ports (six of the top ten)\(^3\) including Hong Kong and Singapore, the two biggest in the world, each of which is one and a half times the size of the biggest in any industrialized country.

Port container traffic growth rates in the subregions, during the five years leading up to the survey period have been: South Asia 12.9 per cent, Association of South-East Asian Nations (ASEAN) 7.3 per cent and East Asia 11.3 per cent. With forecast economic growth in the region and the continued penetration of containerization into the general cargo market container traffic is projected to continue to grow at rates far in excess of world levels\(^3\) (see Table 1.13) even though somewhat lower than in previous years.

Countries of the region are also harnessing the economic impetus generated by port development by integrating important processing facilities such as


\(^{35}\) ESCAP, Prospects for Container Shipping and Port Development: South Asia Subregion, 1993 (ST/ESCAP/1318); ASEAN Subregion, 1993 (ST/ESCAP/1210); East Asia Subregion, 1994 (ST/ESCAP/1421).

<table>
<thead>
<tr>
<th>Region</th>
<th>Investment required (millions of dollars)</th>
<th>Investment gap (millions of dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Asia</td>
<td>86</td>
<td>292</td>
</tr>
<tr>
<td>South Asia</td>
<td>881</td>
<td>611</td>
</tr>
<tr>
<td>South-East Asia</td>
<td>14,566</td>
<td>13,104</td>
</tr>
<tr>
<td>East Asia</td>
<td>28,999</td>
<td>26,655</td>
</tr>
<tr>
<td>Pacific islands</td>
<td>206</td>
<td>126</td>
</tr>
<tr>
<td>ESCAP region</td>
<td>44,740</td>
<td>39,796</td>
</tr>
</tbody>
</table>

Source: ESCAP Secretariat estimates.
Table 1.13 Trends in port container throughput

<table>
<thead>
<tr>
<th>Subregion</th>
<th>Projected annual container growth rate 1993-2000 (percentage)</th>
<th>Compared to the world 1993-2000 (multiplier)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Asia</td>
<td>9.3</td>
<td>1.46</td>
</tr>
<tr>
<td>South-East Asia</td>
<td>11.0</td>
<td>1.77</td>
</tr>
<tr>
<td>East Asia</td>
<td>9.2</td>
<td>1.37</td>
</tr>
</tbody>
</table>

Source: ESCAP secretariat estimates.
Note: The multiplier of, for example, 1.46 for South Asia means that the throughput would be 46 per cent higher than if South Asia's container growth rate had been at the world growth rate.

as refineries, steel works or export processing zones, such as at Daxie Island in China, Port Qasim in Pakistan and Map Ta Phut in Thailand. This in turn has seen increased pressure for raw materials and the need for development of liquid and dry bulk facilities.

1. Methods used for forecasting growth in port infrastructure

Outputs generated by the ESCAP Maritime Policy Planning Models (MPPM) recently employed to evaluate container port and shipping demand across continental Asia, through to the year 2000, have been used as the basis for investment demand forecasts for container ports.

For bulk handling ports which often rely on the development of parallel industrial complexes and in which investment levels can vary widely, it has not been possible, within the time frame for this study, to make projections. Instead literature searches have been carried out encompassing national five- and seven-year plans and trade journals. It should be noted, however, that this methodology results in significant underestimation of the investment requirements.

Port expenditures are typically incurred for:

- (a) Creating new ports and terminals for containers, liquid/dry bulk commodities and general cargoes;
- (b) Expanding of existing ports through the construction of additional berths;
- (c) Reconstructing/refurbishing berths and particularly converting break bulk facilities to container handling;
- (d) Deepening channels so that bigger ships can access ports;
- (e) Reclaiming land for port development, port related activities and other usage;
- (f) Replacing/upgrading equipment;
- (g) Maintaining channels, berths and equipment.

Regional factors driving the growth of containerization have been the introduction of multimodal transport, with the opportunity of door-to-door cargo movements, and the potential containerization to alleviate problems of switching between modes of transport and overcoming break of gauge problems for rail traffic in the transit corridors. These and the issues related to reducing the labour content in port activities in the industrialized countries will ensure the continued growth of containerization. For the South Asian subregion and China, which are still in the relatively early stages of containerization, growth of this form of transport will continue unabated far into the next century.

2. Estimates of investment requirements to the year 2000

In the case of container berths the basic infrastructure of the berth, stacking area, minimum equipment configuration and an allowance for dredging, reclamation, buildings/superstructure and access has been estimated to be $90 million for a typical 330 metre berth. In the case of restructuring a general cargo facility for container operations including equipment and paving, $30 million has been used.
For bulk handling facilities with their particular investment requirements it is considered
inadvisable to use estimated unit costs. Instead reported expenditures for specific developments
have been recorded.

Table 1.14 shows the estimated port investment requirements to the year 2000 based on the above
considerations and literature searches for projects proposed and underway.

<table>
<thead>
<tr>
<th>Investment required (millions of dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Asia</td>
</tr>
<tr>
<td>South-East Asia</td>
</tr>
<tr>
<td>East Asia</td>
</tr>
<tr>
<td>ESCAP region</td>
</tr>
</tbody>
</table>

Source: ESCAP, regional estimates.

3. Comparison with other projections

For the reasons explained earlier neither ESCAP nor outside agencies are in a position to make
adequate long-term forecasts (year 2000) of bulk handling ports. There are, however, a number
of projections in the container sector. The most recent ESCAP MFFM projections for world
container traffic growth is 6.7 per cent, somewhat less than the performance of 8.0 per cent achieved
during the 1980s. The ESCAP projection is, however, higher than other published forecasts of
Drewry Shipping Consultants at 4.7 per cent over the period 1990-199737 and a somewhat closer
projection by DRI/McGraw-Hill/Mercer World Trade Service which suggests 5.94 per cent a year.

37 Drewry Shipping Consultants, Container Market
38 Calculated from data presented in DRI/McGraw-Hill/
Mercer Management Consulting Inc., World Trade Service
Review, Second Quarter, 1993, which excludes elements of
world trade and transhipment traffic.