

activities, knowledge development, etc. This way of looking at technology directs our attention from purely the hardware and science issues over to the social and policy issues.

It is the co-evolution of these two factors and their feedback effects that is relevant for considering technological development and its impacts. This way of viewing technological change also brings forward the following questions: How can we enhance the innovation system so that new technologies are created? How do we create the optimal setting for new technologies and innovations to spread in large scale throughout society? How can we avoid and mitigate any negative impacts of new technologies? How should we adapt existing technological applications to a rapidly changing social and natural environment? How do we transfer technology from centres of excellence and innovation (developers) to a wider group of end users? How do we recognise the importance of traditional knowledge, particularly for adaptation purposes?

The innovation system approach has increasingly become a well-established heuristic framework for science and innovation policy by numerous public organisations around the world (Hekkert and Negro 2009). For example, the government of The Netherlands has adopted a wide approach system called *transition management* to transform the country from a fossil fuel-based economy to an economy totally based on renewable energy. The transition management approach was originally developed by Dutch technology and social science researchers in the 1990s (Kemp et al. 2007). Hartikainen and Hetemäki (2008) have analysed the application of the transition management approach for planning and implementing the Finnish national forest policy.

## 9.2 Information and Communication Technology

Information and communication technology is an umbrella term that includes the design, development, implementation, support, and management of computer-based information systems. In essence, the application of this technology deals with the use of computers and software to convert, store, protect, process, transmit, and retrieve information.

The expression “information and communication technology” should, by its very nature, include paper-based writing and printing, which are also technologies. Here, however, we restrict the concept to include only the electronic or digital communication technology.

ICT development has already fundamentally changed the global forest sector, and will continue to do so in the future. Hetemäki and Nilsson (eds. 2005)

provide a wide analysis on the manifold impacts that ICT has had, and is likely to have, for the global forest sector. The study also shows that when discussing the impacts of ICT on the forest sector, it is like asking what have been the impacts of electricity, or the internal combustion engine, to the forest sector. Like these technologies, ICT belongs to a category known as *general purpose technologies*; essentially, they are everywhere and affect everything. It is thus difficult to precisely identify and quantify the role of a general purpose technology in the development of the forest sector. Another feature of general purpose technologies is that immediate, short-term, and visible changes tend to be seen in the technology in question, whereas long-term impacts tend to bring organisational, institutional, and cultural changes. Thus, the full impact of ICT on the forest sector will be apparent only after a long time lapse.

Within this large topic, the focus here is on the impacts of ICT to the pulp and paper industry, and how subsequent changes in this industry will affect the consumption of wood.

### 9.2.1 ICT and the Pulp and Paper Sector

From the perspective of the pulp and paper sector, the most important feature of ICT is that it provides alternative forms of communication to paper-based communication. For example, there could be a direct replacement of reading print newspapers by reading the news on the internet; or there could be indirect substitution. For example, people, especially the younger generation, are increasingly spending their time watching videos and playing video games instead of reading newspapers, magazines, or books. However, the total amount of time (and capacity) consumers can spend on information or entertainment is finite, that is, limited to the 24 hours in a day. Thus, there is inevitably a trade-off between different activities, and the time spent in consuming print media appears to be declining (see Table 9.2).

The impacts of ICT on print media and the paper industry are universal. Electronic communication supersedes print media whether one is in New York, Moscow, Peking, or Nairobi, in exactly the same way. However, there are large differences in the timing and magnitude of the impacts between countries. These differences are not related to geography, but to such social factors as income level and paper consumption level. What do we mean by this?

Table 9.2 shows the internet usage and per capita paper consumption in various regions of the world. The regions are separated into two categories labelled high- and low-income regions. It should be noted that the division between high and low income

**Table 9.2. Media use by United States' consumers in 2001, and projections for 2010 (hours spent annually).**

Media	2001 hours	2010 p hours	% -change 1990–2010p
1. Newspaper	199	158	-20.6
2. Magazines	127	112	-11.8
3. Books	105	109	+3.8
<i>Print media total</i>	<i>431</i>	<i>379</i>	<i>-12.1</i>
4. TV	1 553	1 728	+ 11.3
5. Radio	792	758	-4.3
6. Videos, video games	113	164	+ 45.1
7. Internet	125	184	+ 47.2
<i>Electronic media total</i>	<i>2 583</i>	<i>2 834</i>	<i>+9.7</i>

Source: Statistical Abstract of the United States, US Census Bureau 2009.

**Table 9.3 Population and internet users in 2009, and communication-paper consumption in 2007.**

	Population (million)	Internet users (million)	Penetration (% pop.)	Newsprint per cap. (kg)	Print. writ. pap. per cap. (kg)
Africa	997	64	6.4	0.8	1.8
Asia (-Japan)	3 695	607	16.4	2.8	7.4
Non-EU Europe	314	93	29.6	5.1	10.2
Latin America	589	176	29.9	2.1	5.5
<i>Low-Income Regions</i>	<i>5 595</i>	<i>940</i>	<i>16.8*</i>	<i>2.5*</i>	<i>6.4*</i>
EU27	489	309	63.2	22	61.3
Japan	127	94	74.0	35	77.9
North America	341	252	73.9	25	88.2
Oceania	35	21	59.8	22	46.6
<i>High-Income Regions</i>	<i>992</i>	<i>676</i>	<i>68.1*</i>	<i>24.7*</i>	<i>72.2*</i>
TOTAL	6 790	1 664	24.5	5.7	16.2

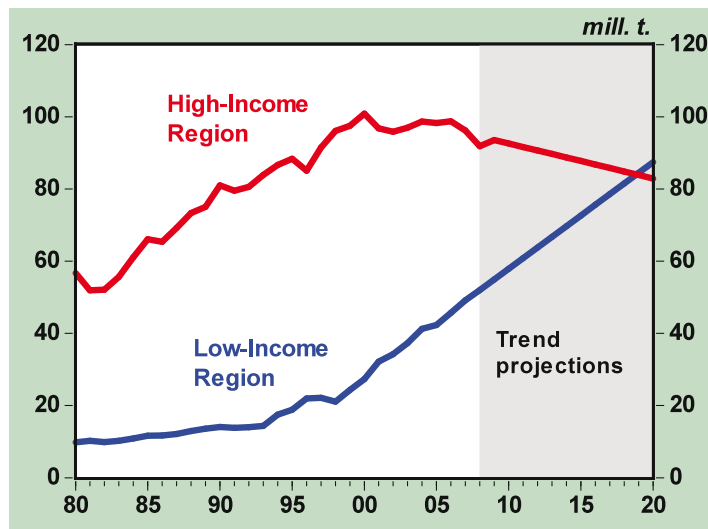
Note. Internet Usage and Population Statistics are for June 30, 2009. Source: Internet World Stats paper consumption figures computed from FAOSTAT data. \*The numbers are population weighted averages.

regions is not exact. For example, the low-income region Non-European Union Europe includes Norway and Switzerland, which clearly are high-income countries. Similarly, the low-income Asian region includes Singapore and South Korea, which clearly should be placed in the high-income category. However, their impacts at an aggregate level for the regional figures are minor.

There are three significant differences between these two types of regions. First, the total number of *population* in the low-income group is almost six times higher than in the high-income group; over 80% of the world's population lives in the low-income region. Secondly, the *per capita consumption* of newsprint and printing and writing paper is about ten times higher in the high-income region. The average person in the high-income region of the world consumed 72.2 kg of printing and writing paper in 2007, whereas the average person in the low-income region consumed only 6.4 kg. Thirdly, the *internet*

*penetration rate*, that is, the percentage of the population using the internet, is also strikingly different between the regions. In the low-income region, on average, every sixth person is using the internet, while in the high-income region, more than one in two people are using the internet.

The above numbers reflect the fact that there is a clear dichotomy between the world regions with respect to the status of paper markets for communication purposes, and the magnitude of ICT impacts on this. In the high-income region, paper consumption has reached the saturation point, and the intensive spread of the internet and other electronic media has already begun to replace paper consumption. In contrast, in the low-income region, paper consumption is growing very rapidly due to economic growth, increasing urbanisation, and population growth. The intensity level of the internet and electronic media usage is still very low, and consequently the impact on paper consumption is also small.



**Figure 9.2** World graphics paper (newsprint + printing and writing paper) consumption 1980–2008, and trend projections to 2020.

The net impacts of the above development are illustrated in Figure 9.2 for the world's high-income and low-income regions. The high-income region is defined here to include North America, "Modified EU", Japan, and Oceania. "Modified EU" means the 27 EU countries minus the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovenia, and Slovakia, plus Iceland, Norway, and Switzerland.

At the turn of the century, the structural change in the world *graphics paper* (= newsprint + printing and writing paper) market started to take place. Up to the end of the 1990s, the high-income region had experienced an increased trend of graphics paper consumption. This started to stagnate at the beginning of this century, and eventually started to decline, despite economic growth. The single most important factor behind this development was the impact of electronic media (Hetemäki 2005, 2008). Businesses, consumers, and organisations increasingly moved their communication and media usage away from print to digital media.

The mirror image of the above trend is the steeply increasing trend of graphics paper consumption in the low-income region, which has doubled in the past decade. In 1999, the consumption of graphics paper in this region was only a quarter of what it was in the high-income region, and now it is about half of what the high-income region consumes. If the trend projections shown in Figure 9.2 are actualised, by 2019, the consumption in the low-income region will surpass that of the high-income region. The major factor behind this situation is the initially very low level of paper consumption per capita coupled with the rapid economic and population growth and urbanisation in the low-income region.

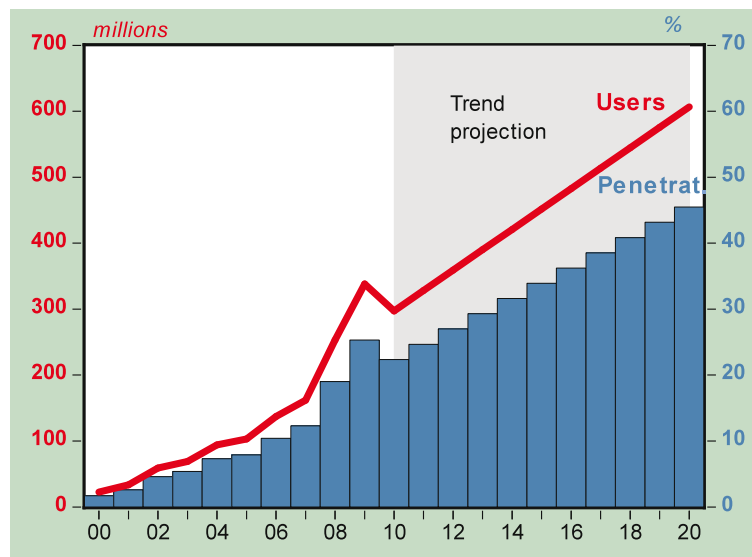
The trend projections for the high-income regions shown in Figure 9.2 were computed as fol-

lows. For each of the high-income regions – North America, EU, Japan, and Oceania – separate trends were estimated. For North America, the trend was estimated using data for the period 2000–2008. However, since the structural change in consumption in other high-income regions started later than in North-America, the trends for these regions were estimated using observations from only the 5-year period (2004–2008). Finally, the trend projections for different high-income regions were summed. For the low-income region, the trend was simply computed for the aggregate region using data for the period 2000–2008.

According to the projections, the consumption of graphics paper would decline in high-income regions by 18 million tonnes in 2020 from its maximum level in 2000. In contrast, over the same period, it would increase by 60 million tonnes in low-income regions. The world net increase would, therefore, be 42 million tonnes, which would be a 33% increase from 2000.

The trend projections in Figure 9.2 will probably capture the overall pattern of the future development. However, they are likely to turn out to be clear overestimates. First, the current economic slump is likely to strengthen the structural change in high-income regions. In 2009, the consumption of graphics paper in high-income regions is likely to end up being about 15–20% lower than in 2008. The lower demand is mainly due to cyclical reasons, but some of it may turn out to be structural or lasting. The reasons for this are described in the following paragraphs.

In order to save costs during an economic downturn, businesses adapt ways to reduce paper usage. For example, newspaper publishers may reduce the size of a newspaper from a broadsheet to a tabloid size, or they may move some material only to the



**Figure 9.3 Internet Users and Penetration Rate in China 2000–2009 and Trend Projection to 2020 (Data source: Internet World Stats).**

internet, such as stock exchange pages. Or banks, insurance companies, and federal and local government organisations may transfer business-to-business and business-to-consumer communication to digital form, such as by dropping paper forms and providing them online instead. Once these measures have been adapted, it is unlikely that they would return to the old modes when the economic slump is over. This pattern is what seems to have happened in the USA after the so called mini-slump in 2001. The implication of this development is that the consumption of graphics paper is likely to be lower than what the trend projection for high-income region suggests.

Secondly, the trend projections do not take into account new developments related to digital hardware, software, and services. These will undoubtedly strengthen the move from print to digital media. Consider, for example, e-books. They have been around for about a decade or so, but due to their incompleteness, they have not become popular. However, recent advancements in e-book technology and related services have given them a significant boost. The Amazon Kindle and the iPad, for example, have been major successes. There will be even further developments on this front that will make the devices and services more consumer-friendly. Also, the price of e-book devices is bound to decline. Similar developments are likely to take place on many other digital media fronts. Given this pattern, the trends in Figure 9.1 are likely to over-estimate the graphics paper consumption in the future.

In principle, the above arguments are valid in both the high-income and low-income regions. But the magnitudes of the impacts are likely to be greater in high-income regions, at least in the near future. The big question is, when will the electronic media

start to replace the print media to a larger degree in the low-income regions? Currently, the low-income region population weighted average internet penetration rate is still only 16.8%, which is about the same as it was in the USA in 1997. But in some major low-income countries, such as China, change is taking place rapidly.

According to *Internet World Stats*, in China, there were 360 million internet users in September 2009, which is the largest number for any country. However, the internet penetration rate is about 27%; whereas, in the USA, it is about 74%. But the internet penetration in China grows very rapidly – the number of internet users has increased by ten times in the last seven years (see Figure 9.3). Just in the first half of 2009, 40 million more Chinese connected to the internet. Also, China's telecommunication firms – China Telecom, China Mobile, and China Unicom – plan to invest USD 40 billion in improving the 3G networks that support voice and video communications, high-speed mobile internet, and mobile television.

In summary, given the rapid spread of the internet and electronic media in the low-income regions, it is likely that the trend projection for low-income region graphics paper consumption shown in Figure 1 will turn out to be an over-estimate. In the coming decade, the currently very low internet penetration ratio will undoubtedly increase significantly in these regions. The impacts of this will also be large due to the fact that the bulk of the world's population lives in low-income regions.

### 9.2.2 Implications for the Forest Sector

What are the major implications of the ICT development for the global forest sector? First, the demand for graphics paper products will be lower than it would be without ICT development. In order to give an idea of the possible magnitude of the impact, consider the following case.

Assume that the historical pattern of graphics paper consumption in high-income regions had continued, and the trend between 1990–1999 was used to project the consumption up to 2020. Based on this trend, the consumption would be 137 million tonnes in 2020, instead of the 83 million tonnes projected in Figure 9.2. The difference is 54 million tonnes, and it is to a large extent due to the impact of ICT.

These 54 million tonnes equals the sum of graphics paper consumption in North America and Japan in 2007. How many pulp and paper mills are needed to satisfy the current level of North American and Japanese graphics paper consumption? What are the direct and indirect impacts of these mills to turnover, taxes, and employment? What about the implications to pulpwood consumption?

Assume that the graphics paper production in 2020 would be based on the mix of wood fibre we observe today in high-income regions. That is, the share of chemical pulp would be about 40%, mechanical pulp 13%, and recovered paper 54%. Then, the 54 million tonnes decline in paper consumption would imply about 128 million cubic meters less of pulpwood demand (assuming that one unit of chemical pulp requires 5 units of pulpwood, and one unit of mechanical pulp requires 2.8 units of pulpwood, according to Finnish Statistical Yearbook of Forestry 2008). This is more than the total sum of annual industrial roundwood production in Finland and Sweden in 2007.

Even though the above projections and calculations make many assumptions and simplifications, they help to point out that the impacts of ICT to the global forest sector will be of major significance. Moreover, the negative impacts are not restricted to declining paper, pulp, and pulpwood consumption, but also to declining prices and profits. The pulp and paper industry companies are not only competing against other paper companies, but also against the electronic media. Partly due to this, the real prices of graphics paper products have been significantly declining in this century. This also implies that the pulp and paper companies have increasing difficulties to pass their higher production costs onto paper prices (Hetemäki 2008).

The other side of the impacts of ICT on the global forest sector is that it helps to boost productivity and creation of new products. ICT hardware, software, and services are essential tools for increasing the productivity of pulp and paper mills, as well as forestry

productivity. On the other hand, the convergence of print and electronic media is creating new products, such as the radio-frequency identification (RFID) tags and intelligent packing products. These provide new opportunities for the pulp and paper companies, and re-structuring of their product mix.

### 9.3 Biotechnology Applications in Forestry

Biotechnology is any biology-based technology that develops or uses living organisms to produce, alter, or improve a product or organism for a specified purpose. It has many applications in industry and in the environment (environmental technology). Biotechnology is based on several methods and approaches. Plants can be multiplied by clonal propagation, giving identical offspring. Gene transfer of valuable genes has been conducted for the genetic improvement of forests. In plant breeding, genetic markers are used to develop better plants. Trees cannot exist without soil microbes that influence tree growth in many ways. This fact was only recognised some 20 years ago and has slowly resulted in more detailed data on how microbes can affect the growth of woody plants. Awareness of the immense biodiversity in the microbial world has contributed to the development of microbial ecology. Microbes can and will be used to improve plant performance, and the plant-microbe system may improve soil quality and forests. Although genetic techniques are fundamental in the biotechnology of plants and their associated microbes, this endeavour will not implicitly lead to the construction of transgenic plants and genetically modified organisms (GMOs) in the finalised technology. The challenge in this venture is to get products that are ecologically friendly and that will function well in changing environmental circumstances.

World demand for forest products has increased substantially with increases in population and wealth (FAO 2008). Meeting people's basic needs for living and providing a good quality environment could be better realised by more effective use of fundamental ecosystem services; this has become the great challenge. In general, technological advances in forest sciences followed in the footsteps of advances in agriculture, so it would not be a surprise to see many applications of biotechnology being used in forestry. Biotechnology has the potential to improve the quality and quantity of wooden raw material supplies in a long-term perspective and could also have a radical effect on pulping processes, waste-to-energy systems, and other aspects of the manufacture and use of forest products. Reduced costs and increased yields are the potential economic benefits of biotechnology, which implies that society could get more outputs for